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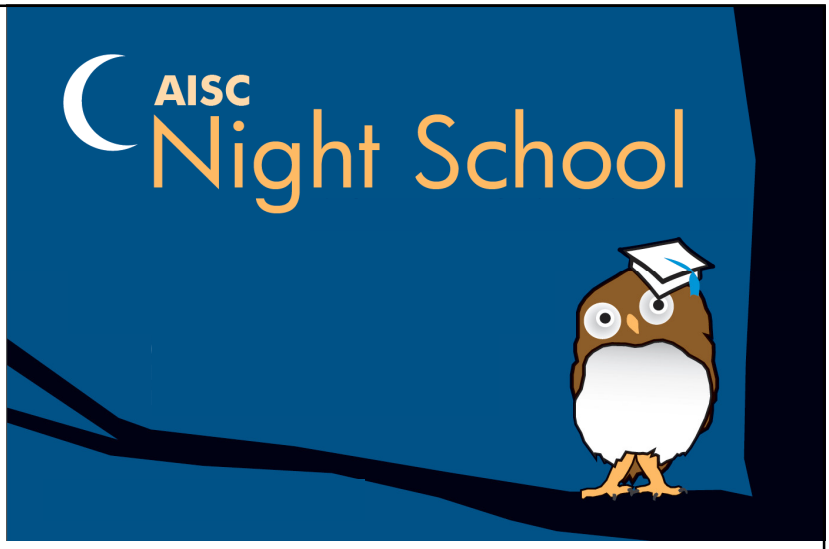

Welded Connections

A Primer for Engineers

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Course Description

21.6 Seismic Welding Issues
November 26, 2019

This session will discuss seismic design and ductility, the 1994 Northridge earthquake and the requirements of the AWS D1.8 Seismic Welding Supplement. AWS D1.8 will be reviewed with a specific focus on the requirements that must be specified by the Engineer, what compliance to these requirements looks like, and why such provisions are in the Code. AISC 358 – Prequalified Connections for Special and Intermediate Steel Moment Frames will be introduced.

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Learning Objectives

- Name the key lessons learned from the Northridge earthquake and performance of moment connections.
- Describe the applicability of AISC 358: Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications.
- Describe the applicability of AWS D1.8 Seismic Welding Supplement.
- List information that the Engineer of Record is required to provide in the Contract Documents per AWS D1.8.

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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

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Night School 21
Welded Connections --
A Primer for Engineers

Session 6: Seismic Welding Issues
November 26, 2019

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

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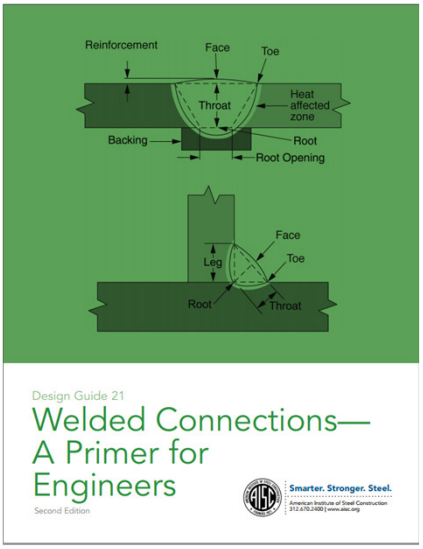
SEISMIC WELDING ISSUES

AISC Design Guide 21, 2nd Edition

Welded Connections – A Primer for Engineers



SEISMIC WELDING ISSUES

Chapter 11 Seismic Welding Issues

11.1 Introduction

11.2 The Northridge Earthquake

11.3 Seismic Welding Specifications

11.4 Seismic Terminology

11.5 AWS D1.8

11.6 AISC *Seismic Provisions* Welding Requirements

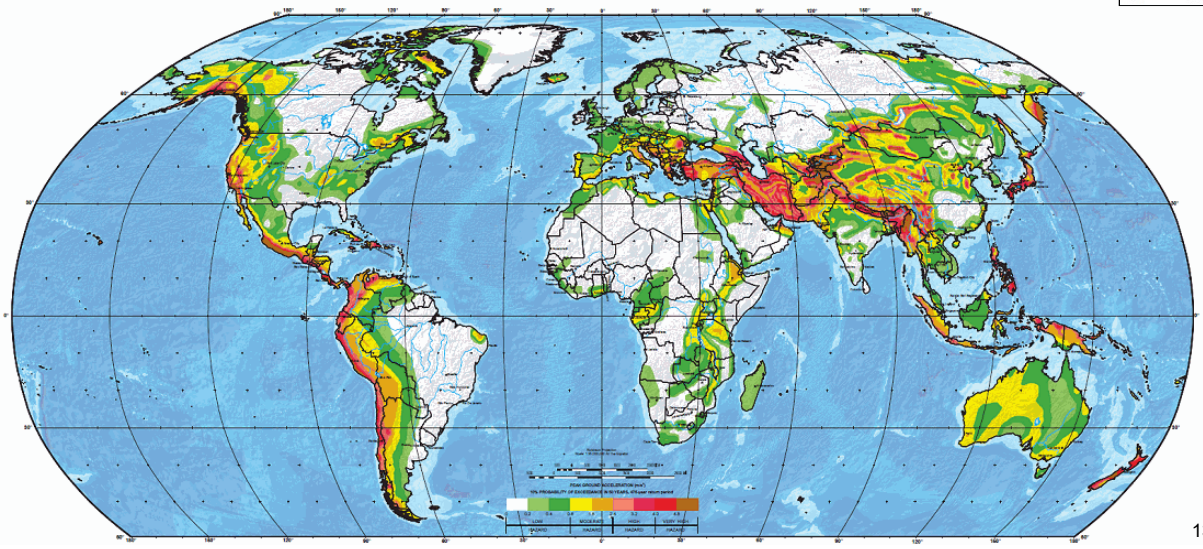
11.7 AISC *Prequalified Connections* Welding Requirements

11.8 Welded Details For Prequalified Connections

SEISMIC WELDING ISSUES

GLOBAL SEISMIC HAZARD MAP

Produced by the Global Seismic Hazard Assessment Program (GSHAP),
a demonstration project of the UN/International Decade of Natural Disaster Reduction, conducted by the International Lithosphere Program.
Global map assembled by D. Giardini, G. Grünthal, K. Shedlock, and P. Zhang
1999



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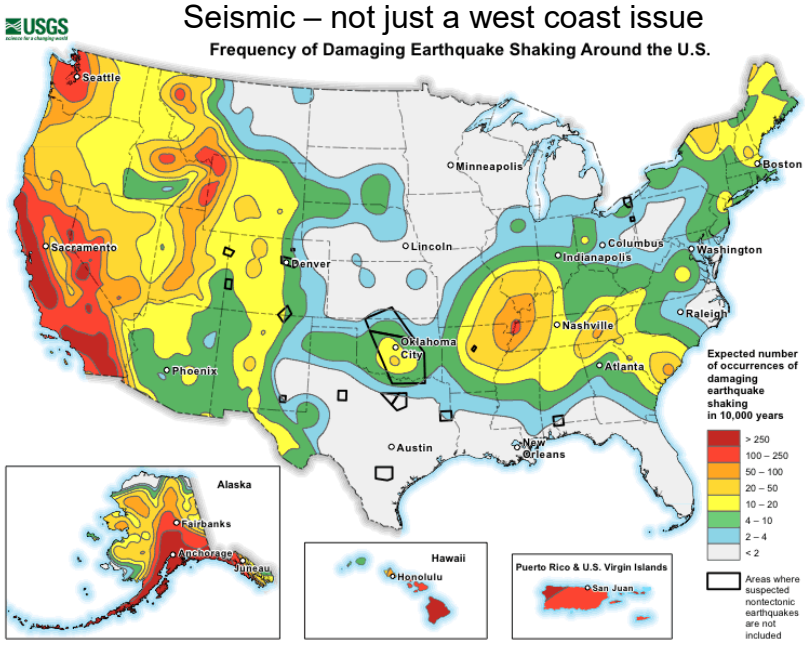
SEISMIC WELDING ISSUES

Seismic – not just a west coast issue



14

SEISMIC WELDING ISSUES

Outline

- Seismic Design and Ductility
- The Northridge Experience
- AISC Prequalified Seismic Connections
- D1.8 Seismic Welding Supplement
- Conclusion

15

ANSI/AISC 341-16

Seismic Provisions for Structural Steel Buildings

16

AISC 341-16 SEISMIC PROVISIONS

COMMENTARY CHAPTER A

GENERAL REQUIREMENTS

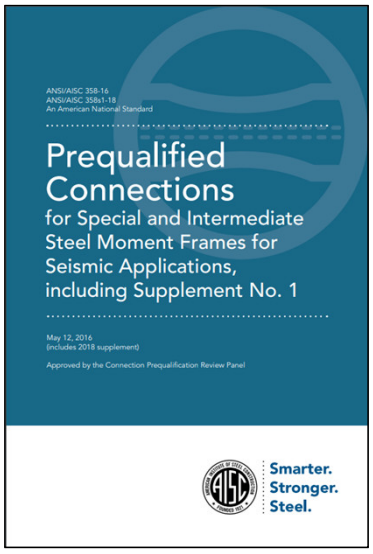
A1. Scope

Structural steel systems in seismic regions are generally expected to dissipate seismic input energy through controlled inelastic deformations of the structure. The Provisions supplement the *Specification* for such applications. The seismic design loads specified in the building codes have been developed considering the energy dissipation generated during inelastic response.

17

ANSI/AISC 358-16
ANSI/AISC 358s1-18

Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications, including Supplement No. 1



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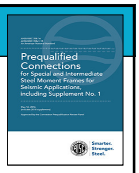
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



COMMENTARY CHAPTER 1

GENERAL

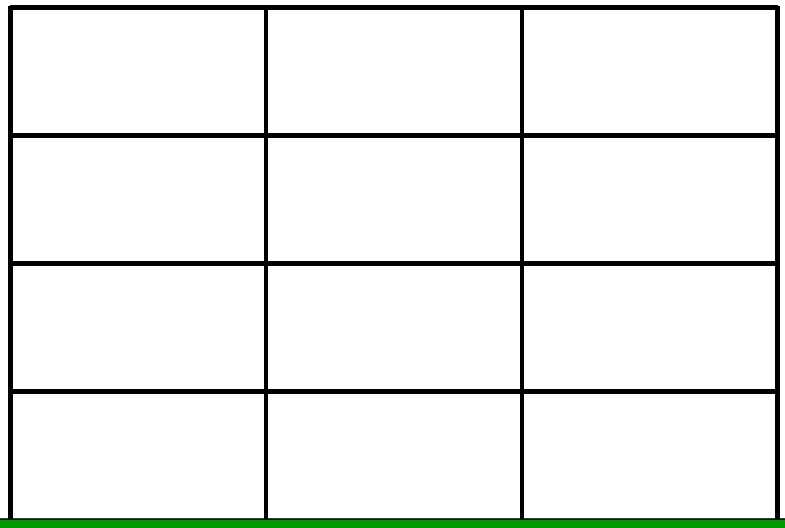
1.1. Scope

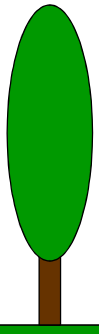
Design of special moment frames (SMF) and intermediate moment frames (IMF) in accordance with the AISC *Seismic Provisions for Structural Steel Buildings*… and applicable building codes includes an implicit expectation that they will experience substantial inelastic deformations when subjected to design-level earthquake ground shaking, generally concentrated at the moment-resisting beam-to-column connections.

19

SEISMIC WELDING ISSUES

Special
Moment
Frame





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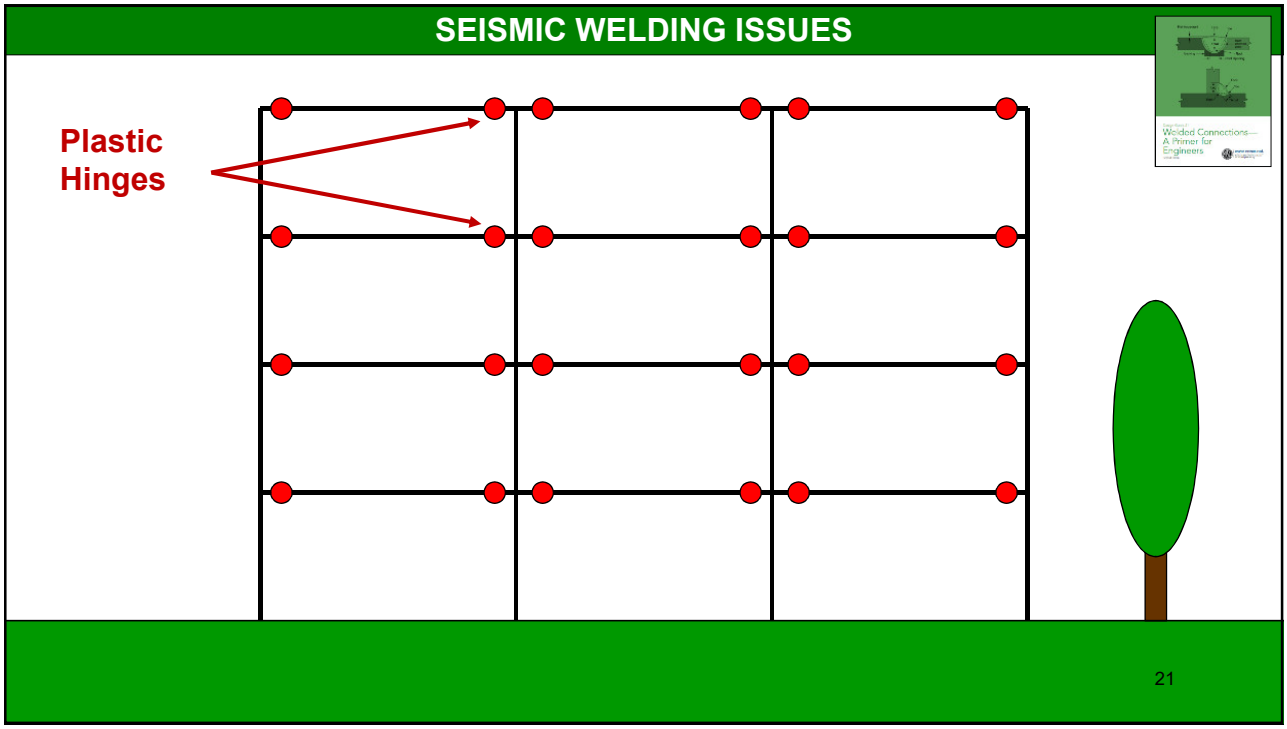
SEISMIC WELDING ISSUES



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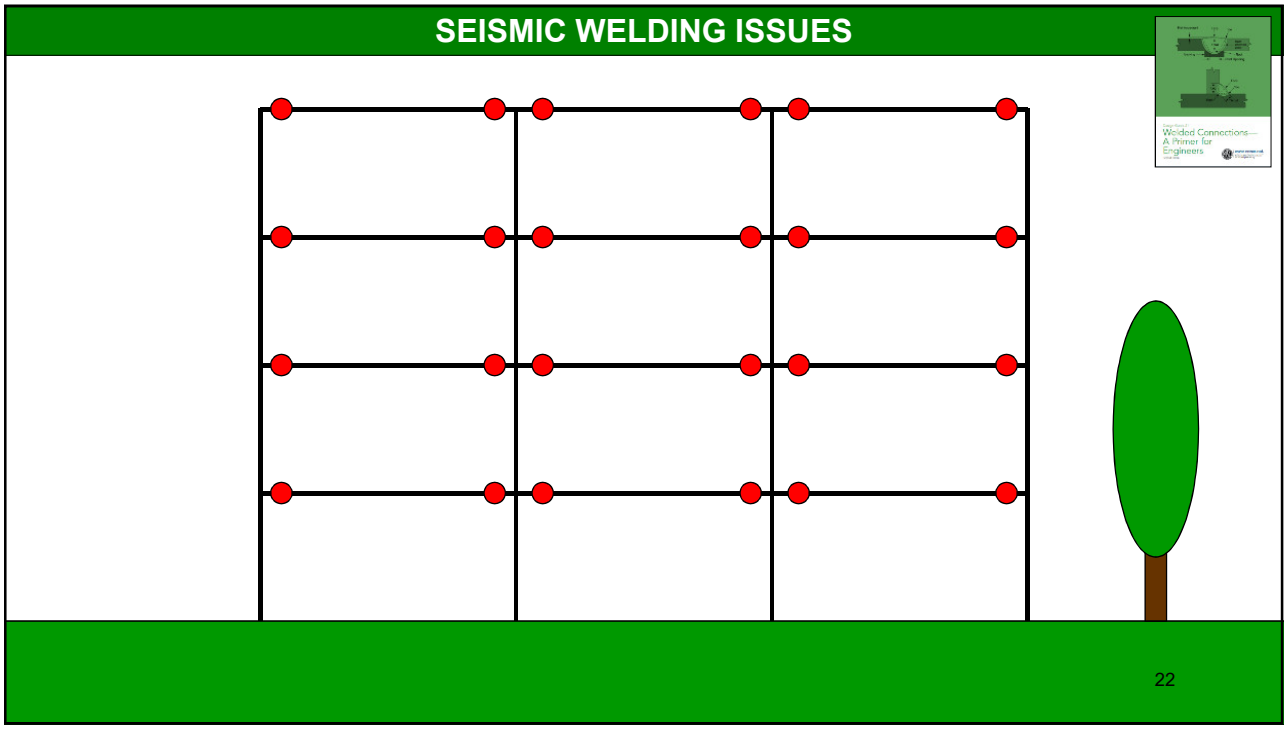

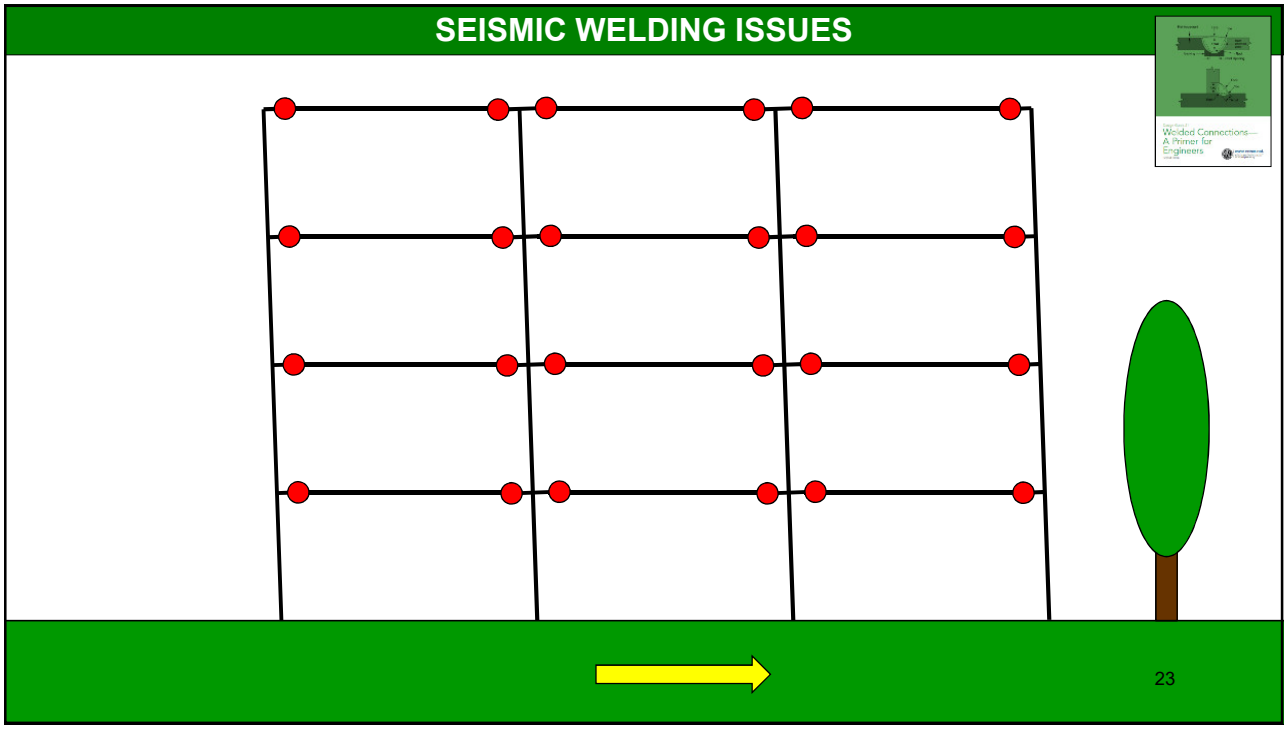

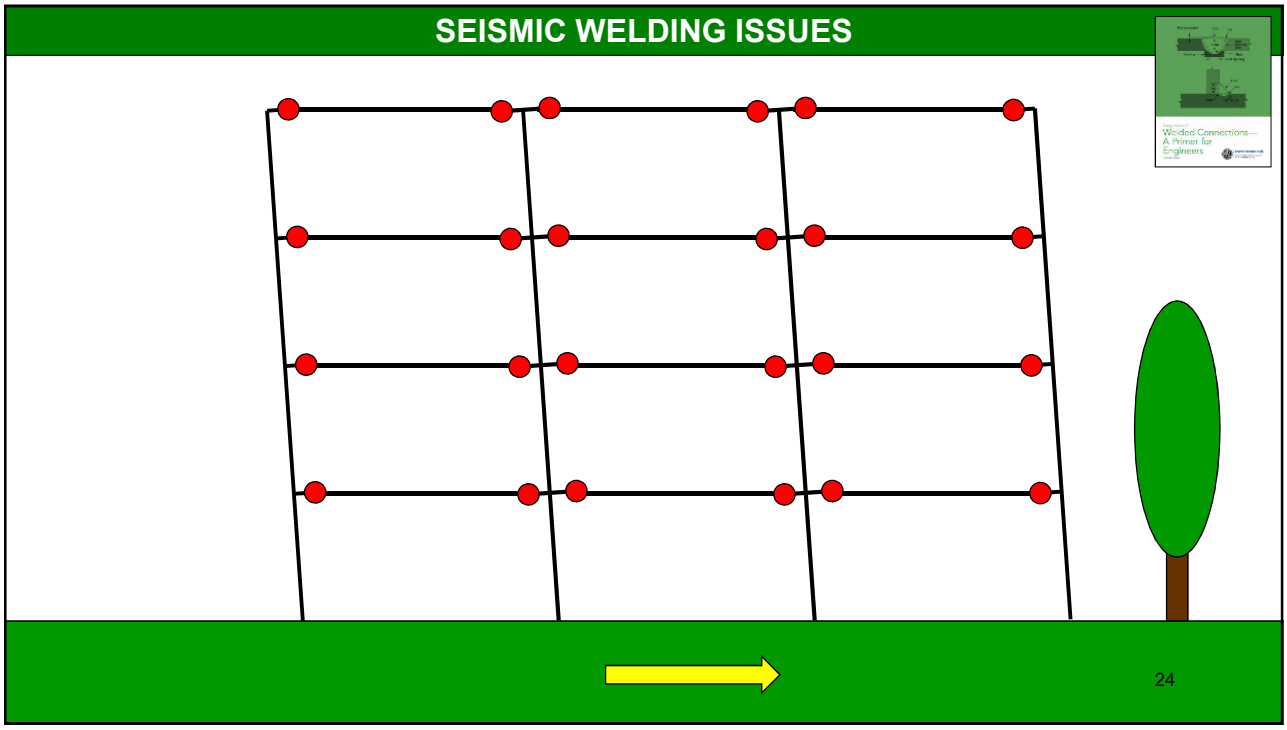

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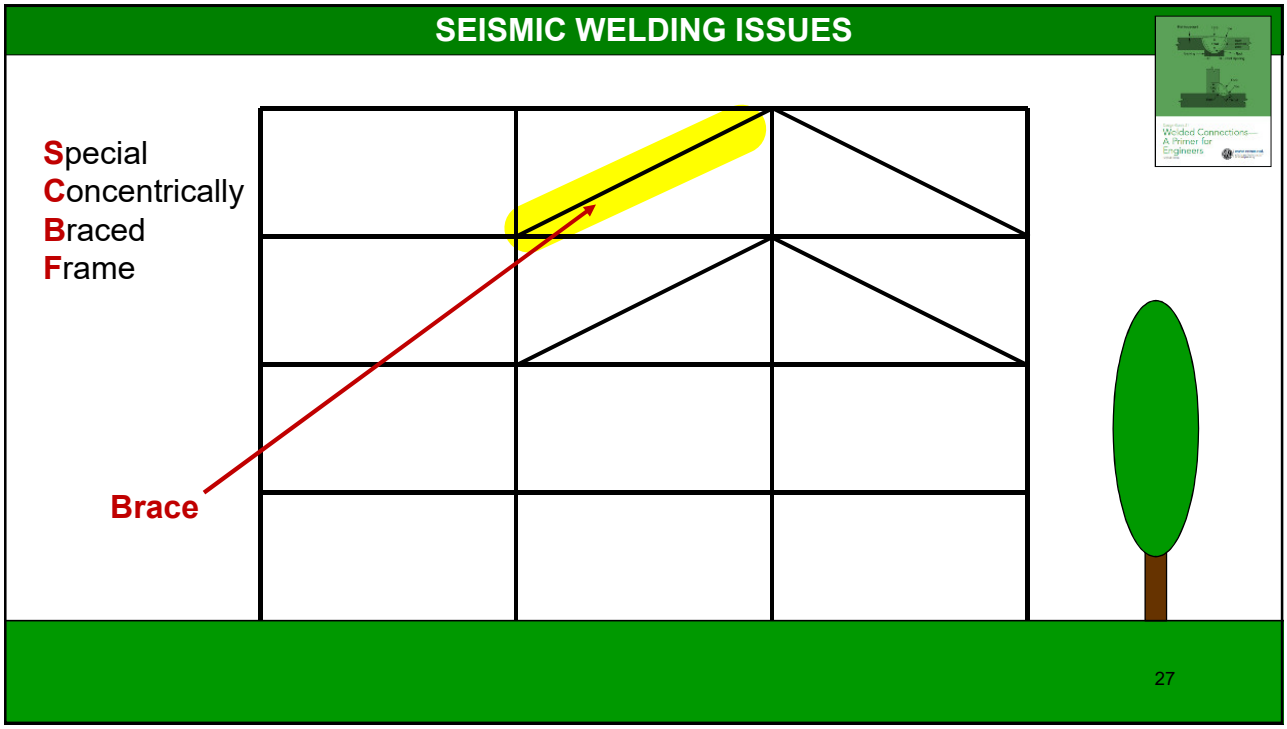

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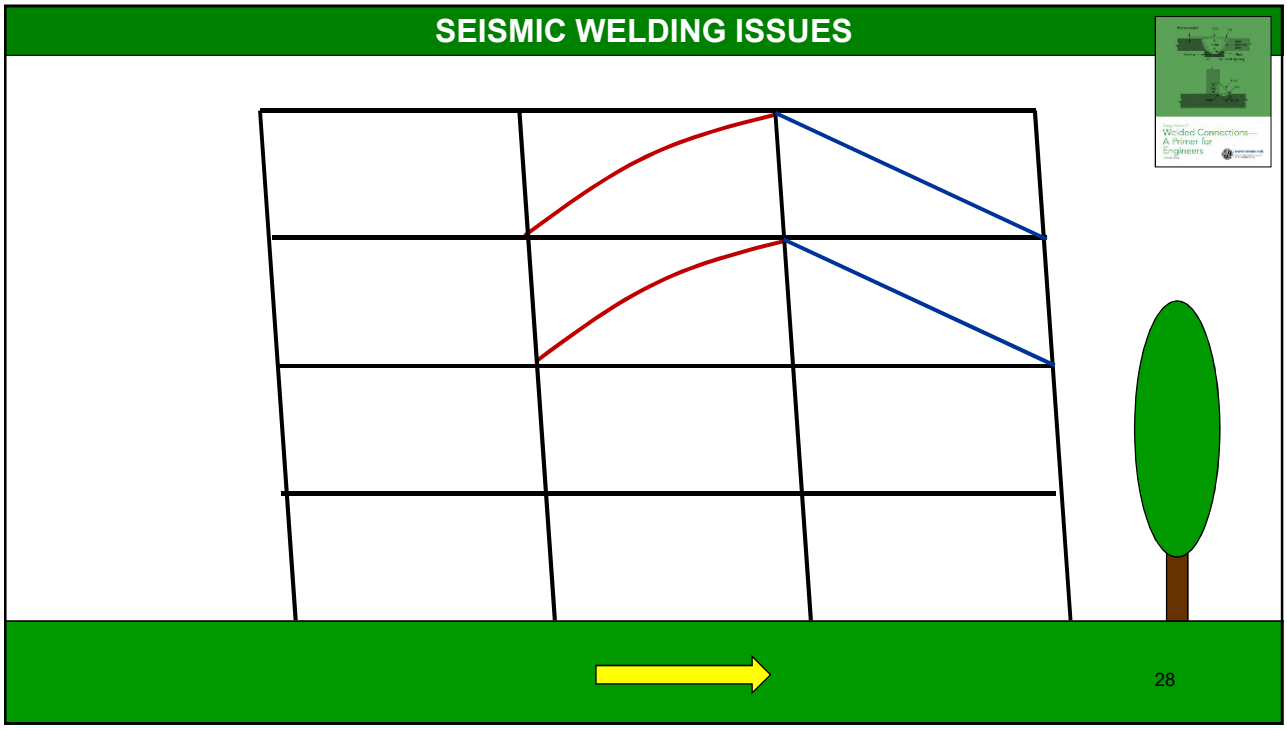

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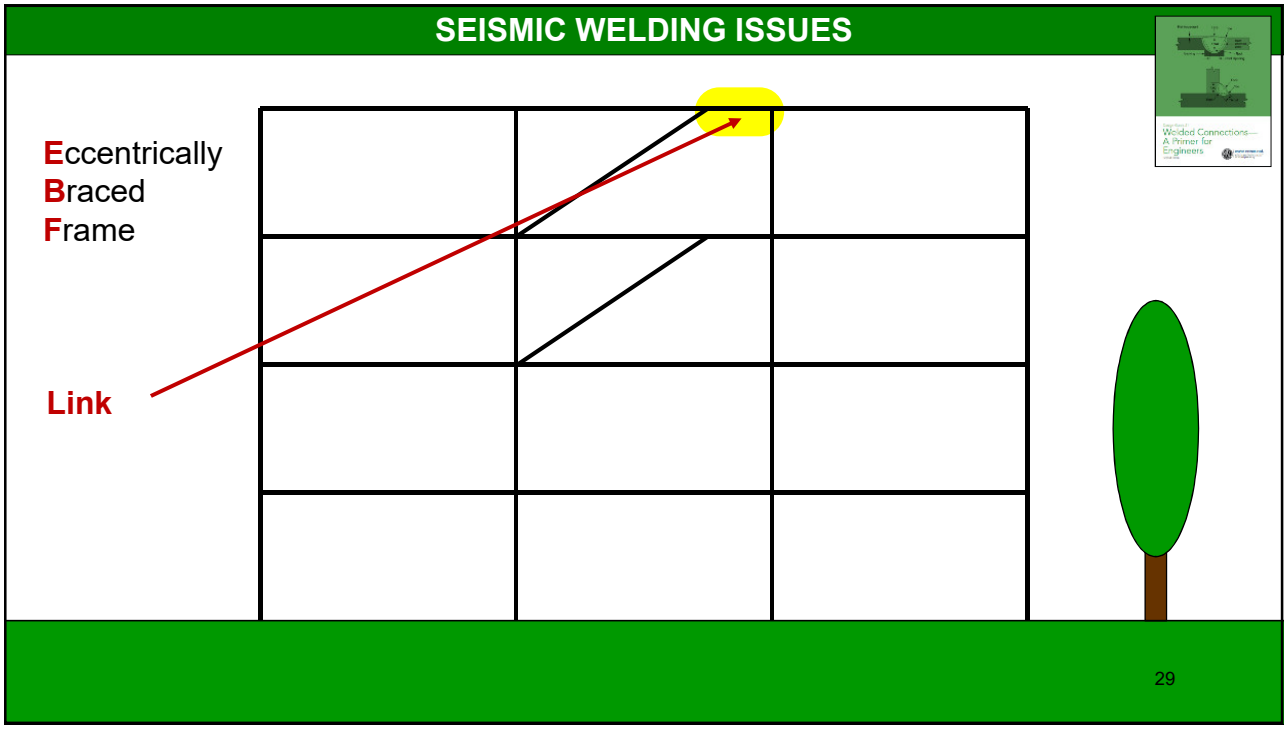

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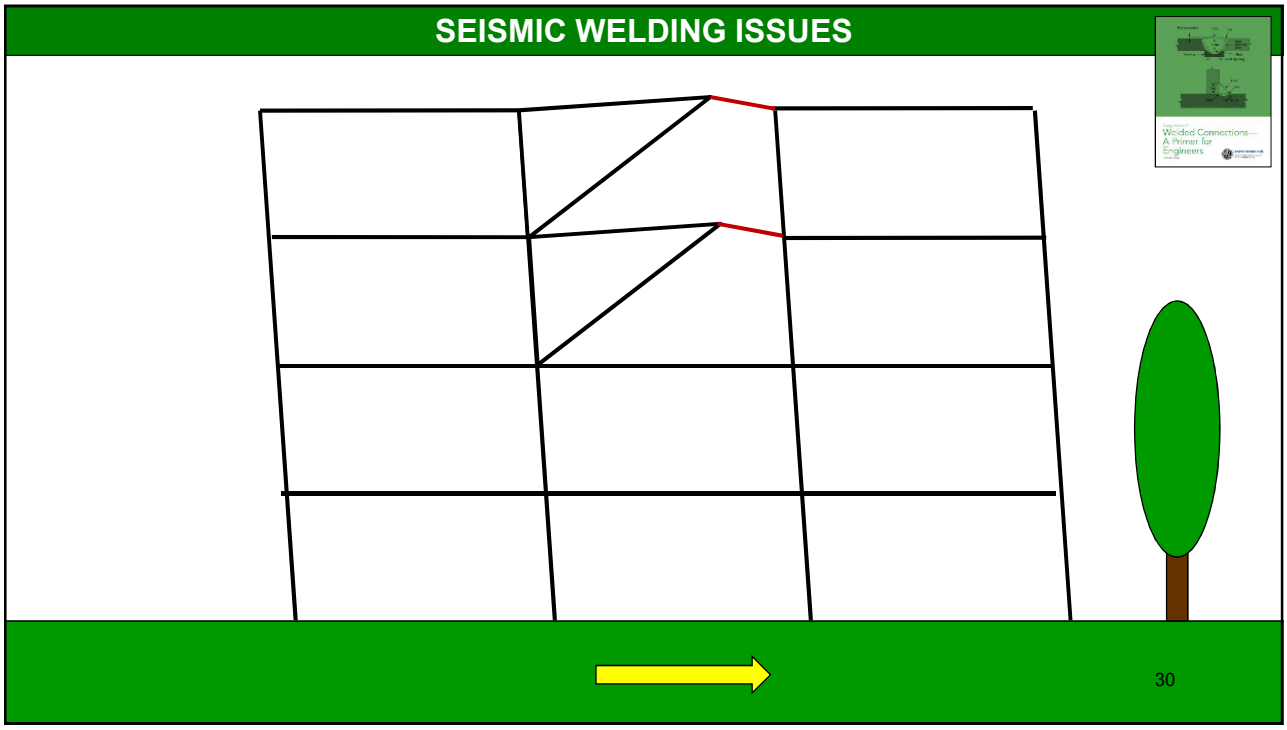

SEISMIC WELDING ISSUES

Outline

- Seismic Design and Ductility
- The Northridge Experience
- AISC Prequalified Seismic Connections
- D1.8 Seismic Welding Supplement
- Conclusion

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The Northridge Earthquake
January 17, 1994

Los Angeles Times

TUESDAY, JANUARY 18, 1994

33 Die, Many Hurt in 6.6 Quake

L.A. Area Freeways Buckle, Buildings Topple

Sylmar Jolted by Ghosts of Horror Past

■ **History:** The city that crumpled under a 6.5 quake in 1971 remembers well the terror that came when the earth gave way. On Monday, it seemed like it was cursed.

By CRAIG TURNER and RICHARD E. MEYER
TIMES STAFF WRITERS

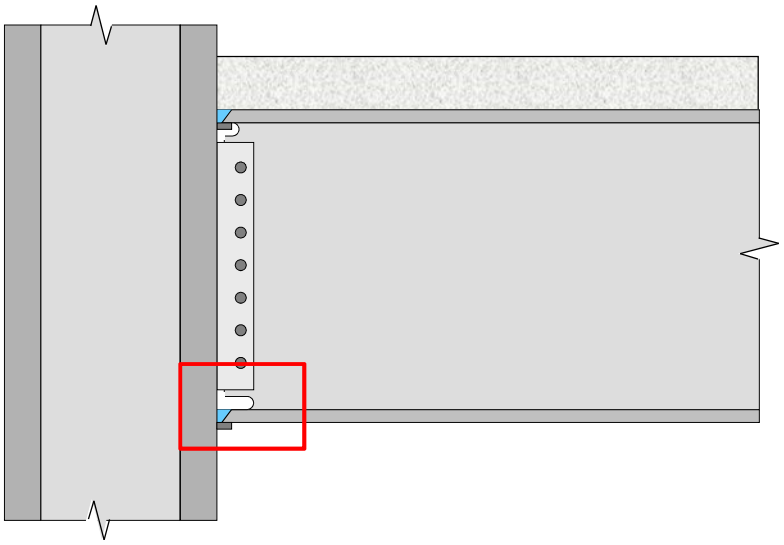
■ **Disaster:** Epicenter is in Northridge, where three-story apartment complex pancakes. Ruptured gas lines erupt in fire in strongest temblor in city's modern history.

By TRACEY KAPLAN and GREG KRIKORIAN
TIMES STAFF WRITERS

The body of LAPD Officer Clarence W. Dean lies near his motorcycle, lapsed onto the Golden State Freeway during Monday's earthquake.

32

SEISMIC WELDING ISSUES



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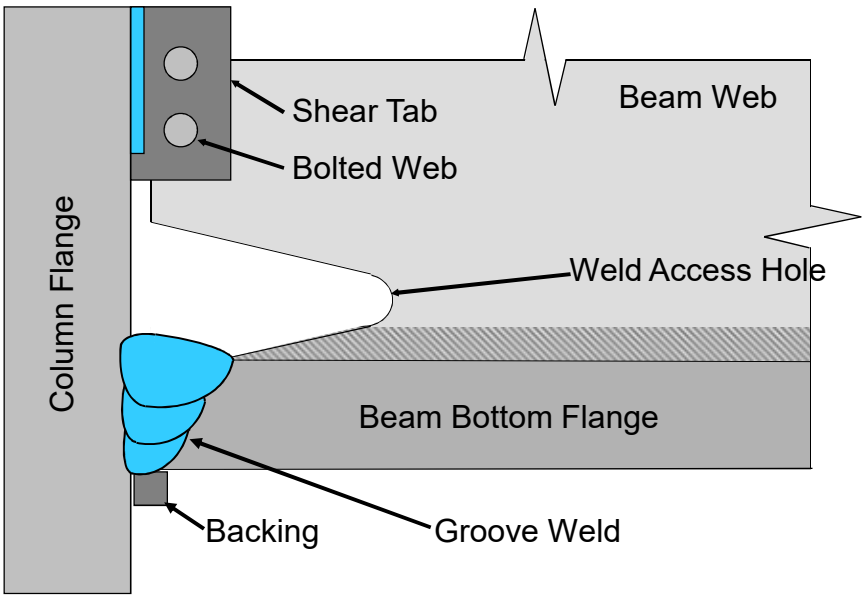
SEISMIC WELDING ISSUES



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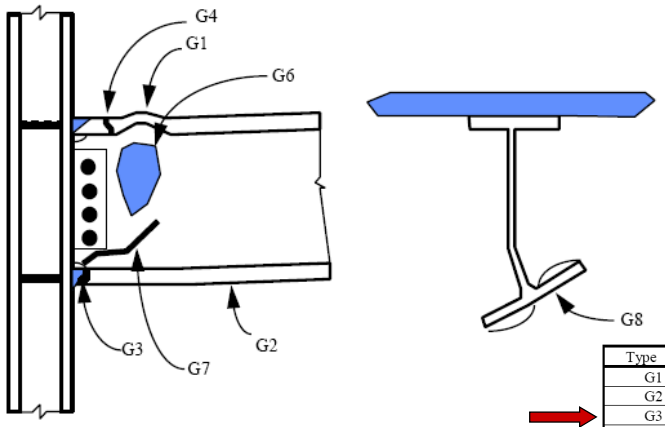
FEMA 267 - Interim Guidelines: Evaluation, Repair, Modification and Design of Welded Steel Moment Frame Structures

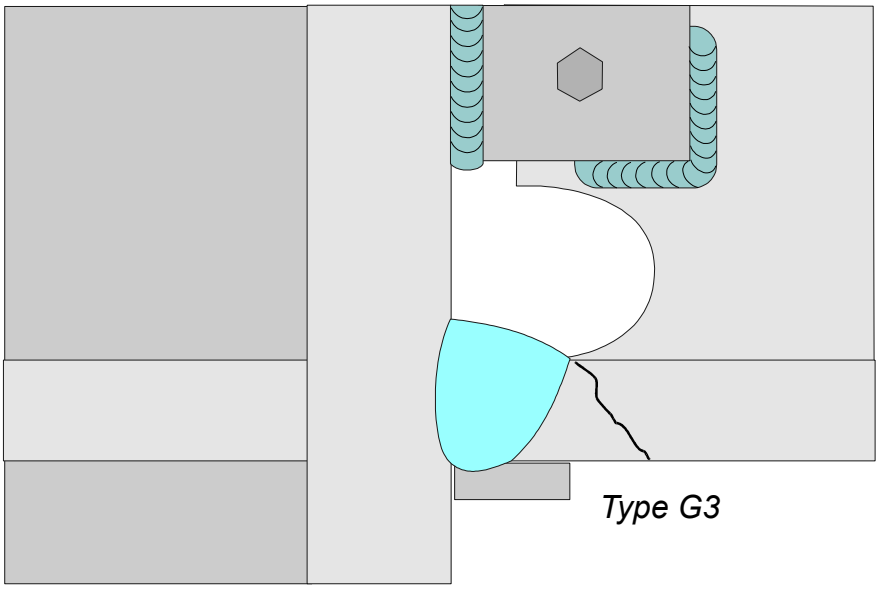


Type	Description
G1	Buckled flange (top or bottom)
G2	Yielded flange (top or bottom)
G3	Flange fracture in HAZ (top or bottom)
G4	Flange fracture outside HAZ (top or bottom)
G5	Flange fracture top and bottom
G6	Yielding or buckling of web
G7	Fracture of web
G8	Lateral torsional buckling of section

Figure 3-2 Types of Girder Damage

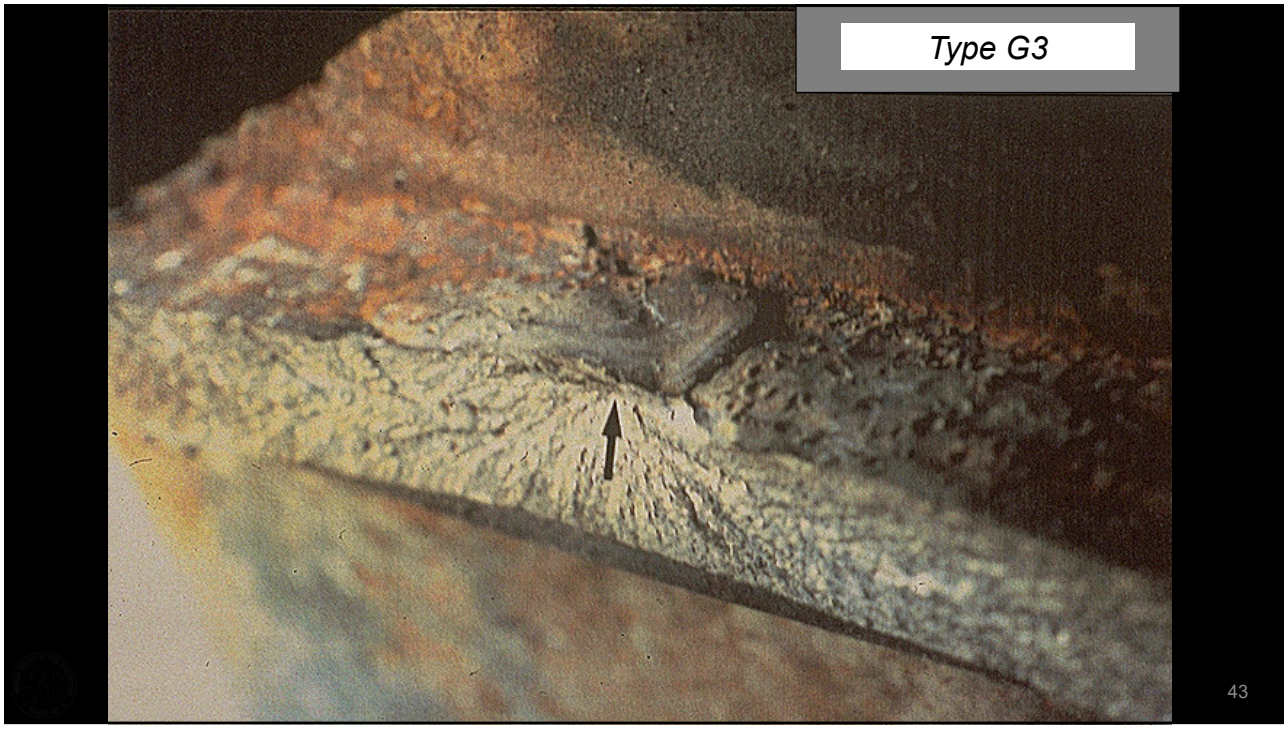
41

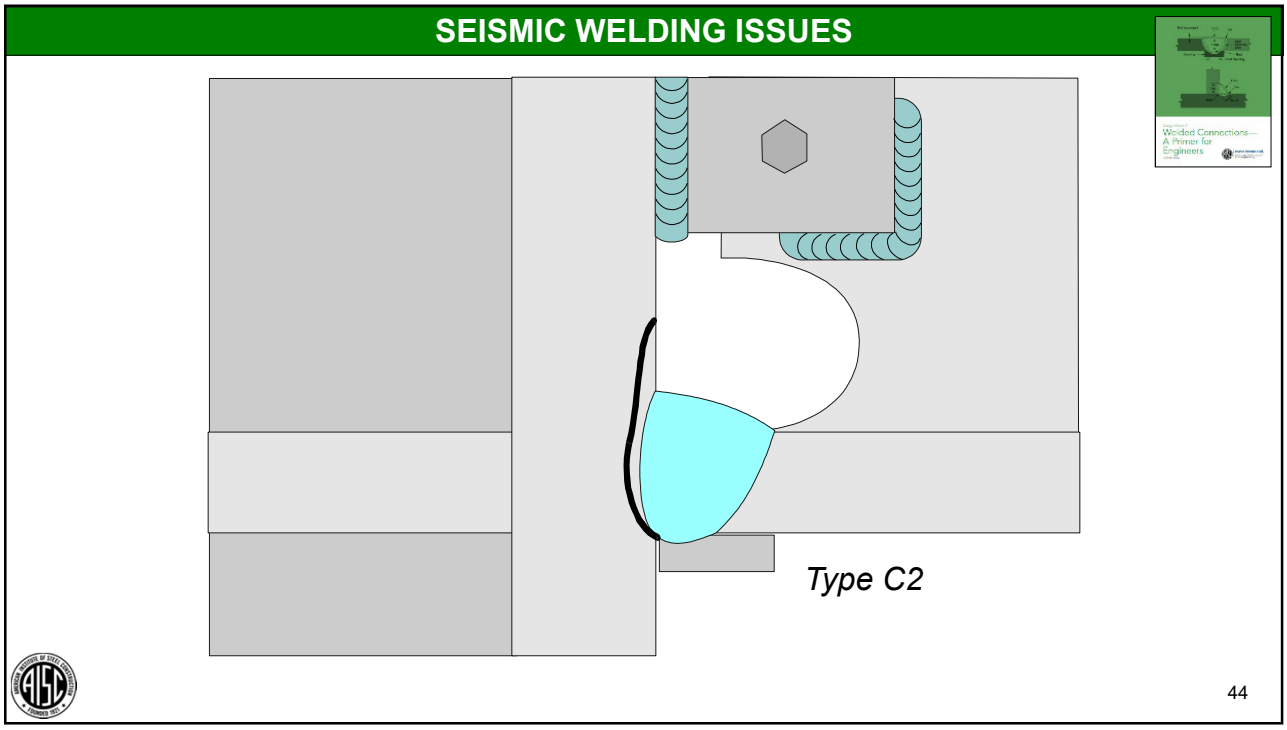
SEISMIC WELDING ISSUES

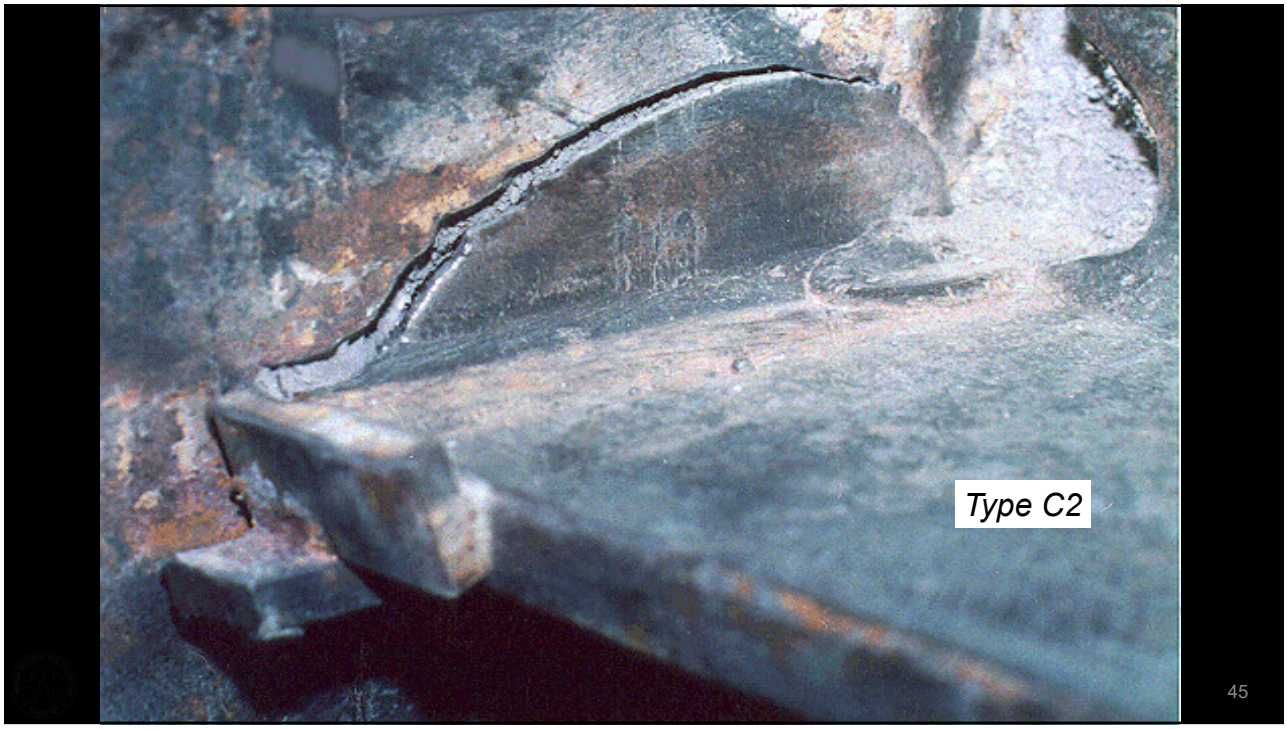


Type G3

42







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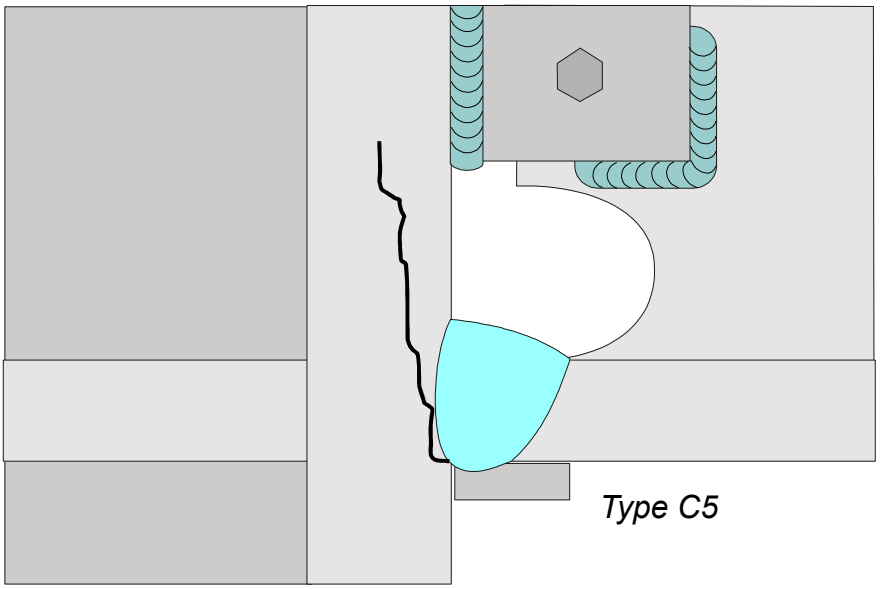
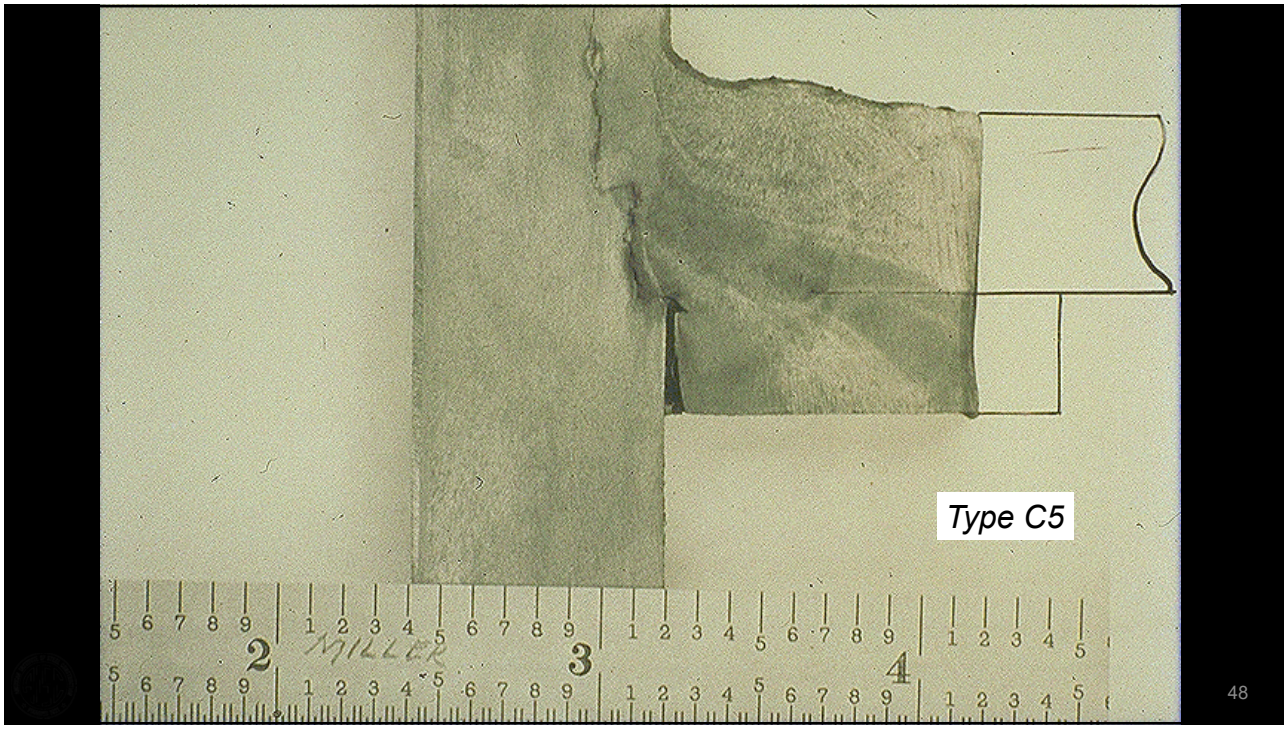


Type C5

47



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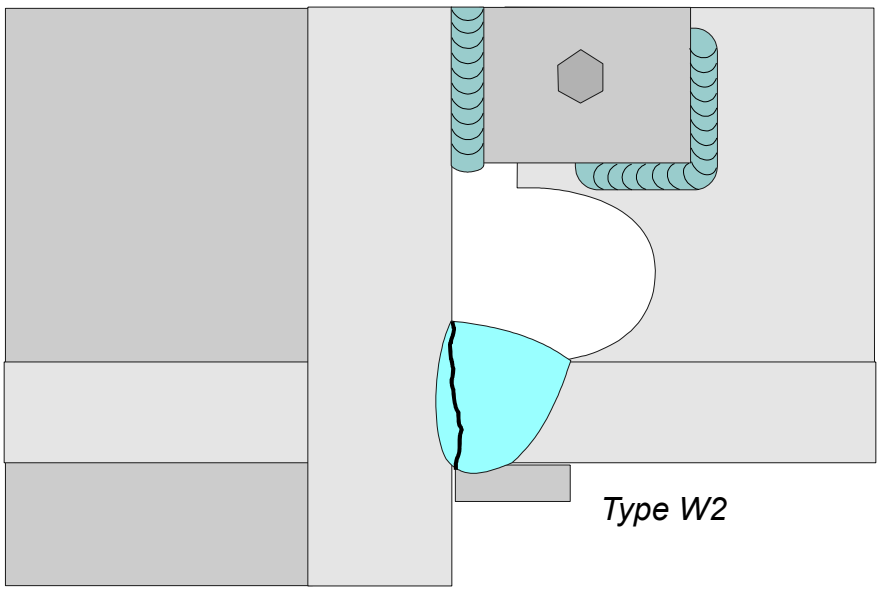
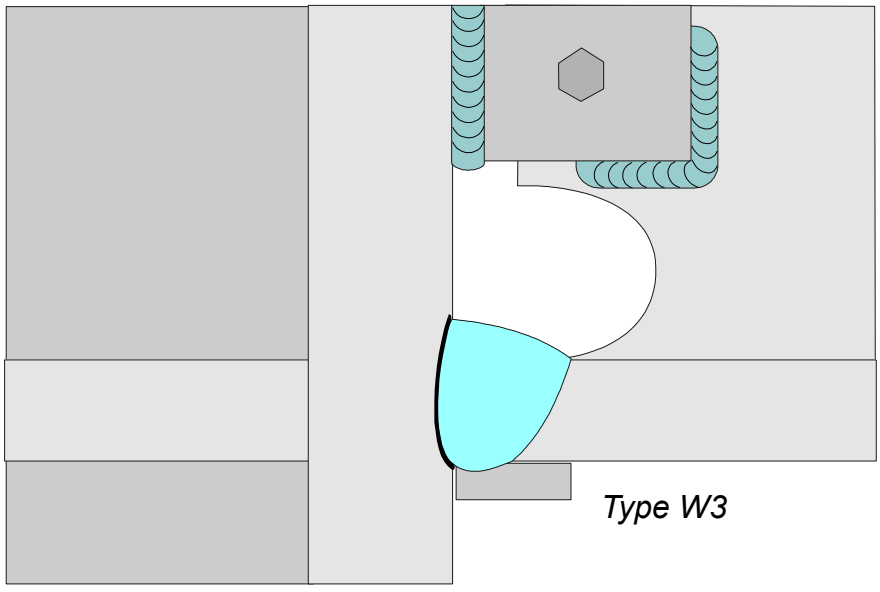
SEISMIC WELDING ISSUES



Type W2

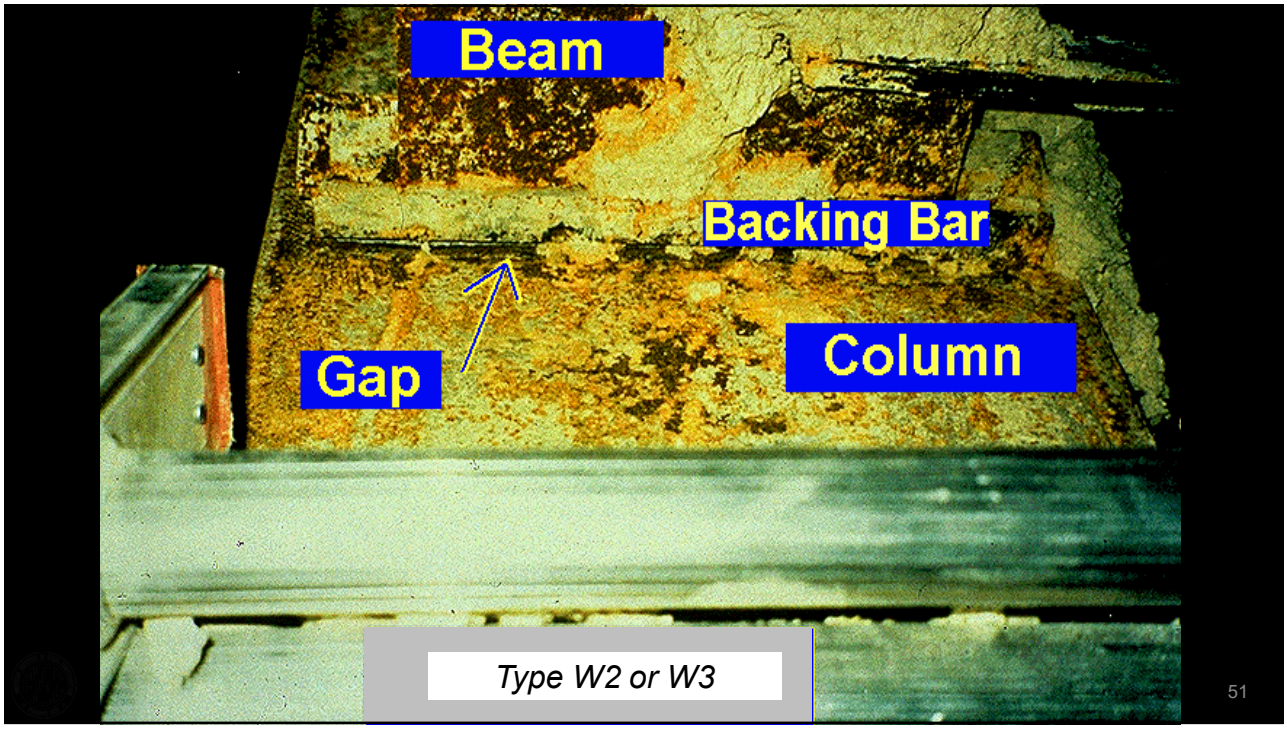
49

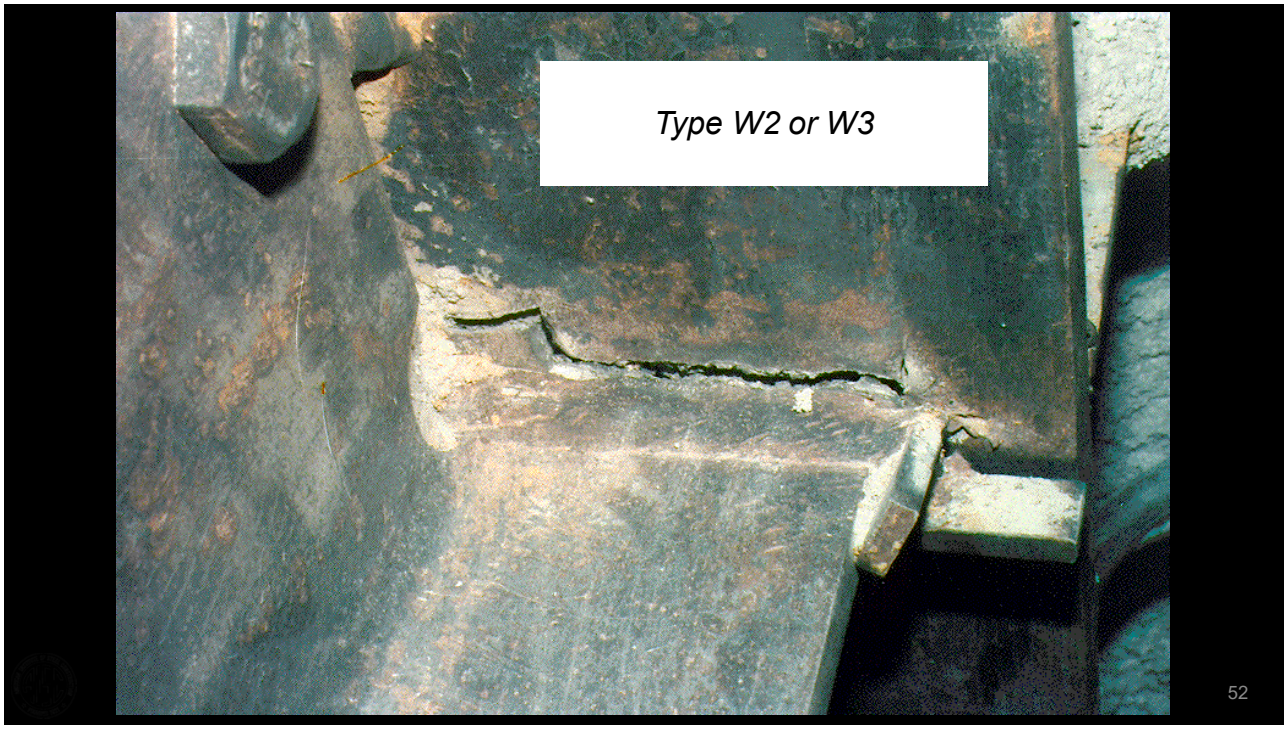
SEISMIC WELDING ISSUES

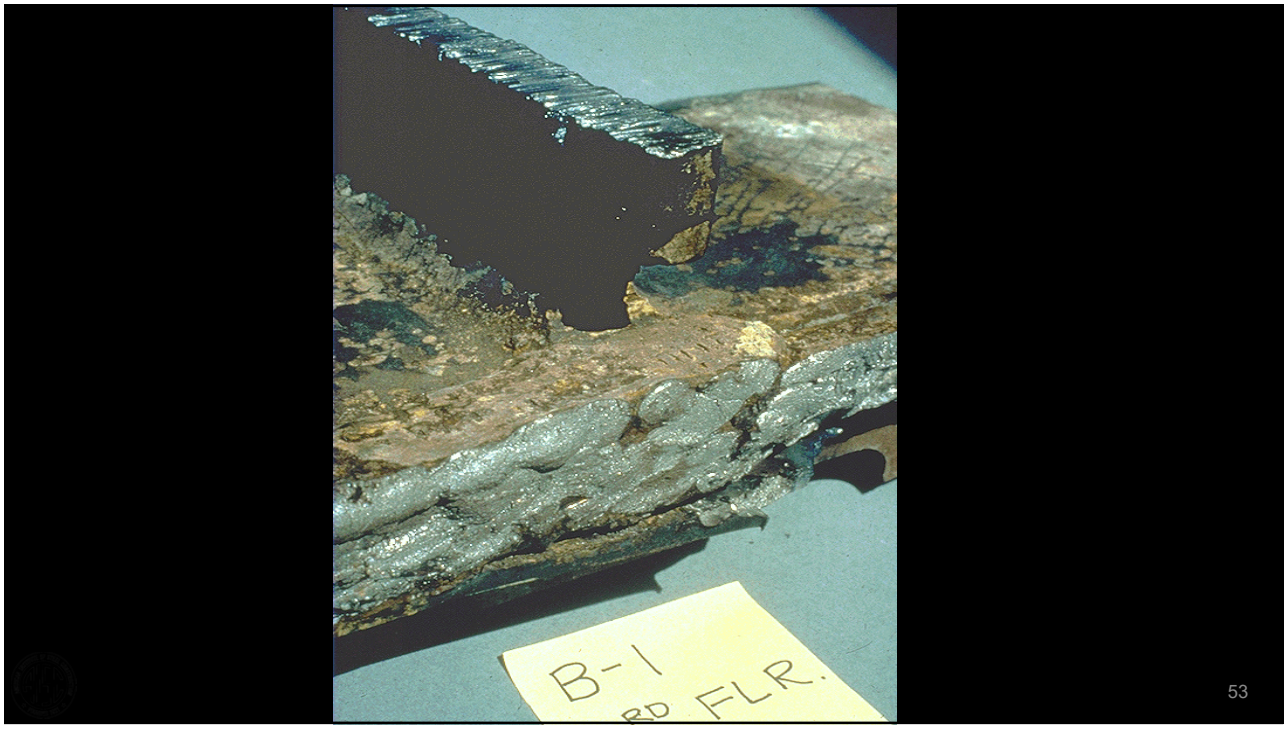


Type W3

50







Likely a W4

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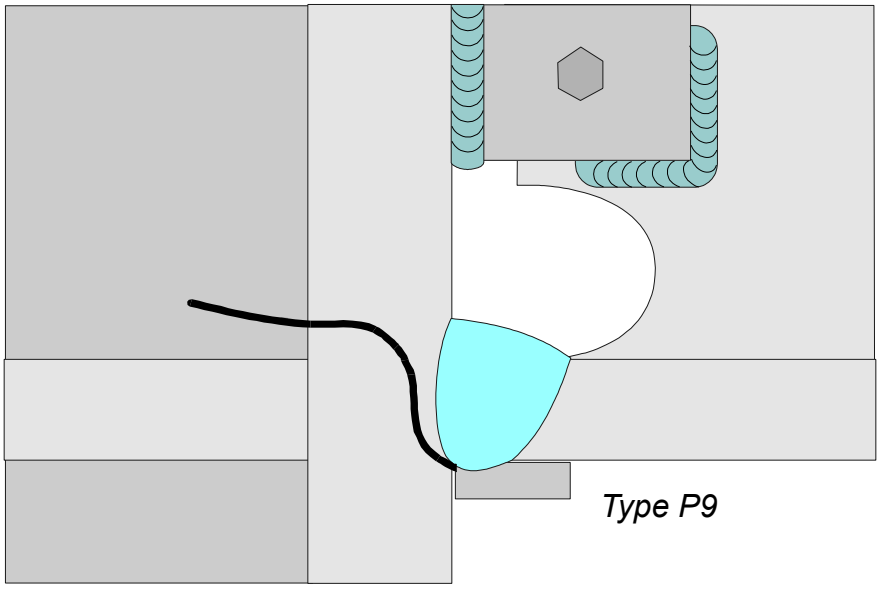
SEISMIC WELDING ISSUES



Type P9

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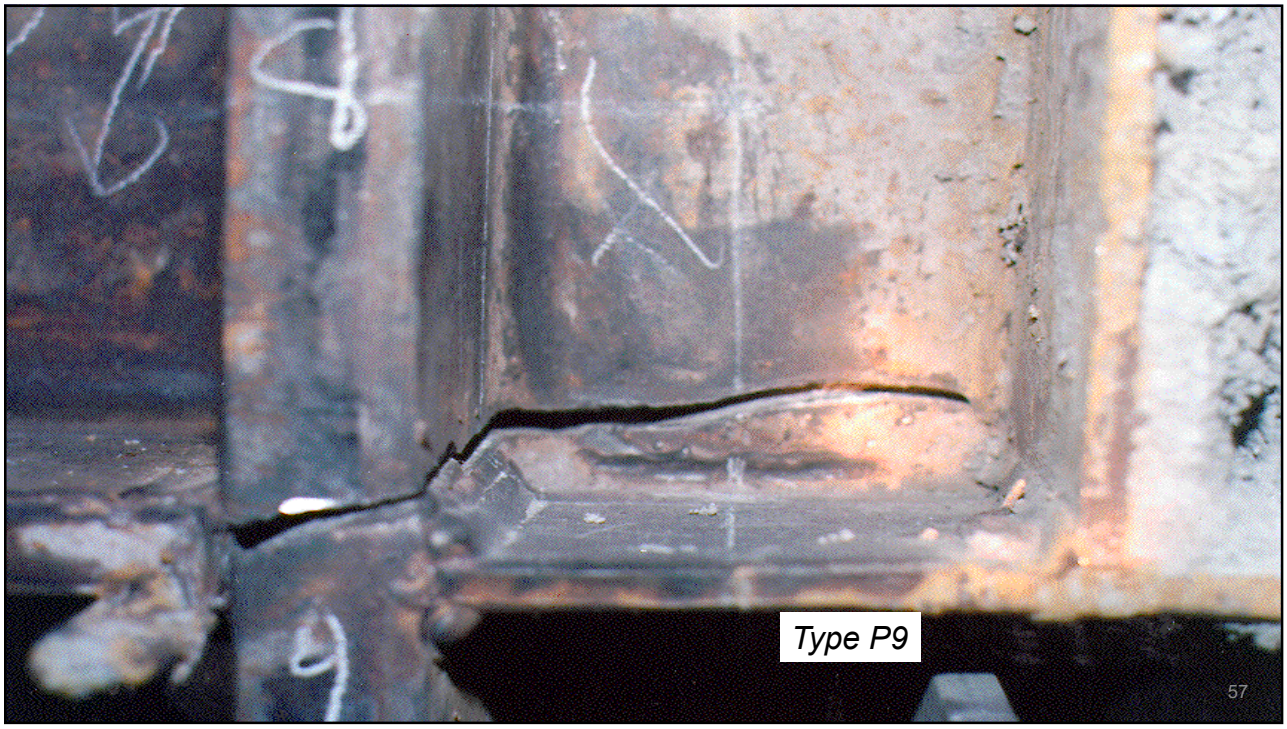
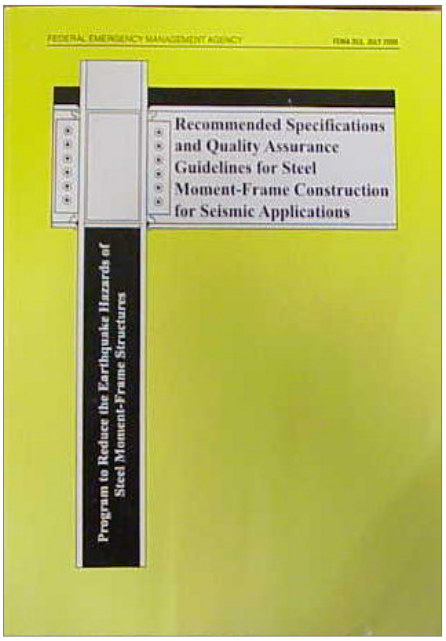


Federal **E**mergency **M**anagement **A**gency (FEMA)

FEMA 353: Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications July 2000



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FEMA 353: Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications

"As a result of these studies, and independent research conducted by others, it is now known that the typical moment-resisting connection detail employed in steel moment-frame construction prior to the 1994 Northridge earthquake…had a number of features that rendered it inherently susceptible to brittle fracture. These included the following:"

(seven items are then listed)

From FEMA 353, page 1-9

59

FEMA 353: Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications

- "The most severe stresses in the connection assembly occur where the beam joins to the column."
- "…the weld…must be interrupted at the beam web, with either a start or stop of the weld at this location. This welding technique often results in poor quality welding at this critical location…."
- "The basic configuration of the connection makes it difficult to detect hidden defects at the root of the welded beam-flange-to-column-flange joints."

60

FEMA 353: Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications

- "… the beam flanges at the connection carry a significant amount of the beam shear. This results in significant flexural stresses on the beam flange at the face of the column…."

- "… severe strain concentrations can occur in the beam flange at the toe of these weld access holes. These strain concentrations can result in low-cycle fatigue and the initiation of ductile tearing of the beam flanges…."

61

FEMA 353: Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications

- "Steel material at the center of the beam-flange-to-column-flange joint is restrained from movement, particularly in connections of heavy sections with thick column flanges. This condition of restraint inhibits the development of yielding at this location, resulting in locally high stresses on the welded joint, which exacerbates the tendency to initiate fractures at defects in the welded joints."

62

FEMA 353: Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications

- "In connections with excessively weak panel zones, inelastic behavior of the assembly is dominated by shear deformation of the panel zone. This panel zone shear deformation results in a local kinking of the column flanges adjacent to the beam-flange-to-column-flange joint…."

63

FEMA 353: Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications

"In addition to the above, additional conditions contributed significantly to the vulnerability of connections constructed prior to 1994."

(three items are then listed)

From FEMA 353, page 1-10

64

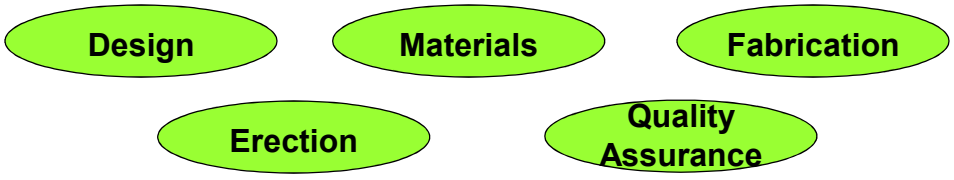
FEMA 353: Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications

- "The welding consumables that building erectors most commonly used inherently produced welds with very low toughness."
- "… as member sizes increased, strain demands on the welded connections also increased, making the connections more susceptible to brittle behavior."
- "… many beams actually had yield strengths that approximated or exceeded that required for grade 50 material. As a result of this increase in base metal yield strength, the weld metal in the beam-flange-to-column-flange joints became under-matched…."

65

FEMA 353: Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications

"At this time, it is clear that in order to obtain reliable ductile behavior of steel moment-frame construction a number of changes to past practices in design, materials, fabrication, erection and quality assurance are necessary."



From FEMA 353, page 1-10

66

SEISMIC WELDING ISSUES

Outline

- Seismic Design and Ductility
- The Northridge Experience
- AISC Prequalified Seismic Connections
- D1.8 Seismic Welding Supplement
- Conclusion

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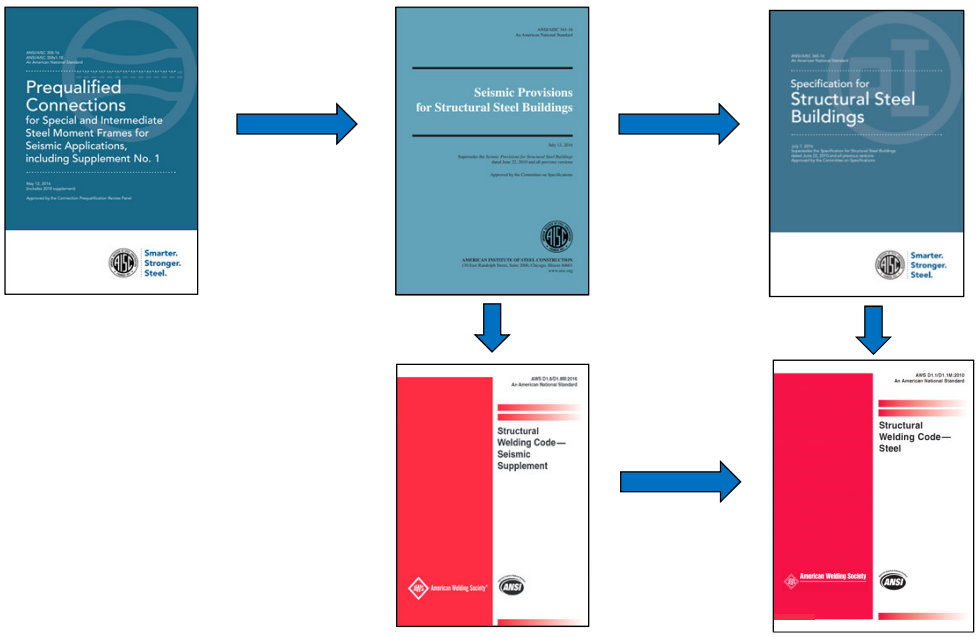

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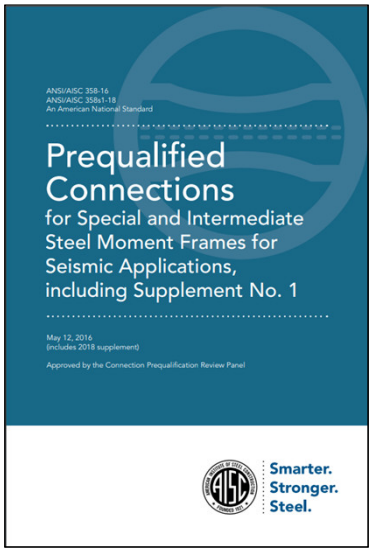
ANSI/AISC 358-16
ANSI/AISC 358s1-18

Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications, including Supplement No. 1



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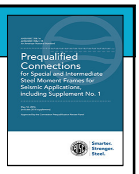
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



CHAPTER 1

GENERAL

1.1. Scope

This Standard specifies design, detailing, fabrication and quality criteria for connections that are prequalified in accordance with the AISC *Seismic Provisions for Structural Steel Buildings* (herein referred to as the AISC *Seismic Provisions*) for use with special moment frames (SMF) and intermediate moment frames (IMF). The connections contained in this Standard are prequalified to meet the requirements in the AISC *Seismic Provisions* only when designated and constructed in accordance with the requirements of this Standard.

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AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS

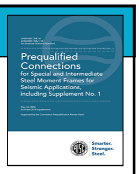
TABLE 2.1.
Prequalified Moment Connections

Welded

Connection Type	Chapter	Systems
Reduced beam section (RBS)	5	SMF, IMF
Bolted unstiffened extended end plate (BUEEP)	6	SMF, IMF
Bolted stiffened extended end plate (BSEEP)	6	SMF, IMF
Bolted flange plate (BFP)	7	SMF, IMF
Welded unreinforced flange-welded web (WUF-W)	8	SMF, IMF
Kaiser bolted bracket (KBB)	9	SMF, IMF
ConXtech ConXL moment connection (ConXL)	10	SMF, IMF
SidePlate moment connection (SidePlate)	11	SMF, IMF
Simpson Strong-Tie Strong Frame moment connection	12	SMF, IMF
Double-tee moment connection	13	SMF, IMF

71

AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



CHAPTER 3

WELDING REQUIREMENTS

3.1. FILLER METALS

Filler metals shall conform to the requirements of the AISC Seismic Provisions.

3.2. WELDING PROCEDURES

Welding procedures shall be in accordance with the AISC Seismic Provisions.

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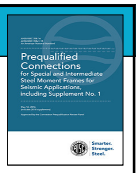
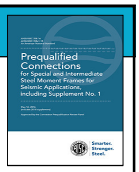
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



3.3. BACKING AT BEAM-TO-COLUMN AND CONTINUITY PLATE-TO-COLUMN JOINTS

73

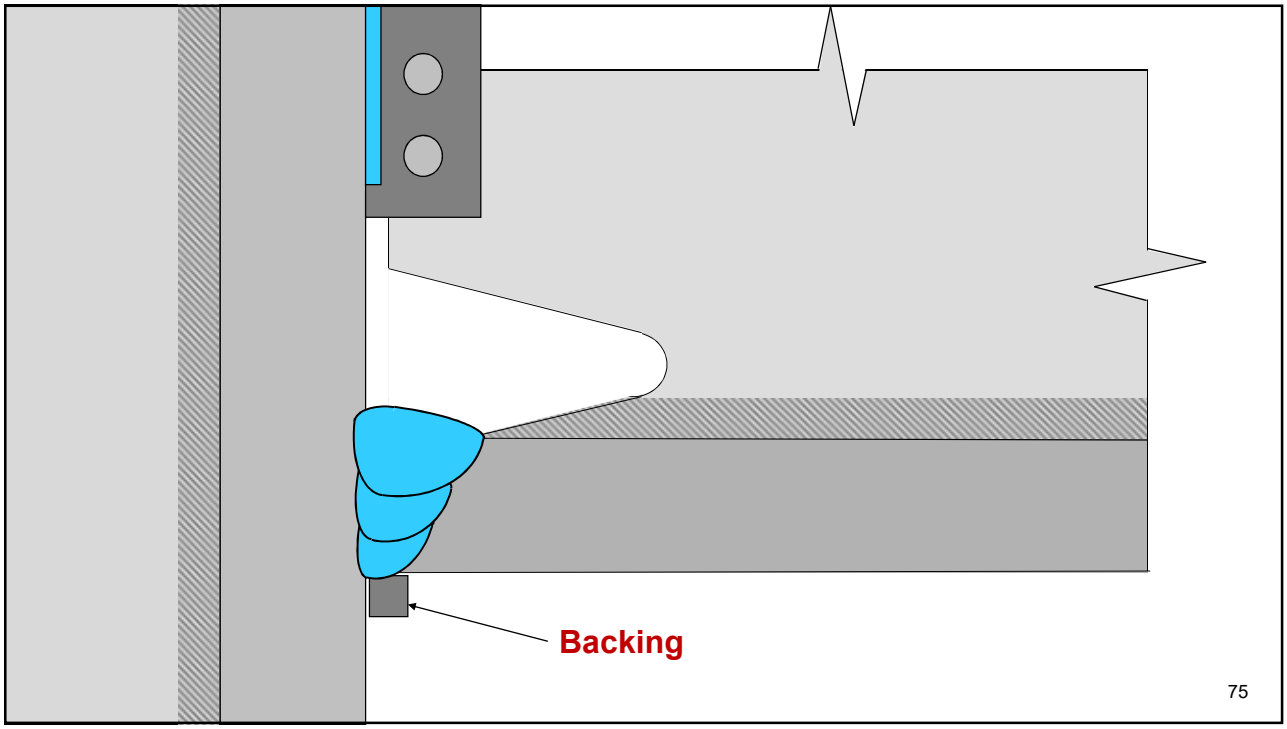
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



GLOSSARY

Backing. Piece of metal or other material, placed at the weld root to facilitate placement of the root pass.

74



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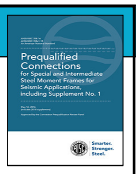
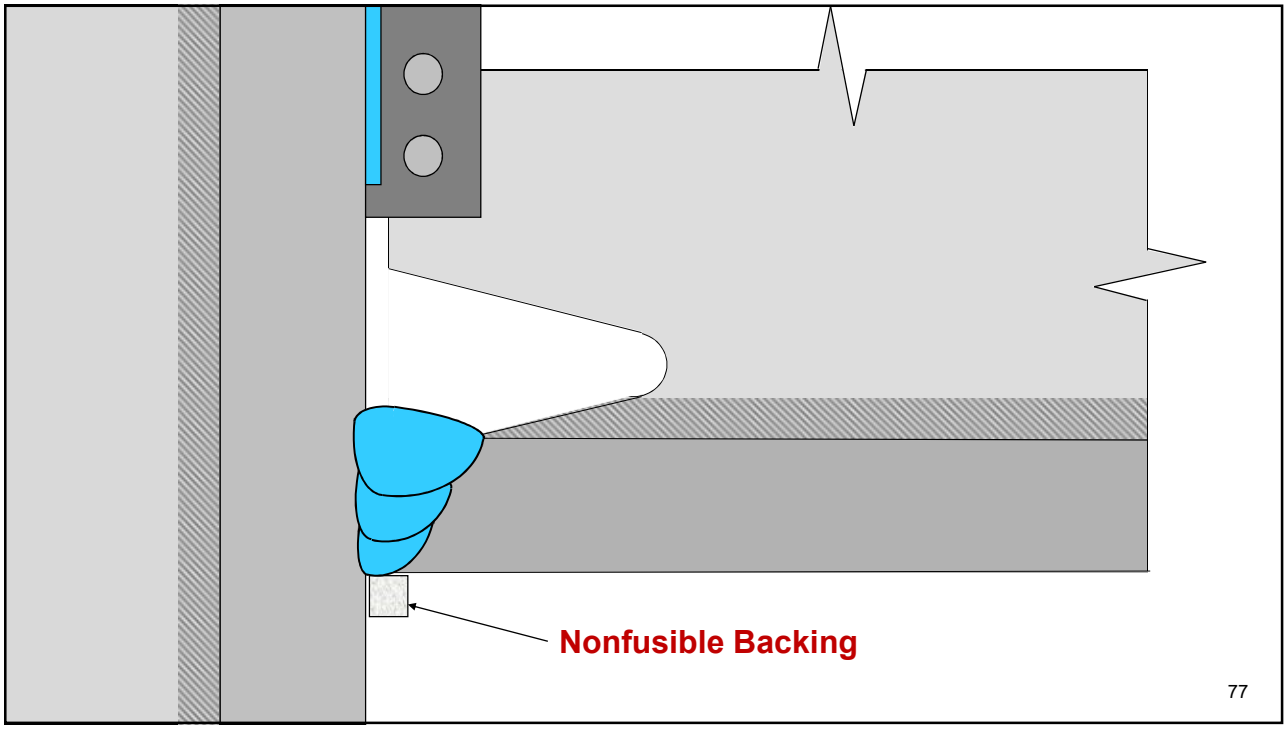
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS

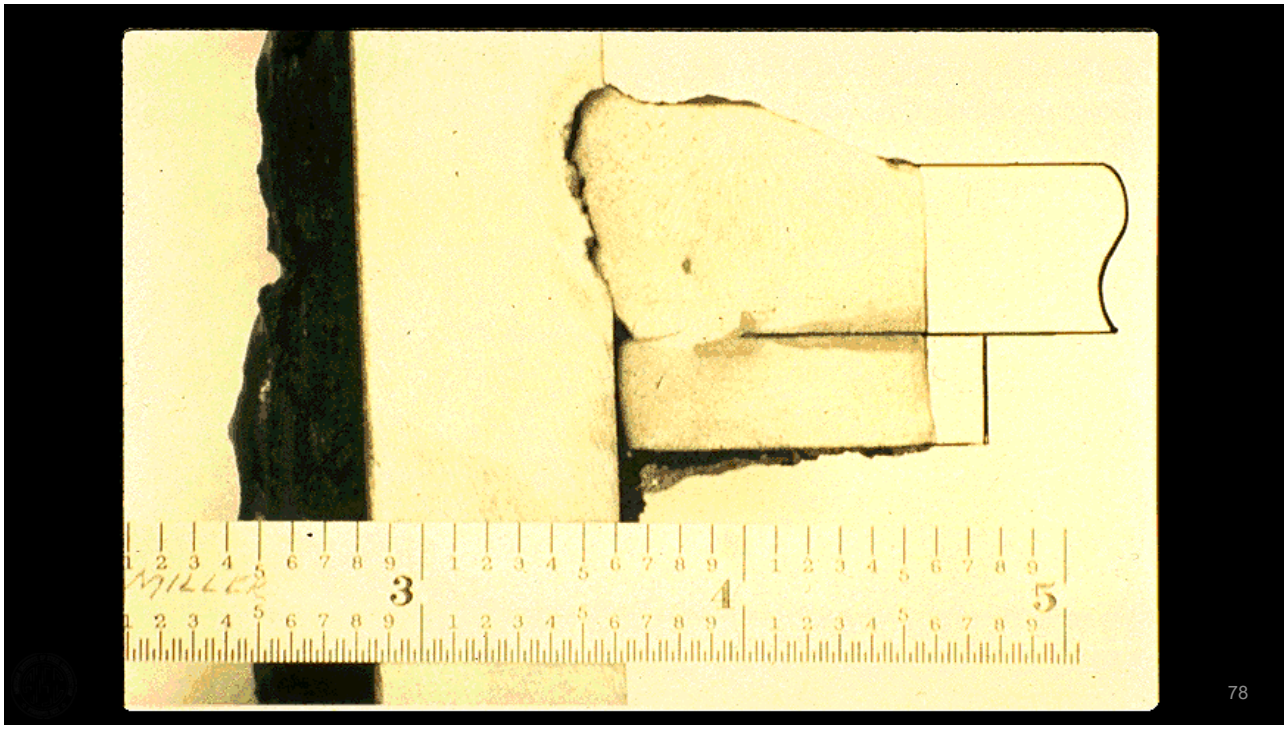


GLOSSARY

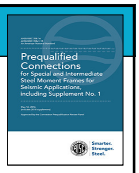
Nonfusible backing. Backing material that will not fuse with the base metals during the welding process.

76





AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



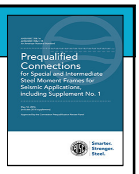
3.3. BACKING AT BEAM-TO-COLUMN AND CONTINUITY PLATE-TO-COLUMN JOINTS

1. Steel Backing at Continuity Plates

Steel backing used at continuity plate-to-column welds need not be removed. At column flanges, steel backing left in place shall be attached to the column flange using a continuous 5/16 in. (8-mm) fillet weld on the edge below the CJP groove weld. When backing is removed, the root pass shall be backgouged to sound weld metal and backwelded with a reinforcing fillet. The reinforcing fillet shall be continuous with a minimum size of 5/16 in. (8 mm).

79

AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS

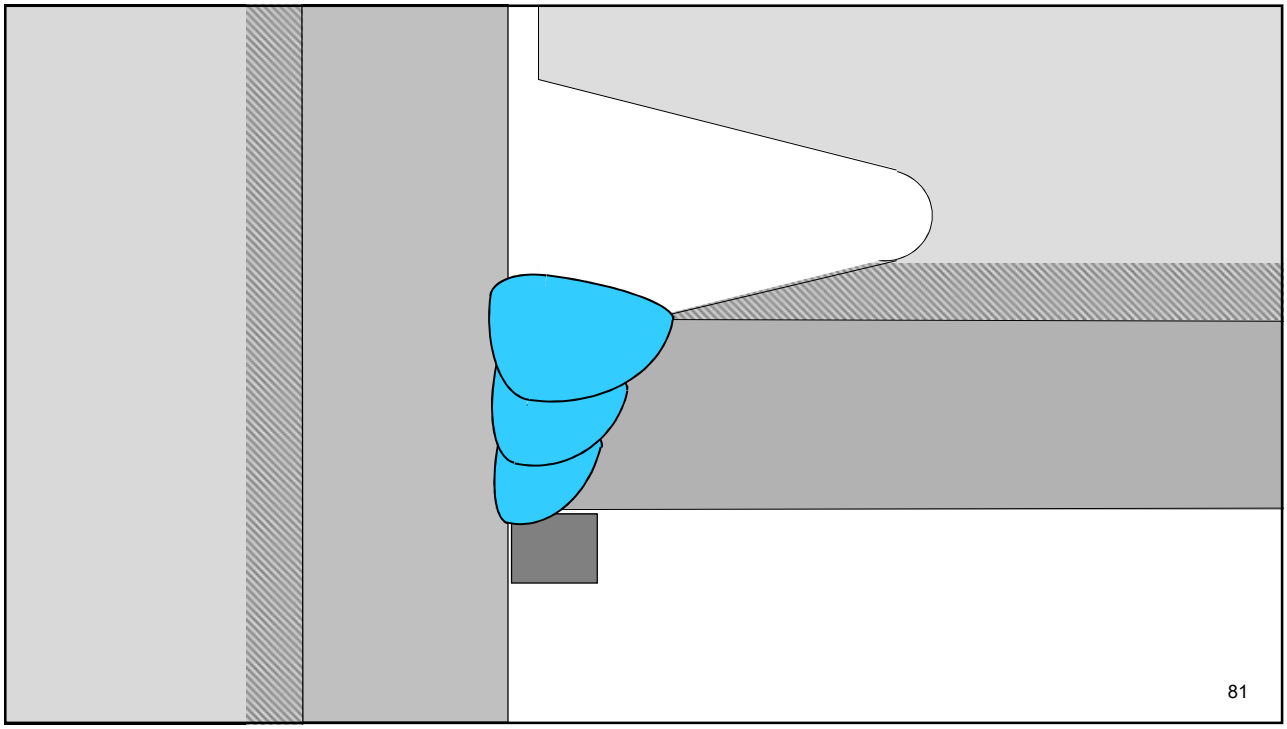


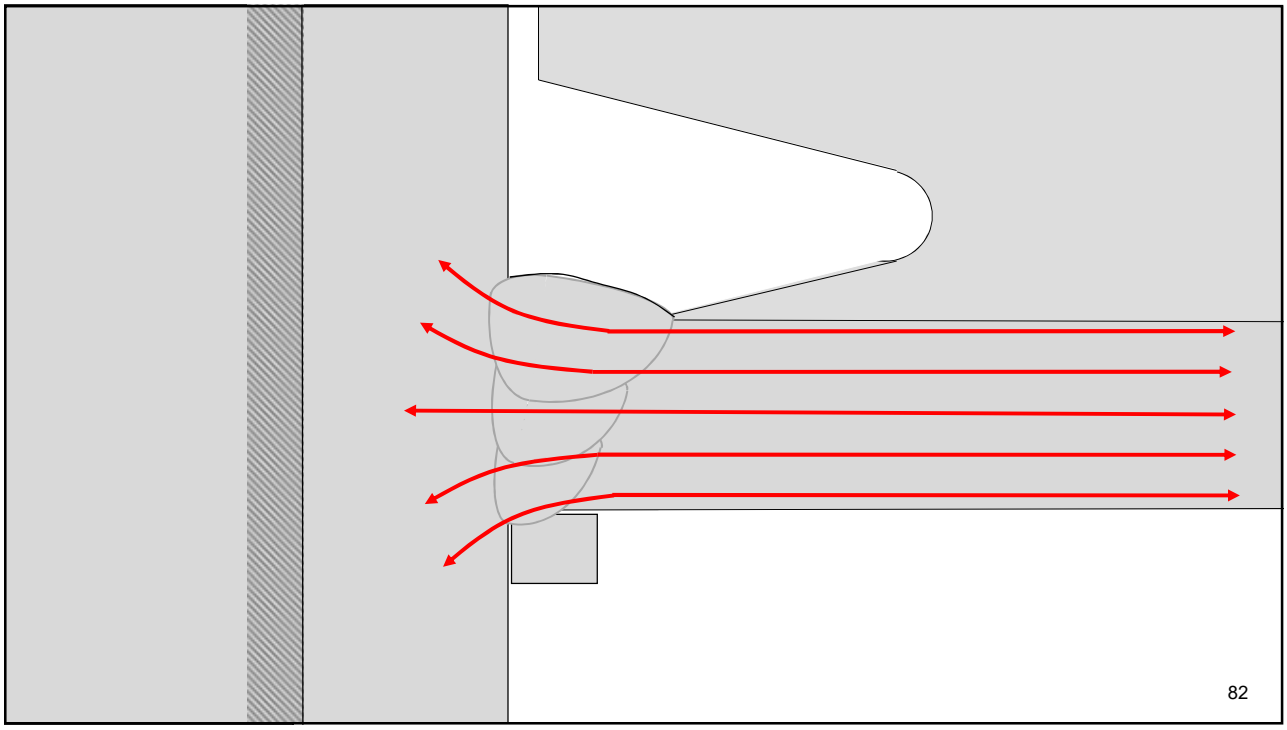
3.3. BACKING AT BEAM-TO-COLUMN AND CONTINUITY PLATE-TO-COLUMN JOINTS

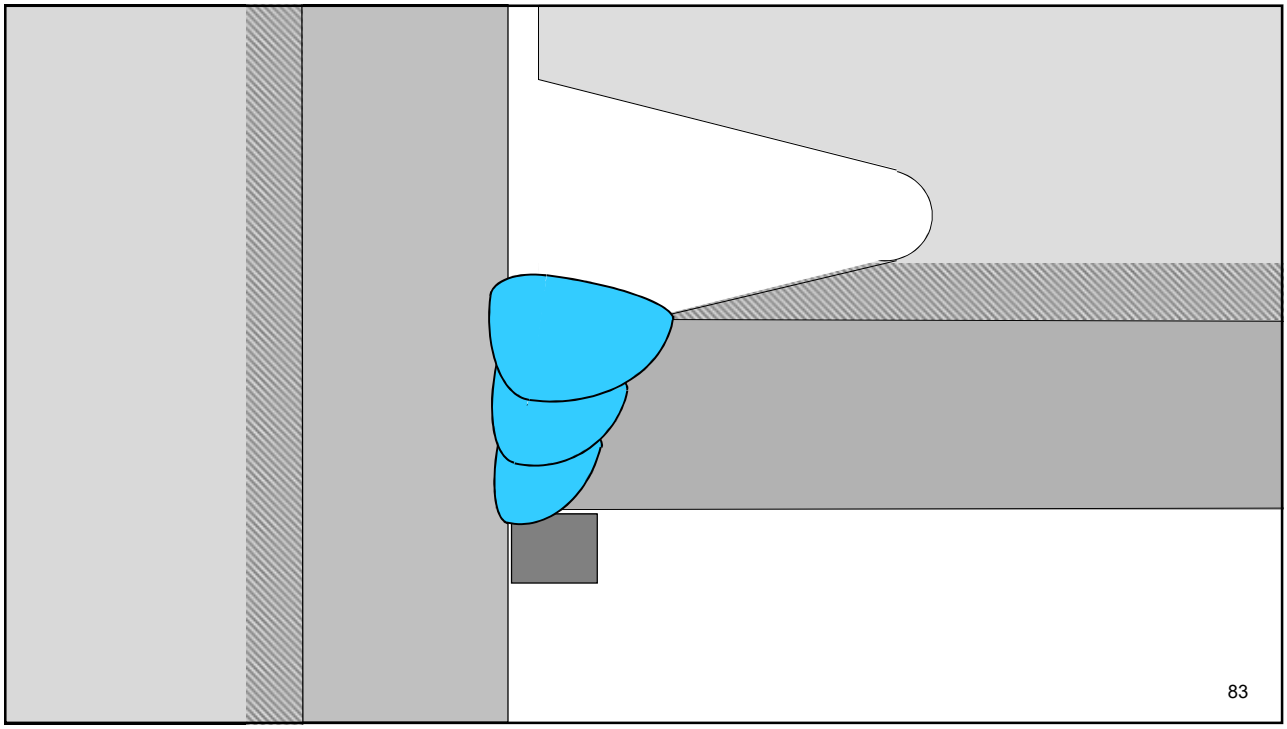
2. Steel Backing at Beam Bottom Flange

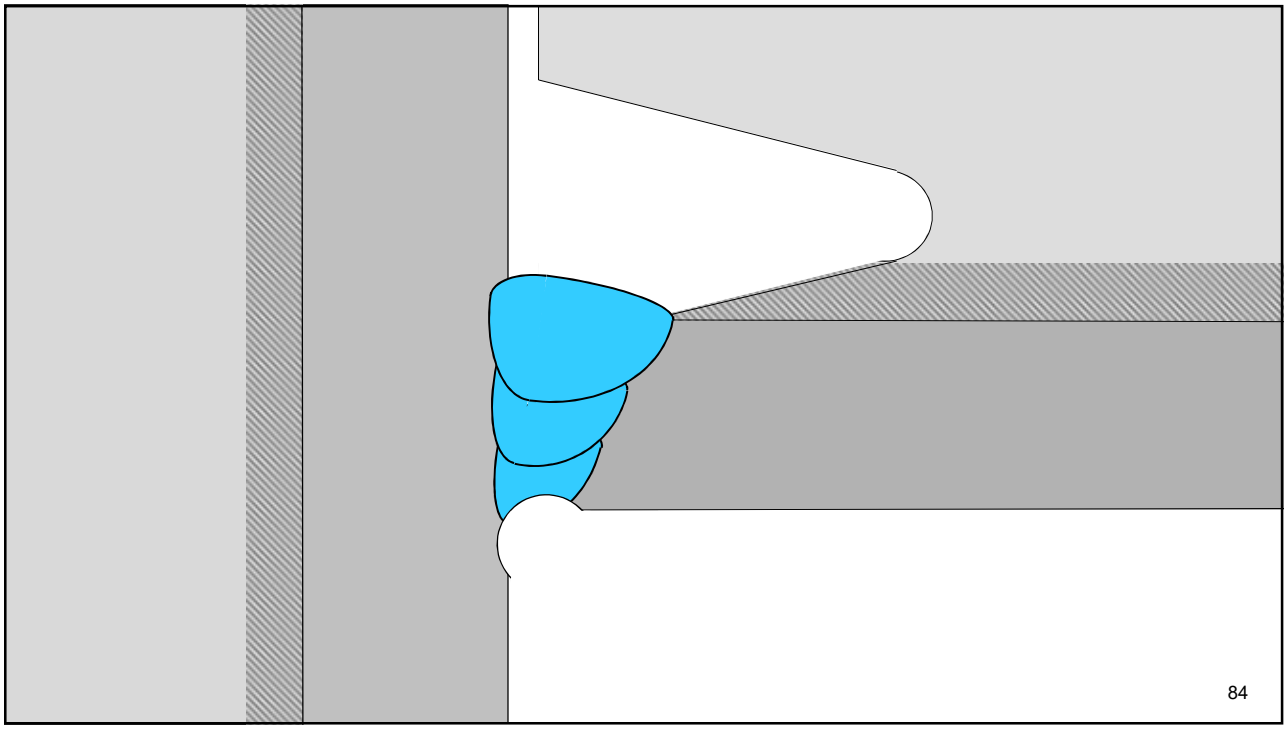
Where steel backing is used with CJP groove welds between the bottom beam flange and the column, the backing shall be removed. Following the removal of steel backing, the root pass shall be backgouged to sound weld metal and backwelded with a reinforcing fillet. The size of the reinforcing fillet leg adjacent to the column flange shall be a minimum of 5/16 in. (8 mm), and the reinforcing fillet leg adjacent to the beam flange shall be such that the fillet toe is located on the beam flange base metal.

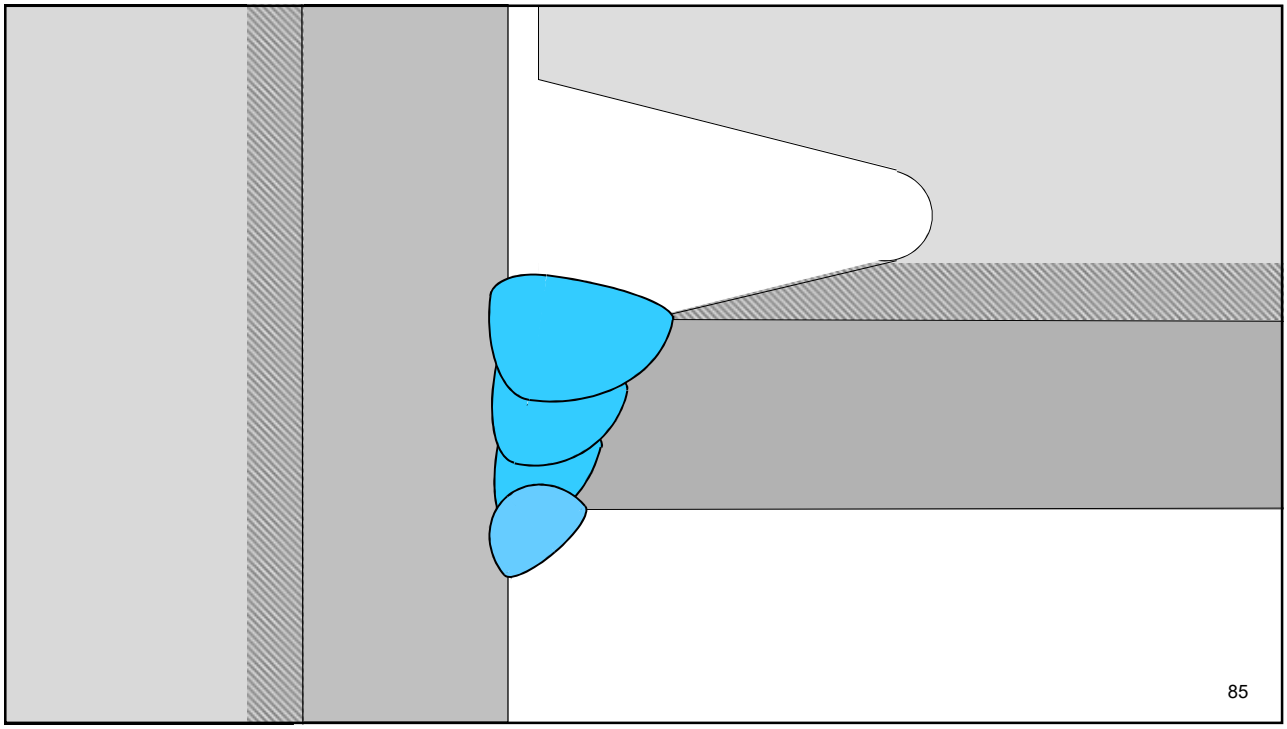
80

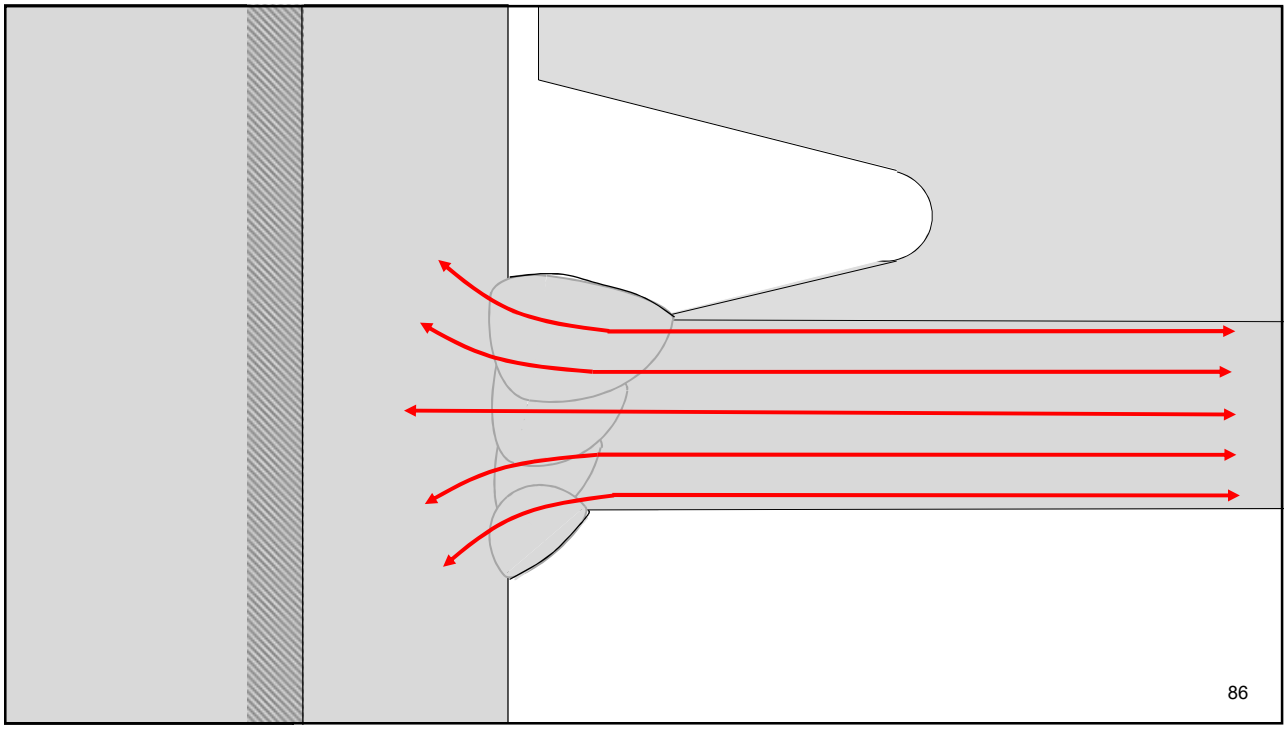




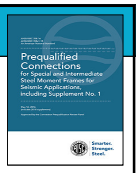








AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS

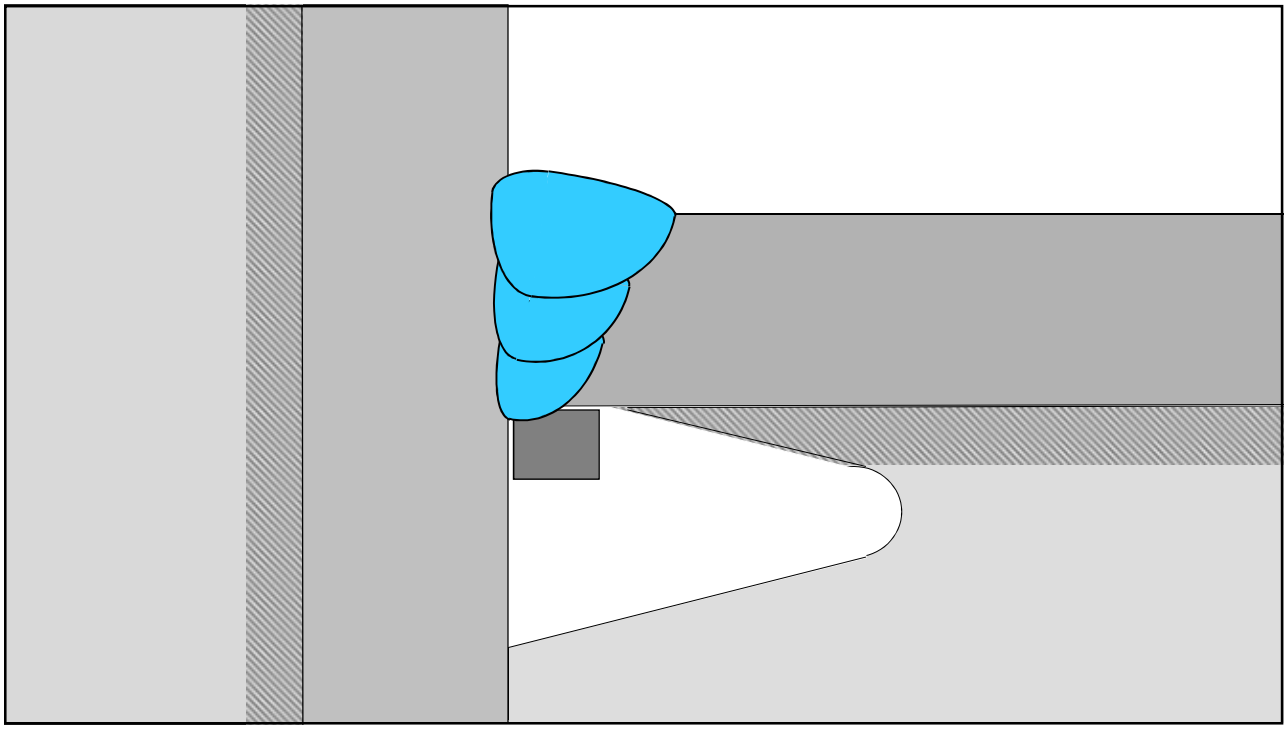


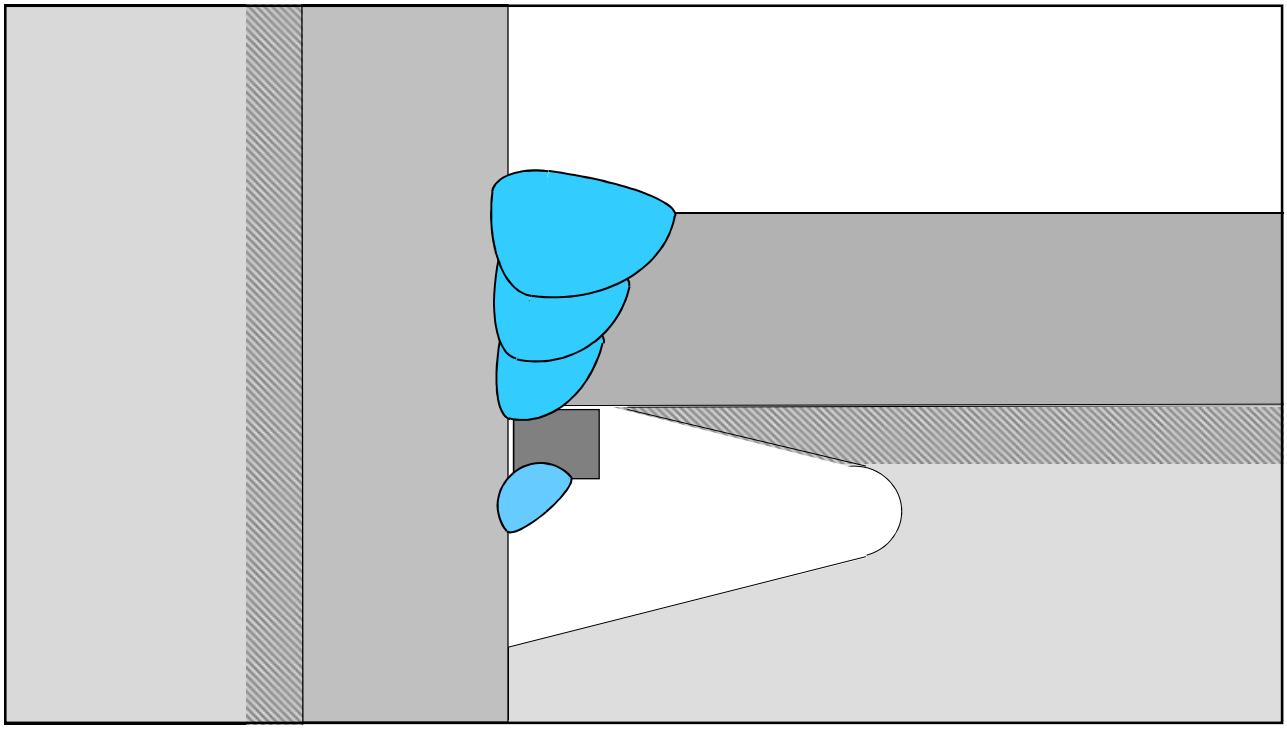
3.3. BACKING AT BEAM-TO-COLUMN AND CONTINUITY PLATE-TO-COLUMN JOINTS

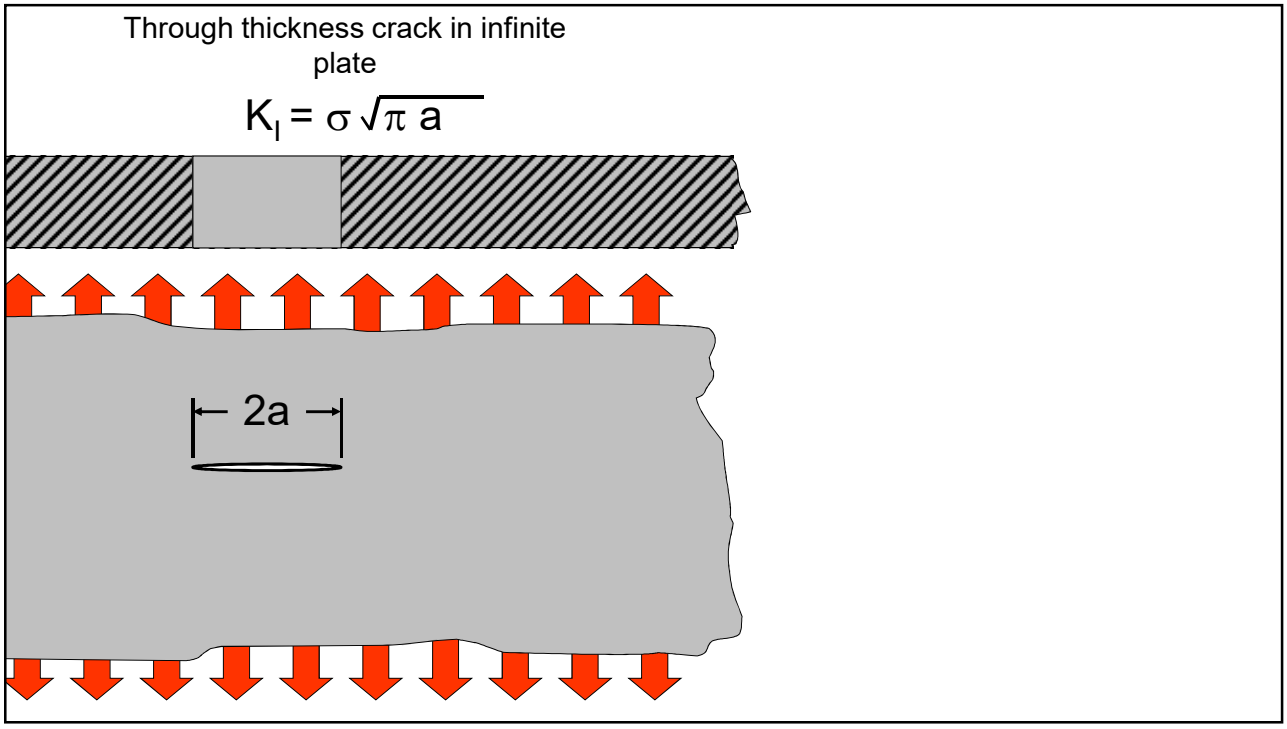
3. Steel Backing at Beam Top Flange

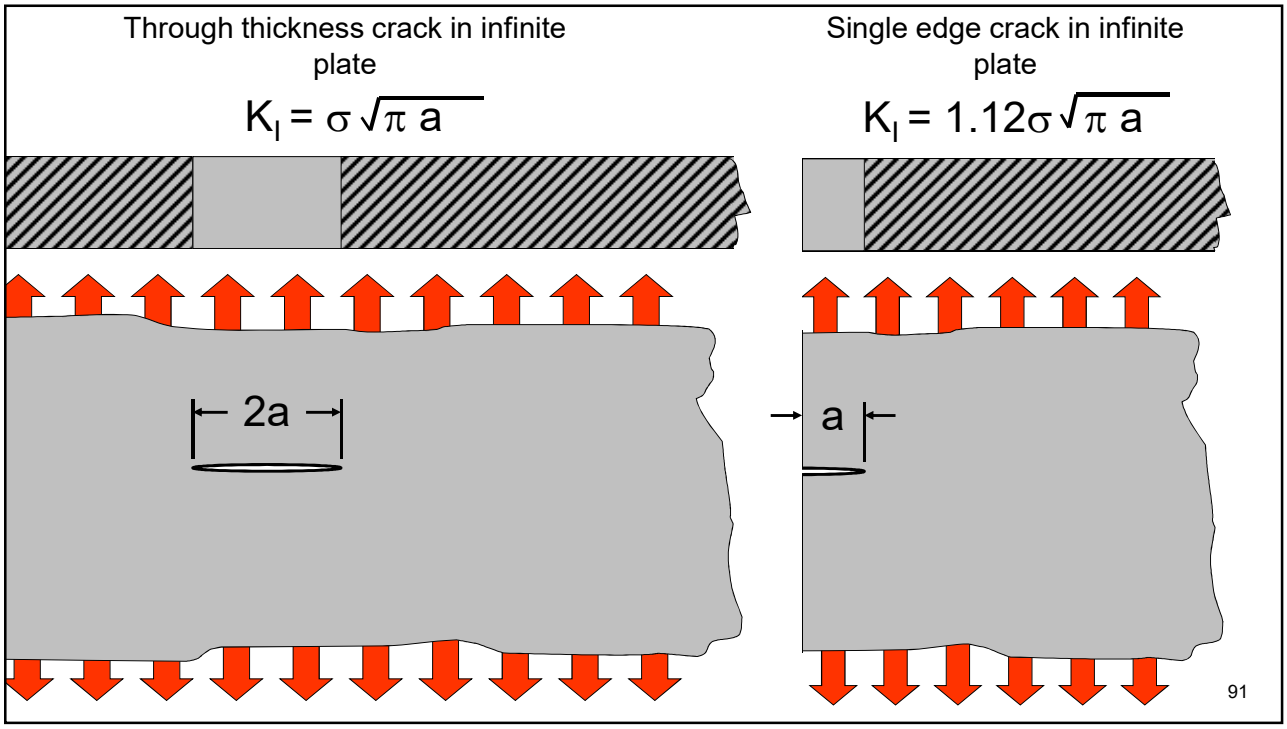
Where steel backing is used with CJP groove welds between the top beam flange and the column, and the steel backing is not removed, the steel backing shall be attached to the column by a continuous 5/16 in. (8 mm) fillet weld on the edge below the CJP groove weld.

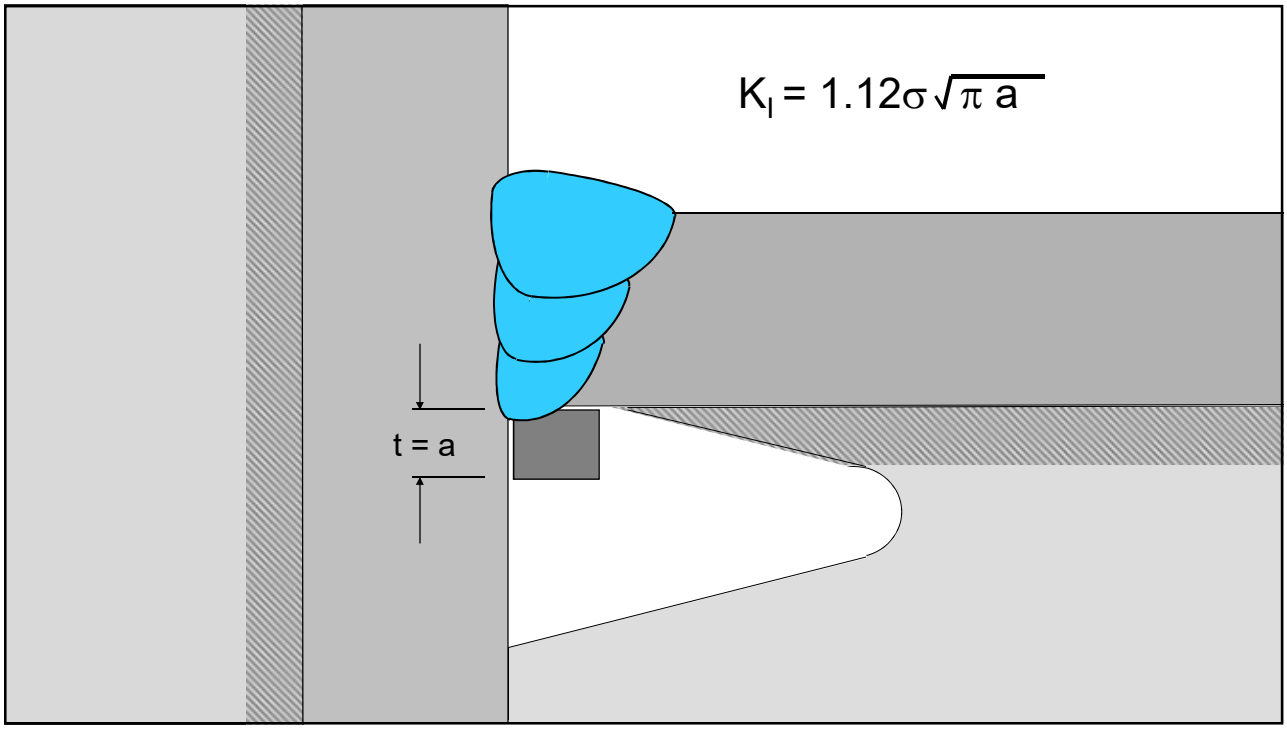
87

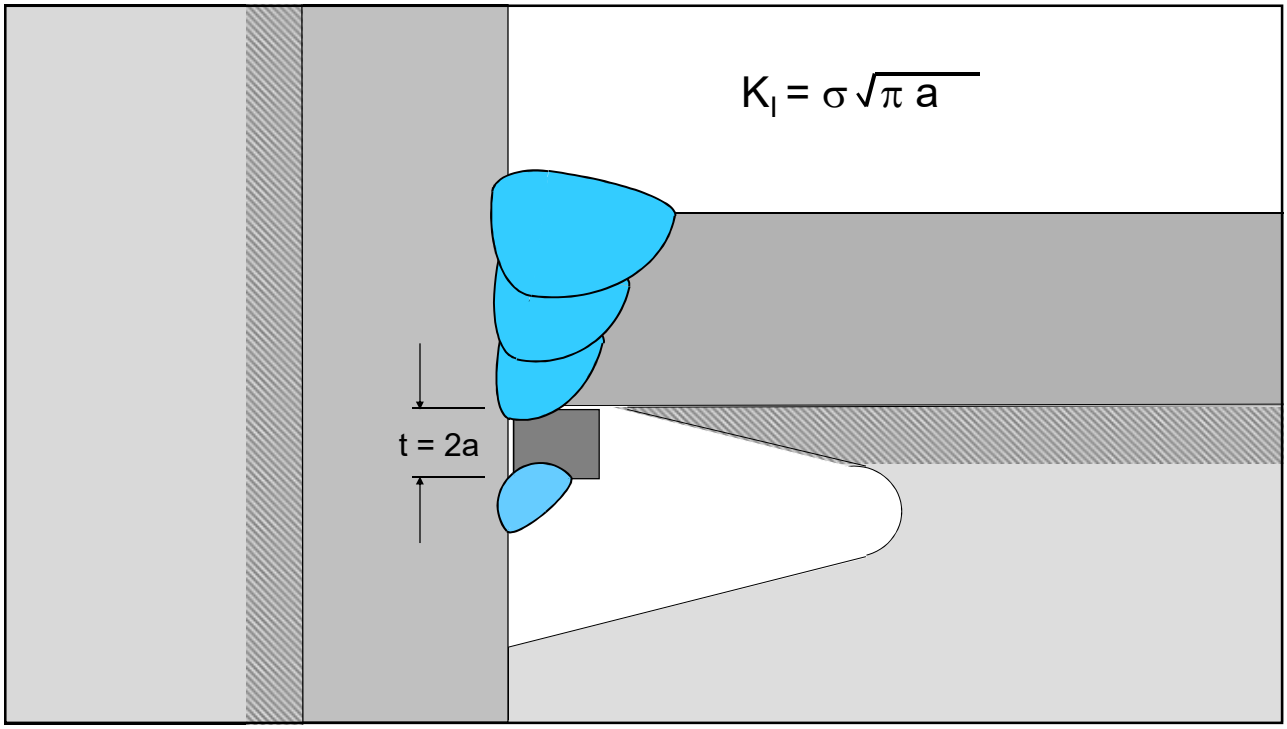


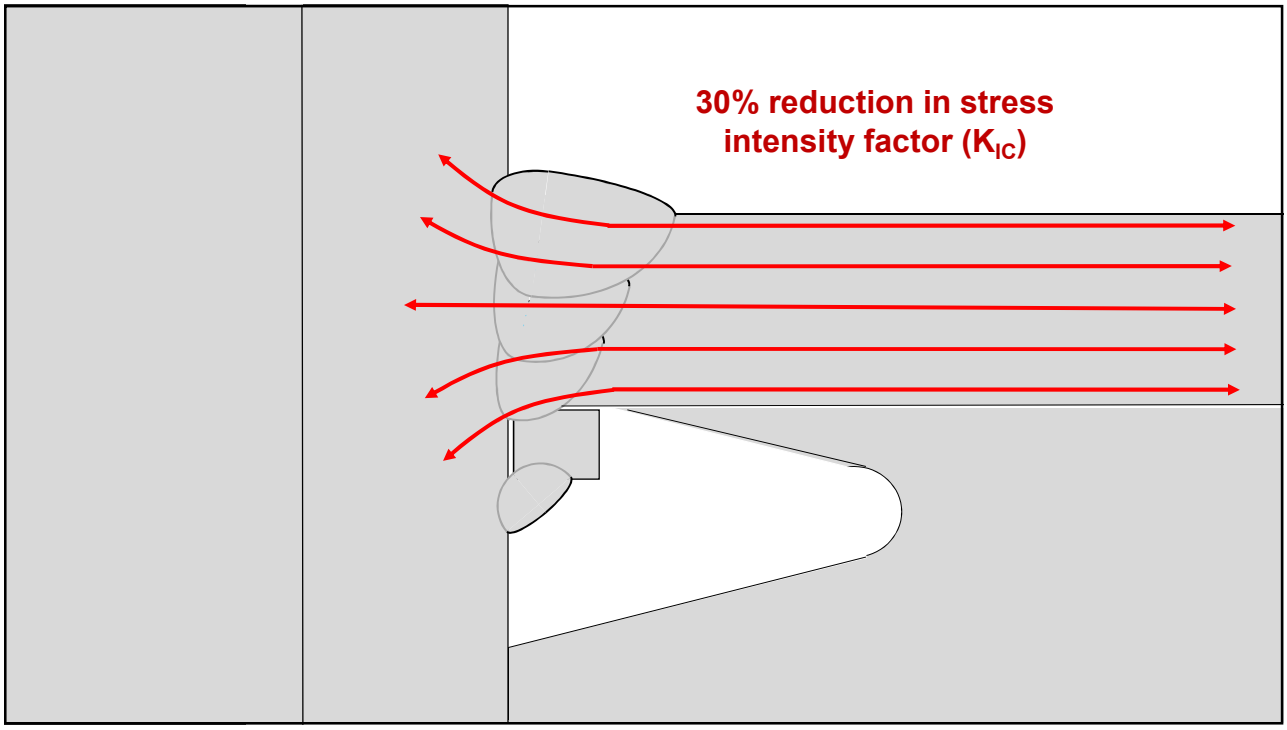




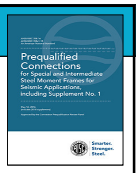








AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



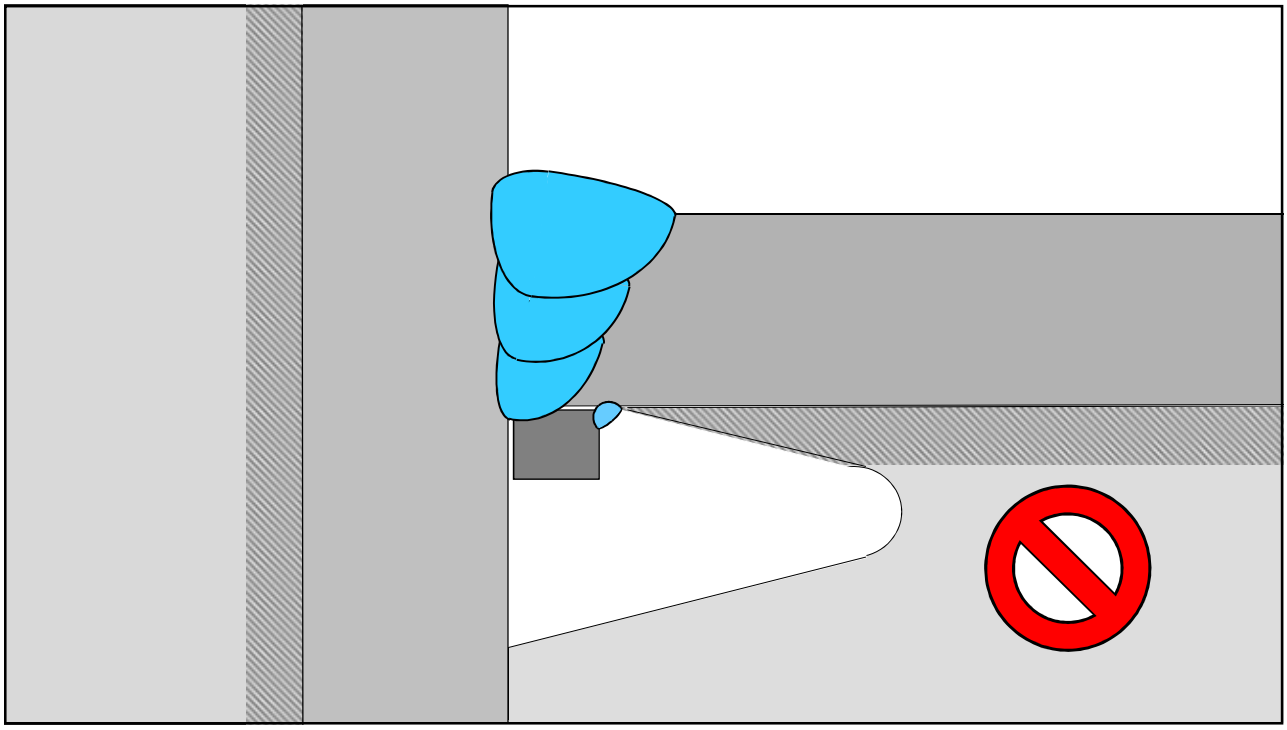
3.3. BACKING AT BEAM-TO-COLUMN AND CONTINUITY PLATE-TO-COLUMN JOINTS

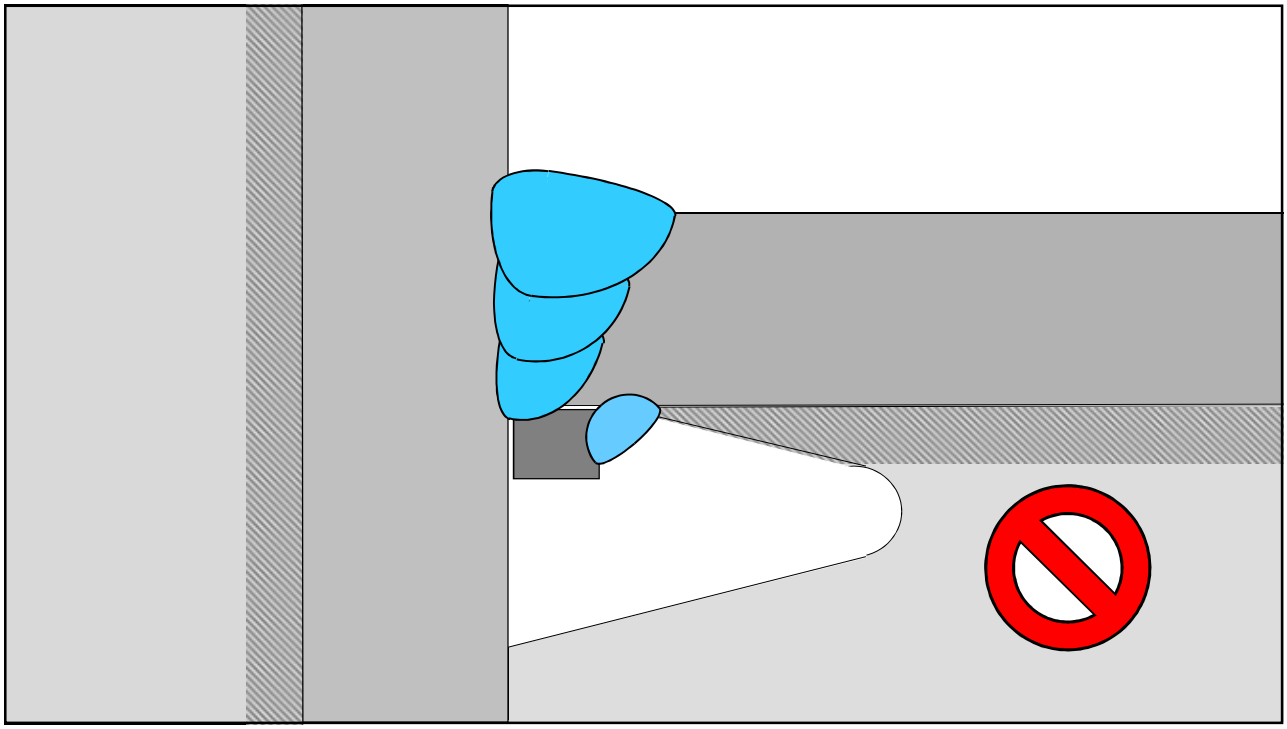
4. Prohibited Welds at Steel Backing

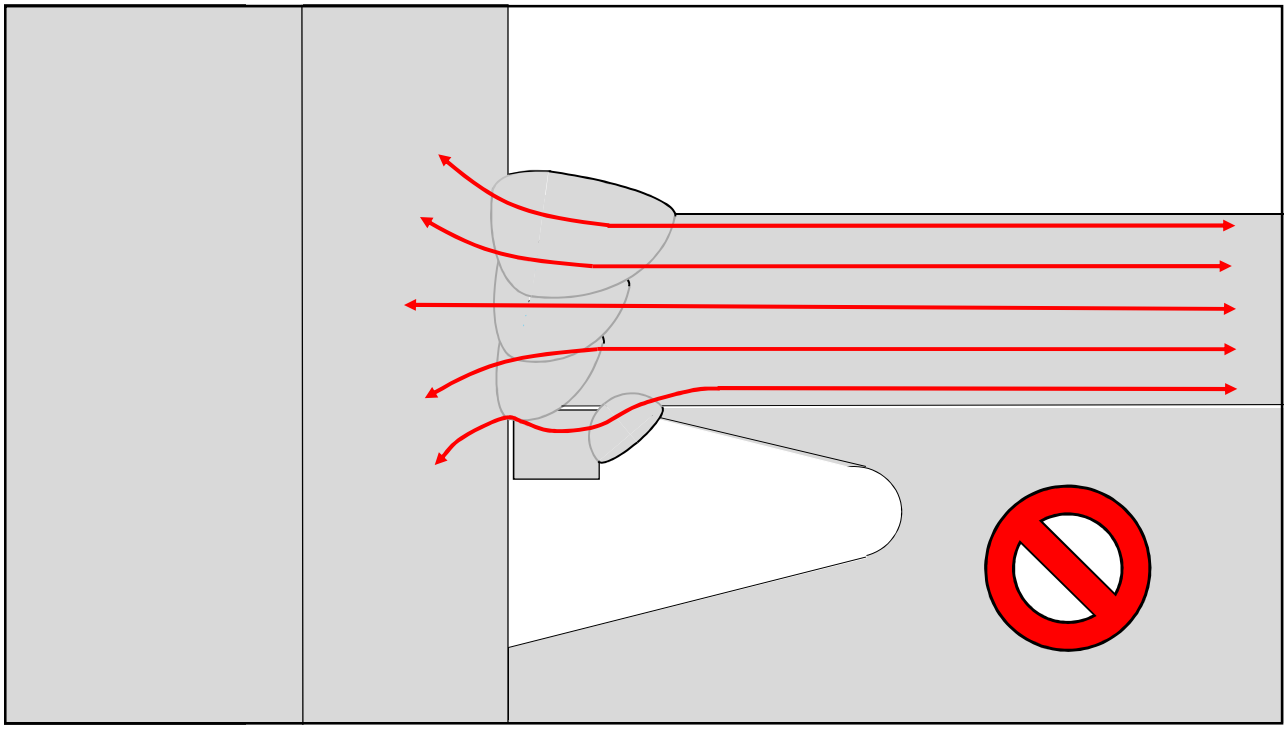
Backing at beam flange-to-column flange joints shall not be welded to the underside of the beam flange, nor shall tack welds be permitted at this location. If fillet welds or tack welds are placed between the backing and the beam flange in error, they shall be repaired as follows:

(1) The weld shall be removed such that the fillet weld or tack weld no longer attaches the backing to the beam flange.

95







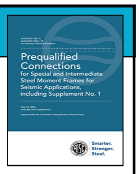
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS

3.4. WELD TABS

Where used, weld tabs shall be removed to within 1/8 in. (3 mm) of the base metal surface and the end of the weld finished, except at continuity plates where removal to within 1/4 in. (6 mm) of the plate edge shall be permitted. Removal shall be by air carbon arc cutting (CAC-A), grinding, chipping, or thermal cutting. The process shall be controlled to minimize errant gouging. The edges where weld tabs have been removed shall be finished to a surface roughness of 500 μ-in. (13 microns) or better. The contour of the weld end shall provide a smooth transition to adjacent surfaces, free of notches, gouges, and sharp corners. Weld defects greater

99

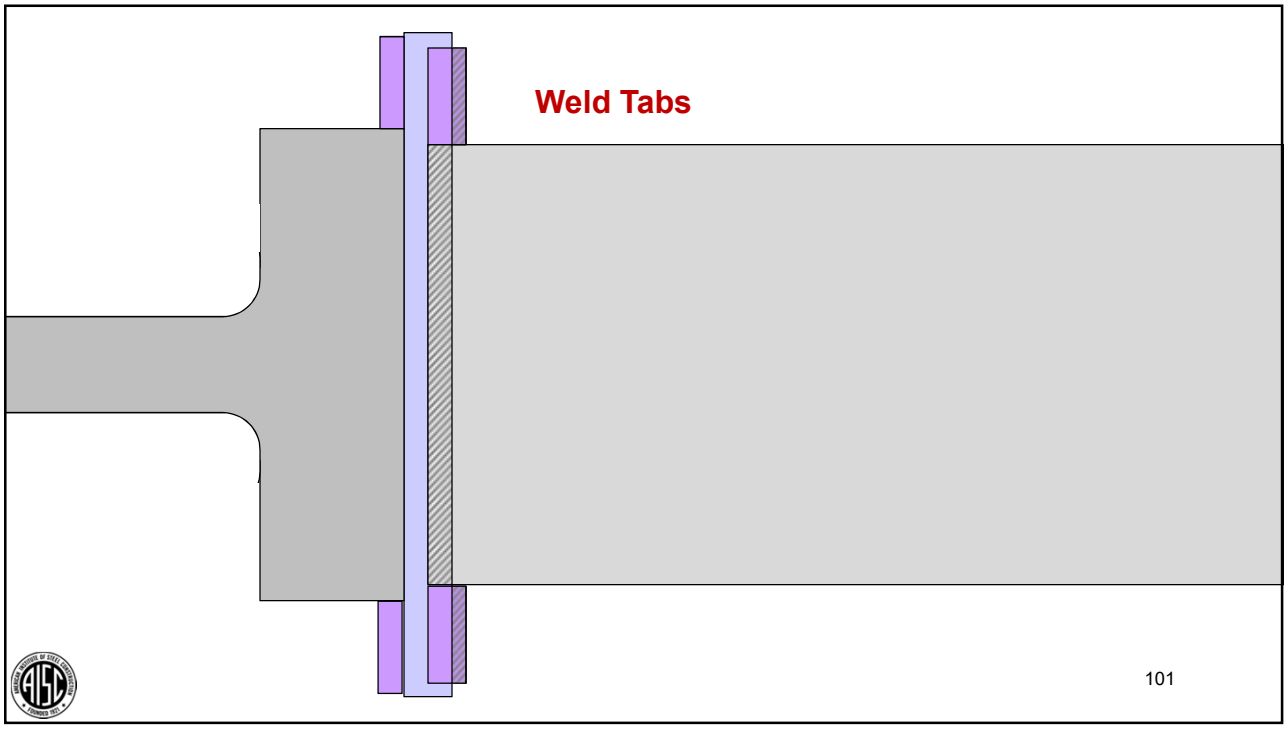
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS

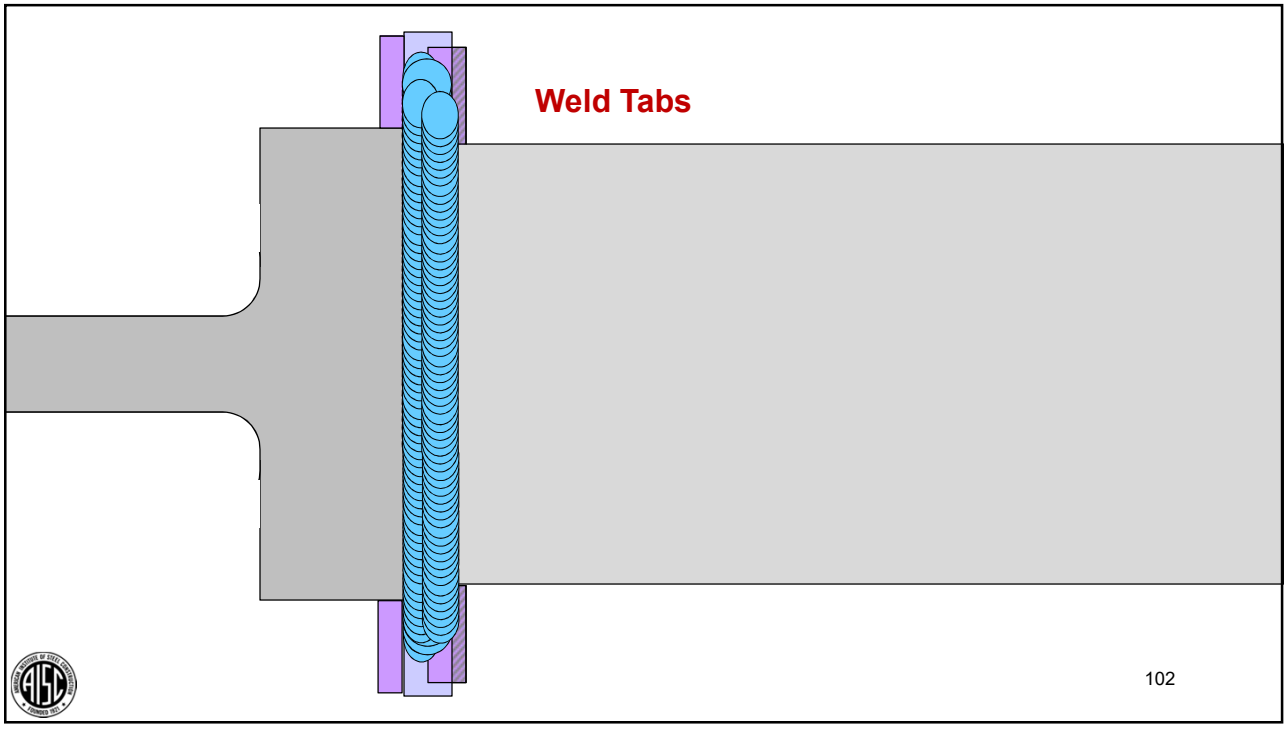


GLOSSARY

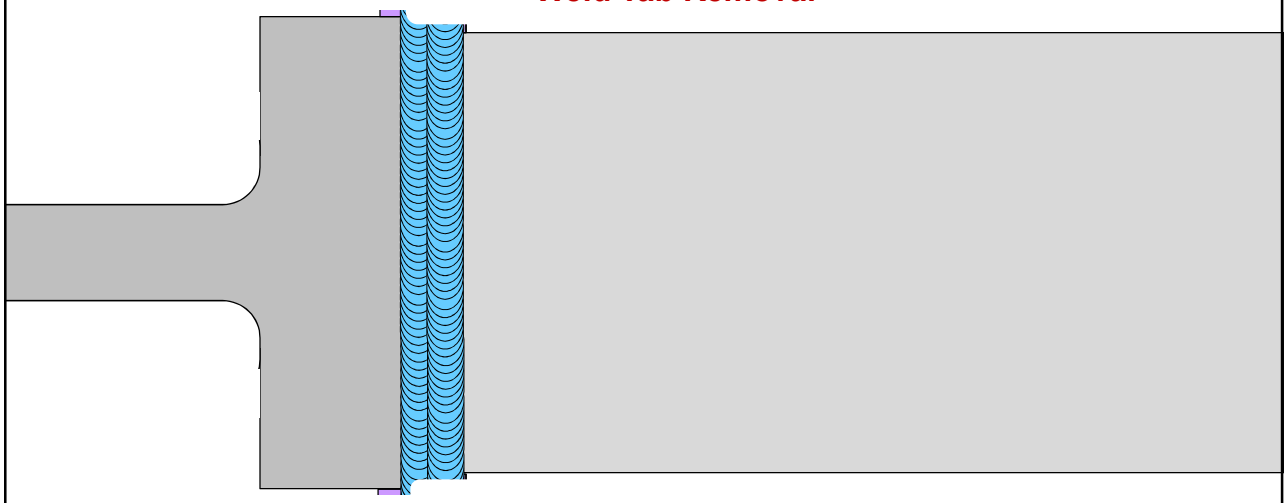
Weld tab. Piece of metal affixed to the end of a welded joint to facilitate the initiation and termination of weld passes outside the structural joint.

100





Weld Tab Removal



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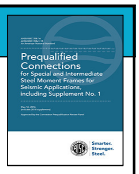
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



3.5. TACK WELDS

In the protected zone, tack welds attaching backing and weld tabs shall be placed where they will be incorporated into a final weld.

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AISC 341-16 SEISMIC PROVISIONS

GLOSSARY

Protected zone. Area of members or connections of members in which limitations apply to fabrication and attachments.

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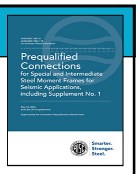
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



CHAPTER 2

DESIGN REQUIREMENTS

2.6. PROTECTED ZONE

The protected zone shall be as defined for each prequalified connection. Unless otherwise specifically indicated in this Standard, the protected zone of the beam shall be defined as the area from the face of the column flange to one-half of the beam depth beyond the plastic hinge. The protected zone shall meet the requirements of the AISC *Seismic Provisions*, except as indicated in this Standard. Bolt holes in beam webs, when detailed in accordance with the individual connection provisions of this

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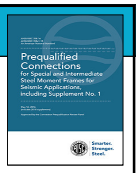
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



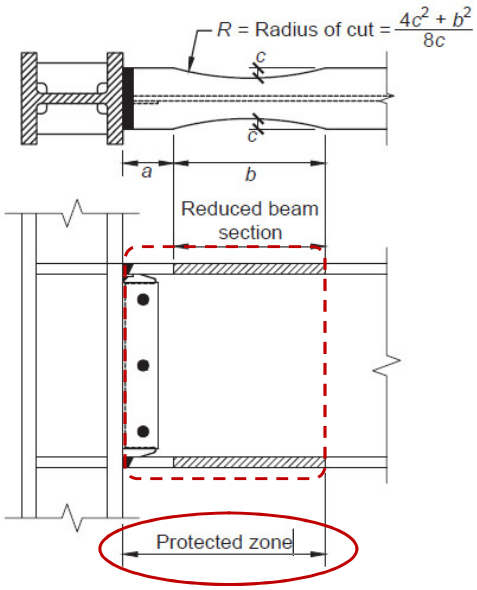


Fig. 5.1. Reduced beam section connection.

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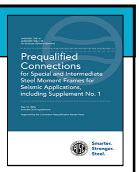
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



3.5. TACK WELDS

In the protected zone, tack welds attaching backing and weld tabs shall be placed where they will be incorporated into a final weld.

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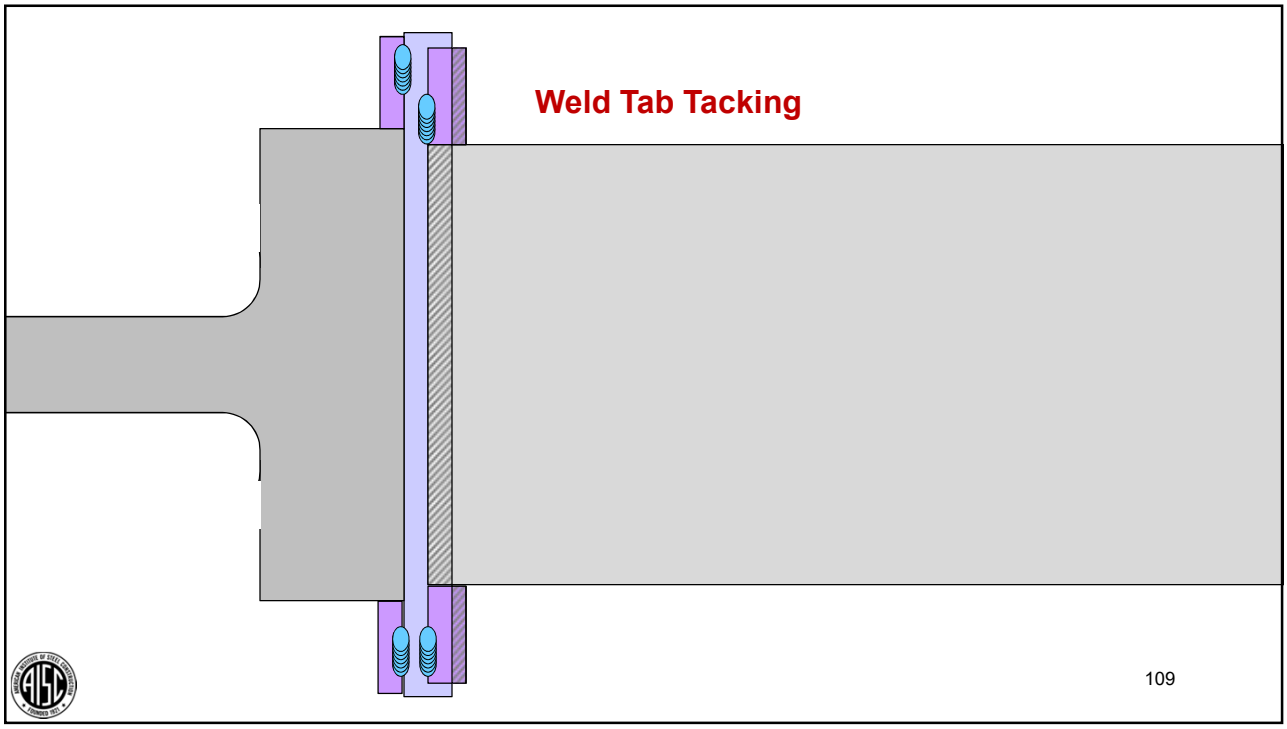
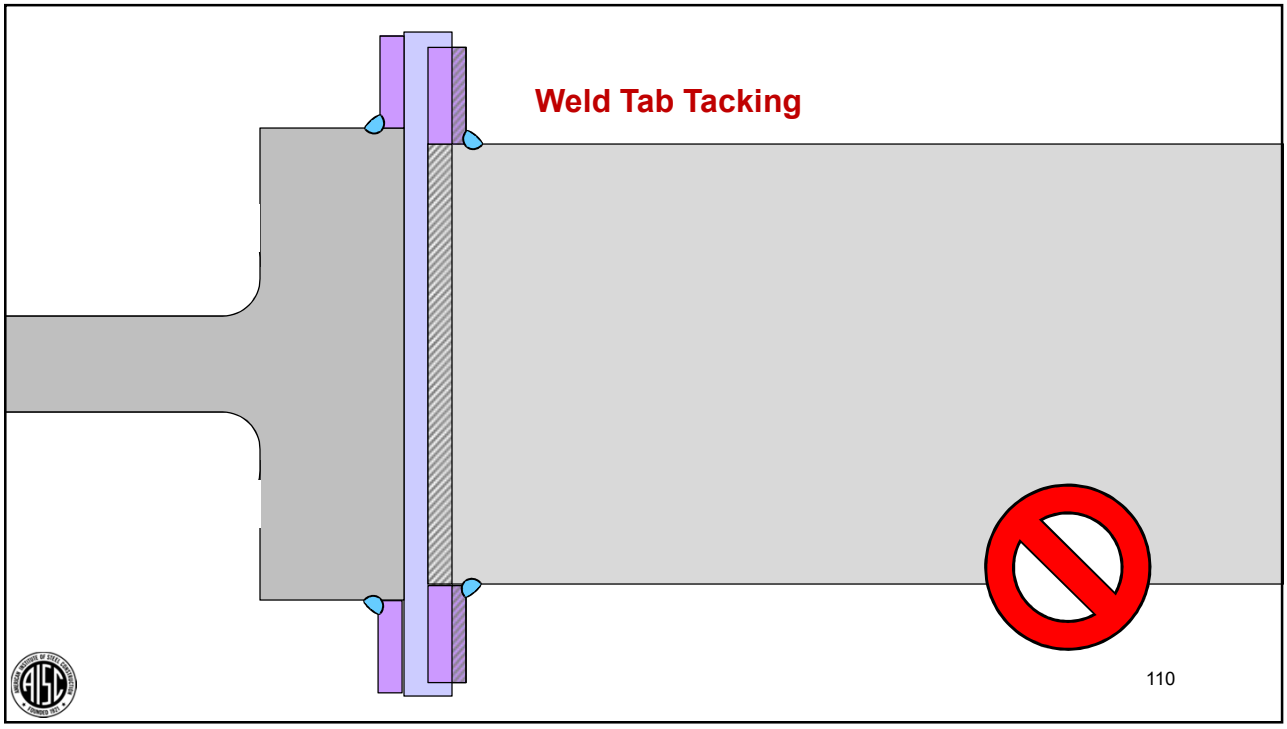
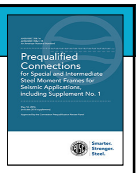




AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



3.6. CONTINUITY PLATES

Along the web, the corner clip shall be detailed so that the clip extends a distance of at least 1-1/2 in. (38 mm) beyond the published k_{det} dimension for the rolled shape. Along the flange, the plate shall be clipped to avoid interference with the fillet radius of the rolled shape and shall be detailed so that the clip does not exceed a distance of 1/2 in. (13 mm) beyond the published k_1 dimension. The clip shall be detailed to facilitate suitable weld terminations for both the flange weld and the web weld. When a curved corner clip is used, it shall have a minimum radius of 1/2 in. (13 mm).

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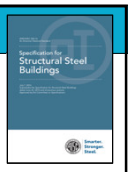
AISC 360-16 Specification for Structural Steel Buildings



GLOSSARY

k-area. The region of the web that extends from the tangent point of the web and the flange-web fillet (AISC *k* dimension) a distance 1-1/2 in. (38 mm) into the web beyond the *k* dimension.

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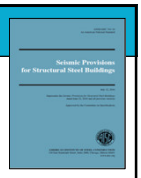
AISC 341-16 SEISMIC PROVISIONS



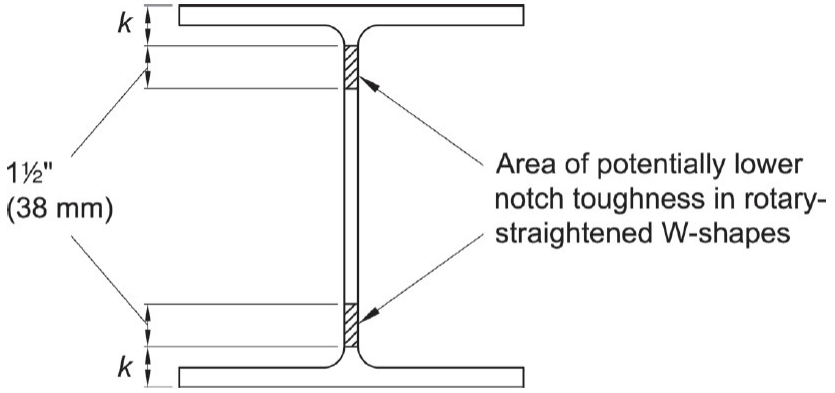


Fig. C-A3.1. "k-area."

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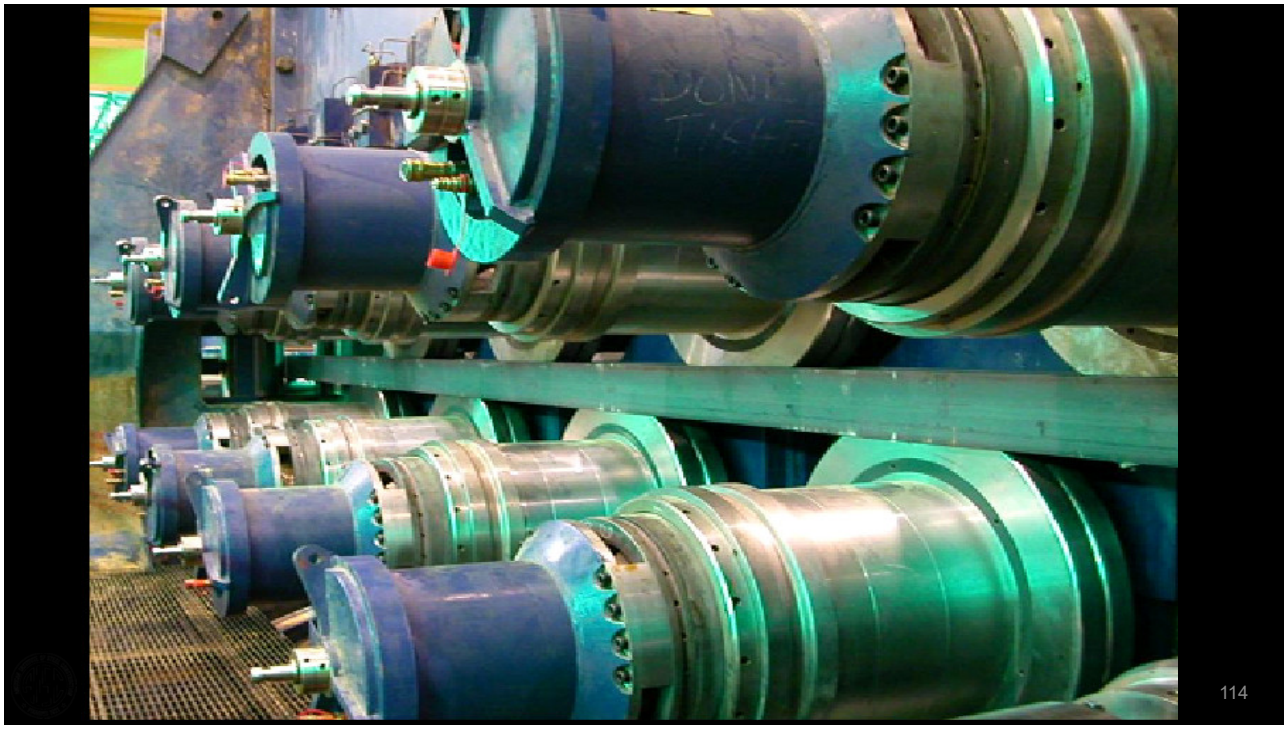

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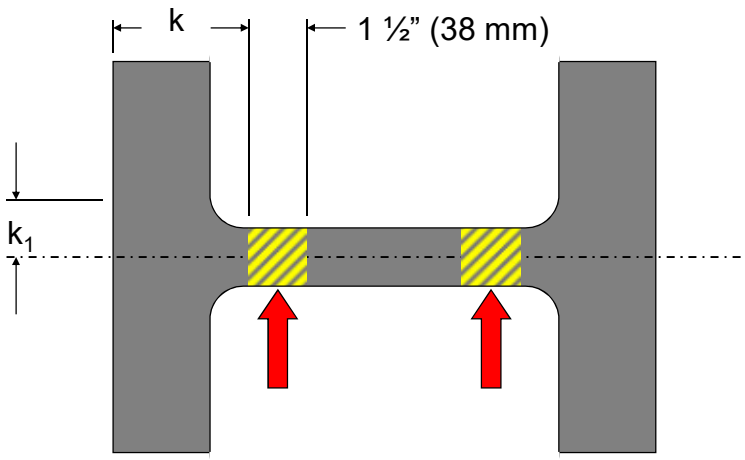
k-area



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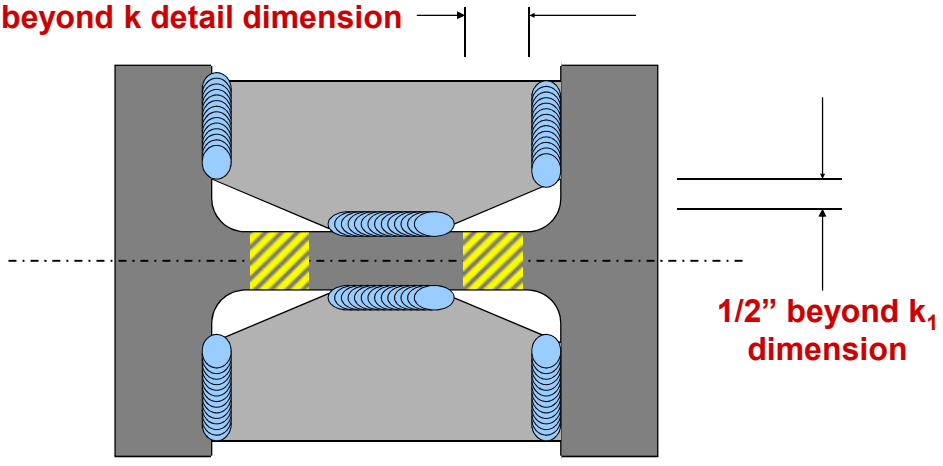
Continuity plate detailing



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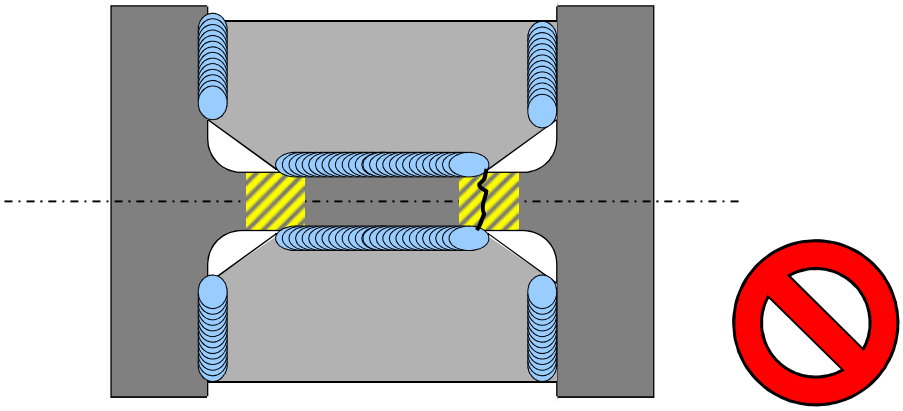
Continuity plate detailing



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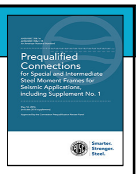
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS

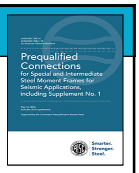


3.7. QUALITY CONTROL AND QUALITY ASSURANCE

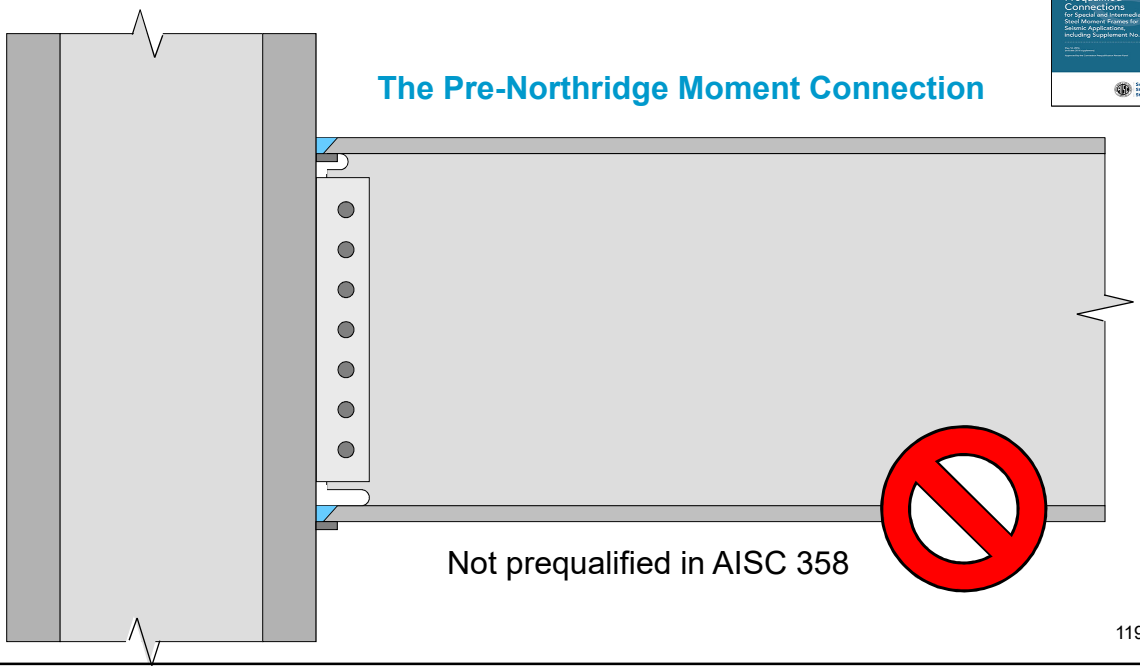
Quality control and quality assurance shall be in accordance with the AISC Seismic Provisions.

118

AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



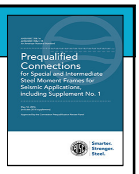
The Pre-Northridge Moment Connection



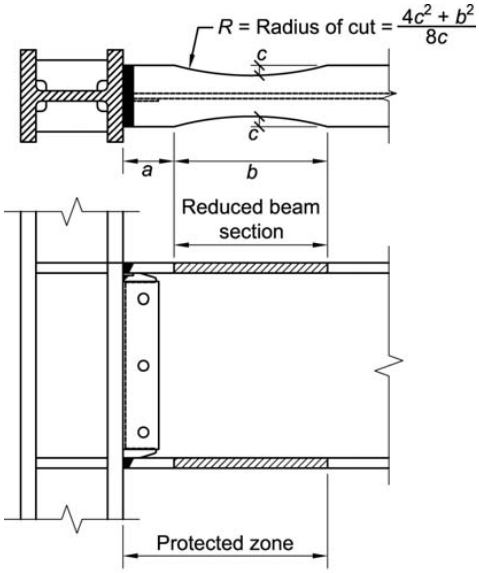
Not prequalified in AISC 358

119

AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



Reduced Beam Section (RBS) Moment Connection



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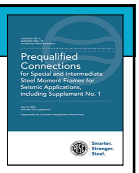
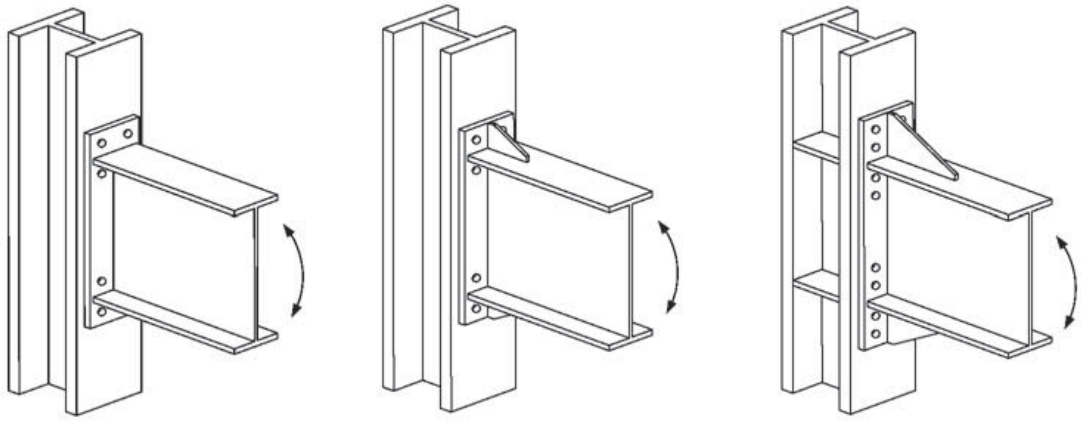
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



Bolted Unstiffened and Stiffened Extended End-Plate Moment Connections (BUEEP, BSEEP)



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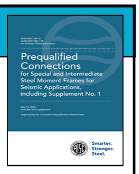
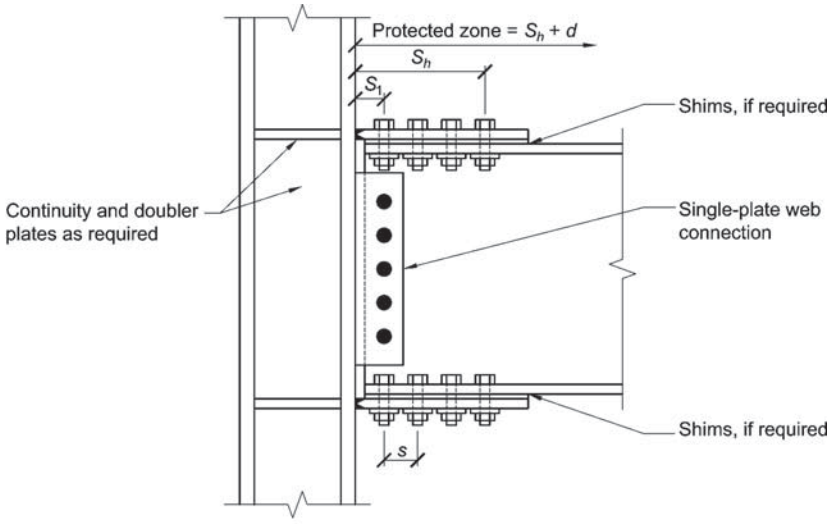
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



Bolted Flange Plate (BFP) Moment Connection



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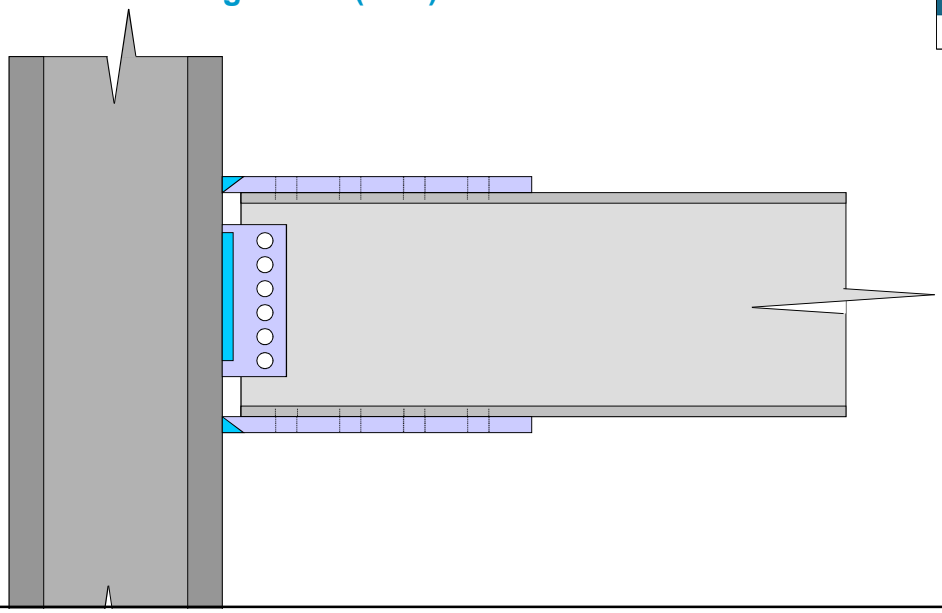
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS

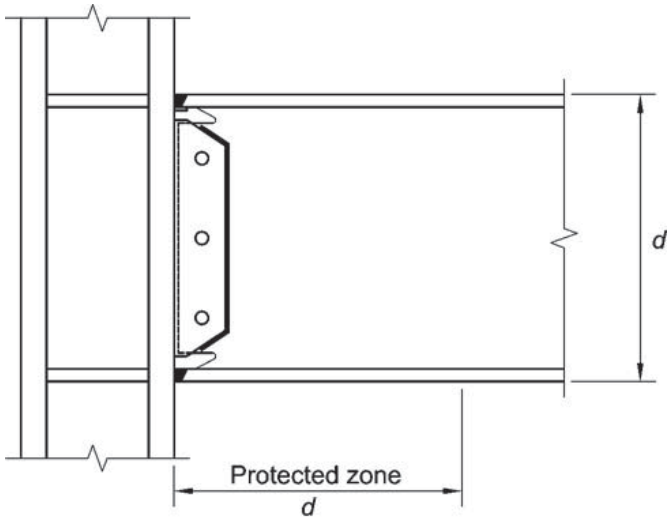
Bolted Flange Plate (BFP) Moment Connection



123

AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS

Welded Unreinforced Flange-Welded Web (WUF-W) Moment Connection



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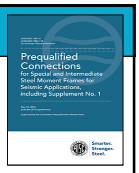
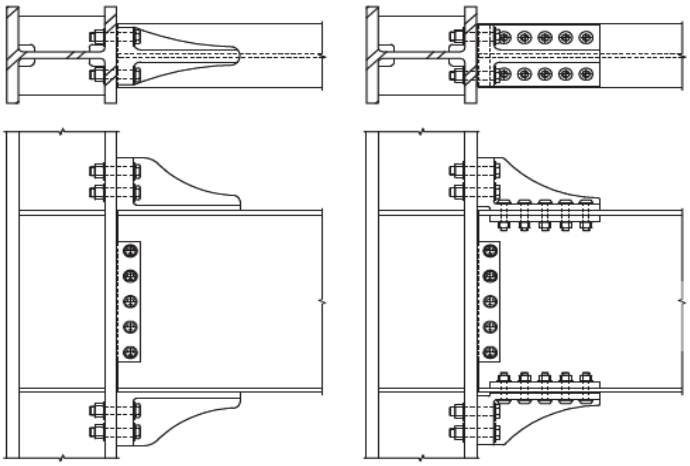
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



Kaiser Bolted Bracket (KBB) Moment Connection



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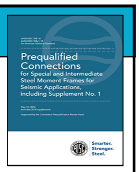
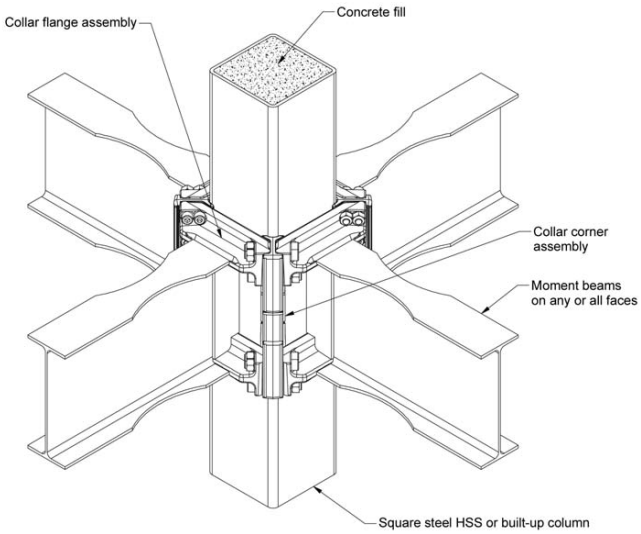
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



CONXTECH® CONXL™ Moment Connection



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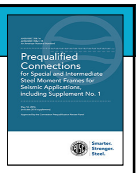
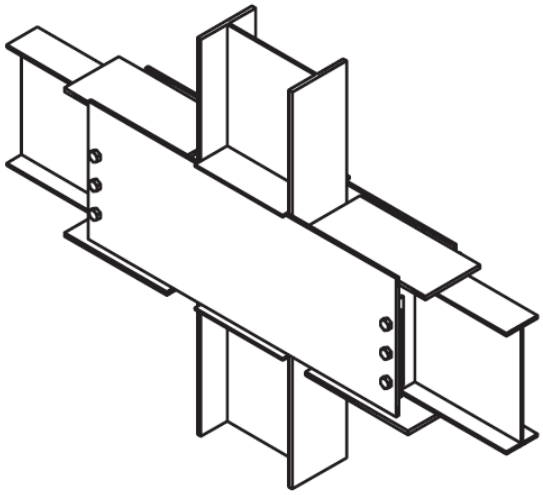
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



SidePlate® Moment Connection



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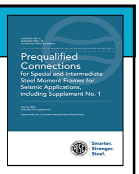
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



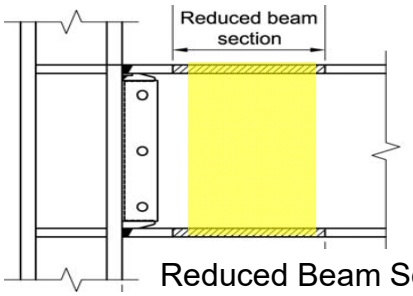
COMMENTARY CHAPTER 1

GENERAL

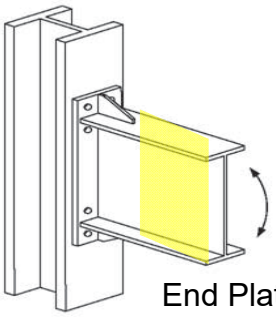
1.3. General

Connections prequalified under this Standard are intended to withstand inelastic deformation primarily through controlled yielding in specific behavioral modes. To obtain connections that will behave in the indicated manner, proper determination of the strength of the connection in various limit states is necessary. The strength formulations contained in the LRFD method are consistent with this approach.

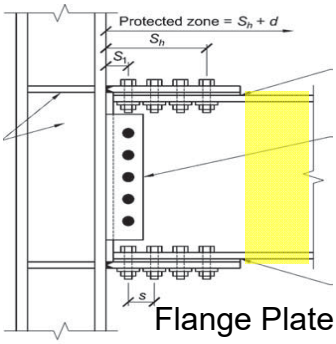
128



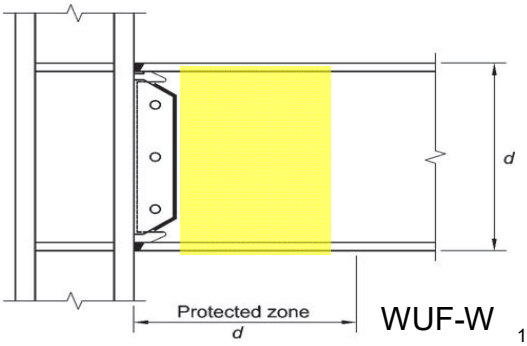
Reduced Beam Section



End Plate

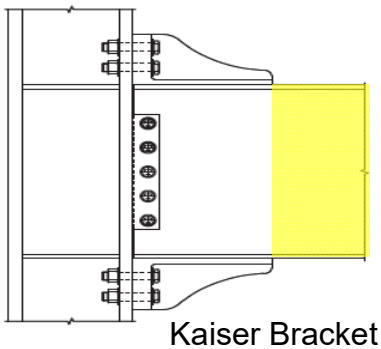


Flange Plate

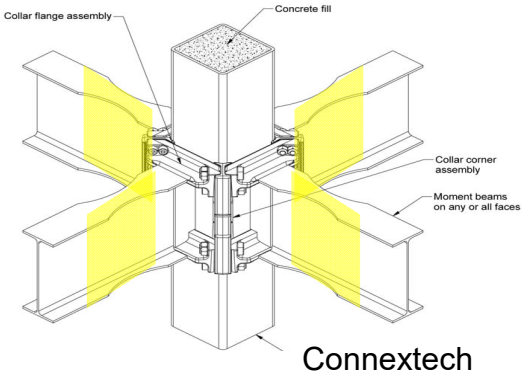


WUF-W

129



Kaiser Bracket



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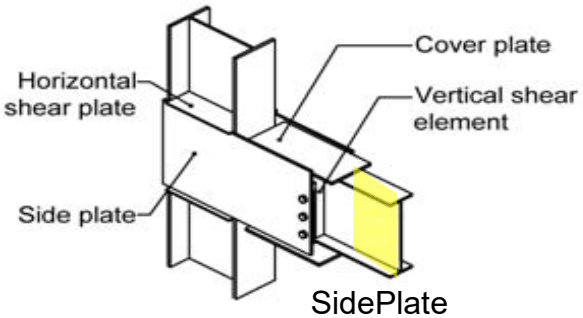

SidePlate

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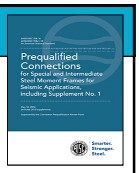
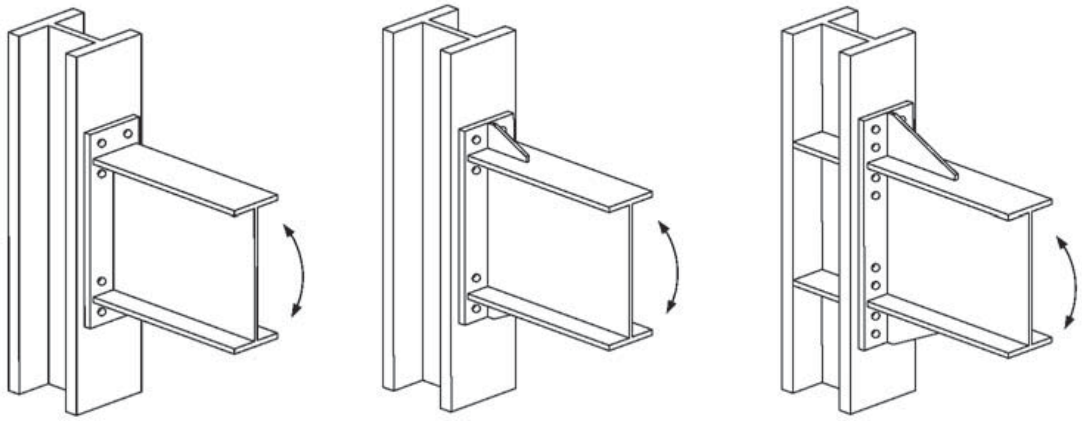
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



Bolted Unstiffened and Stiffened Extended End-Plate Moment Connections (BUEEP, BSEEP)



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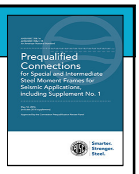
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



Bolted Unstiffened and Stiffened Extended End-Plate Moment Connections (BUEEP, BSEEP)

6.7. CONNECTION DETAILING

6. Welding Details

Welding of the beam to the end-plate shall conform to the following limitations:

(1) Weld access holes shall not be used.

(2) The beam flange to end-plate joint shall be made using a CJP groove weld without backing. The CJP groove weld shall be made such that the root of the weld is on the beam web side of the flange. The inside face of the flange shall have a 5/16-in. (8 mm) fillet weld. These welds shall be demand critical.

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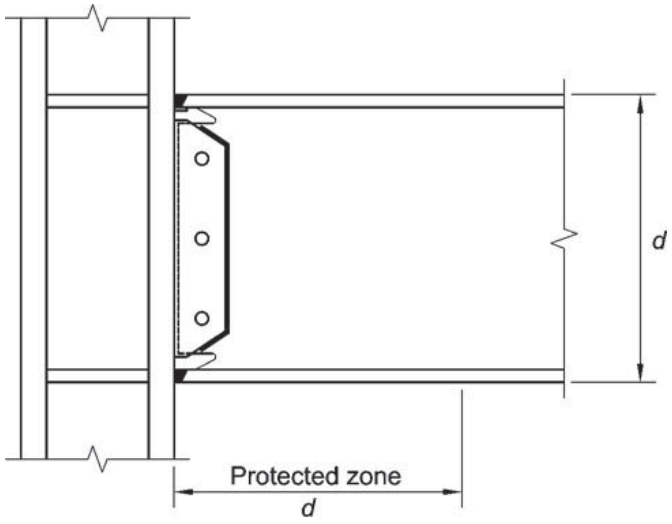
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS

Welded Unreinforced Flange-Welded Web (WUF-W) Moment Connection



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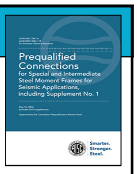
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



Welded Unreinforced Flange-Welded Web (WUF-W) Moment Connection

8.5. BEAM FLANGE-TO-COLUMN FLANGE WELDS

Beam flange-to-column flange connections shall satisfy the following limitations:

(2) Weld access hole geometry shall conform to the requirements of AWS D1.8/D1.8M Section 6.11.1.2. Weld access hole quality requirements shall conform to the requirements of AWS D1.8.

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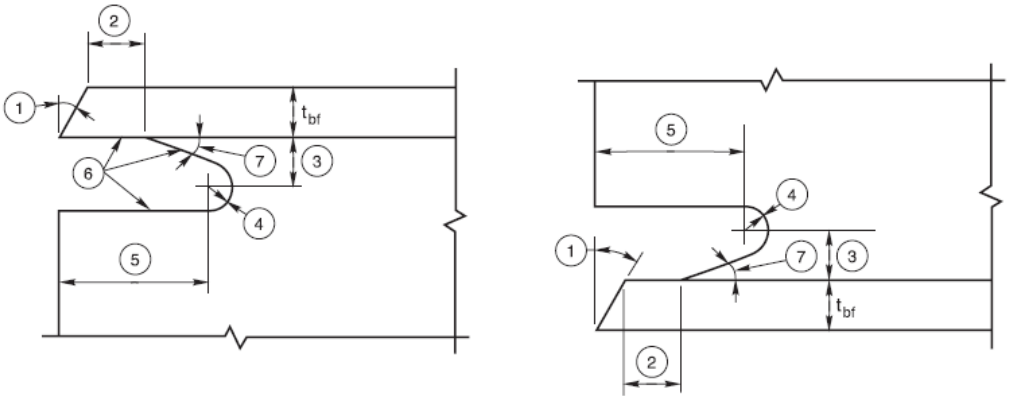
AWS D1.8:2016 Seismic Welding Supplement



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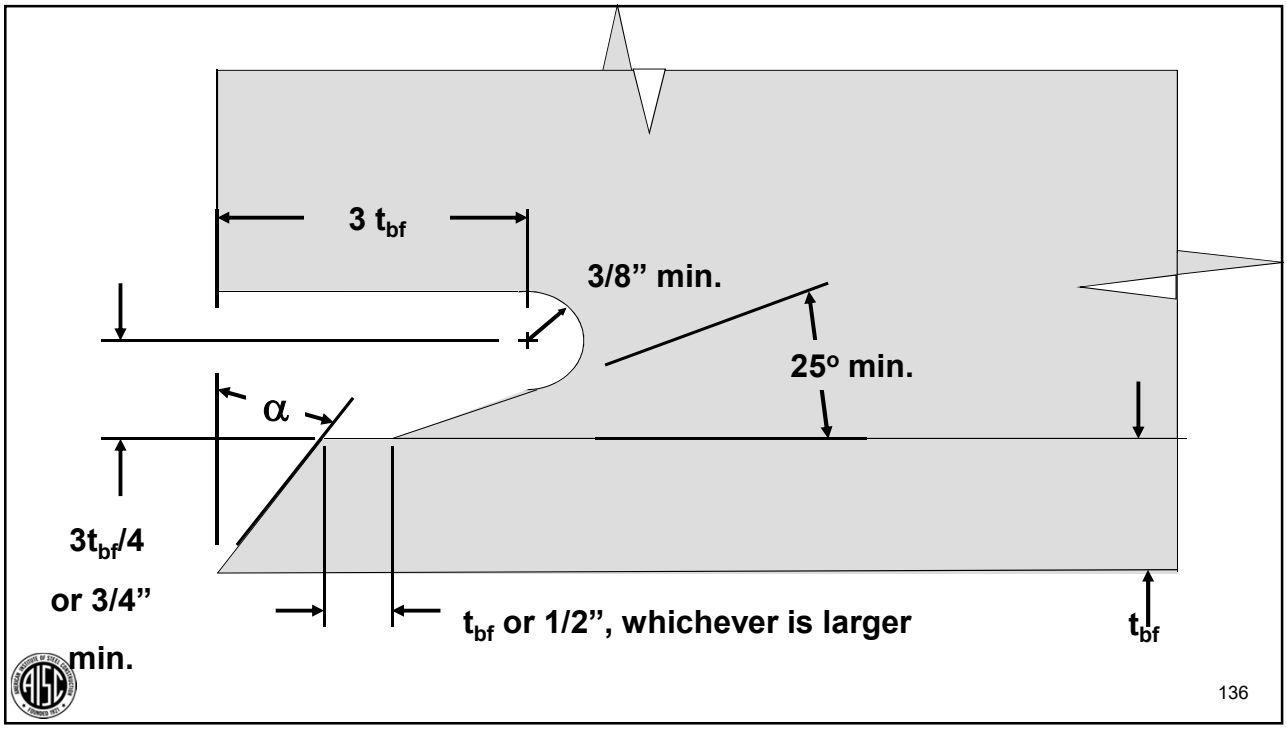

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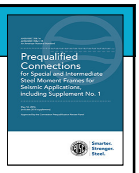
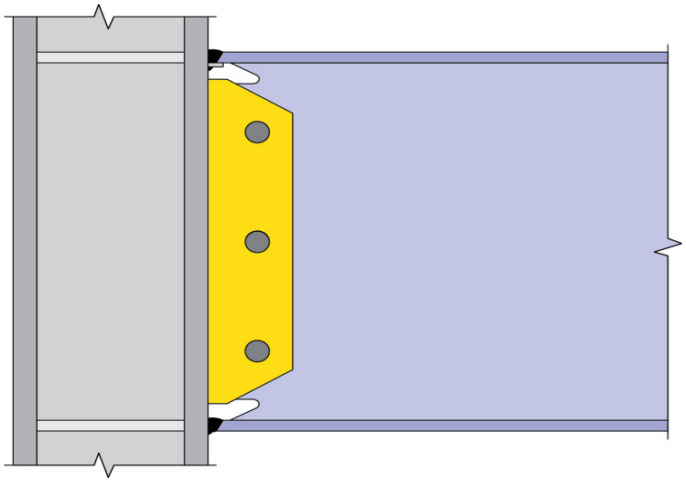
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



Welded Unreinforced Flange-Welded Web (WUF-W) Moment Connection



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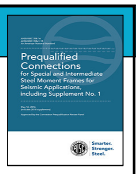
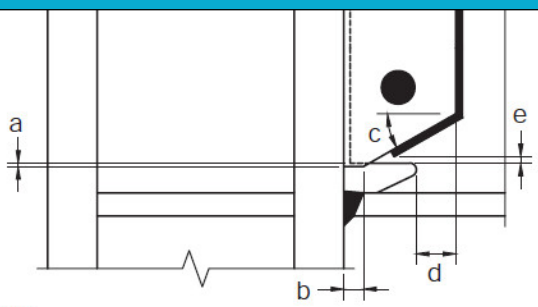
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS





Notes

a = ¼ in. (6 mm) minimum, ½ in. (12 mm) maximum
b = 1 in. (25 mm) minimum
c = 30° (±10°)
d = 2 in. (50 mm) minimum
e = ½ in. (12 mm) minimum distance, 1 in. (25 mm) maximum distance from end of fillet weld to edge of access hole

Fig. 8.3. Details at top and bottom of single-plate shear connection.

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SEISMIC WELDING ISSUES

Chapter 11 Seismic Welding Issues

11.1 Introduction

11.2 The Northridge Earthquake

11.3 Seismic Welding Specifications

11.4 Seismic Terminology

11.5 AWS D1.8

11.6 AISC *Seismic Provisions* Welding Requirements

11.7 AISC *Prequalified Connections* Welding Requirements

➡ 11.8 Welded Details For Prequalified Connections

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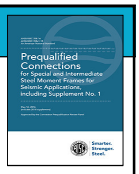
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



CHAPTER 1

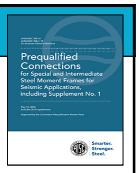
GENERAL

1.1. Scope

This Standard specifies design, detailing, fabrication and quality criteria for connections that are prequalified in accordance with the AISC *Seismic Provisions for Structural Steel Buildings* (herein referred to as the AISC *Seismic Provisions*) for use with special moment frames (SMF) and intermediate moment frames (IMF). The connections contained in this Standard are prequalified to meet the requirements in the AISC *Seismic Provisions* only when designed and constructed in accordance with the requirements of this Standard.

140

AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



CHAPTER 3

WELDING REQUIREMENTS

3.1. Filler Metals

Filler metals shall conform to the requirements of the AISC *Seismic Provisions*.

3.2. Welding Procedures

Welding Procedures shall be in accordance with the AISC *Seismic Provisions*.

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AISC 341-16 SEISMIC PROVISIONS

CHAPTER A

GENERAL REQUIREMENTS

A3 MATERIALS

4. Consumables for Welding

4a. Seismic Force-Resisting System Welds

All welds used in members and connections in the SFRS shall be made with filler metals meeting the requirements specified in clauses 6.1, 6.2 and 6.3 of *Structural Welding Code—Seismic Supplement* (AWS D1.8/D1.8M), hereafter referred to as AWS D1.8/D1.8M.

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AISC 341-16 SEISMIC PROVISIONS

CHAPTER A

GENERAL REQUIREMENTS

A3 MATERIALS

4. Consumables for Welding

4b. Demand Critical Welds

Welds designated as demand critical shall be made with filler metals meeting the requirements specified in AWS D1.8/D1.8M clauses 6.1, 6.2 and 6.3.

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AISC 341-16 SEISMIC PROVISIONS

GLOSSARY

Demand critical weld. Weld so designated by these Provisions.

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AISC 341-16 SEISMIC PROVISIONS

COMMENTARY CHAPTER A

GENERAL REQUIREMENTS

A3. Materials

4. Consumables for Welding

Demand critical welds are generally complete-joint-penetration groove (CJP) welds so designated because they are subject to yield level or higher stress demand and located in a joint whose failure would result in significant degradation in the strength or stiffness of the SRFS.

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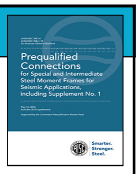
AISC 358-16 / AISC 358s1-18 PREQUALIFIED CONNECTIONS



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WELDING REQUIREMENTS

3.1. Filler Metals

Filler metals shall conform to the requirements of the AISC *Seismic Provisions*.

3.2. Welding Procedures

Welding Procedures shall be in accordance with the AISC *Seismic Provisions*.

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AISC 341-16 SEISMIC PROVISIONS

CHAPTER I

FABRICATION AND ERECTION

I2. FABRICATION AND ERECTION

3. Welded Joints

Welding and welded connections shall be in accordance with AWS D1.8/D1.8M and *Structural Welding Code—Steel* (AWS D1.1/D1.1M), hereafter referred to as AWS D1.1/D1.1M.

Welding procedure specifications (WPS) shall be approved by the engineer of record.

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AISC 341-16 SEISMIC PROVISIONS

CHAPTER A

GENERAL REQUIREMENTS

A4. Structural Design Drawings and Specifications

2. Steel Construction

In addition to the requirements of Section A4.1, structural design drawings and specifications for steel construction shall indicate the following items, as applicable:

a) Configuration of the connections.
b) Connection material specifications and sizes.
c) Locations of demand critical welds.
d) Locations where gusset plates are to be detailed to accommodate inelastic rotation.
e) Locations of connection plates requiring Charpy V-notch toughness in accordance with Section A3.3(b)

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AISC 341-16 SEISMIC PROVISIONS

CHAPTER A

GENERAL REQUIREMENTS

A4. Structural Design Drawings and Specifications

2. Steel Construction (cont'd)

f) Lowest anticipated service temperature of the steel structure, if the structure is not enclosed and maintained at a temperature of 50° F (10°C) or higher

g) Locations where weld backing is required to be removed

h) Locations where fillet welds are required when weld backing is permitted to remain

i) Locations where fillet welds are required to reinforce groove welds or to improve connection geometry

j) Locations where weld tabs are required to be removed

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AISC 341-16 SEISMIC PROVISIONS

CHAPTER A

GENERAL REQUIREMENTS

A4. Structural Design Drawings and Specifications

2. Steel Construction (cont'd)

k) Splice locations where tapered transitions are required.

l) The shape of weld access holes, if a shape other than those provided for in the *Specification* is required

m) Joints or groups of joints in which a specific assembly order, welding sequence, welding technique, or other special precautions are required, where such items are designated to be submitted to the engineer of record

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AISC 341-16 SEISMIC PROVISIONS

CHAPTER D
GENERAL MEMBER AND CONNECTION DESIGN REQUIREMENTS

A4. Structural Design Drawings and Specifications

5. Column Splices

(c) Where butt joints in column splices are made with complete-joint penetration groove welds and when tension stress at any location in the smaller flange exceeds $0.30F_y/\alpha_s$, tapered transitions are required between flanges of unequal thickness or width. Such transitions shall be in accordance with AWS D1.8/D1.8M clause 4.2.

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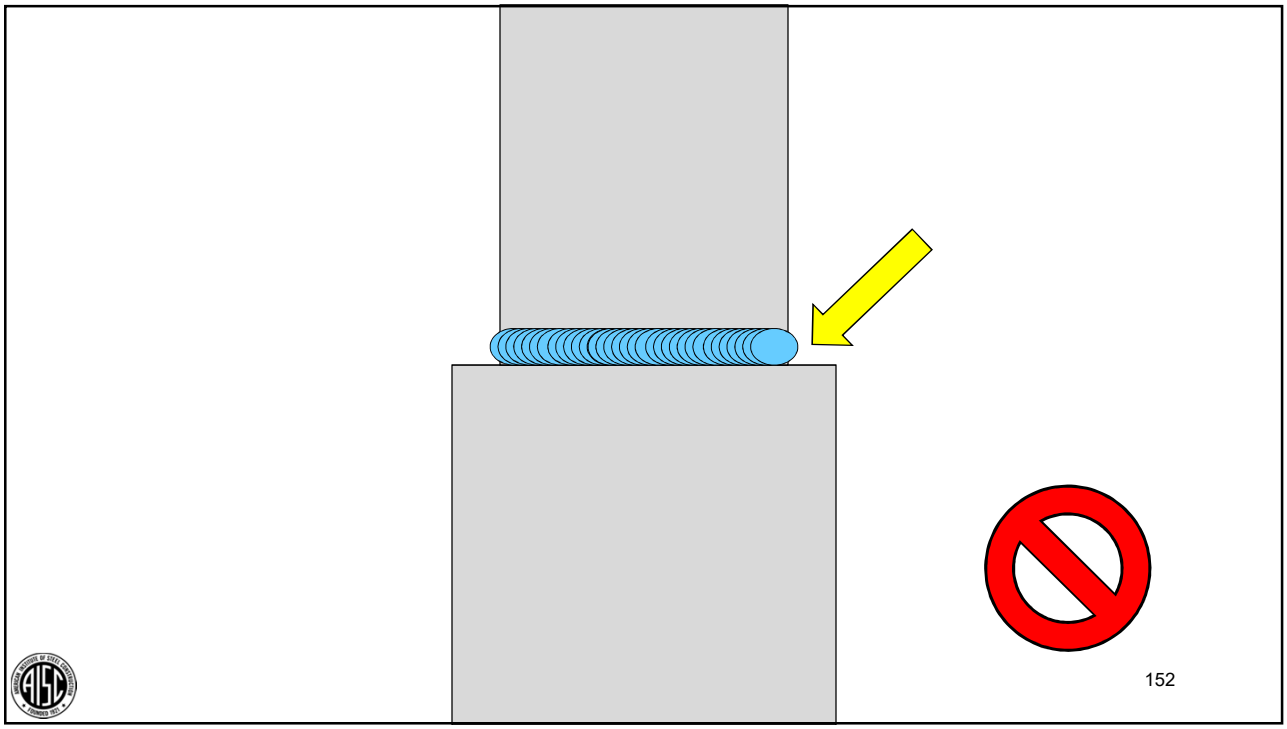

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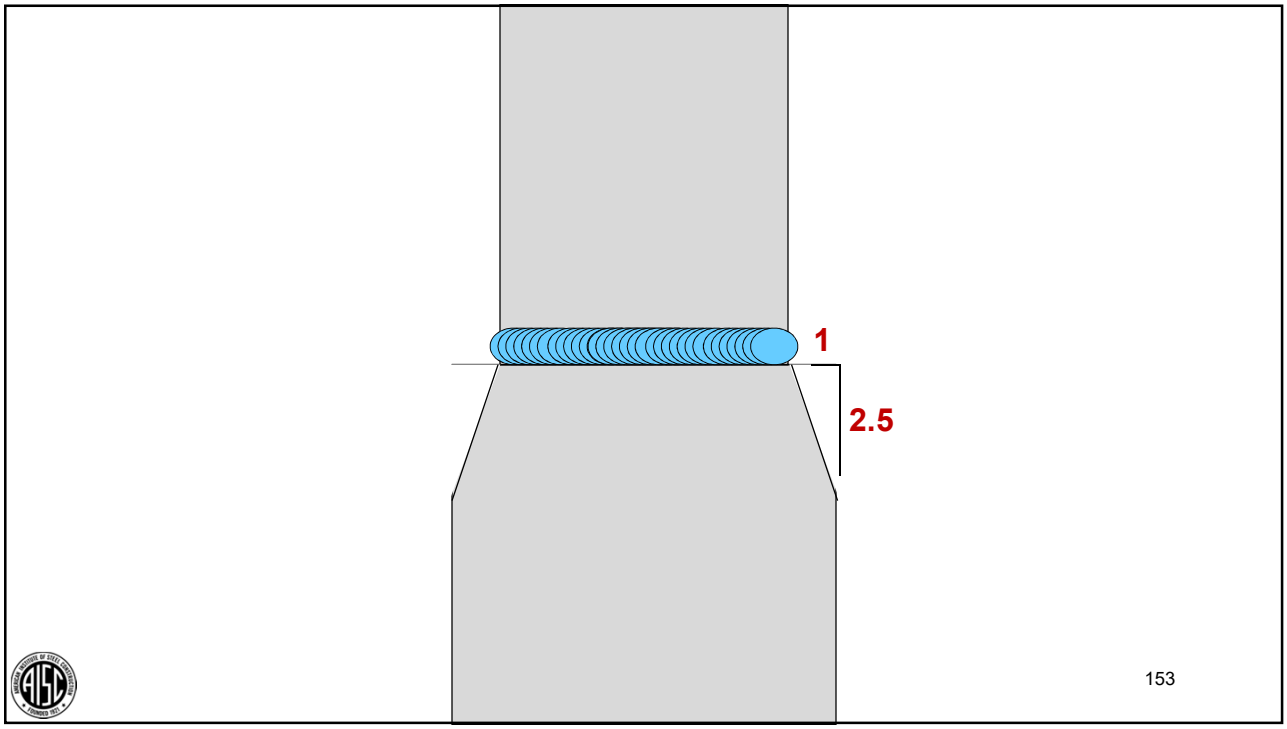
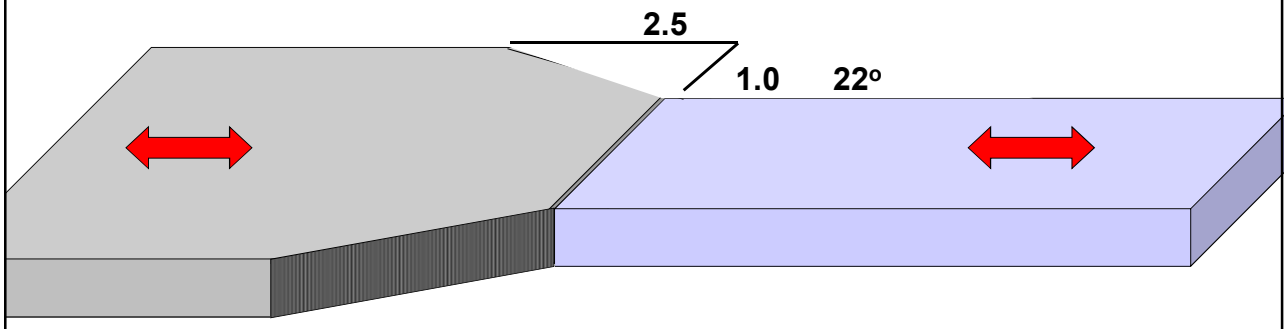


AWS D1.1:2015 Structural Welding Code – Steel

Butt Joint—different widths



2.17.1.2 Provide transition for cyclically loaded members with width changes.

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SEISMIC WELDING ISSUES

Outline

- Seismic Design and Ductility
- The Northridge Experience
- AISC Prequalified Seismic Connections
- D1.8 Seismic Welding Supplement
- Conclusion

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AWS D1.8

Structural Welding Code –
Seismic Supplement

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AWS D1.8:2016 Seismic Welding Supplement

1. General Requirements
2. Normative Reference
3. Terms and Definitions
4. Welded Connection Details
5. Welder Qualification
6. Fabrication
7. Inspection

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AWS D1.8:2016 Seismic Welding Supplement

Outline

- Overview
- Heat Input Testing
- Restricted Access Welder Qualification
- Fabrication Details

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AWS D1.8:2016 Seismic Welding Supplement

COMMENTARY

C-1.1 Scope

The provisions contained in this standard complement the AISC Seismic Provisions and are intended to ensure that welded joints that are designed to undergo significant repetitive inelastic strains as a result of earthquakes, or that are used to connect members designed to resist such inelastic strains have adequate strength, notch toughness, and integrity to perform as intended.

STRENGTH **TOUGHNESS** **INTEGRITY**

LIMIT STRESS CONCENTRATIONS

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SEISMIC WELDING ISSUES

STRENGTH

- No new requirements: D1.1 applies

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SEISMIC WELDING ISSUES

TOUGHNESS

- For members of SFRS: 20 ft-lbs @ 0°F [27J @ -18°C] by AWS A5 classification (Table 6.1)
- For Demand Critical welds: 40 ft-lbs @ +70°F [54J @ +20°C] by special high and low heat input tests (Table 6.2, Annex A)
- Intermix testing for combinations that include FCAW-S (Annex B)
- Controls on wind speed for gas-shielded processes (clause 6.6.3.1)
- Filler metal lot control, or alternatives (clause 6.3.1)
- Maximum interpass temperature control (clause 6.7)

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SEISMIC WELDING ISSUES

INTEGRITY

- Restricted access welder qualification test (Annex D)
- Bottom flange welding sequence (clause 6.9)
- Welder identification system (clause 6.10)
- Moisture-resistant FCAW packaging (clause 6.4.1)
- Exposure limits for FCAW electrode (clause 6.4.3), including extended exposure tests (Annex E)
- Controls on wind speed for gas-shielded processes (clause 6.6.3.1)
- Inspection criteria for specific conditions (clauses 7.4-7.10)

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SEISMIC WELDING ISSUES

LIMIT STRESS CONCENTRATIONS

- Protected Zone restrictions (clause 6.18)
- Backing removal (clause 6.13)
- Left-in-place backing treatment (clause 6.15)
- Weld access hole profiles (clause 6.11)
- Weld tab removal (clause 6.16.3)
- Restrictions on end dams (clause 6.17)
- Corner clips and continuity plates and stiffener detailing (clause 4.1)
- Width and thickness transition details (clause 4.2)

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AWS D1.8:2016 Seismic Welding Supplement

1.1 Scope

The provisions of this code supplement the provisions of AWS D1.1/D1.1M, *Structural Welding Code—Steel*, and shall apply to the design, fabrication, quality control, and quality assurance of welded joints designed in accordance with the AISC *Seismic Provisions for Structural Steel Buildings*.

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AWS D1.8:2016 Seismic Welding Supplement

1.1 Scope (continued)

All provisions of AWS D1.1/D1.1M for statically loaded structures shall apply to the designated welds, except as specifically modified herein.

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AWS D1.8:2016 Seismic Welding Supplement

Three kinds of welds:

Type of Weld	D1.1	D1.8	D1.8 DC
Not part of SFRS	✓		
Part of SFRS	✓	✓	
Demand Critical	✓	✓	✓

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AISC 341-16 SEISMIC PROVISIONS

CHAPTER A

GENERAL REQUIREMENTS

A3 MATERIALS

4. Consumables for Welding

4a. Seismic Force-Resisting System Welds

All welds used in members and connections in the SFRS shall be made with filler metals meeting the requirements specified in clauses 6.1, 6.2 and 6.3 of *Structural Welding Code—Seismic Supplement* (AWS D1.8/D1.8M), hereafter referred to as AWS D1.8/D1.8M.

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AWS D1.8:2016 Seismic Welding Supplement

Welds: Part of the SFRS

Table 6.1
Filler Metal Mechanical Property Requirements

Property	Classification Strength Levels		
	70 ksi [490 MPa]	80 ksi [550 MPa]	90 ksi [620 MPa]
Yield Strength, ksi [MPa] [a]	58 [400] min.	68 [470] min.	78 [540] min.
Tensile Strength, ksi [MPa]	70 [490] min.	80 [550] min.	90 [620] min.
Elongation (%)	22 min.	19 min.	17 min.
CVN Toughness, ft-lbf [J] [b]	20 [27] min. @ 0°F [–18°C]	20 [27] min. @ 0°F [–18°C]	25 [34] min. @ –20°F [–30°C]

[a] 0.2% offset method.
[b] Filler metals classified as meeting the required absorbed energy at a temperature lower than the required test temperature also meet this requirement.

20 ft-lbs @ 0°F

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AISC 341-16 SEISMIC PROVISIONS

CHAPTER A

GENERAL REQUIREMENTS

A3 MATERIALS

4. Consumables for Welding

4b. Demand Critical Welds

Welds designated as demand critical shall be made with filler metals meeting the requirements specified in AWS D1.8/D1.8M clauses 6.1, 6.2 and 6.3.

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AWS D1.8:2016 Seismic Welding Supplement

Demand Critical Welds

Table 6.2
Mechanical Property Requirements for Demand Critical Welds

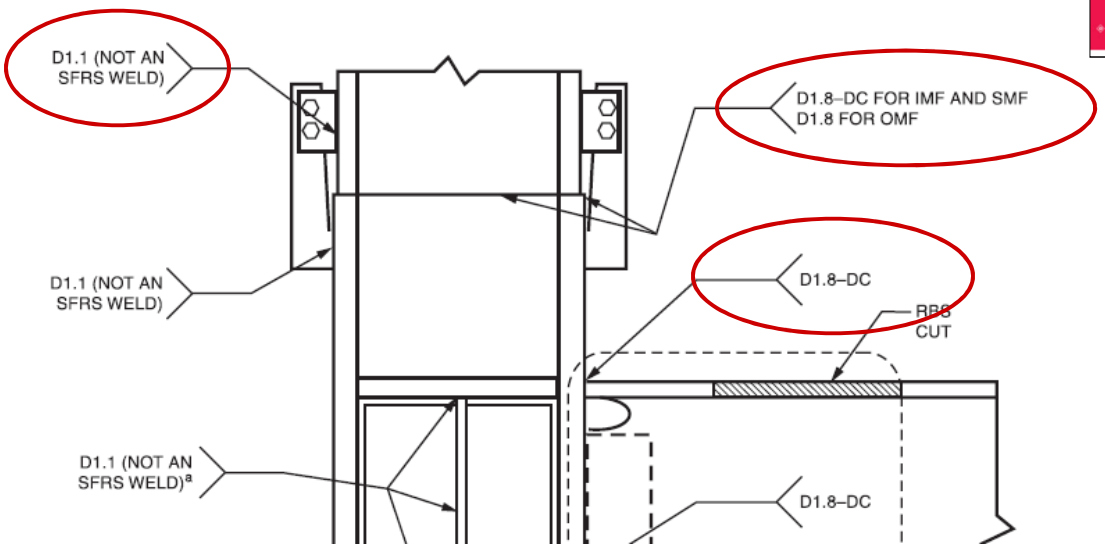
	Classification Strength Levels		
Property	70 ksi [490 MPa]	80 ksi [550 MPa]	90 ksi [620 MPa]
Yield Strength, ksi [MPa][a]	58 [400] min.	68 [470] min.	78 [540] min.
Tensile Strength, ksi [MPa]	70 [490] min.	80 [550] min.	90 [620] min.
Elongation (%)	22 min.	19 min.	17 min.
CVN Toughness, ft-lbf [J][b,c]	40 [54] min. @ +70°F [+20°C]	40 [54] min. @ +70°F [+20°C]	40 [54] min. @ +50°F [+10°C]

[a] 0.2% offset method.
[b] For LAST of +50°F [+10°C]. For LAST less than + 50°F [+10°C], see 6.2.2.
[c] Tests conducted in accordance with Annex A meeting 40 ft-lbf [54 J] min. at a temperature lower than the required test temperature also meet this requirement.

40 ft-lbs @ 70°F in hi/lo tests for LAST of +50°F

DEMAND CRITICAL

AWS D1.8:2016 Seismic Welding Supplement



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AWS D1.8:2016 Seismic Welding Supplement

Outline

- Overview
- Heat Input Testing
- Restricted Access Welder Qualification
- Fabrication Details

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AWS D1.8:2016 Seismic Welding Supplement

Annex A (Normative)

WPS Heat Input Envelope Testing of

Filler Metals for Demand Critical Welds

A1. Purpose

This annex provides testing procedures used to determine the suitability of filler metals to be used in producing Demand Critical welds in accordance with this code. These procedures are intended to assure that welds deposited with filler metals tested in accordance with these procedures will be capable of providing welded joints with the required strength, ductility, and notch toughness at the anticipated service temperatures, for the range of heat input rates that may be experienced under the production WPS.

A4. Test Plate Details

Two test plates shall be required, one for each heat input level. The test plate shall be as shown in Figure A.1. Plates for qualification of E7X [E48X] filler metals shall conform either to ASTM A36, A572 Grade 50, or A992. Plates for qualification of E80 [E55] filler metals shall conform to either ASTM A36, A572 Grade 50, ASTM A572 Grade 65, or A913 Grade 65, at the Contractor's option. Plates for qualification of E90 [E62] filler metals shall conform to either A572 Grade 50, ASTM A572 Grade 65, A913 Grade 65, or A913 Grade 70 at the Contractor's option. Steel backing shall be of one of the six specifications and grades listed above, but need not be the same as the base material used for the qualification test plates.

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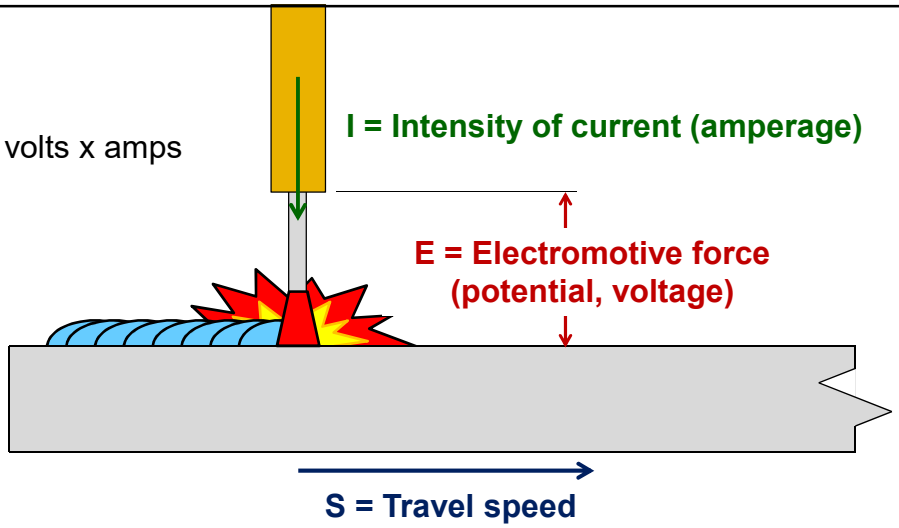
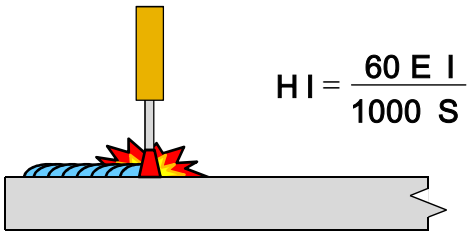
Energy = volts x amps



$$HI = \frac{60\ E\ I}{1000\ S}\ \text{KJ/in [KJ/mm]}$$

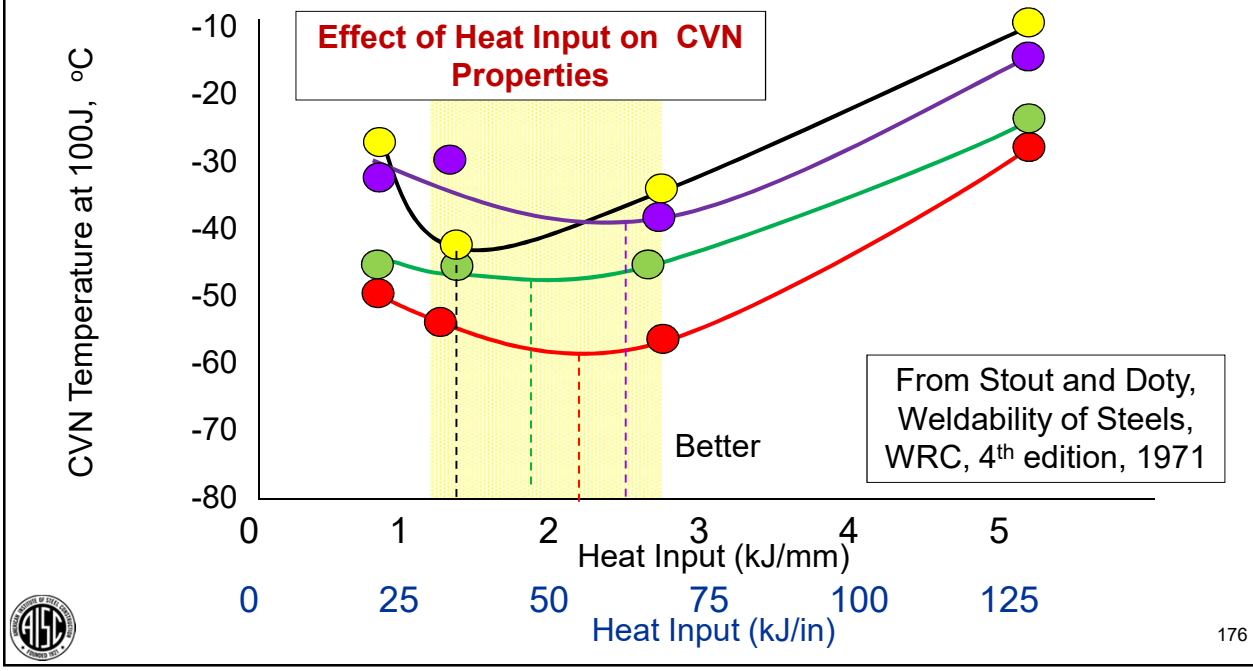


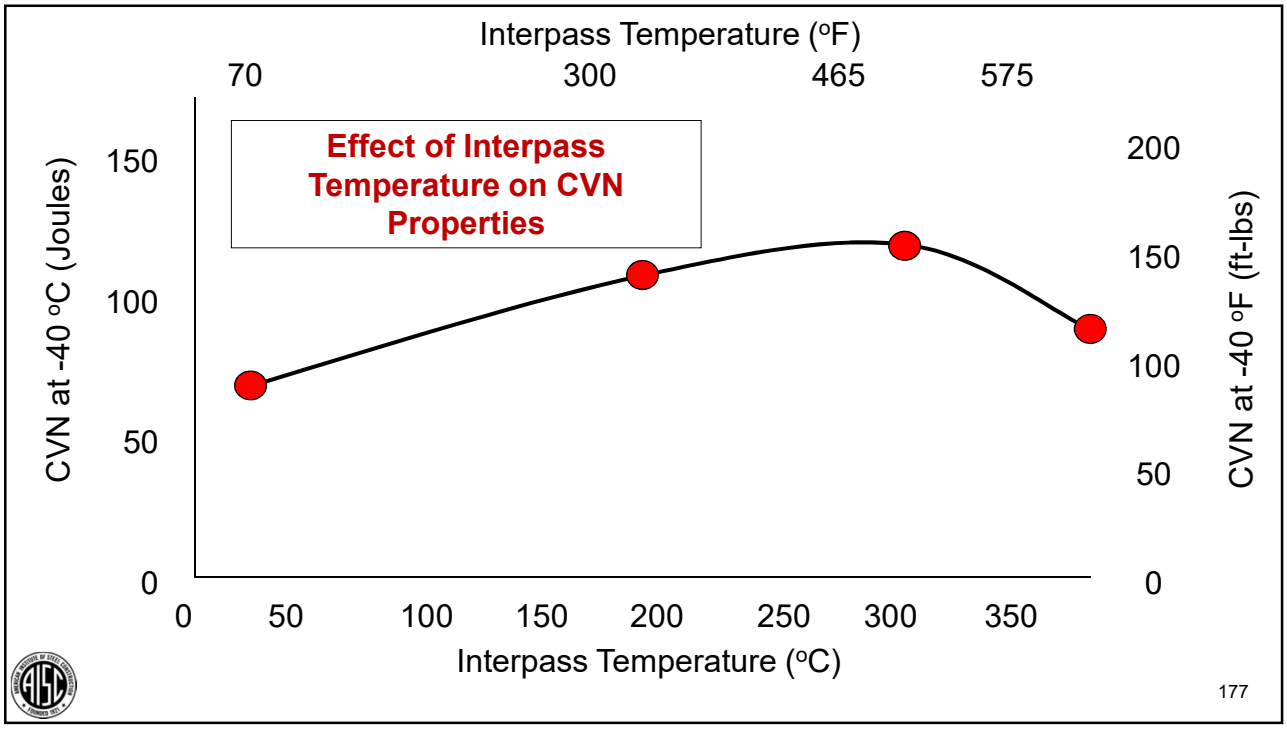
$$HI = \frac{60\ E\ I}{1000\ S}$$

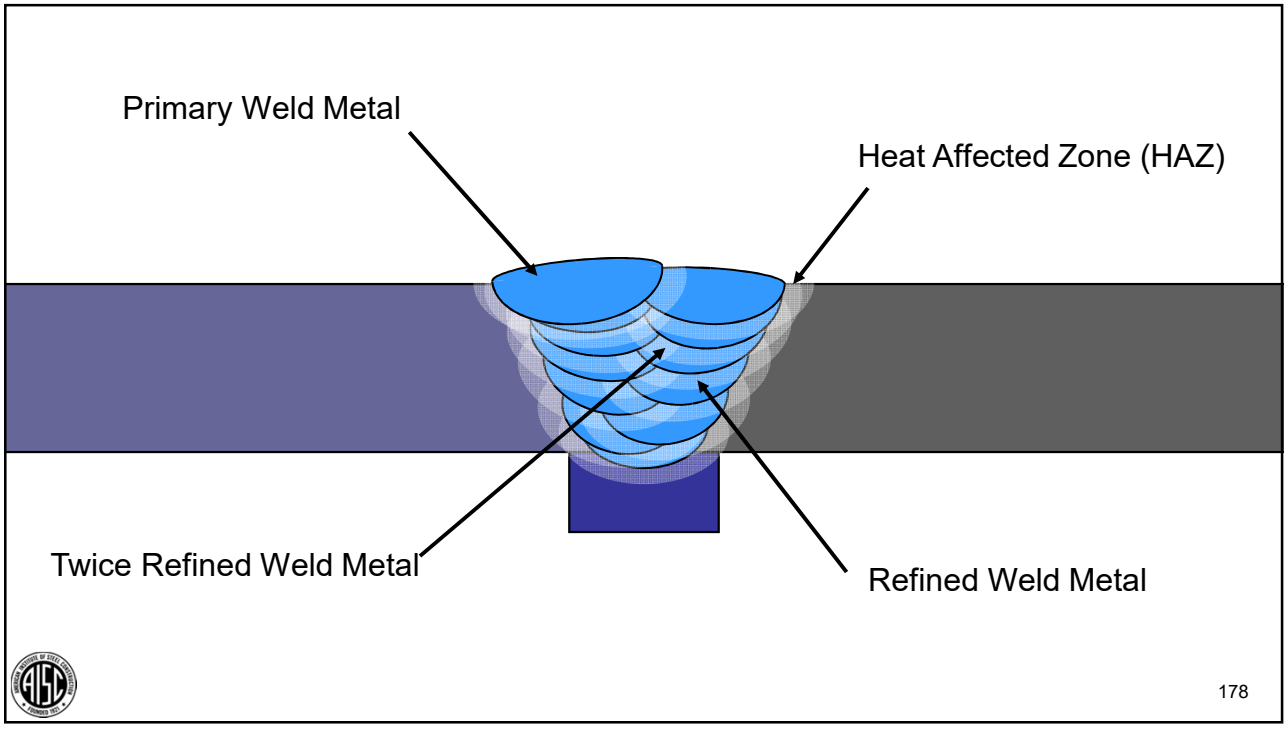
High Heat Input → Slow Cooling Rates → Poorer Notch Toughness

Low Heat Input → High Cooling Rates → Poorer Notch Toughness

Medium Heat Input → Medium Cooling Rates → Optimal Notch Toughness







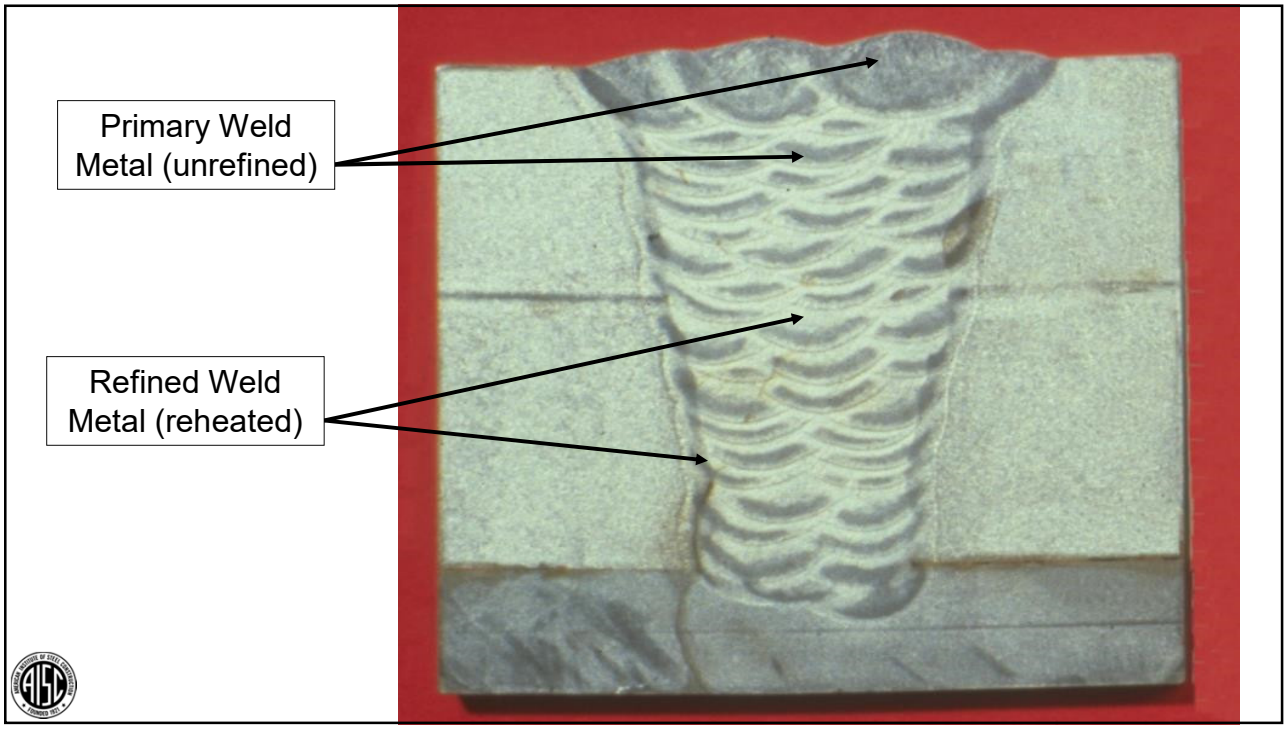


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Table A.1
Heat Input Envelope Testing—Heat Input, Preheat, and Interpass Temperatures

	Suggested Heat Input	Maximum Preheat Temperature	Maximum Interpass Temperature
Low Heat Input Test	30 kJ/in [1.2 kJ/mm]	120°F [40°C]	250°F [120°C]
	Suggested Heat Input	Minimum Preheat Temperature[a]	Minimum Interpass Temperature[a]
High Heat Input Test	80 kJ/in [3.1 kJ/mm]	250°F [120°C]	450°F [240°C]

[a] For the high heat input test, the test plate shall be heated to the minimum preheat, and then welding shall begin. Welding shall continue without substantial, deliberate interruption until the minimum interpass temperature is obtained. After the test plate has been heated to the minimum interpass temperature, all subsequent weld passes shall be made at a temperature not less than the minimum interpass temperature. Should the test plate temperature fall below the minimum interpass temperature for any reason, the test plate shall be heated to a temperature not less than the minimum interpass temperature before welding resumes. If the required interpass temperature is not achieved prior to interruption of the welding operations, welding shall not resume until the test assembly has been heated to the prescribed minimum interpass temperature.

Low Heat Input Test 30 KJ/ in [1.2 KJ/mm] (suggested)

High Heat Input Test 80 KJ/ in [3.1 KJ/mm] (suggested)

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AWS D1.8:2016 Seismic Welding Supplement

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- Overview
- Heat Input Testing
- Restricted Access Welder Qualification
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Annex D (Normative)

Supplemental Welder Qualification for Restricted Access Welding

D1. Purpose

This annex provides supplemental welder qualification testing procedures for welders who will perform production welding on Demand Critical beam bottom flange to column joints, where such welds must be performed by welding through a weld access hole. Welders previously qualified using similar restricted access plate tests, prior to adoption of this code, shall be deemed qualified under these provisions for the duration of their qualification period.

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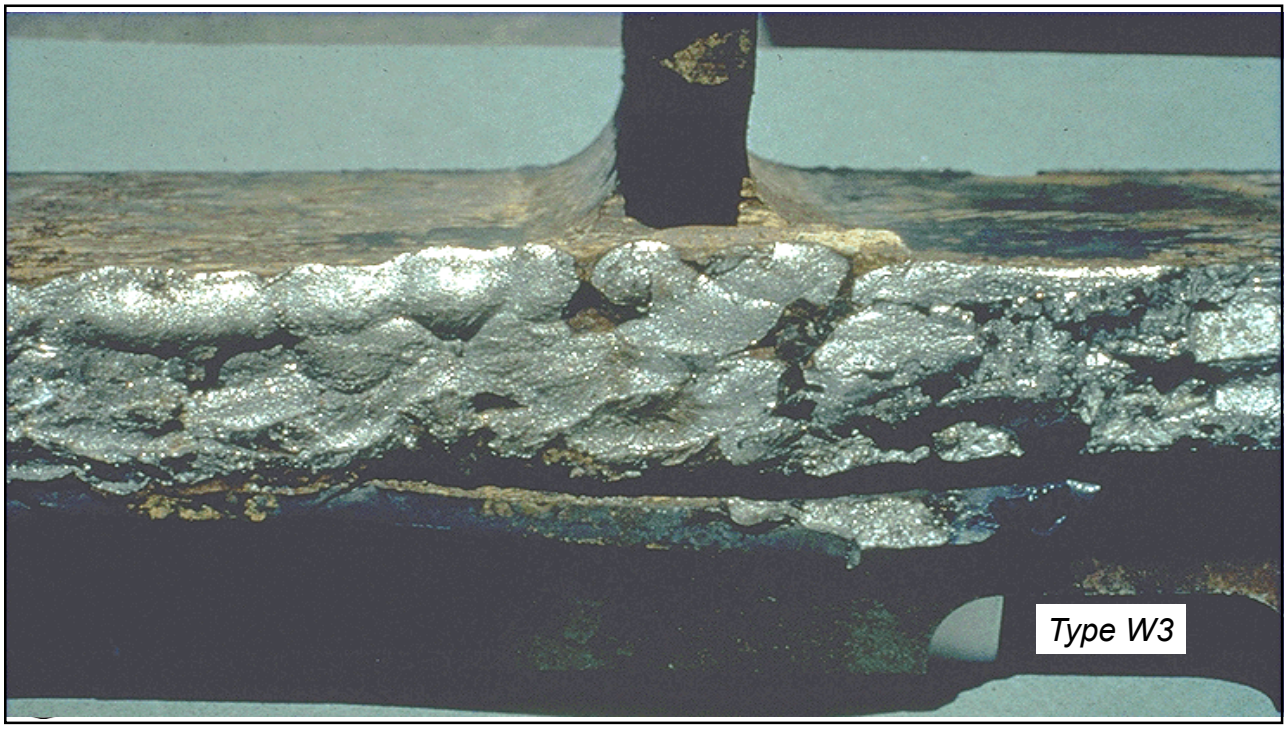

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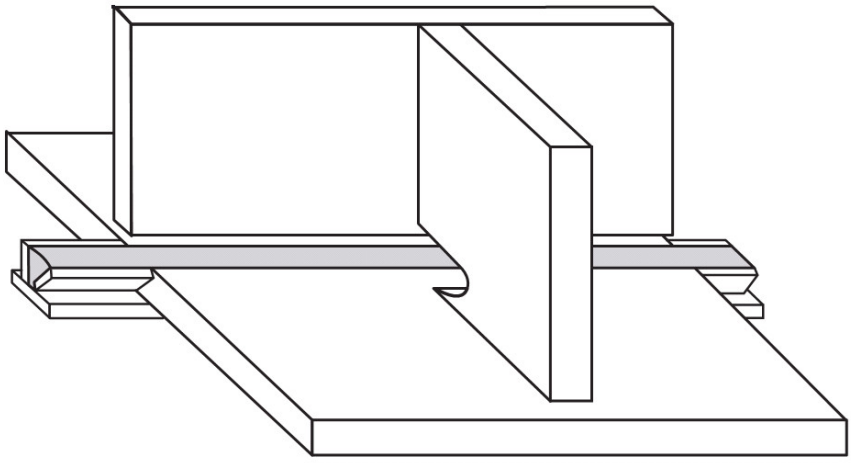

Notes:
1. The web location shall be marked on the test plates prior to disassembling the test configuration (see D3.1.4).
2. The web plate shall be centered on the test plate.

Figure D.3—Test Plate Configuration Illustration (see D2)

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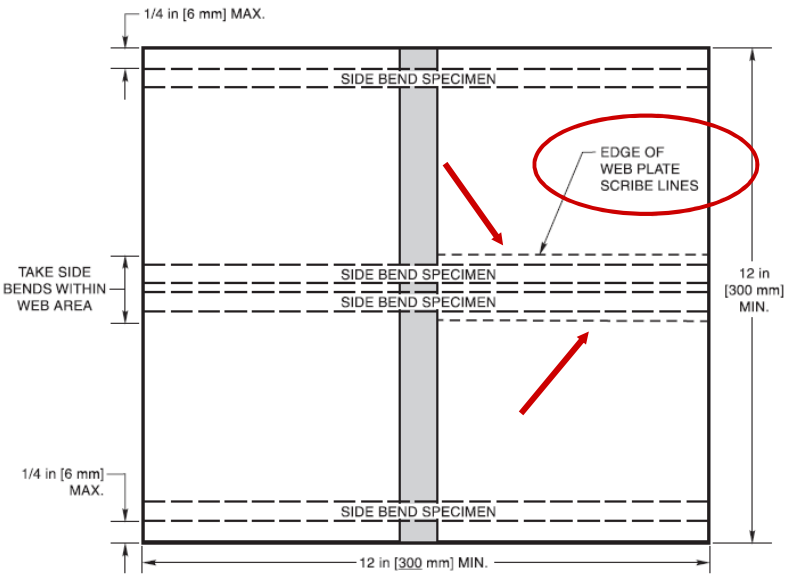

Figure D.4—Location of Side Bend Specimens on Test Plates—Supplemental Welder Qualification (see D4.2.1.1)

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D3.1.2 Welding Procedure Specification.

The test plate assembly shall be welded in accordance with a WPS using the process for which the welder is being qualified. The combination of variables shall be such that the deposition rate used in the qualification test is equal to or greater than the highest deposition rate that will be used in production.

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Outline

- Overview
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6.16.1 Minimum Weld Tab Length.

Where practicable, weld tabs shall extend a minimum of 1 inch [25 mm] or the thickness of the part, whichever is greater, beyond the edge of the joint. Weld tab length need not exceed 2 inches [50 mm]. Where there is inadequate access for weld tabs, such as with closely spaced pieces or pieces intersecting at acute angles, weld ends may be cascaded for approximately one weld size.

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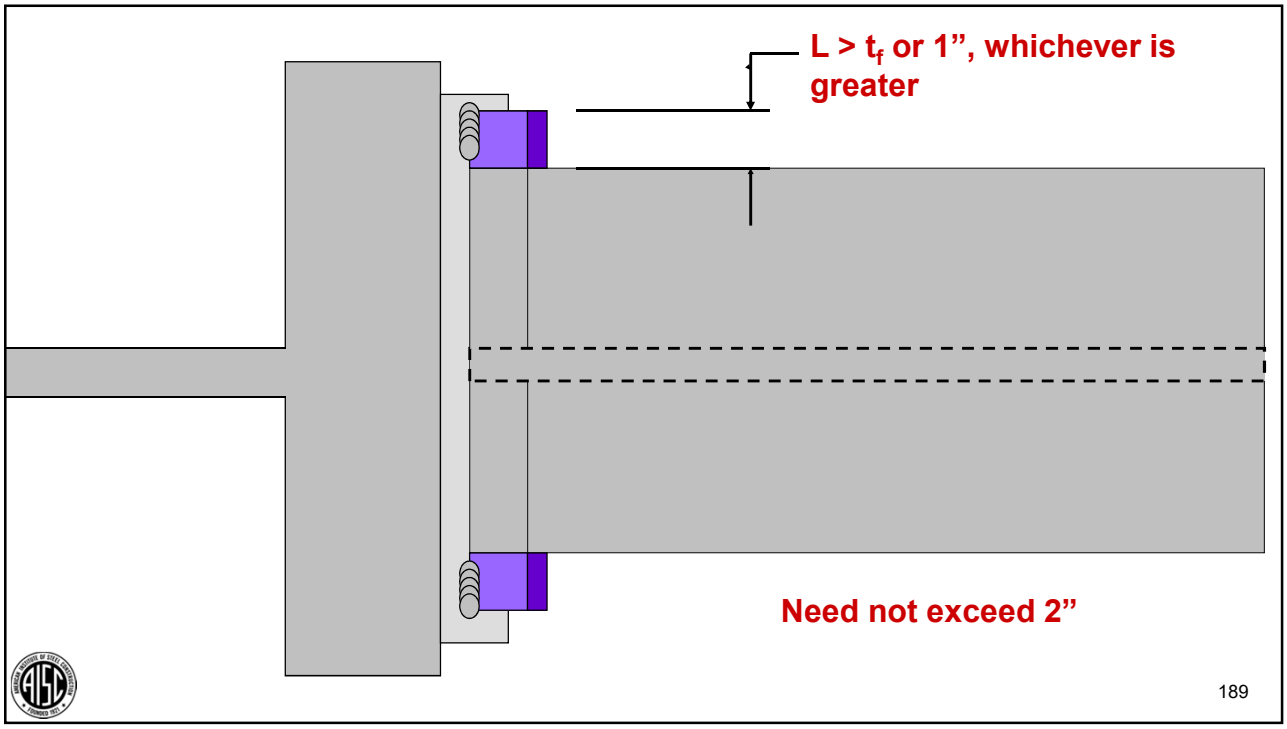

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6.18 Protected Zone

6.18.1 Attachments and Welds.

Welded attachments, including stud welds and fasteners for the connection of other materials, shall be prohibited within the Protected Zone. Arc spot welds (puddle welds) for the attachment of metal decking shall be permitted in the Protected Zone.

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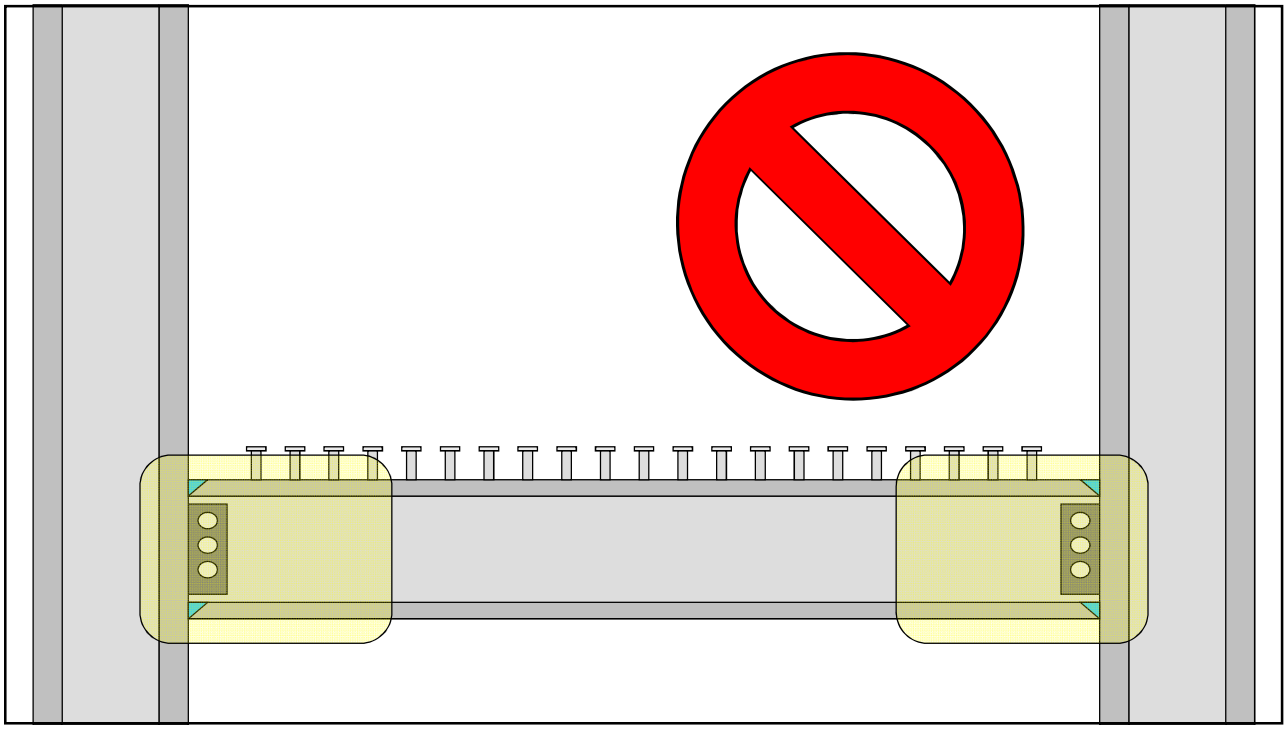

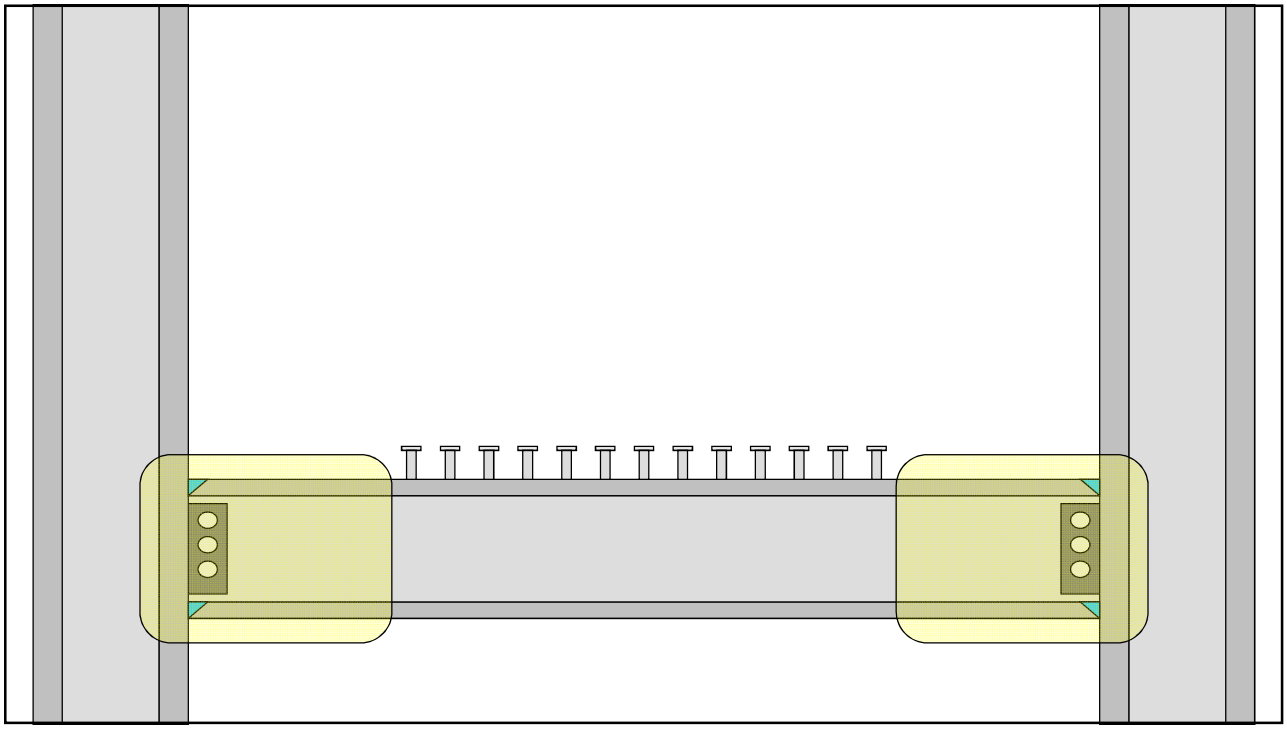

AWS D1.8:2016 Seismic Welding Supplement

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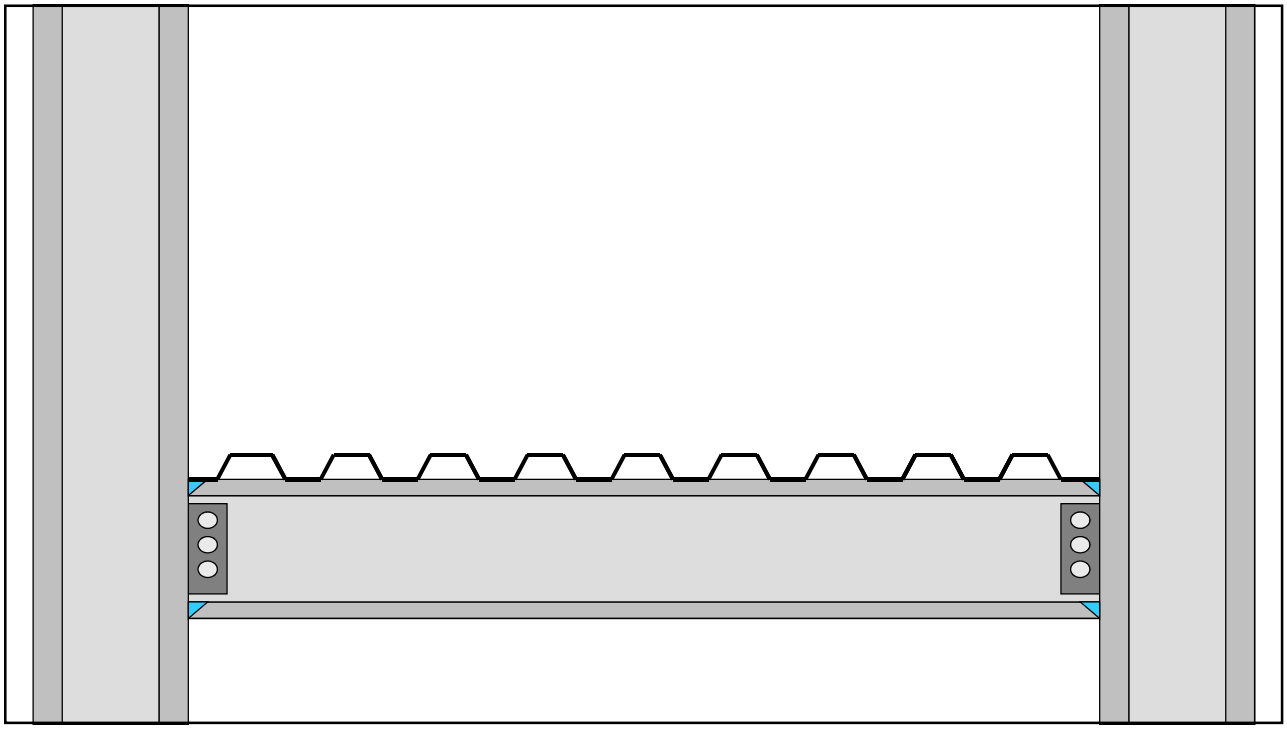

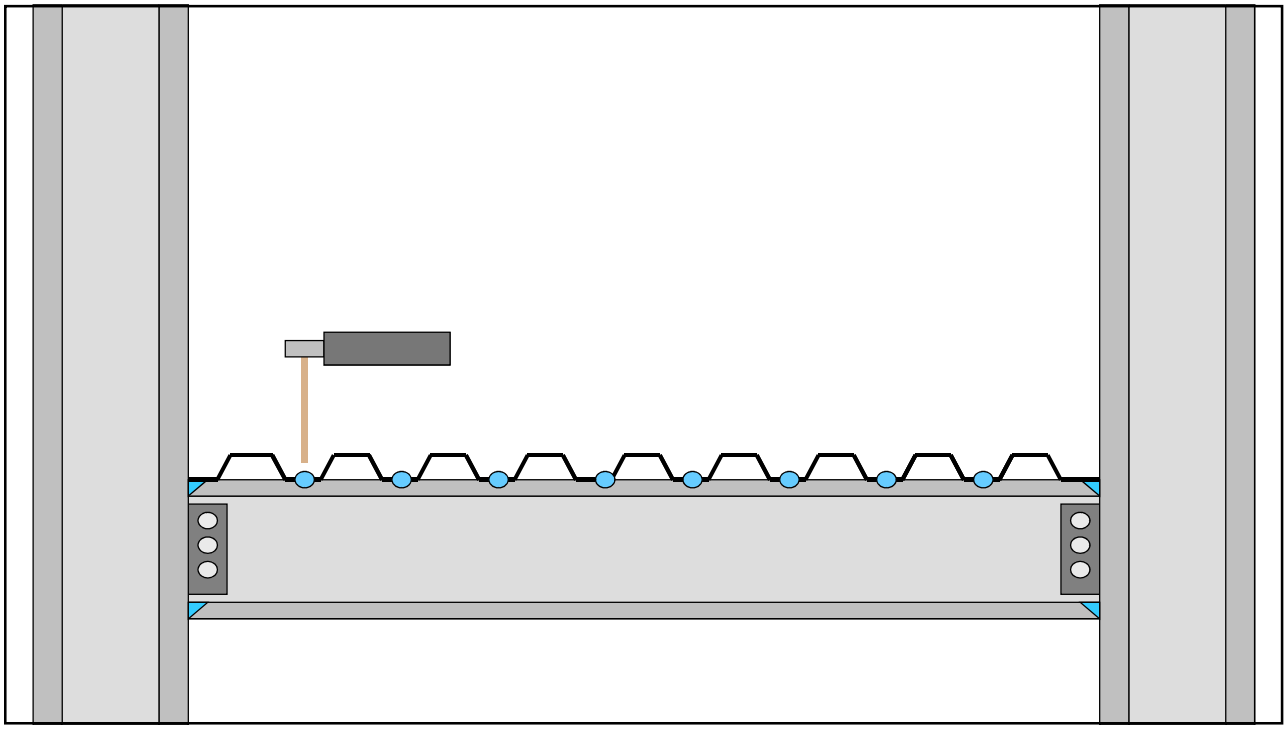

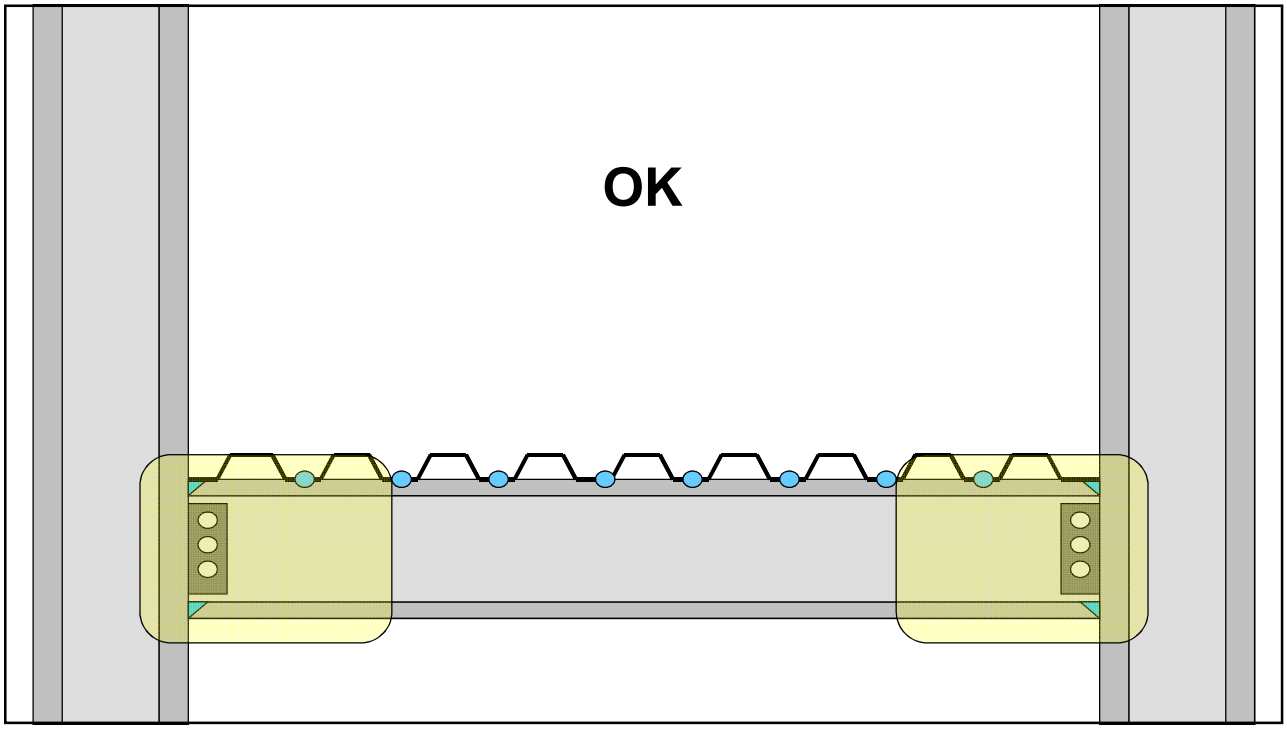

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6.18 Protected Zone

6.18.2 Erection Aids.

If erection aids are required to be attached within the Protected Zone, the Contractor shall obtain the Engineer's approval for the use of such attachments.

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AWS D1.8:2016 Seismic Welding Supplement

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- Overview
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SEISMIC WELDING ISSUES

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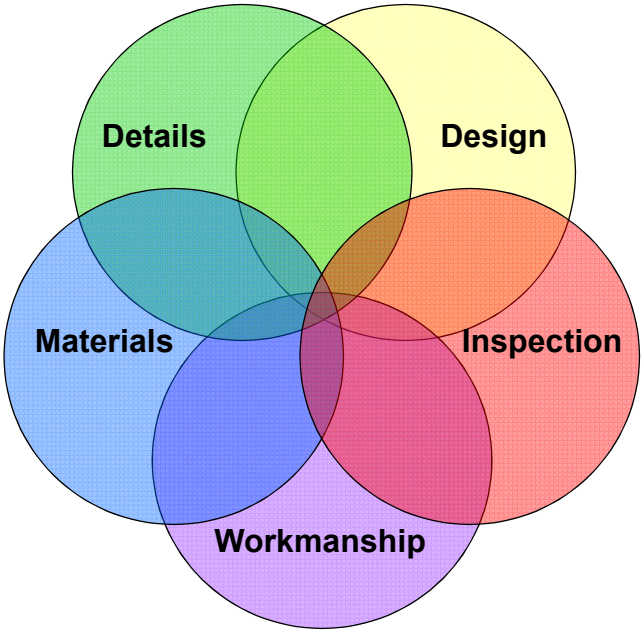

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SEISMIC WELDING ISSUES

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Thank you!

AISC | Questions?

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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!

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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.

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 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

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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.

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8-Session Registrants

Night School Resources

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

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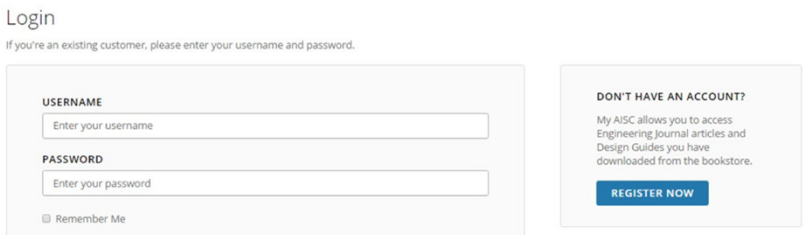
8-Session Registrants

Night School Resources

Go to www.aisc.org and sign in.



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8-Session Registrants

Night School Resources

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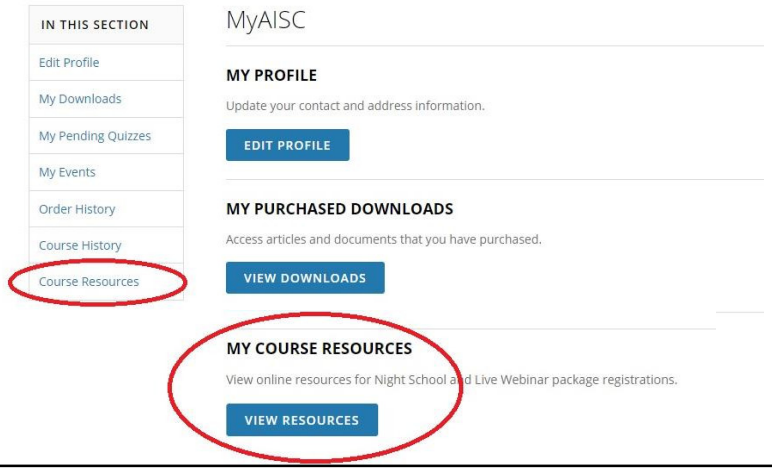

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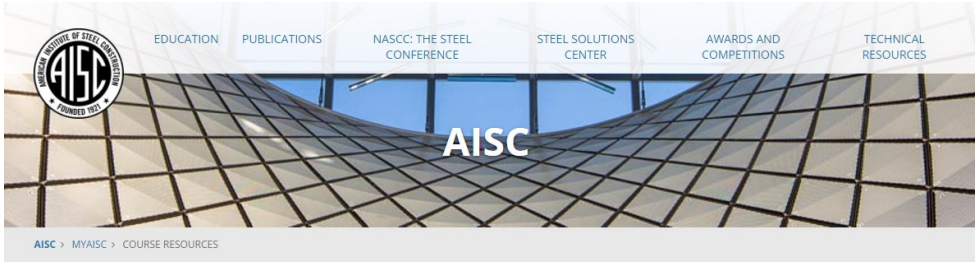
8-Session Registrants

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

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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

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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.

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8-Session Registrants

Night School Resources

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

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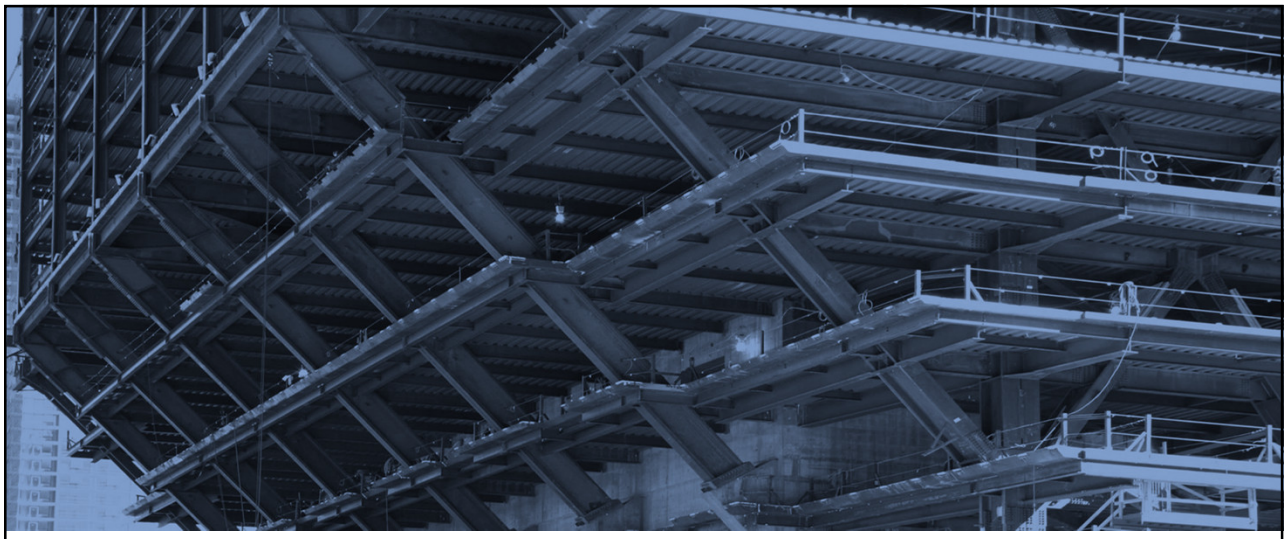

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