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

AISC Live Webinars

Course Description

Part 2: Welded Connections for Seismic Service

July 6, 2017

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.

Learning Objectives

- Name key features that made the typical moment connection in service at the time of the Northridge earthquake susceptible to brittle fracture.
- Describe the applicability of the AISC 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.

There's always a solution in steel.

Welded Connections

Part 2: Welded Connections for Seismic Service
July 6, 2017

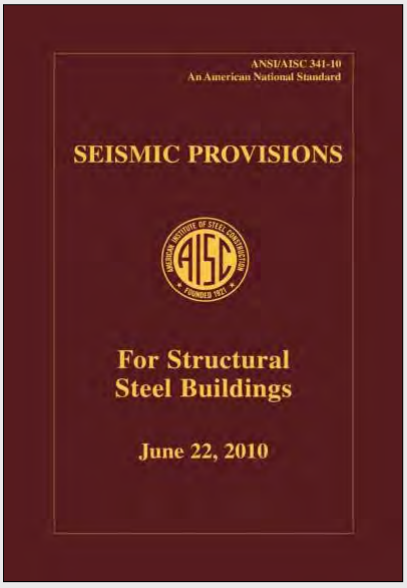
Presented by
Duane Miller, Sc.D., P.E.
Manager of Engineering Services and Welding Design Consultant at The Lincoln Electric Company
Cleveland, OH

structural STEEL

Welded Connections for Seismic Service

ANSI/AISC 341-10
An American National Standard

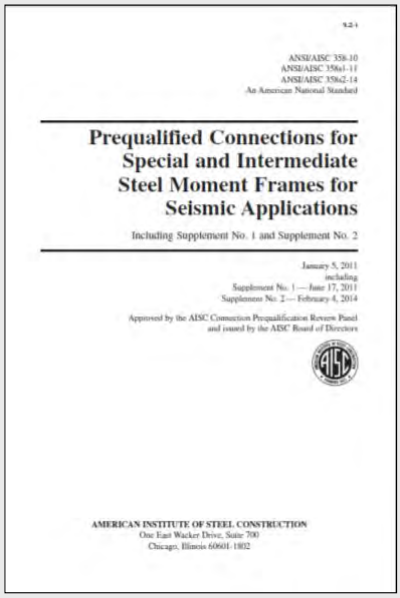
SEISMIC PROVISIONS
For Structural
Steel Buildings



ANSI/AISC 358-10
ANSI/AISC 358s1-11
ANSI/AISC 358s2-14
An American National Standard

Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications

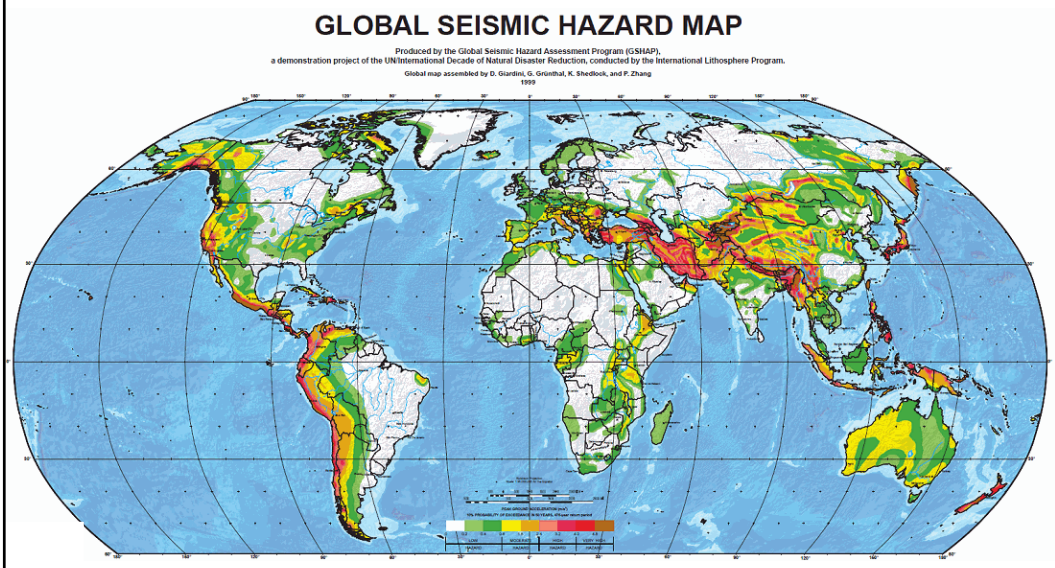
Note: AISC documents are available as free downloads from www.aisc.org



AWS D1.8:2009

Structural Welding Code-Seismic Welding Supplement

Welded Connections for Seismic Service



Welded Connections for Seismic Service

OUTLINE

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

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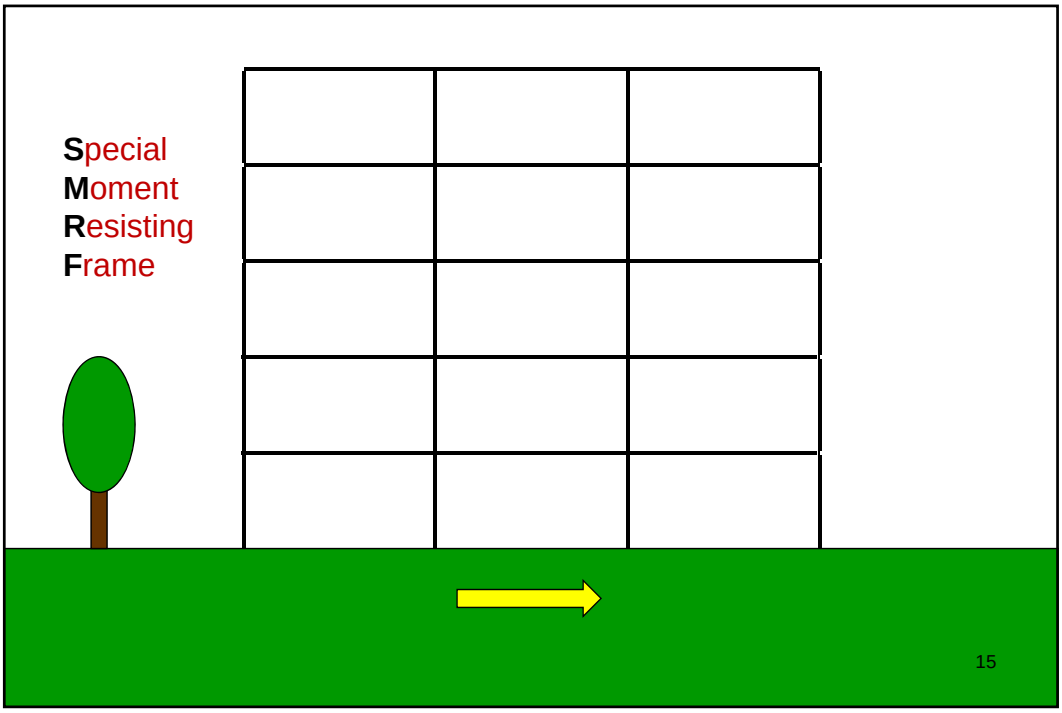

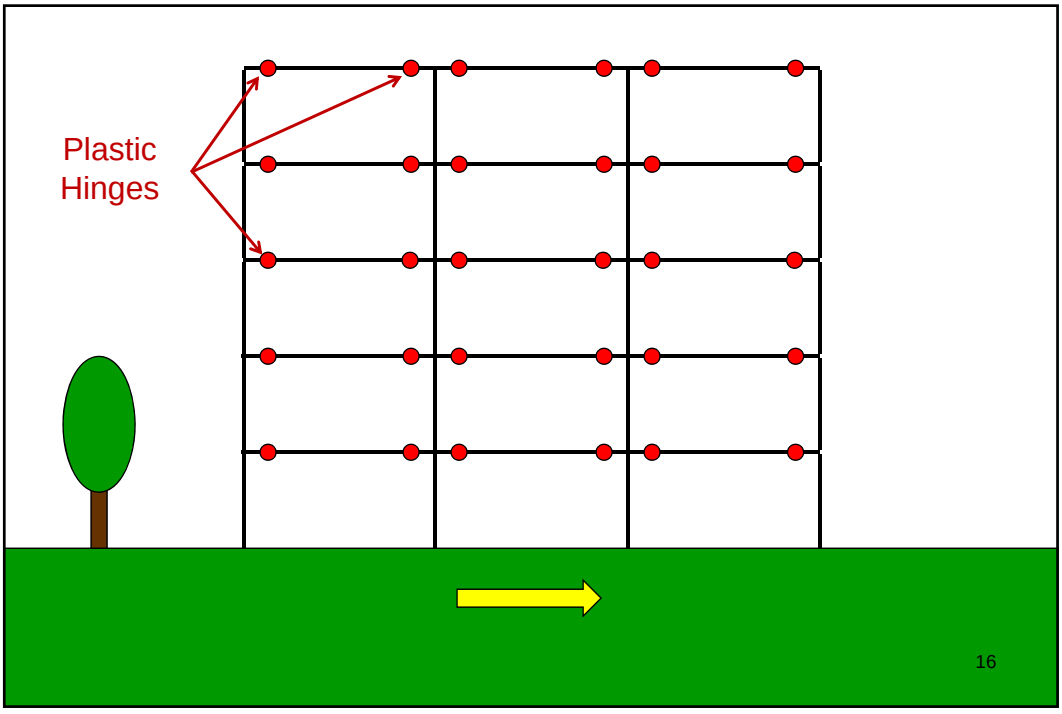

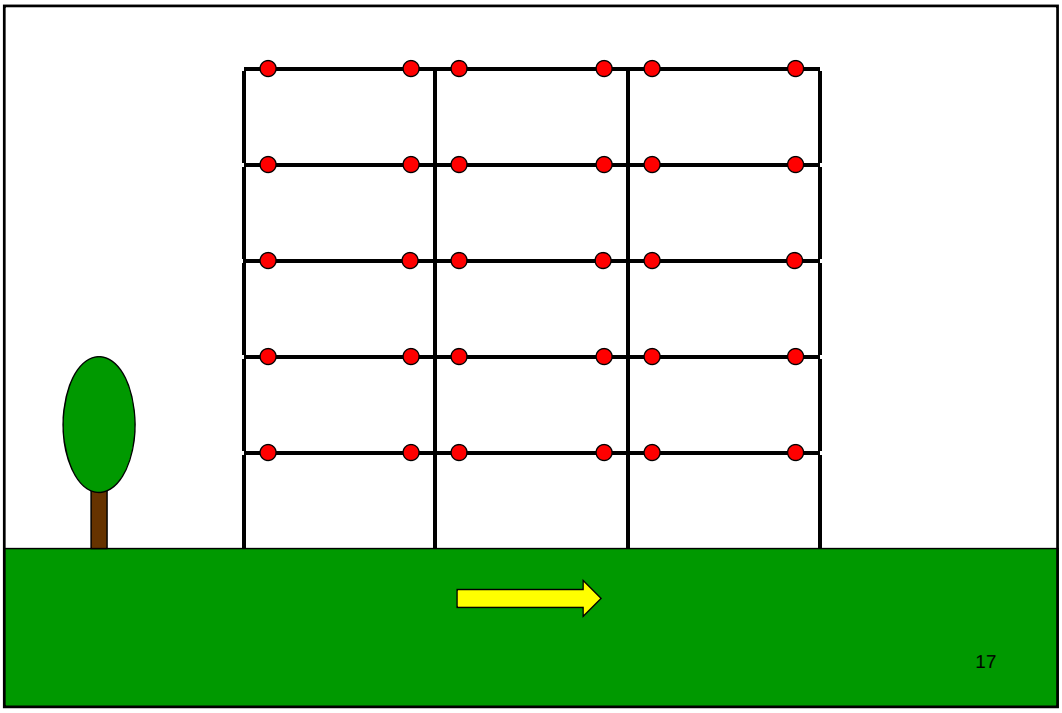

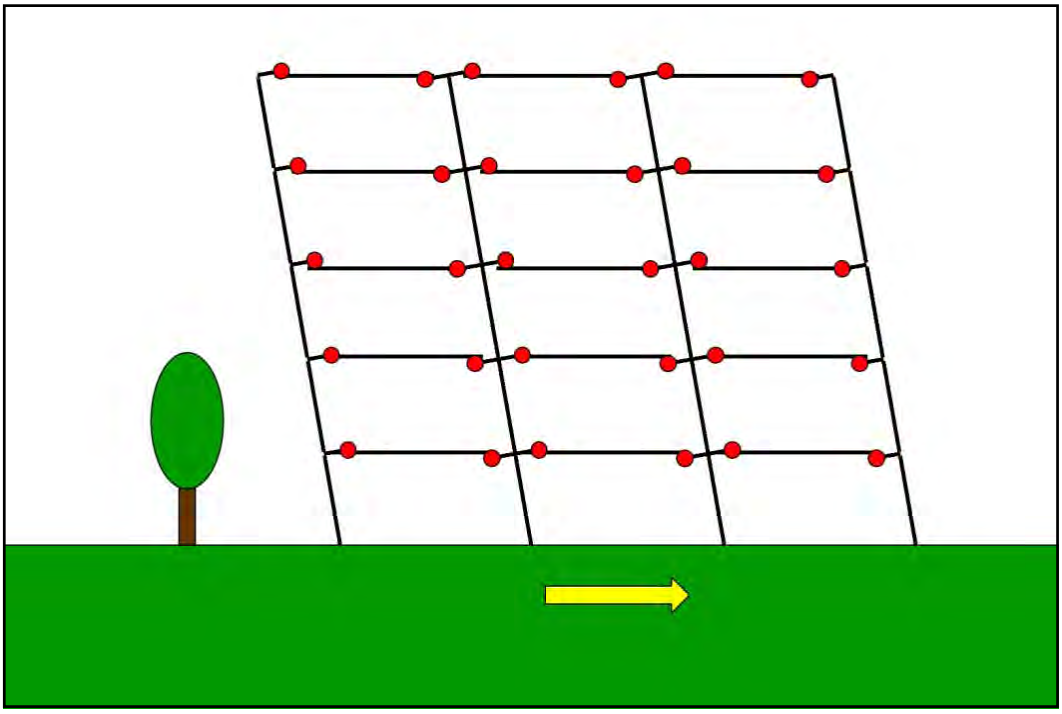

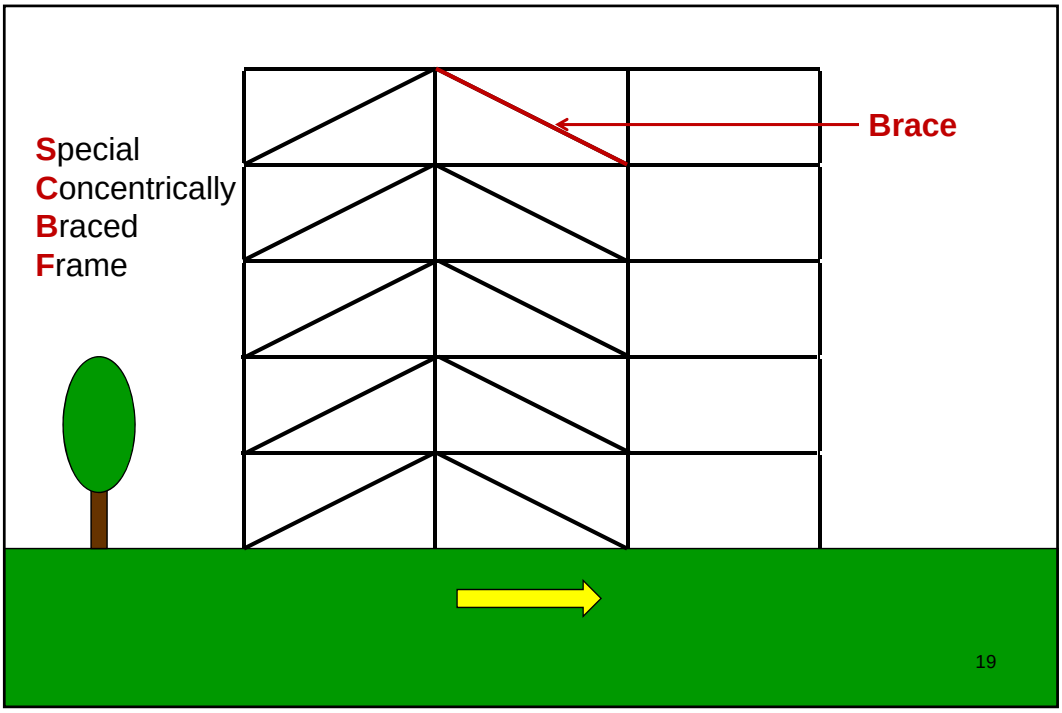

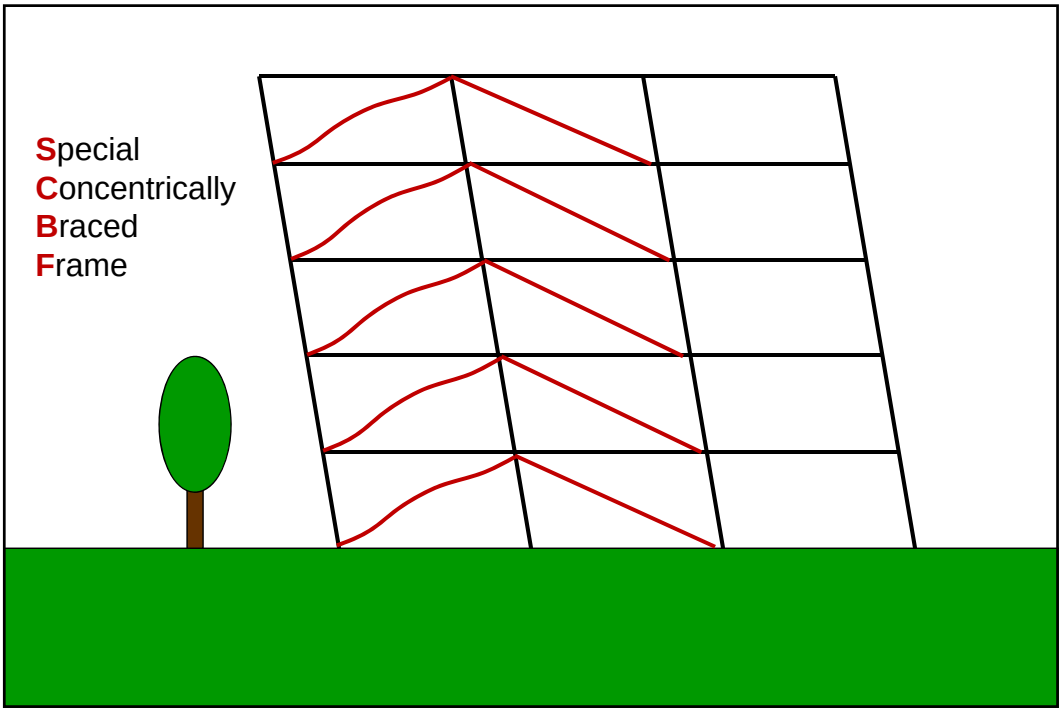

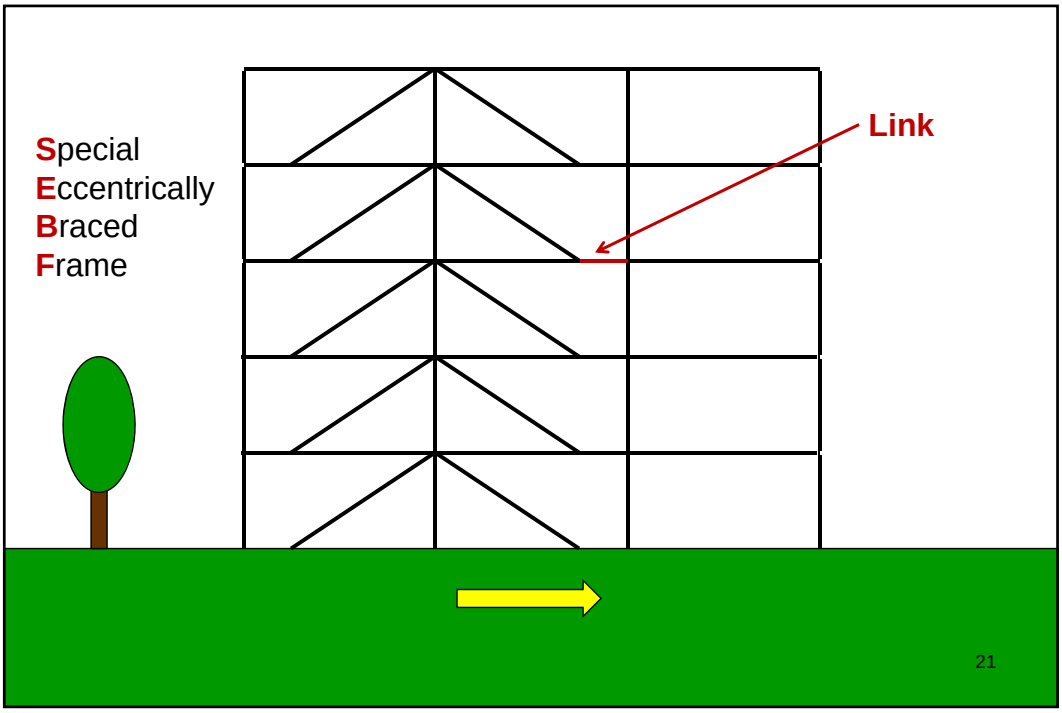

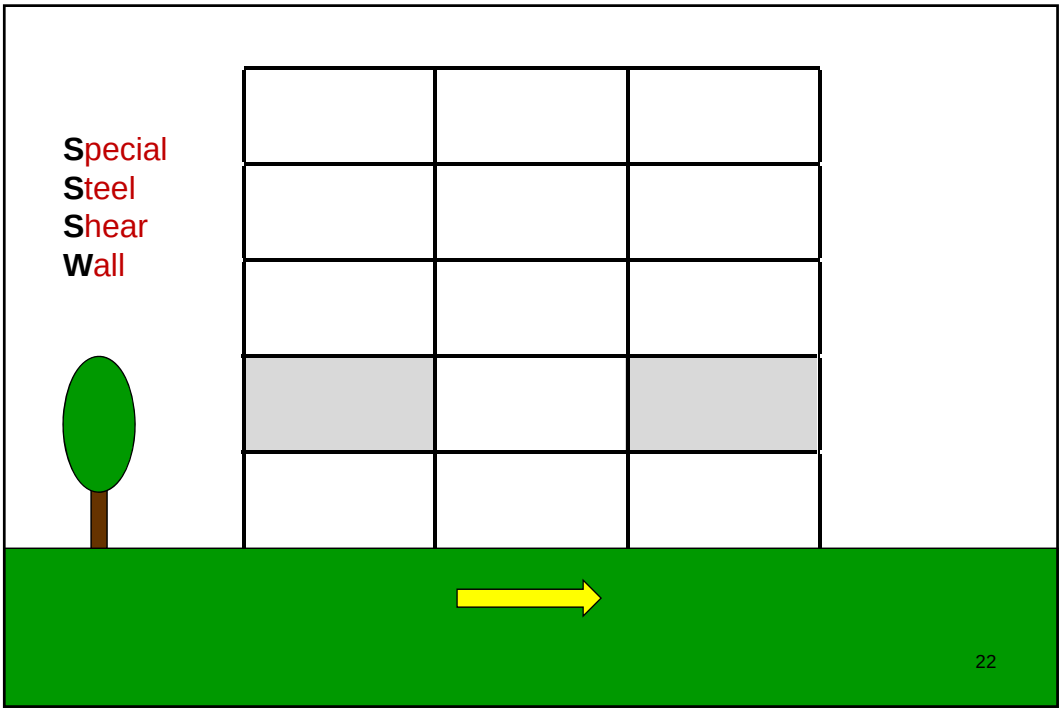

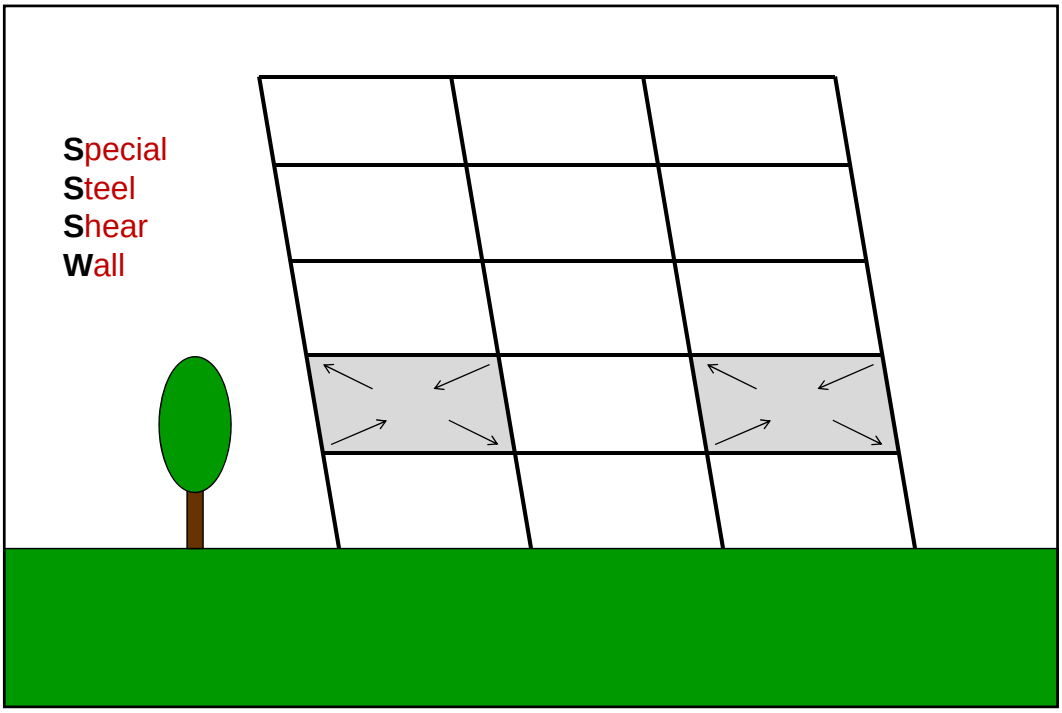

AISC 341-10 SEISMIC PROVISIONS

COMMENTARY A1.
Scope

Structural steel systems in seismic regions are generally expected to dissipate seismic input energy through controlled inelastic deformations of the structure. These 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.

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AISC 358s1-11 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* 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.

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Welded Connections for Seismic Service

OUTLINE

- Seismic Design and Ductility
- The Northridge Experience
- Ductile versus Brittle Behavior
- 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.

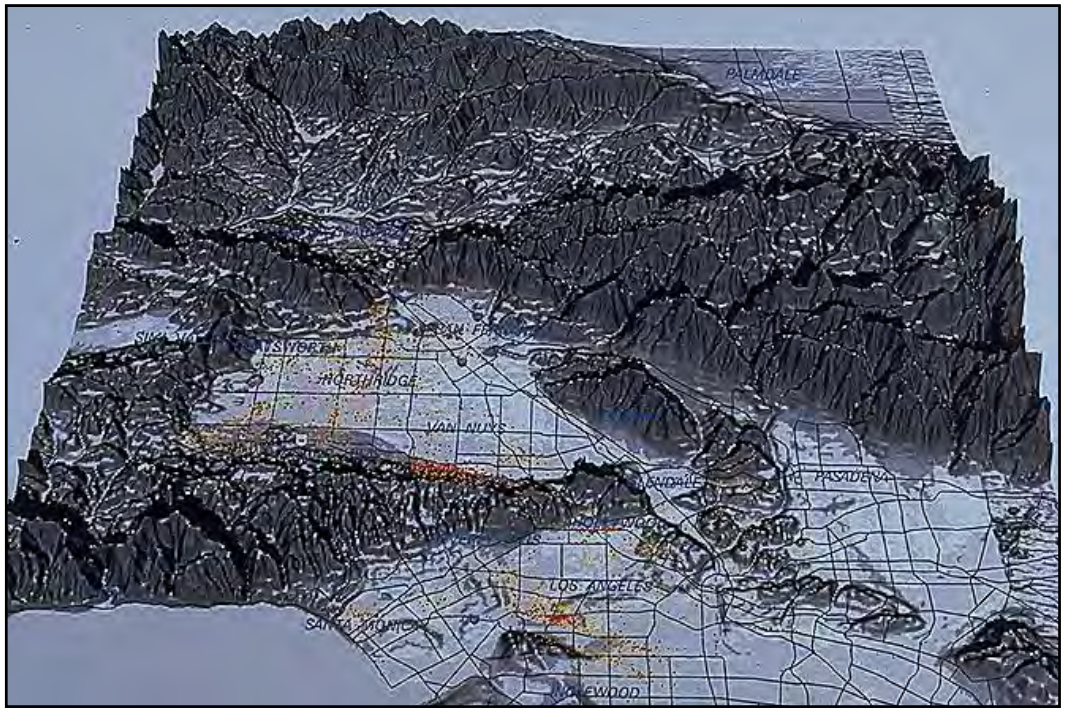
By CRAIG TURNER and RICHARD E. MEYER
TIMES STAFF WRITERS

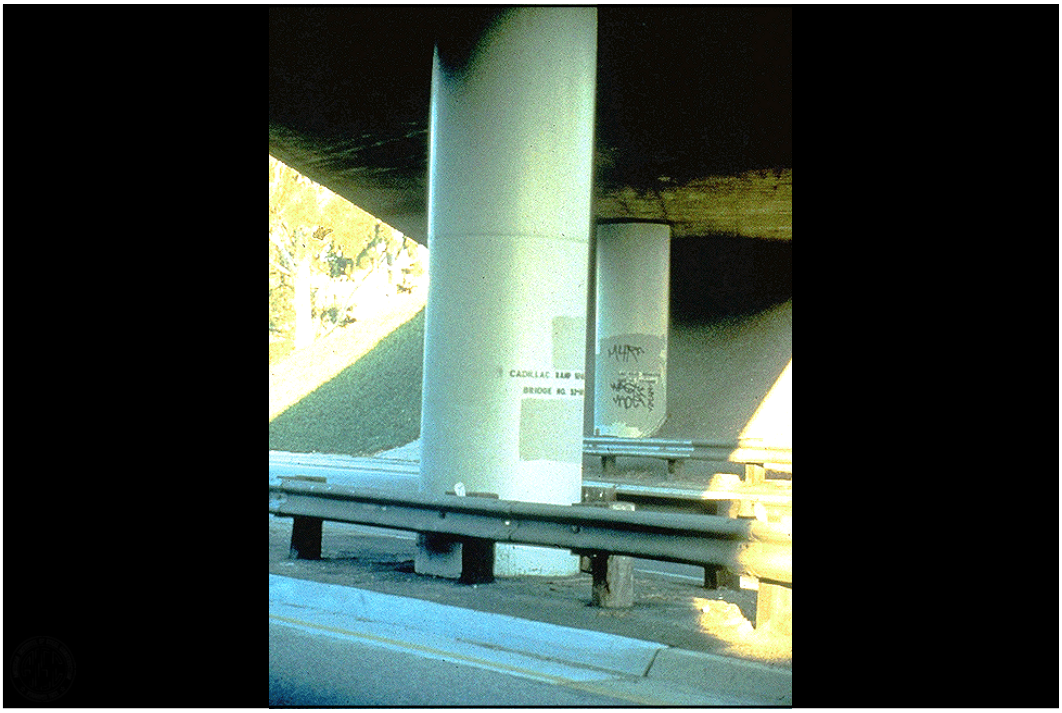
■ **Disaster:** Epicenter is in Northridge, where three-story apartment complex pancakes. Ruptured gas lines erupt in fire in strongest temblor in city's modern history.

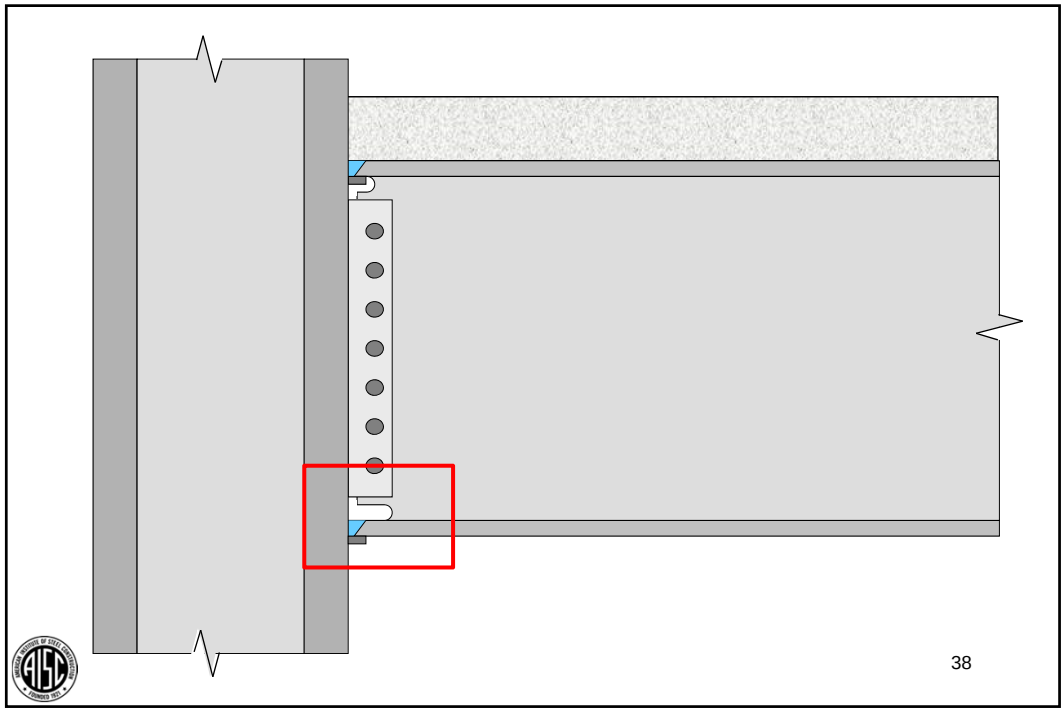
By TRACEY KAPLAN and GREG KRIKORIAN
TIMES STAFF WRITERS

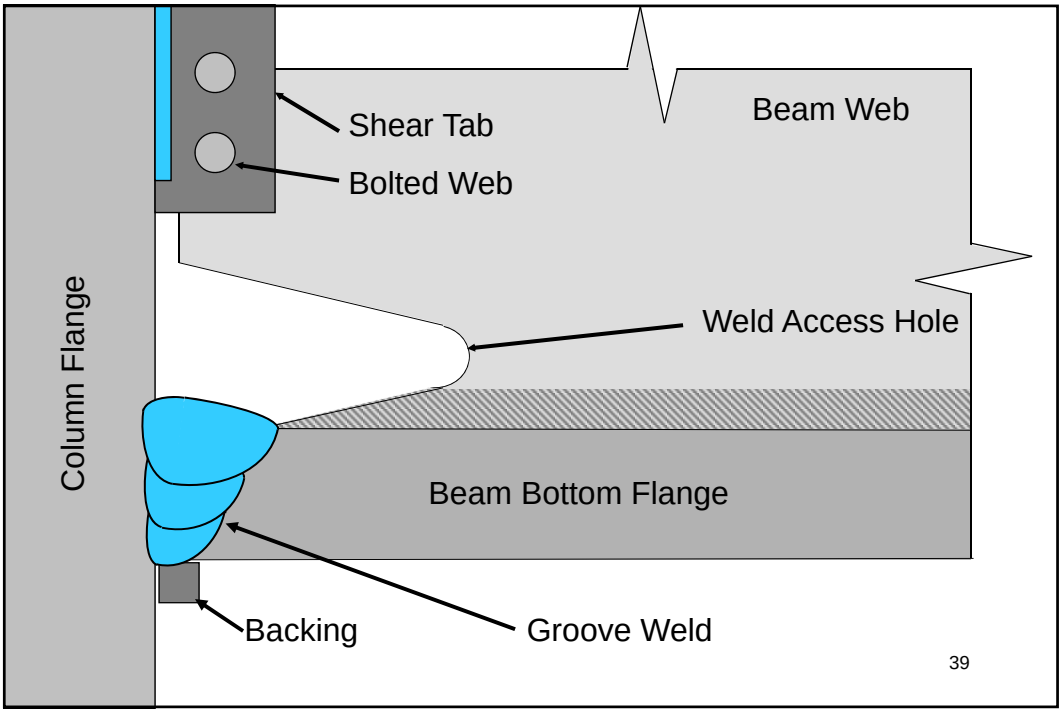
The body of LAPD Officer Clarence W. Dean lies near his motorcycle, lapsed onto the Golden State Freeway during Monday's earthquake.

29

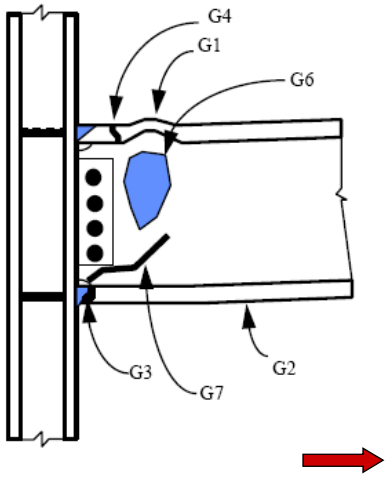


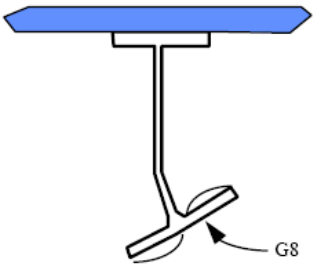






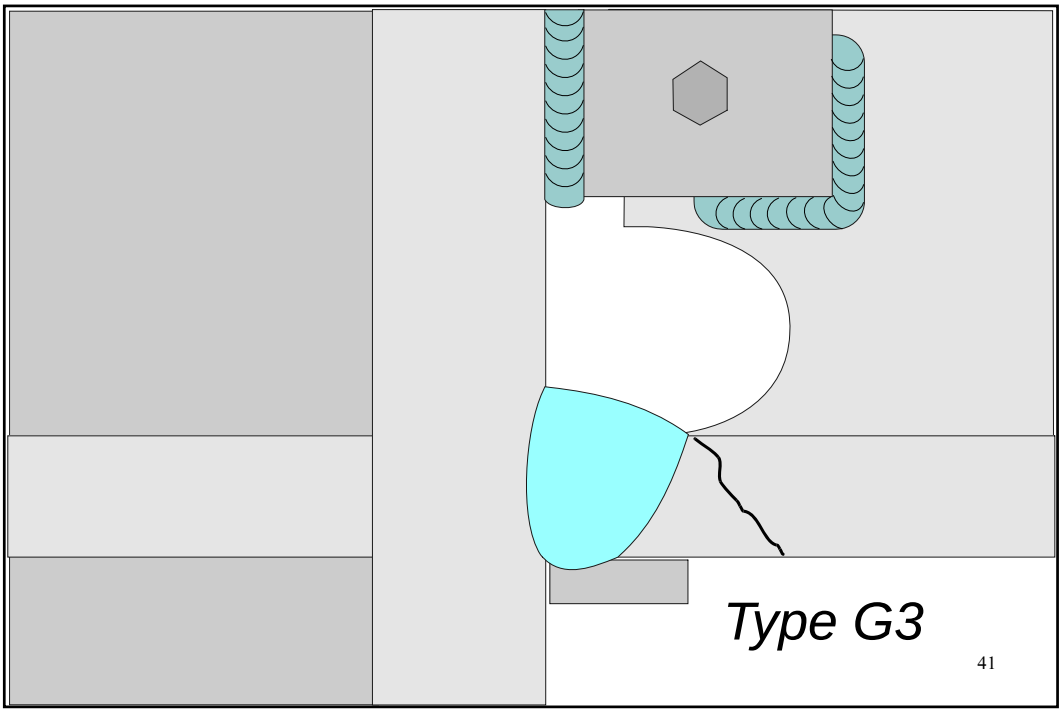
FEMA 267: Interim Guidelines:
Evaluation , Repair, Modification and Design of Welded Steel Moment Frame Structures

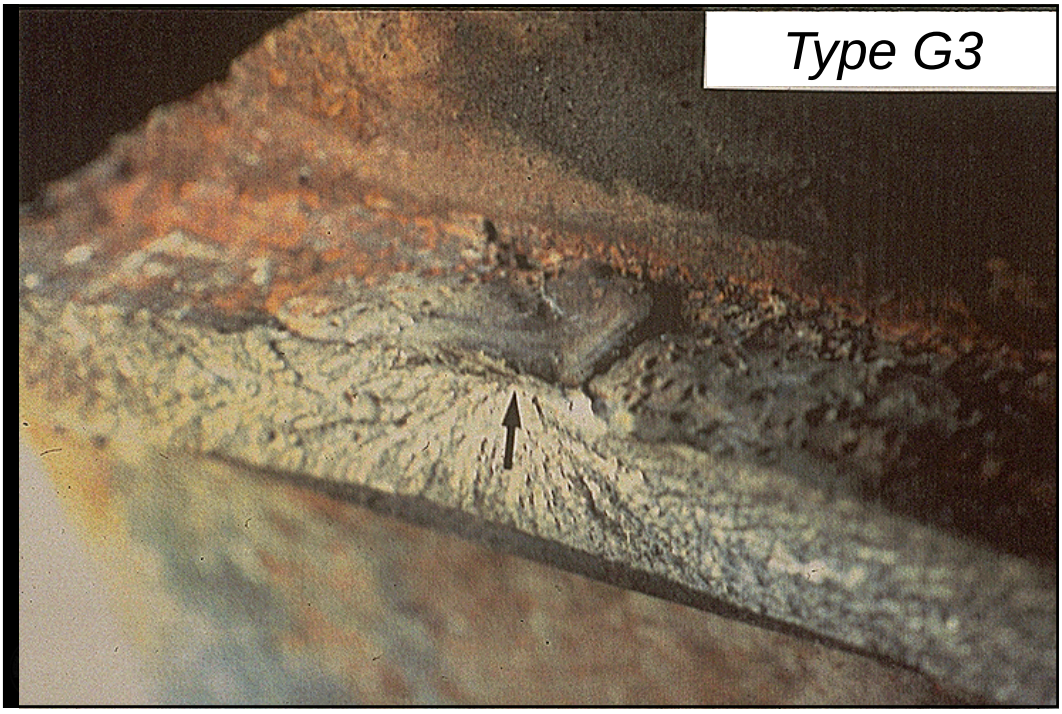


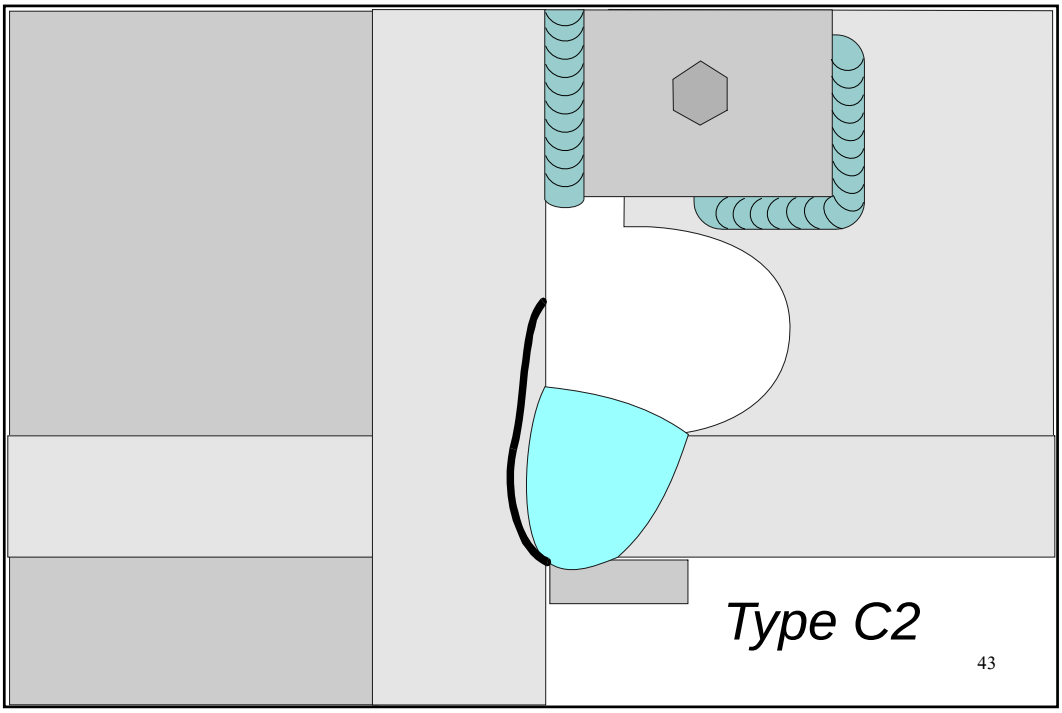


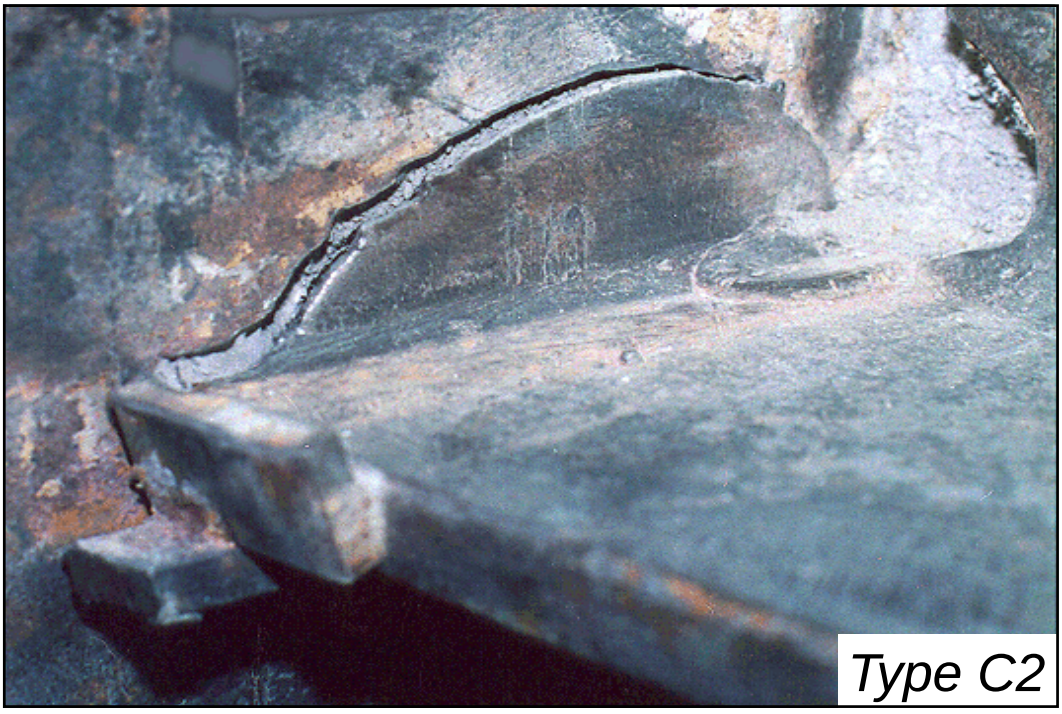
Type	Description
G1	Buckled flange (top or bottom)
G2	Yielded flange (top or bottom)
G3	Flange fracture in HAZ (top or bottom)
G4	Flange fracture outside HAZ (top or bottom)
G5	Flange fracture top and bottom
G6	Yielding or buckling of web
G7	Fracture of web
G8	Lateral torsional buckling of section

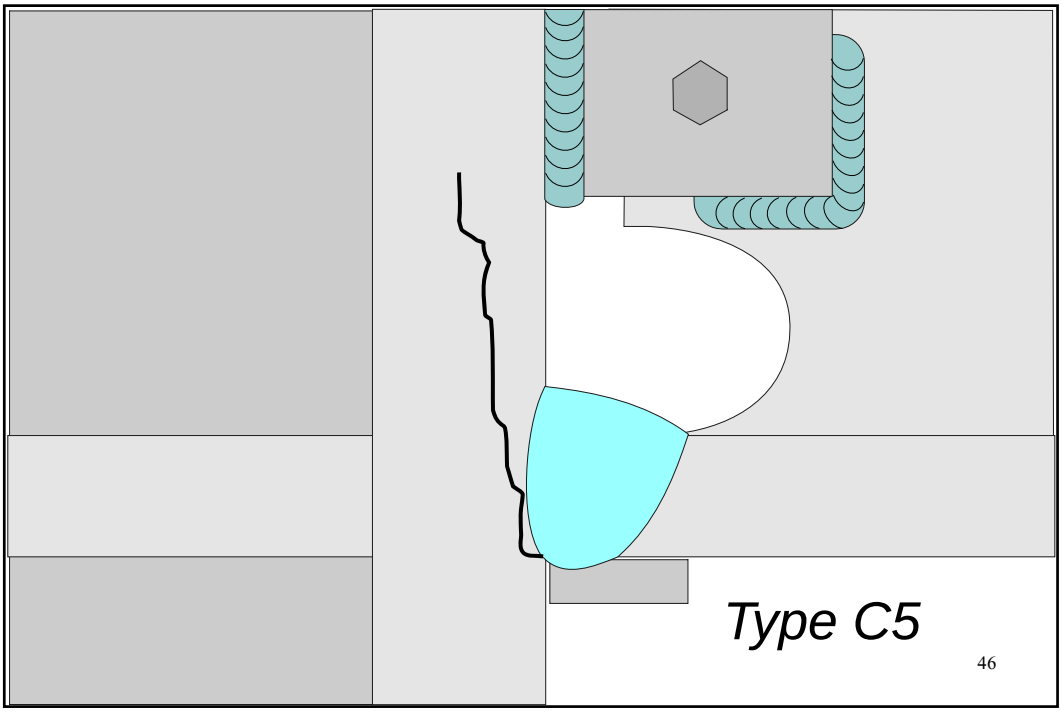
Figure 3-2 Types of Girder Damage

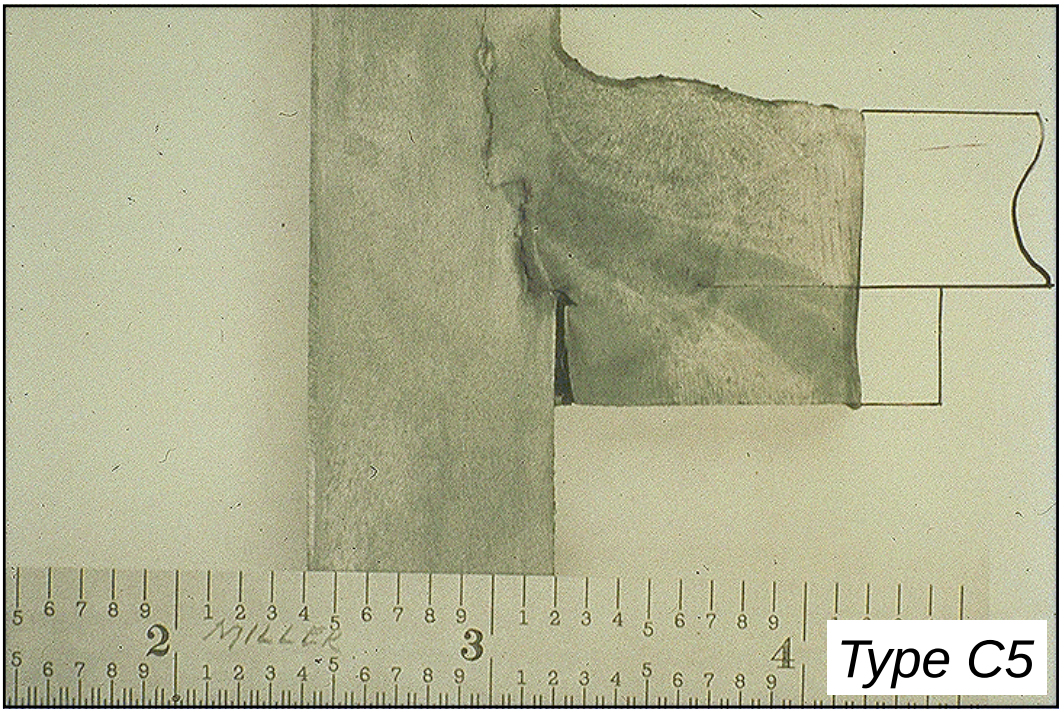


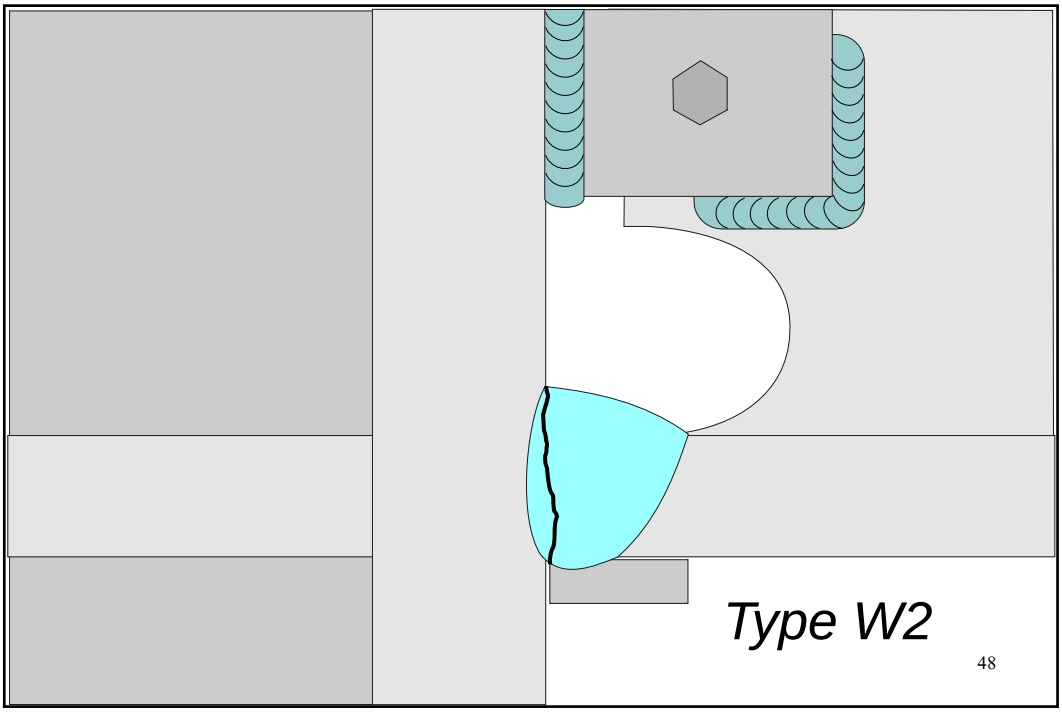


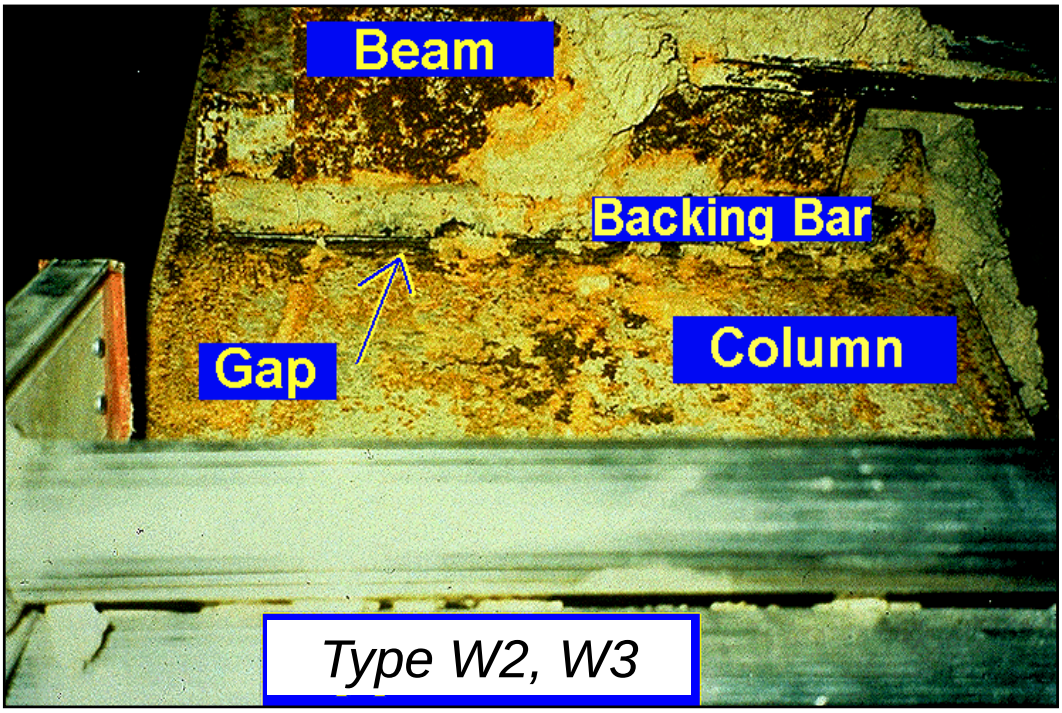


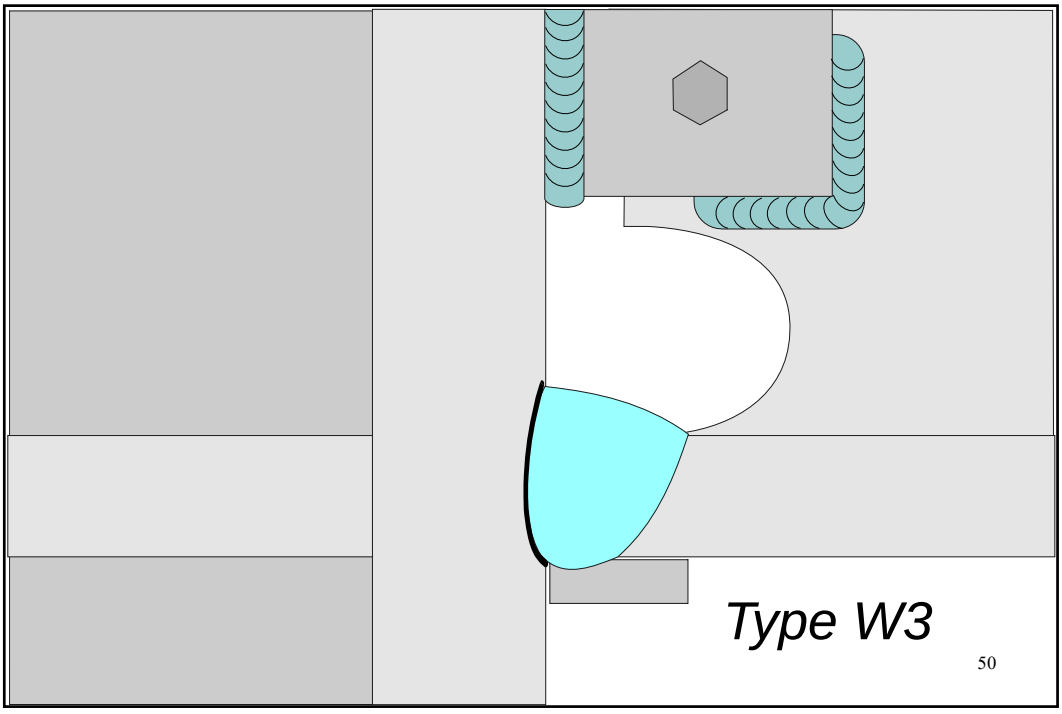


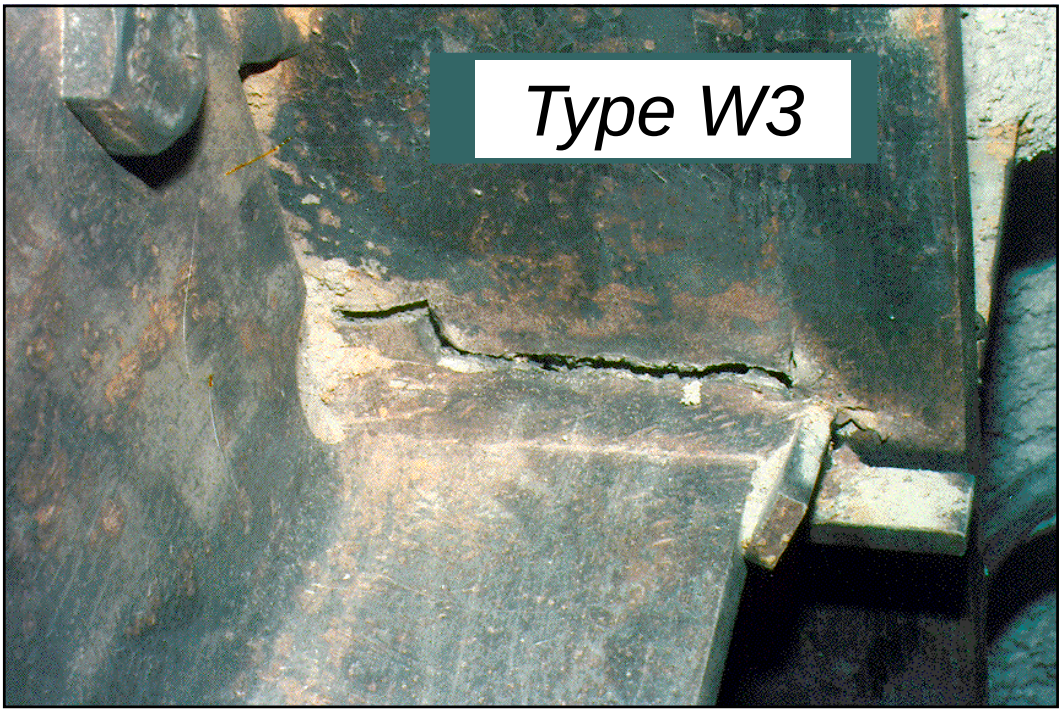


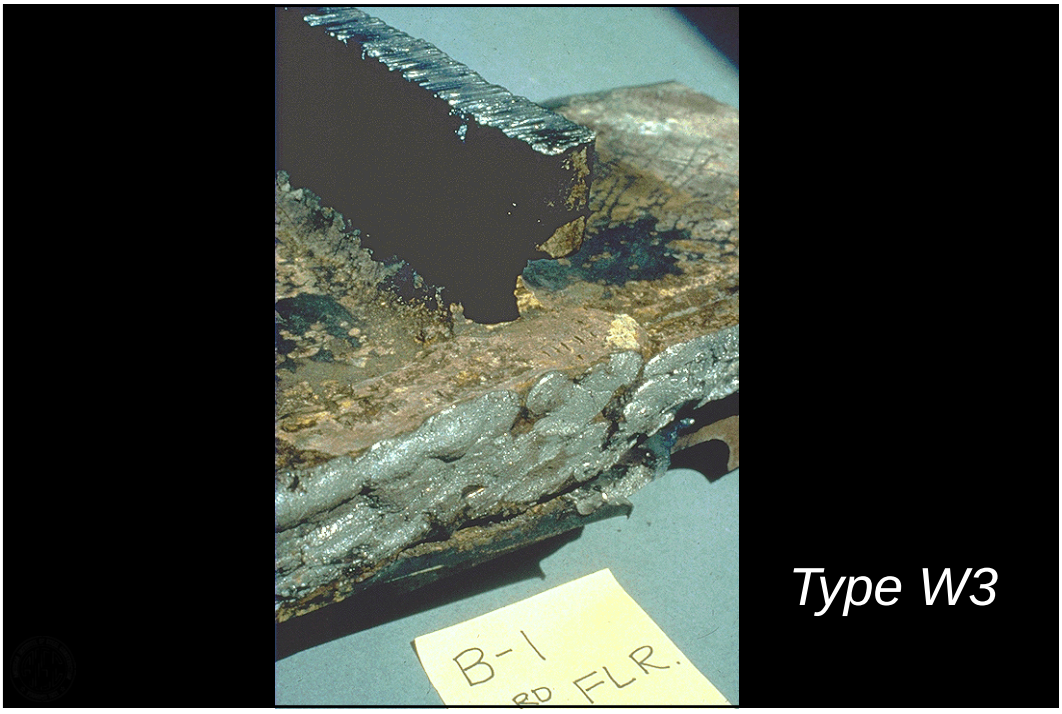


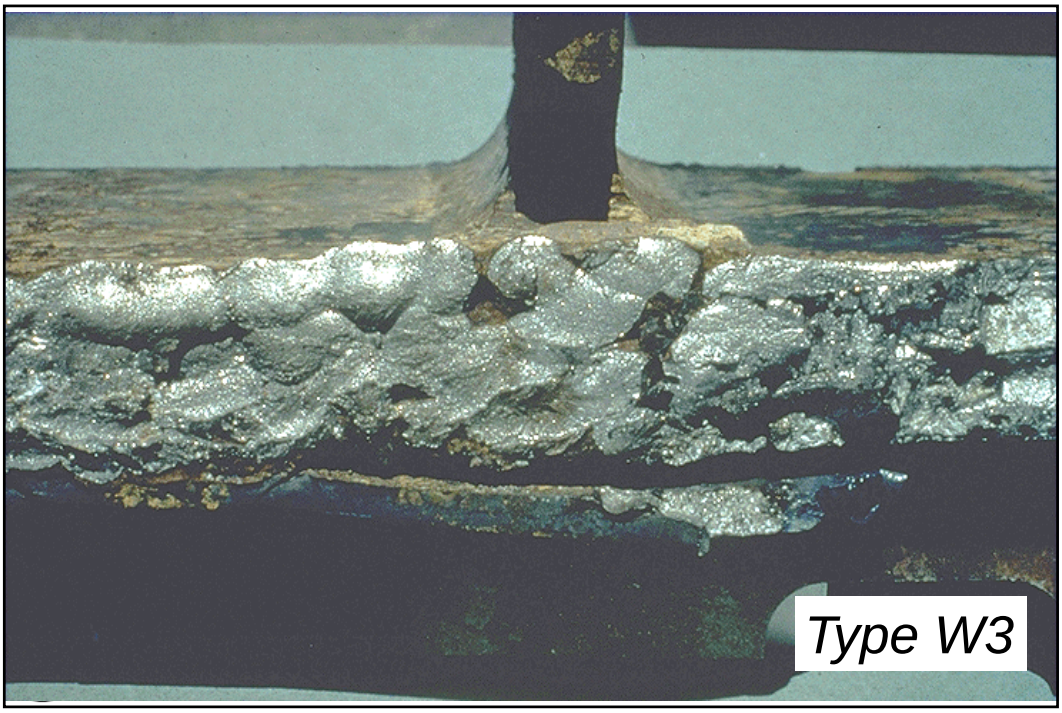


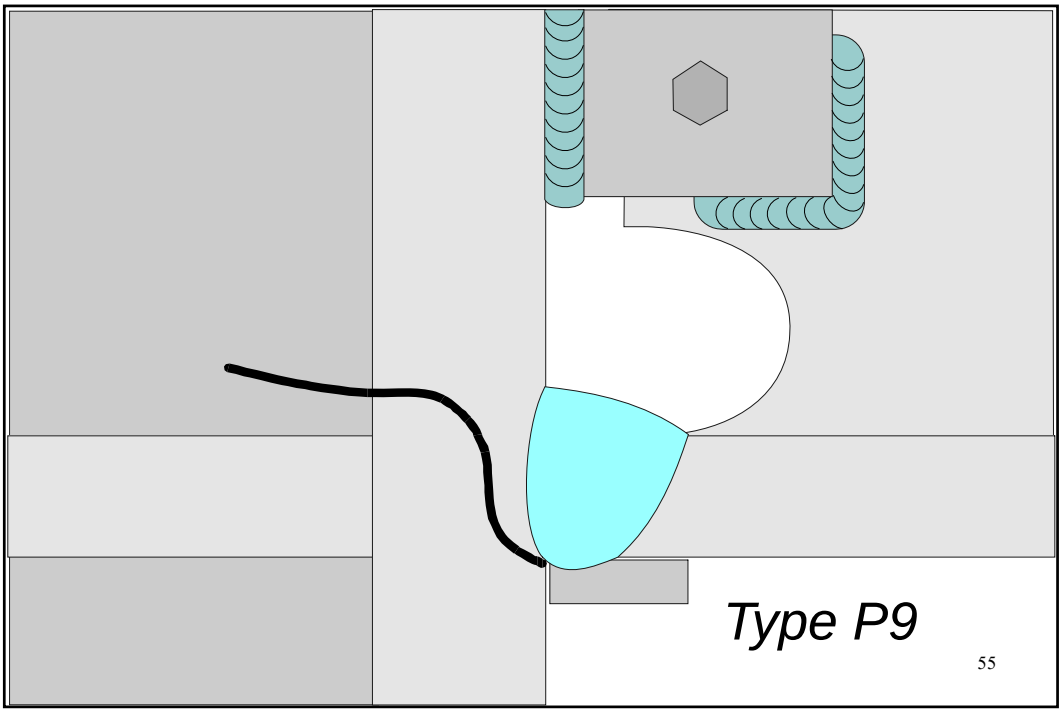


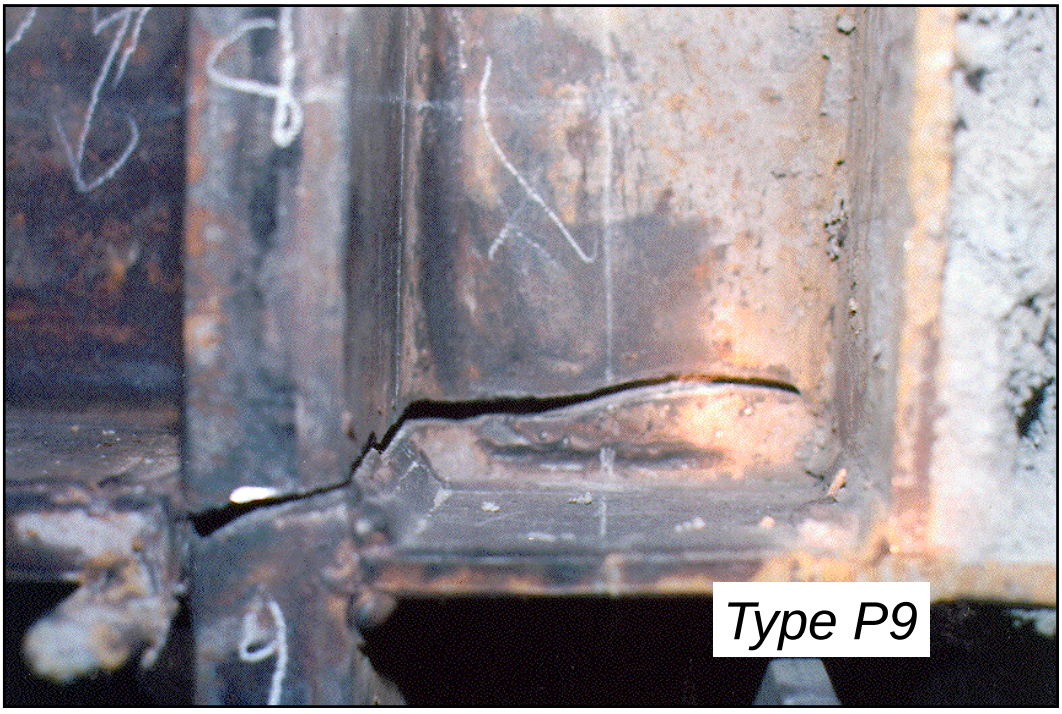


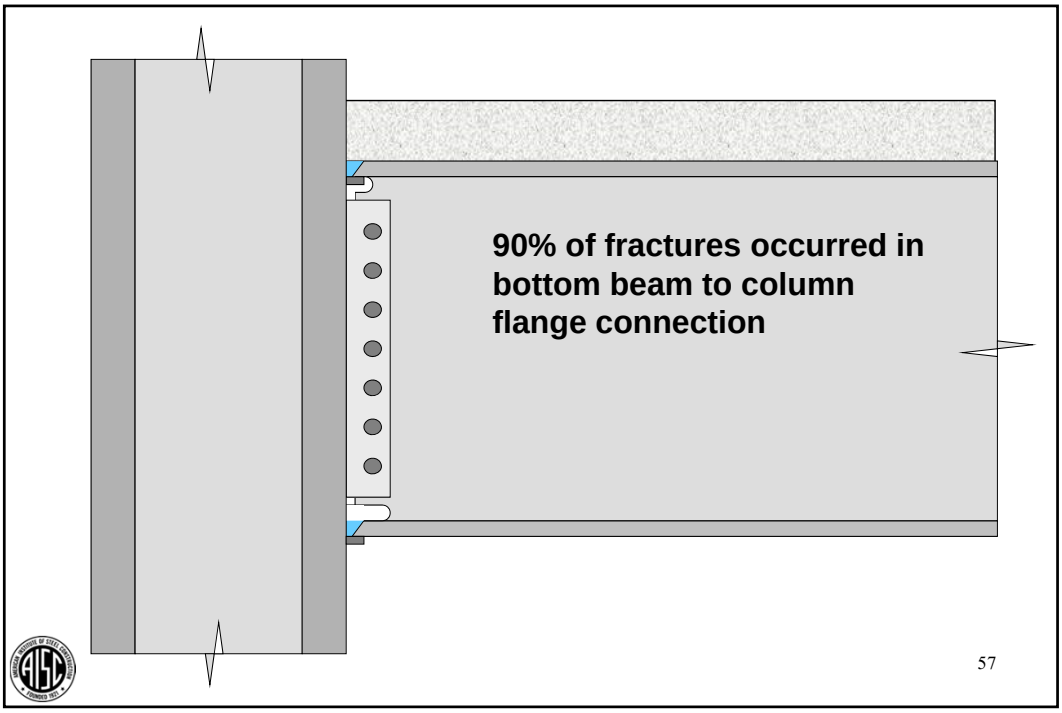






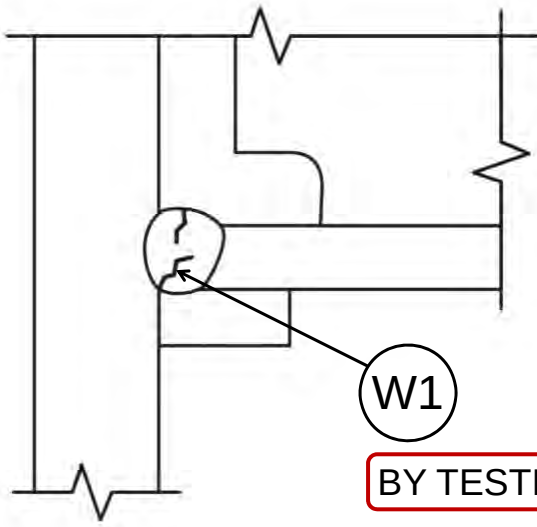






94-01 SAC Invitational Workshop on Steel Seismic Issues

Figure 2c. Form Section V damage types, continued.



94-01 SAC Invitational Workshop on Steel Seismic Issues

Figure 2a. Survey form Section V damage description page.

SURVEY OF STEEL MRF BUILDINGS
DAMAGED BY THE NORTHRIDGE EARTHQUAKE,
JANUARY, 1994

FLOOR ____ FRAME ____

Flange Weld Damage	W1	Incipient weld crack
	W2	Full or partial crack through weld metal
	W3	Fracture at girder interface
	W4	Fracture at column interface

	C5	Lamellar flange crack
Flange Weld Damage	W1	Incipient weld crack
	W2	Full or partial crack through weld metal
	W3	Fracture at girder interface
	W4	Fracture at column interface
Shear Connection Damage	S1	Weld crack at column (welded web only)
	S2	Weld crack at shear tab
	S3	Crack in girder web or shear plate through bolt holes
	S4	Plastic deformation of web or plate at bolt holes
	S5	Loose, damaged, or missing bolts
Panel Zone Damage	P1	Damage to continuity plate
	P2	Crack in continuity plate weld
	P3	Damage to doubler plate
	P4	Crack in doubler plate weld
	P5	Partial depth crack in column web (extension of C3)
	P6	Full (or near full) depth crack in column web

Provide additional descriptions of MRF joint damage as appropriate: _____

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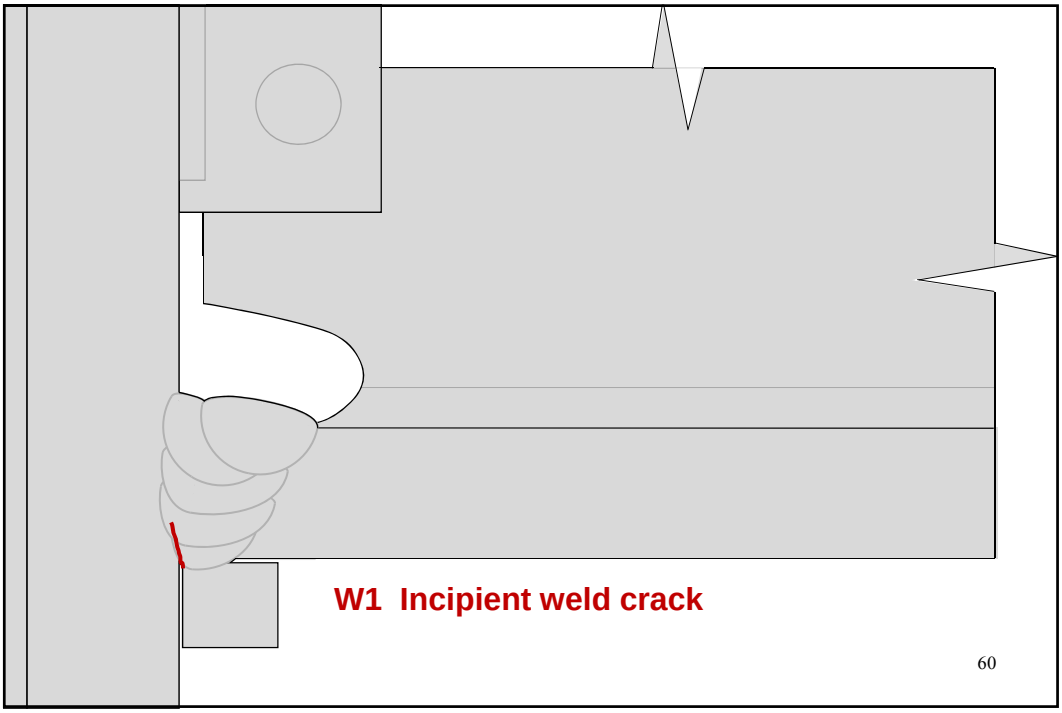
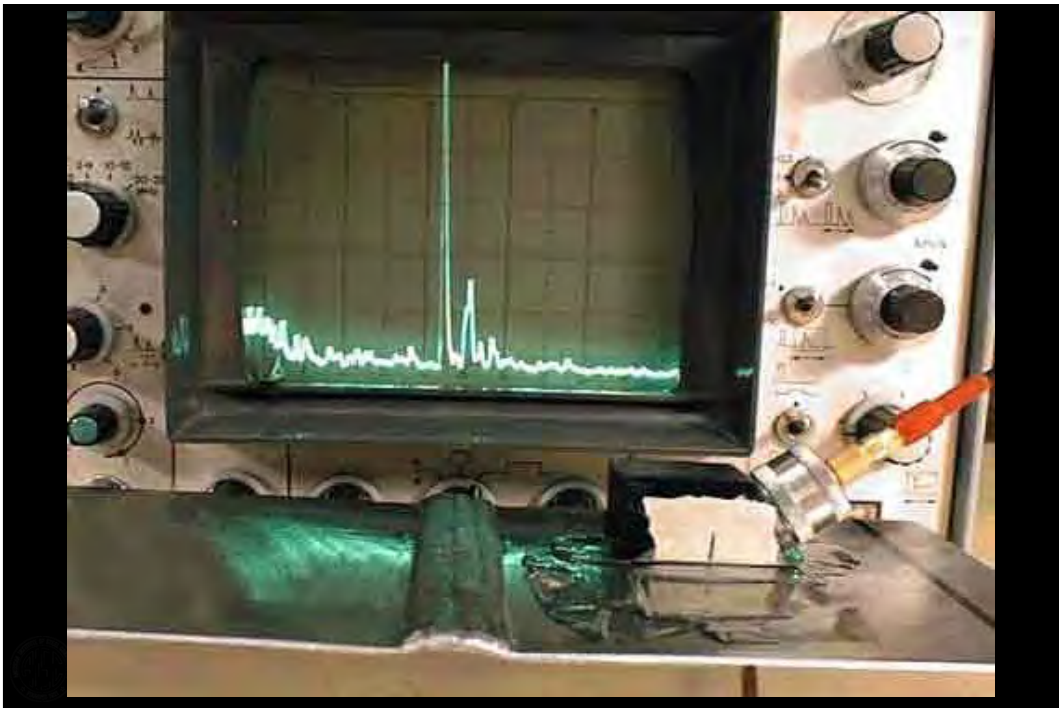
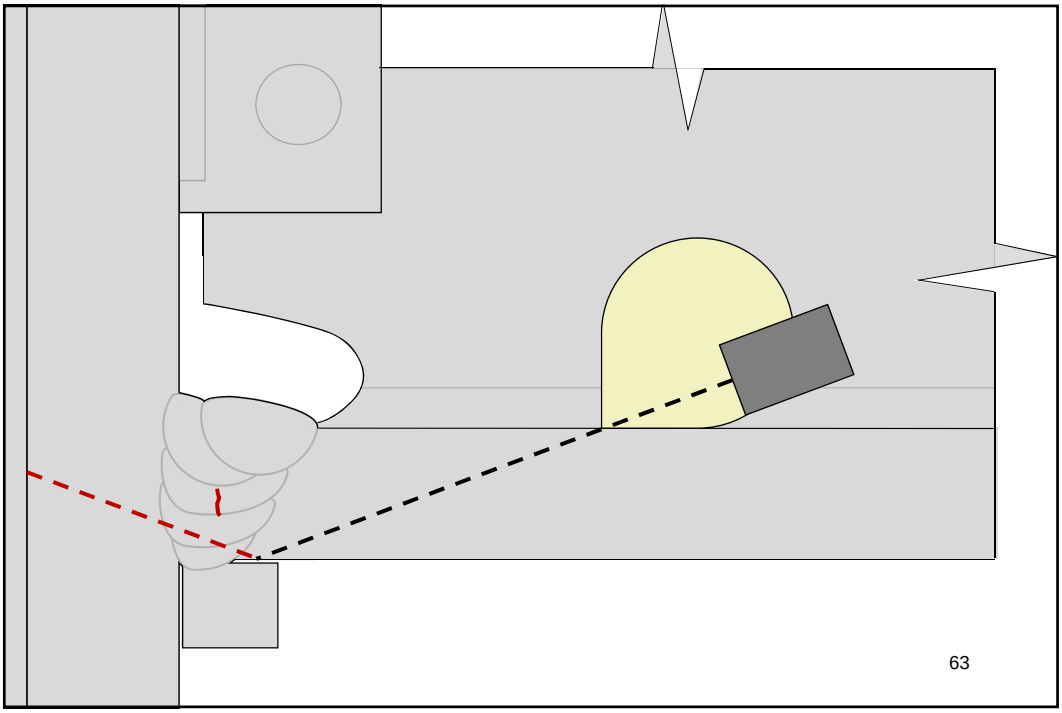
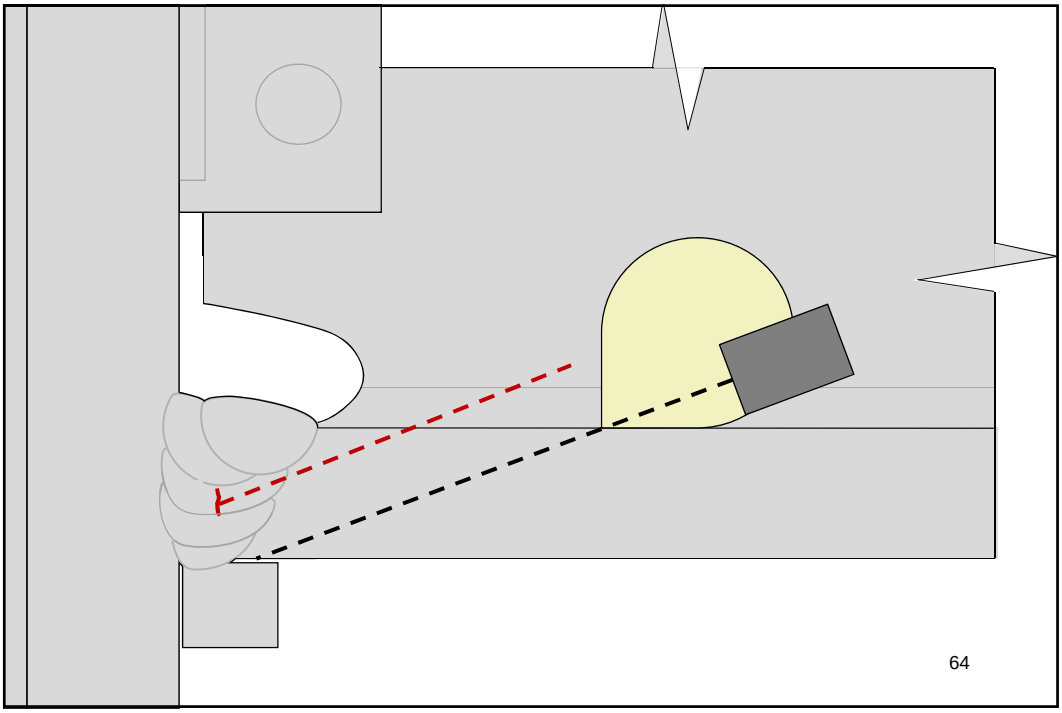


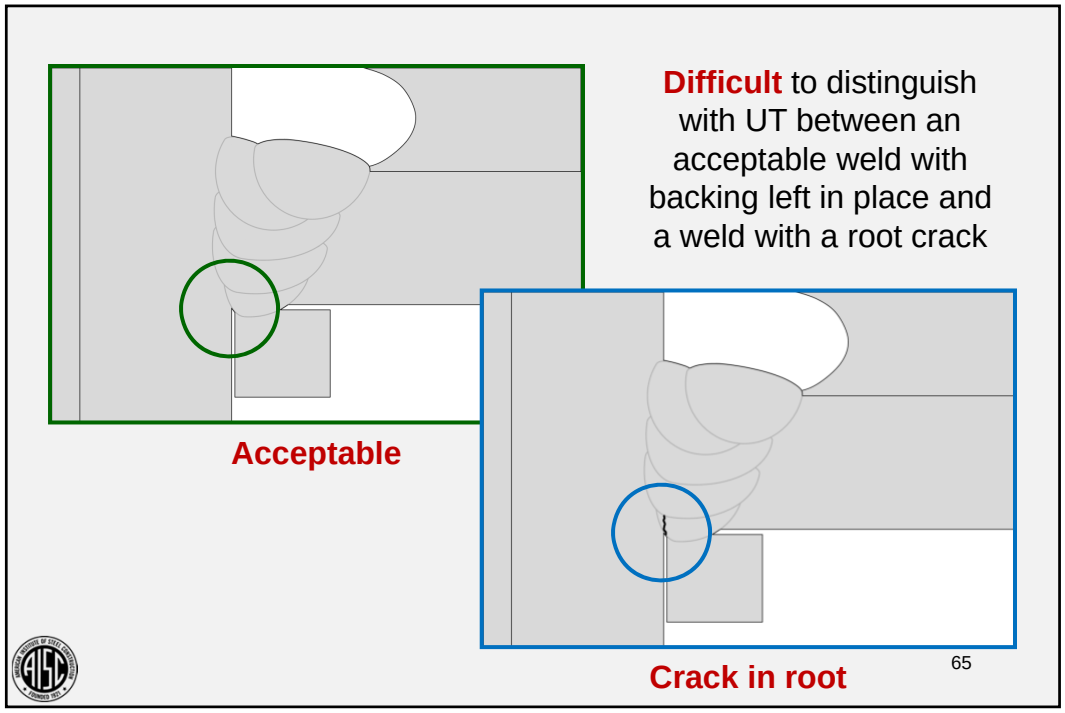
W1 Incipient weld crack

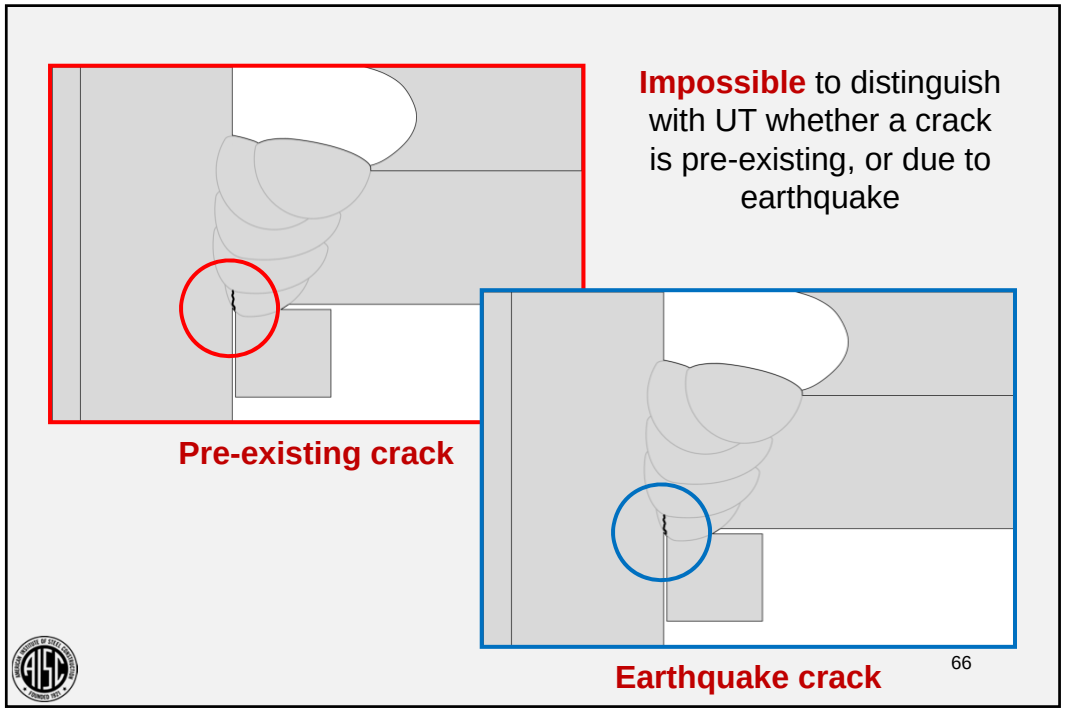
60

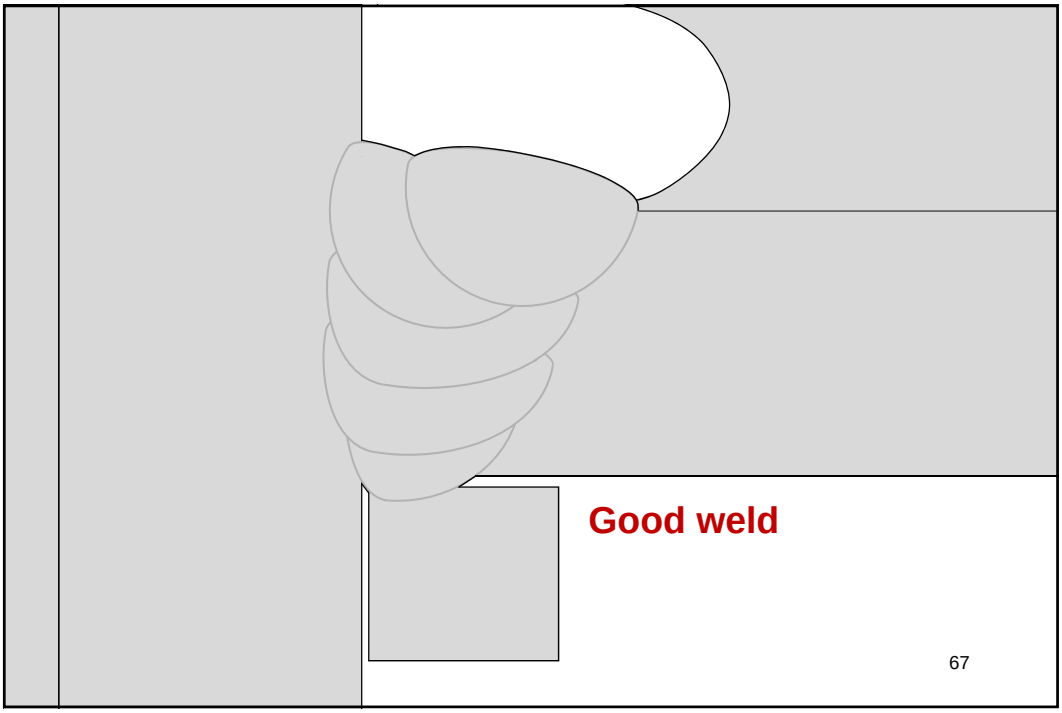


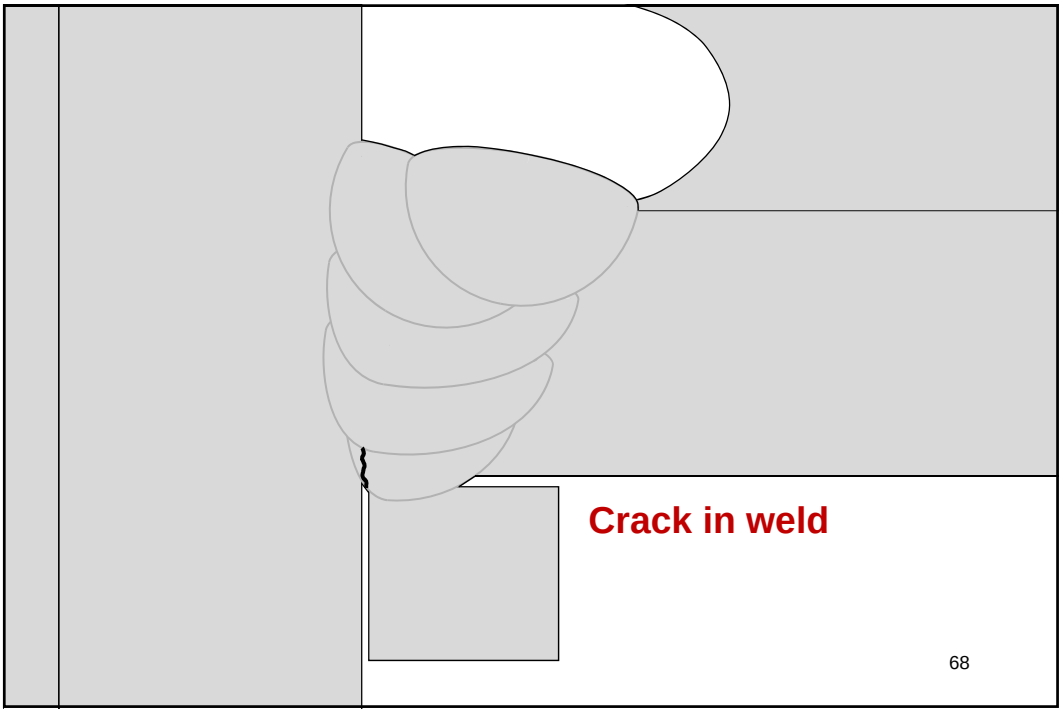


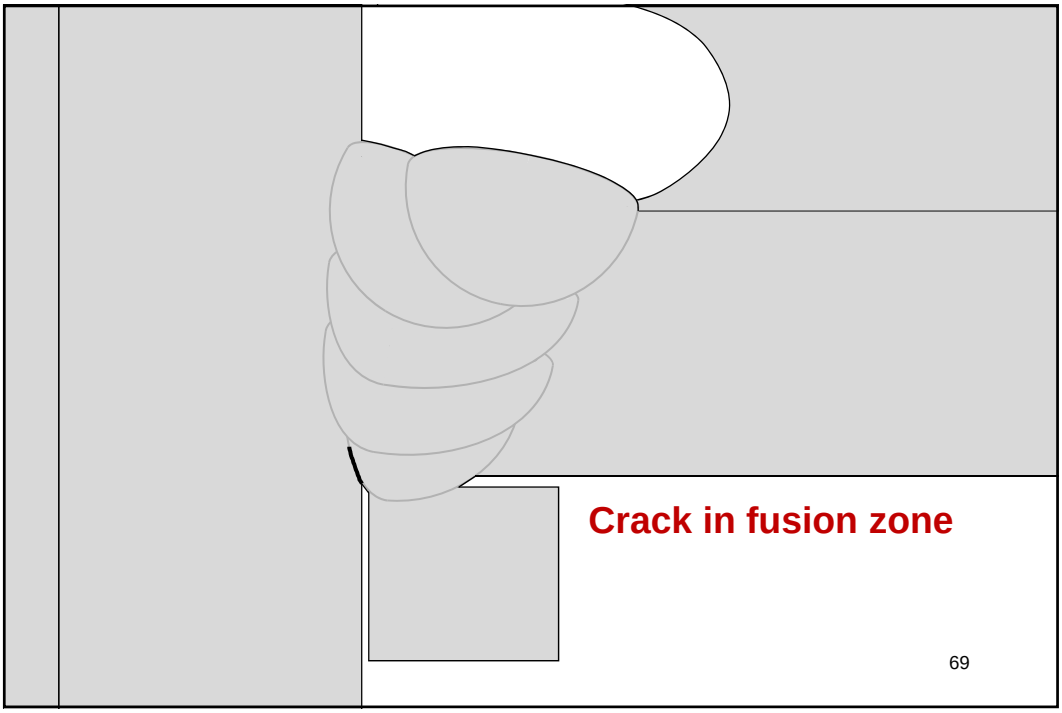


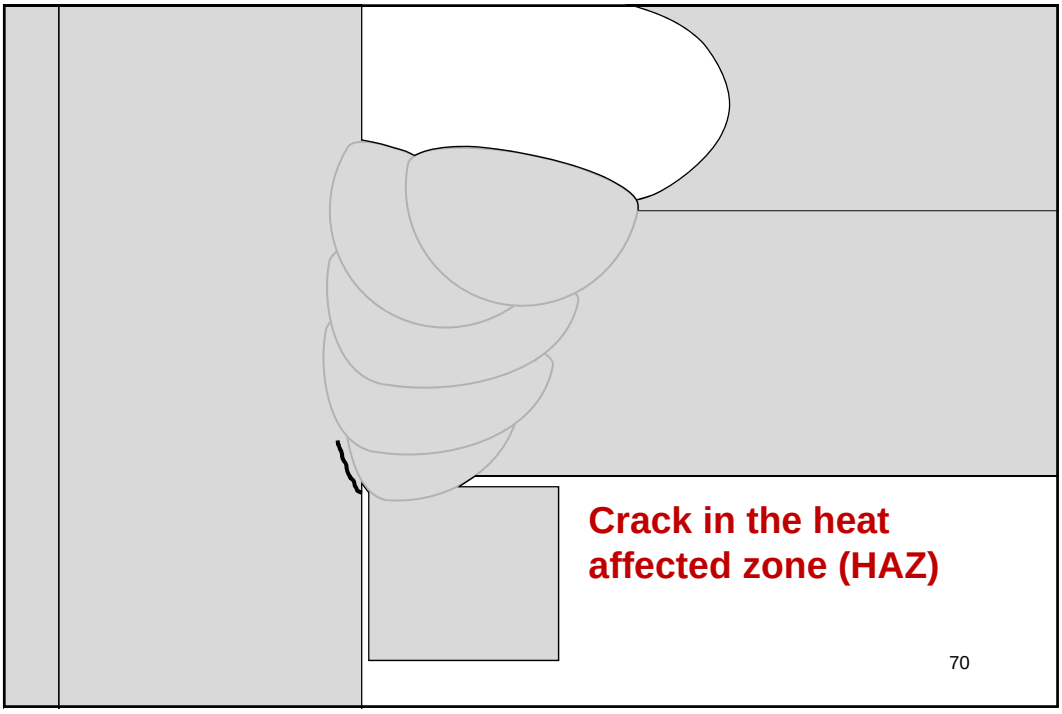


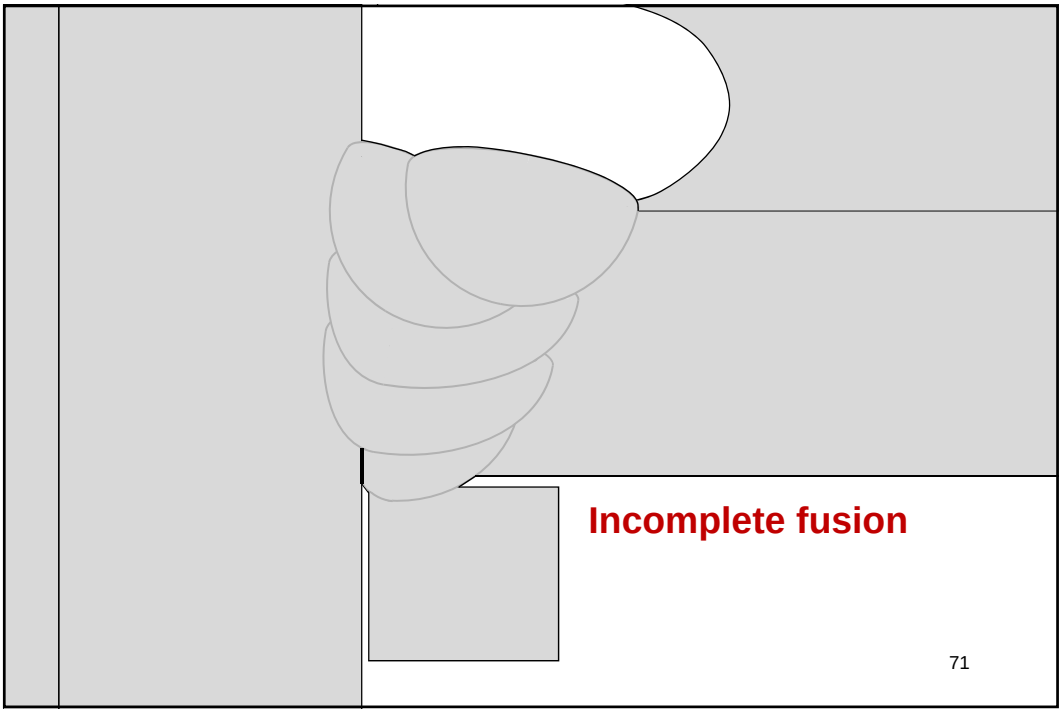


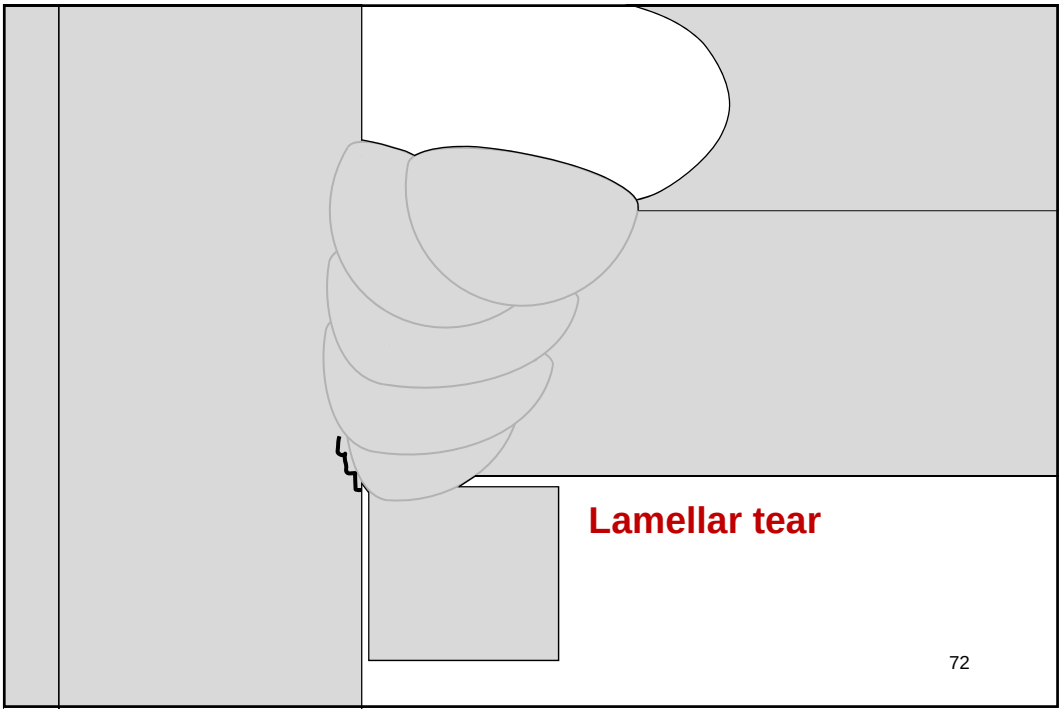


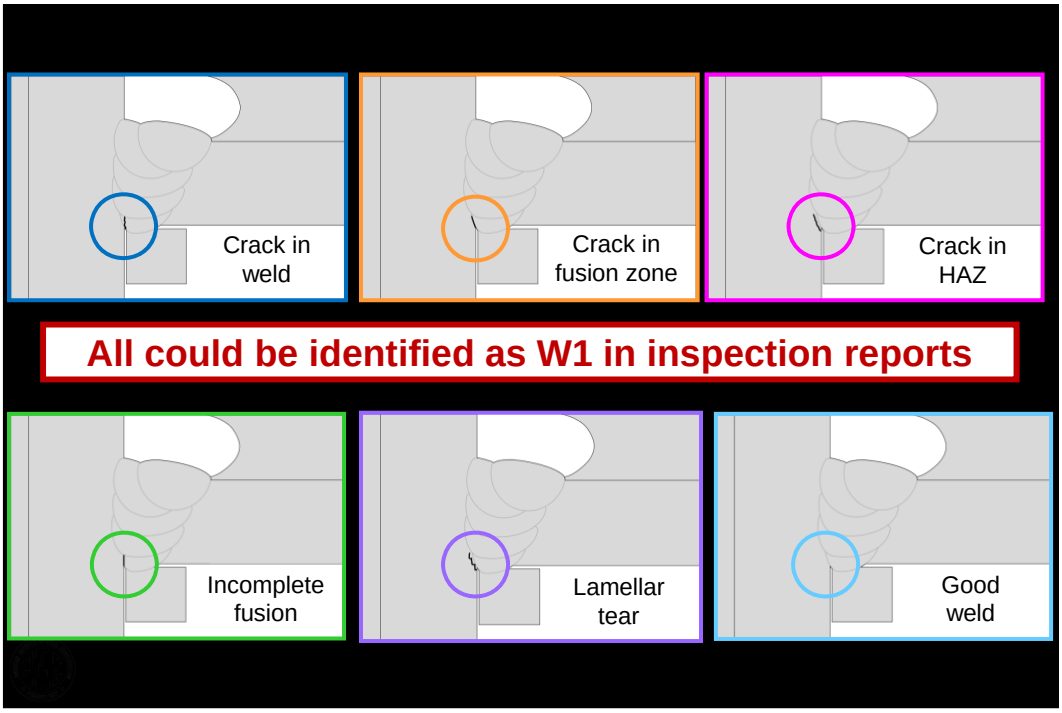


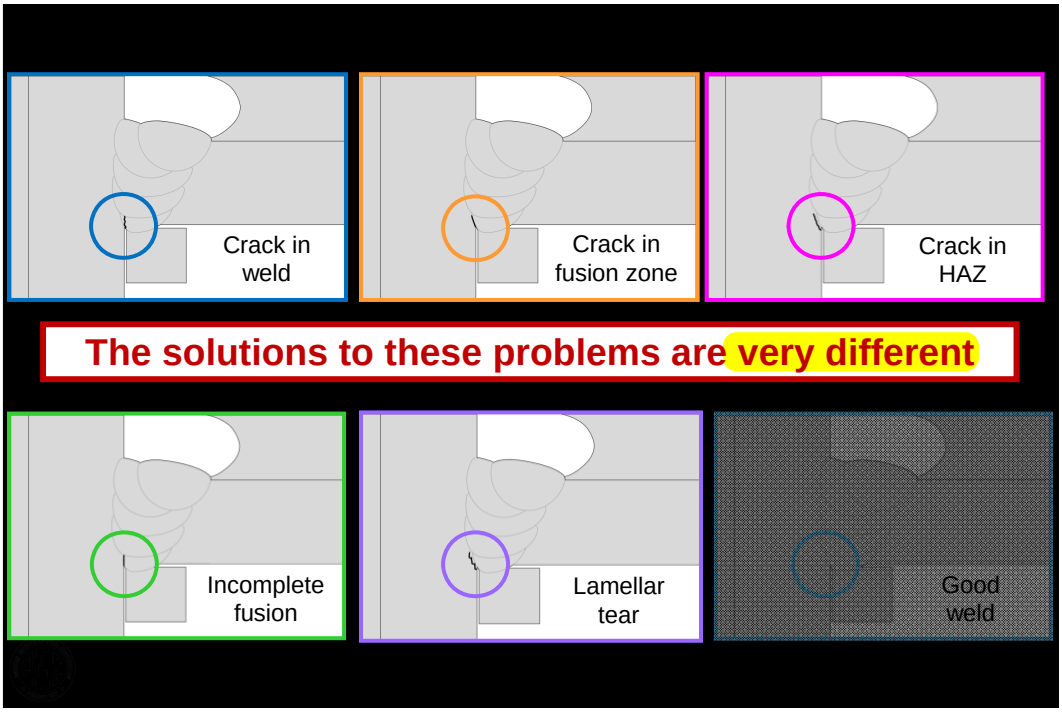












Report No. SAC/BD-99/10 Paret

Clarifying the Extent of Northridge-Induced Weld Fracturing; Examining the Related Issue of UT Reliability

CONCLUSIONS

75

Report No. SAC/BD-99/10 Paret

Clarifying the Extent of Northridge-Induced Weld Fracturing; Examining the Related Issue of UT Reliability

CONCLUSIONS

1. W1's are a result of poor welding and inspection practices during construction, not a result of earthquake ground motions.

76

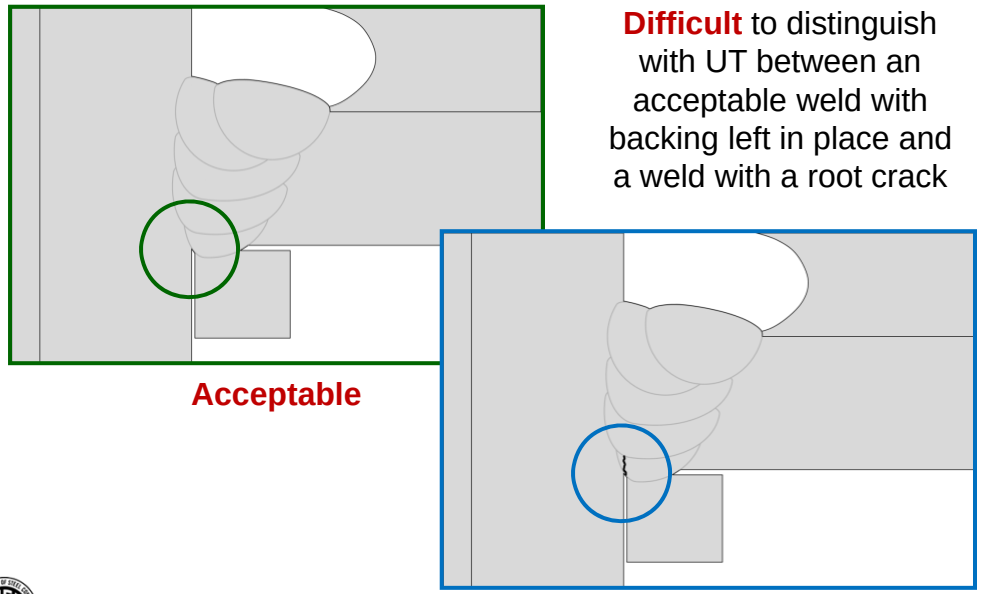
Report No. SAC/BD-99/10 Paret

Clarifying the Extent of Northridge-Induced Weld Fracturing; Examining the Related Issue of UT Reliability

CONCLUSIONS

2. Ultrasonic inspection as normally employed by testing laboratory personnel is not a reliable inspection technique for identifying defects in the roots of welded full penetration "T" joints with backing.

77

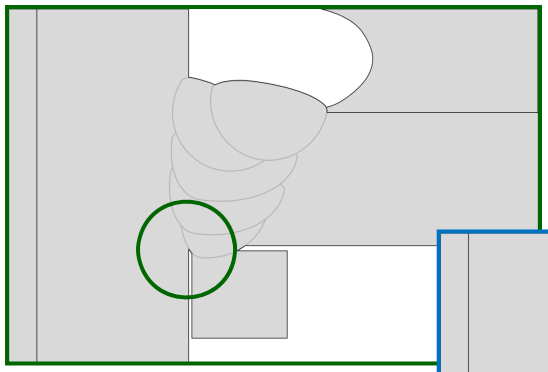


Difficult to distinguish with UT between an acceptable weld with backing left in place and a weld with a root crack

Acceptable

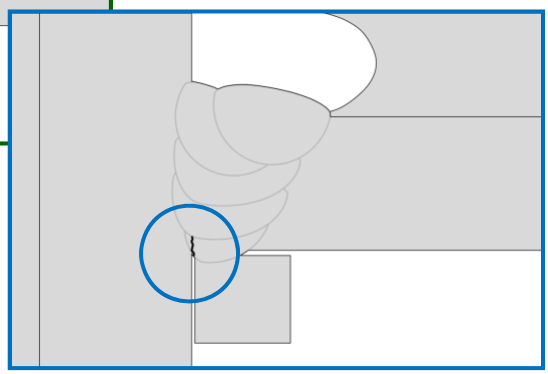
Crack in root

78



"Ultrasonic Inspection…is **not a reliable inspection technique** for identifying defects in the roots of welded full penetration "T" joints with backing."

Acceptable



Crack in root

79

Report No. SAC/BD-99/10 Paret

Clarifying the Extent of Northridge-Induced Weld Fracturing; Examining the Related Issue of UT Reliability

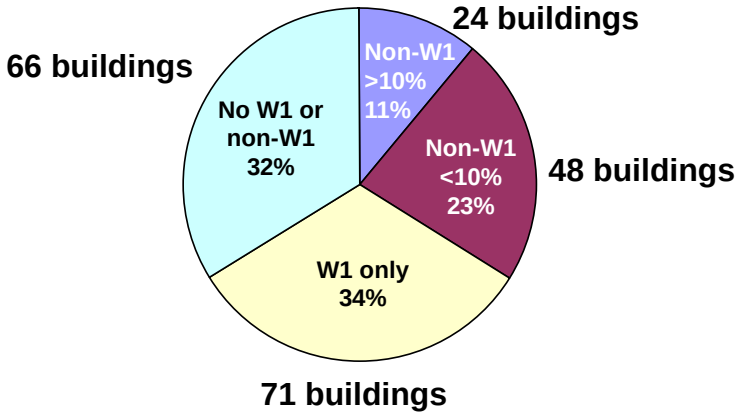
However, assorted anecdotal evidence suggested that W1's might not be earthquake related at all. For example, a number of samples of W1b's trepanned from welded connections and examined in the laboratory were determined to contain only areas of nonfusion and slag, without any crack extension or other potentially earthquake-related conditions.

80

Report No. SAC/BD-99/10 Paret

Clarifying the Extent of Northridge-Induced Weld Fracturing; Examining the Related Issue of UT Reliability

Figure 6 Distribution of W1's and non-W1's in City of Los Angeles Inventory

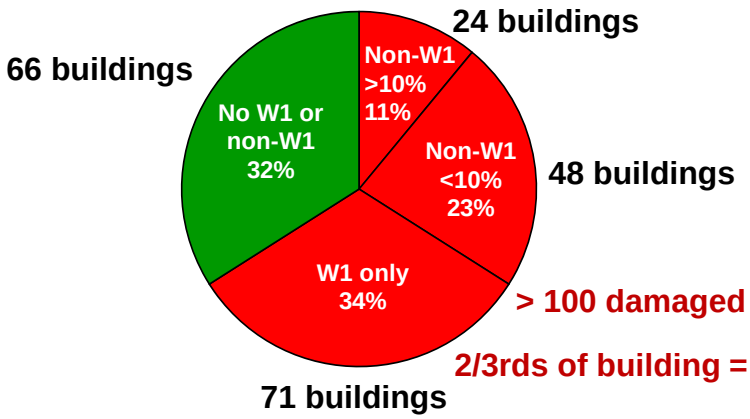


81

Report No. SAC/BD-99/10 Paret

Clarifying the Extent of Northridge-Induced Weld Fracturing; Examining the Related Issue of UT Reliability

Figure 6 Distribution of W1's and non-W1's in City of Los Angeles Inventory

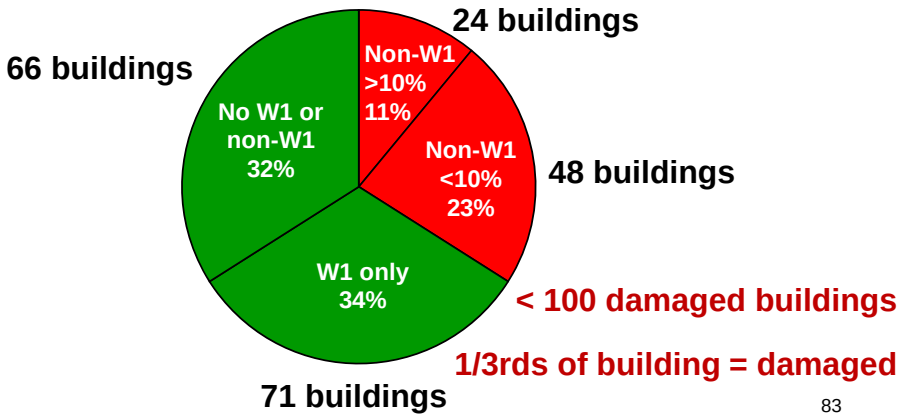


82

Report No. SAC/BD-99/10 Paret

Clarifying the Extent of Northridge-Induced Weld Fracturing; Examining the Related Issue of UT Reliability

Figure 6 Distribution of W1's and non-W1's in City of Los Angeles Inventory



83

Report No. SAC/BD-99/10 Paret

Clarifying the Extent of Northridge-Induced Weld Fracturing; Examining the Related Issue of UT Reliability

CONCLUSIONS

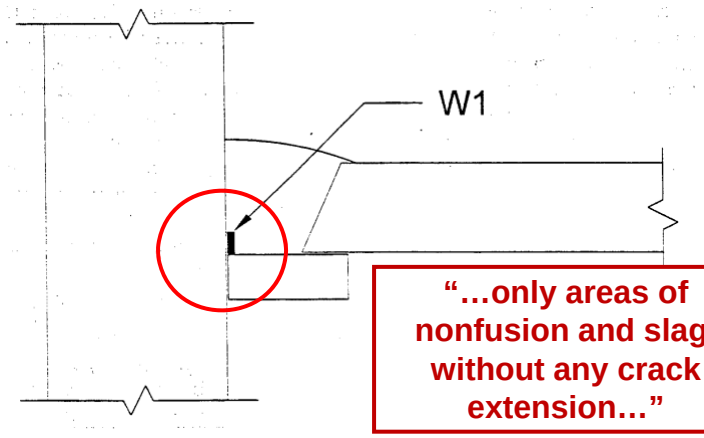
3. The extent of earthquake damage to WSMF buildings is substantially less than has previously been reported.

84

Report No. SAC/BD-99/10 Paret

Clarifying the Extent of Northridge-Induced Weld Fracturing; Examining the Related Issue of UT Reliability

Figure 2. Location most often defined for W1's by ultrasonics



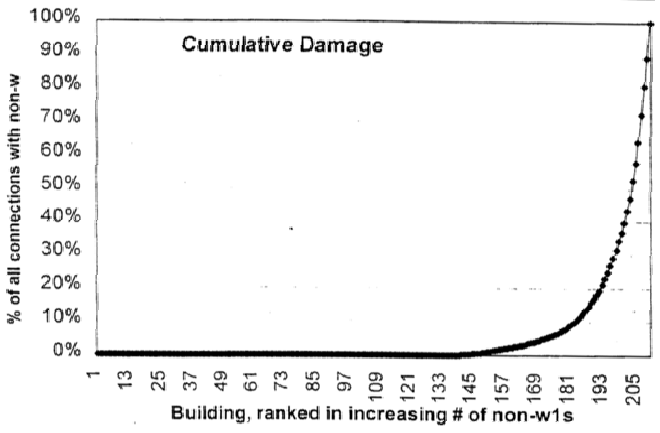
"…only areas of nonfusion and slag, without any crack extension…"

85

Report No. SAC/BD-99/10 Paret

Clarifying the Extent of Northridge-Induced Weld Fracturing; Examining the Related Issue of UT Reliability

Figure 7. Cumulative Occurrence of Non-W1's in City of Los Angeles Inventory



86

Figure 7. Cumulative Occurrence of Non-W1's in City of Los Angeles Inventory

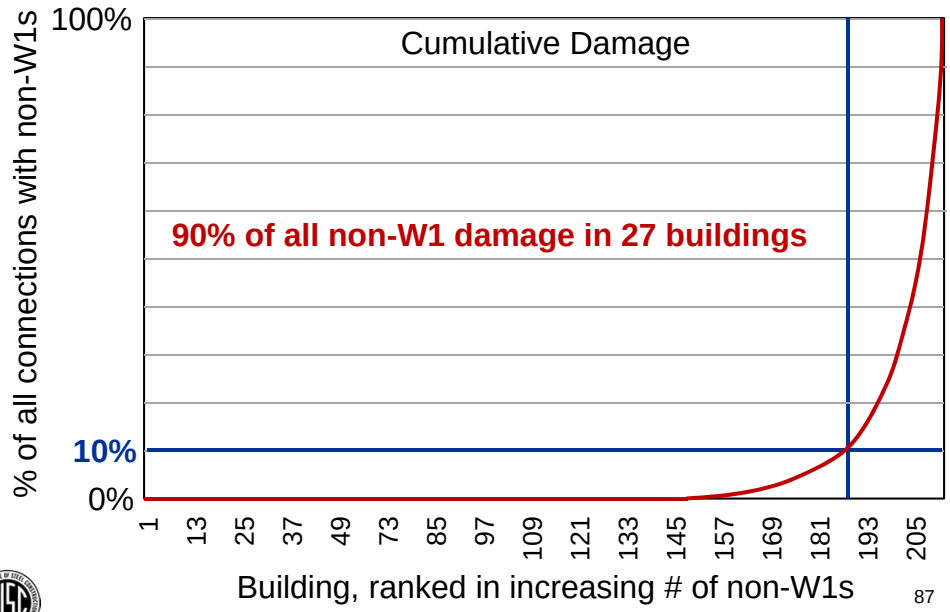


Figure 7. Cumulative Occurrence of Non-W1's in City of Los Angeles Inventory

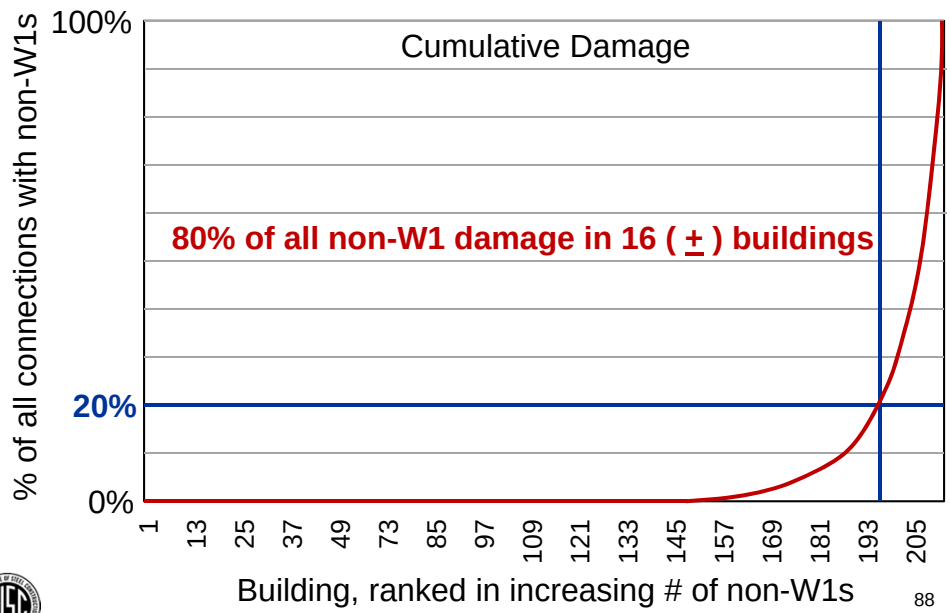
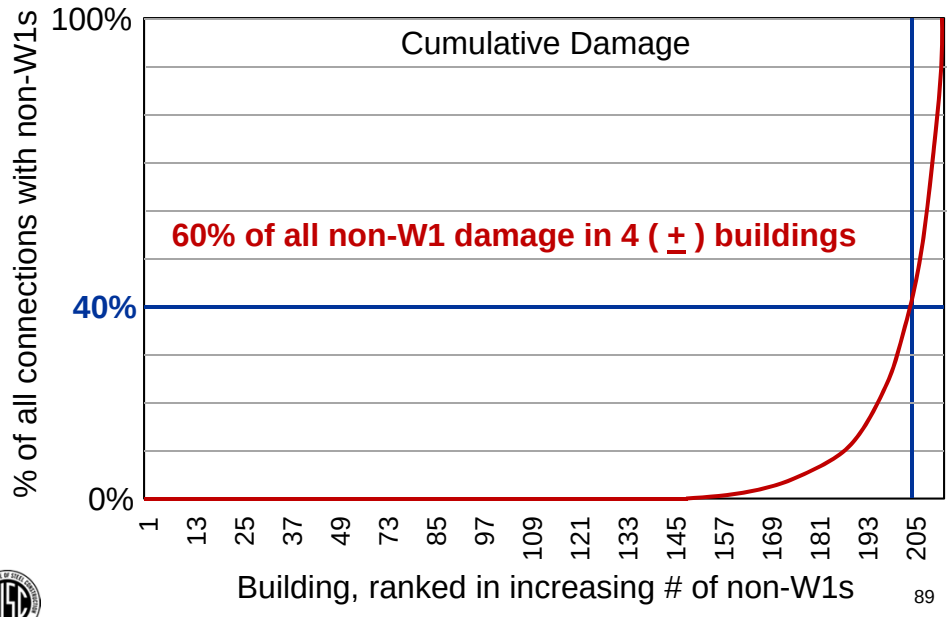


Figure 7. Cumulative Occurrence of Non-W1's in City of Los Angeles Inventory



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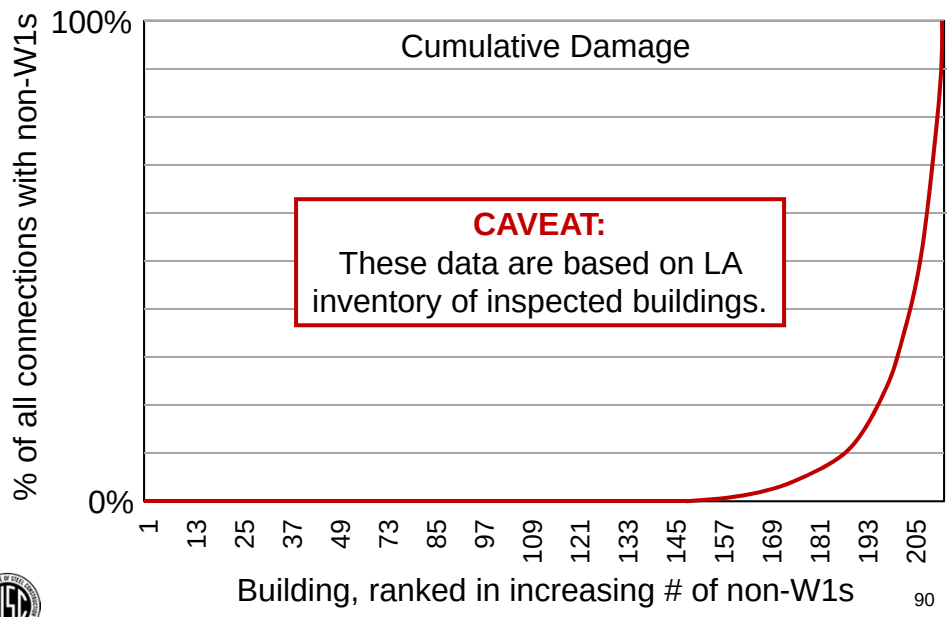

FEMA 353: Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications

Federal
Emergency
Management
Agency (FEMA)

FEMA 353
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)

92

From FEMA 353, page 1-9

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."

93

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…."

94

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."

95

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…."

96

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)

97

From FEMA 353, page 1-10

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…."

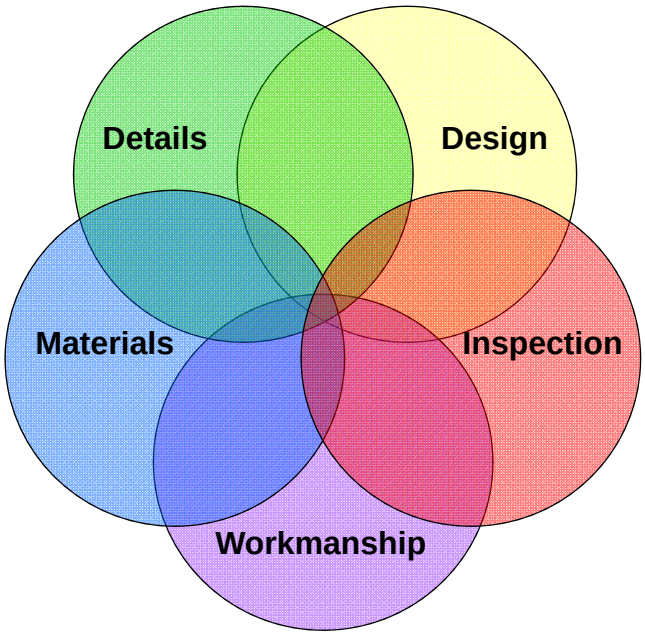
98

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

99



100

Welded Connections for Seismic Service

OUTLINE

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

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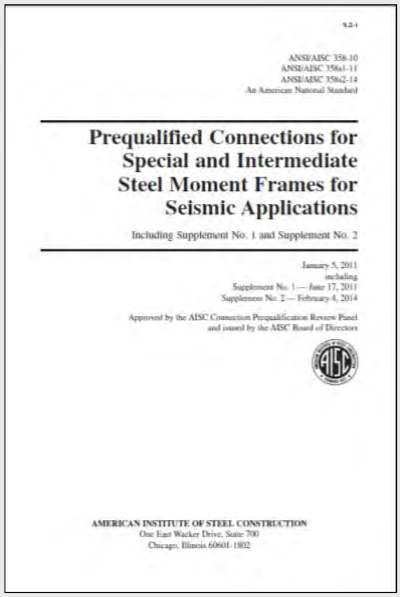
ANSI/AISC 358-10
ANSI/AISC 358s1-11
ANSI/AISC 358s2-14
An American National Standard

Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications


ANSI/AISC 358-10
ANSI/AISC 358s1-11
ANSI/AISC 358s2-14
An American National Standard

Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications

Including Supplement No. 1 and Supplement No. 2

January 5, 2011
including
Supplement No. 1 — June 17, 2011
Supplement No. 2 — February 4, 2014

Approved by the AISC Connection Prequalification Review Panel and issued by the AISC Board of Directors

AMERICAN INSTITUTE OF STEEL CONSTRUCTION
One East Wacker Drive, Suite 700
Chicago, Illinois 60601-1802

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AISC 358s2-14 Prequalified Connections

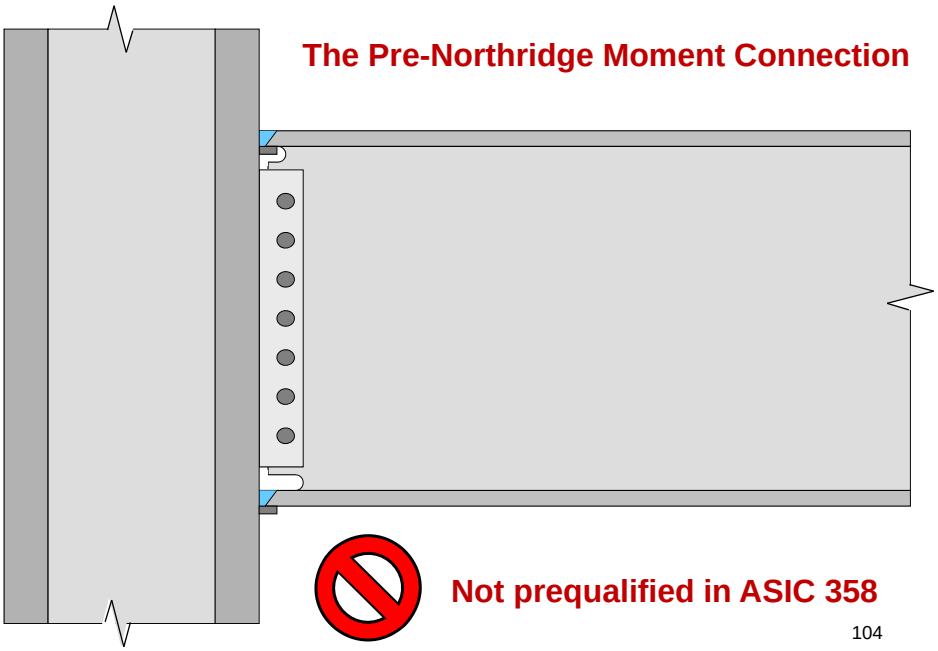
CHAPTER 1
GENERAL

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.

103

The Pre-Northridge Moment Connection

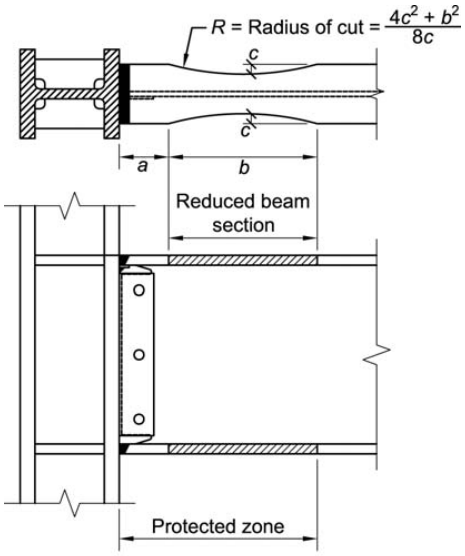


Not prequalified in ASIC 358

104

AISC 358s2-14 Prequalified Connections

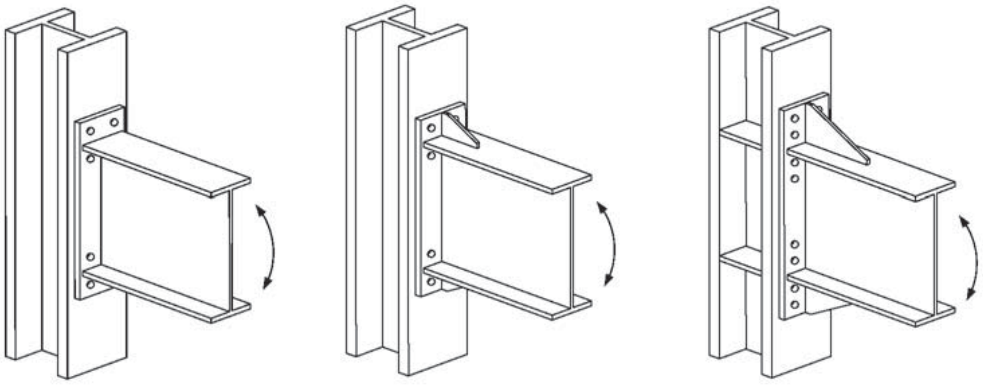
Reduced Beam Section (RBS) Moment Connection



105

AISC 358s2-14 Prequalified Connections

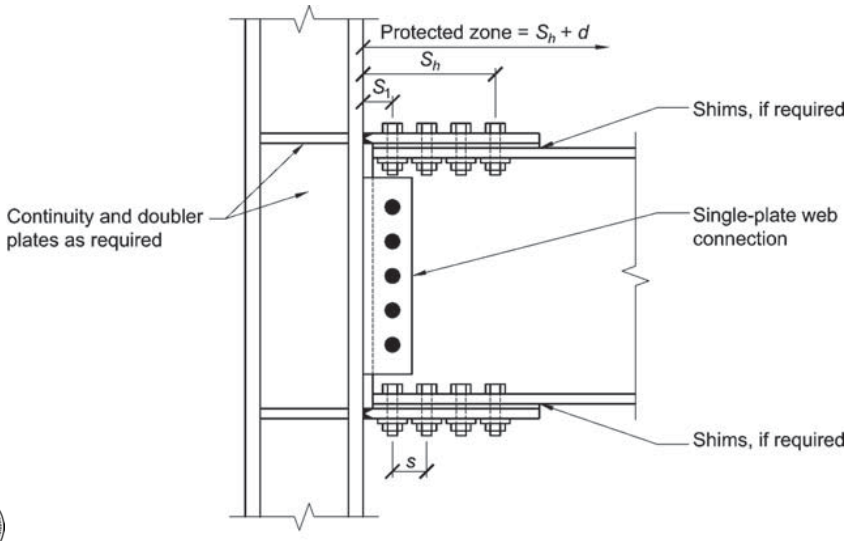
Bolted Unstiffened and Stiffened Extended End-Plate moment connections (BUUEP, BSEEP)



106

AISC 358s2-14 Prequalified Connections

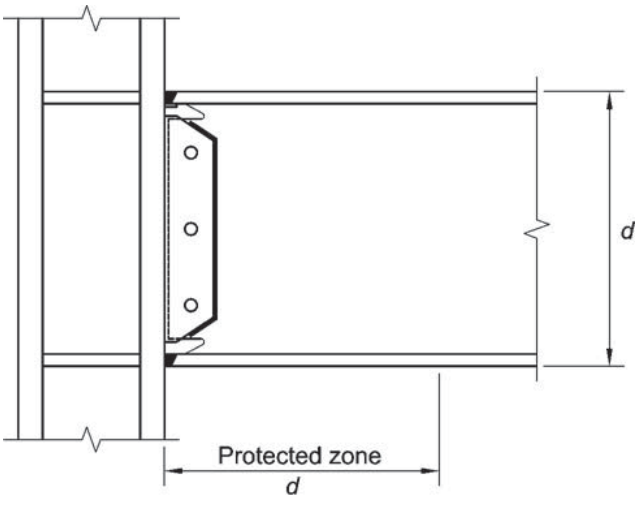
Bolted Flange Plate (BFP) Moment Connection



107

AISC 358s2-14 Prequalified Connections

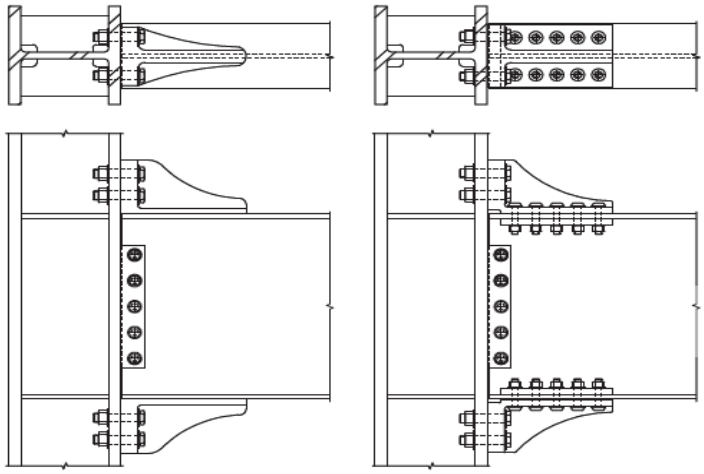
Welded Unreinforced Flange-Welded Web (WUF-W) Moment Connection



108

AISC 358s2-14 Prequalified Connections

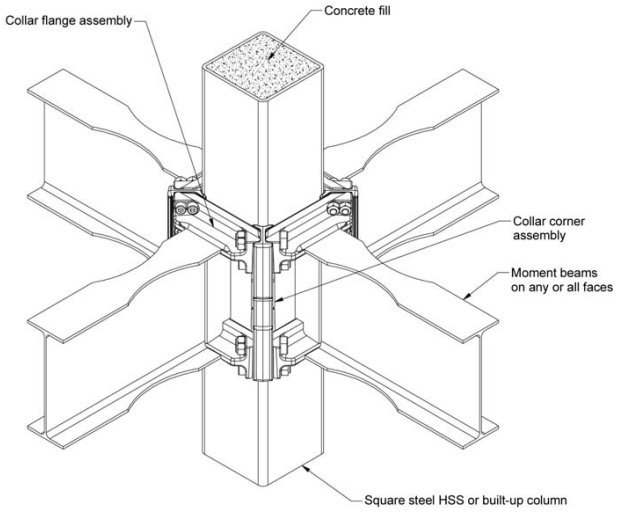
Kaiser Bolted Bracket (KBB) Moment Connection



109

AISC 358s2-14 Prequalified Connections

CONXTECH ® CONXL™ Moment Connection



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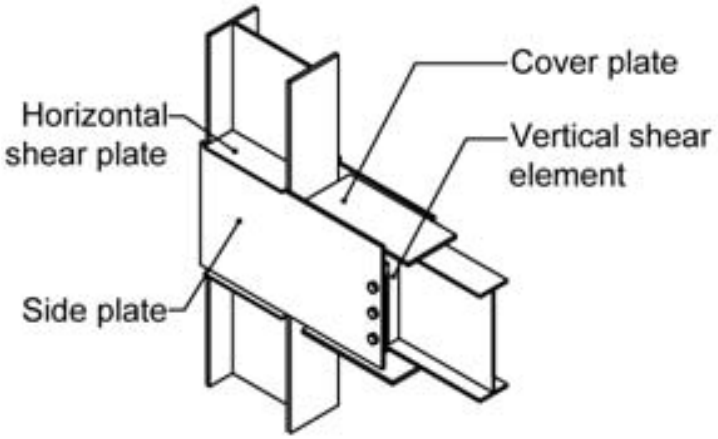
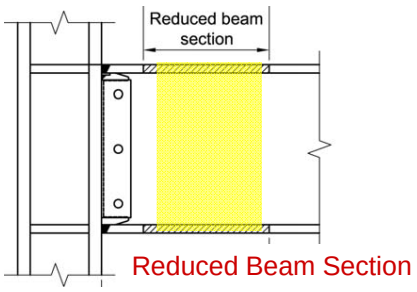
AISC 358s2-14 Prequalified Connections

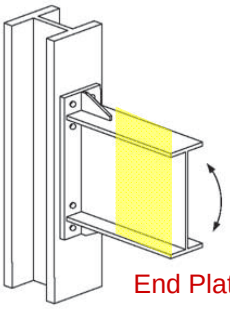
SidePlate® Moment Connection



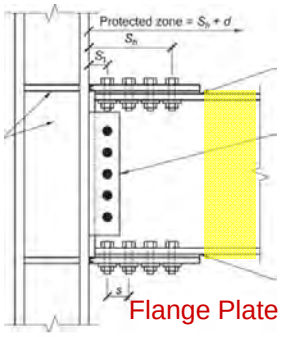
111



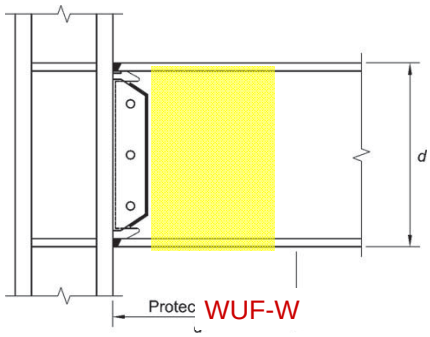
Reduced Beam Section



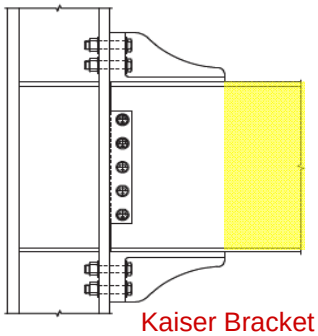
End Plate



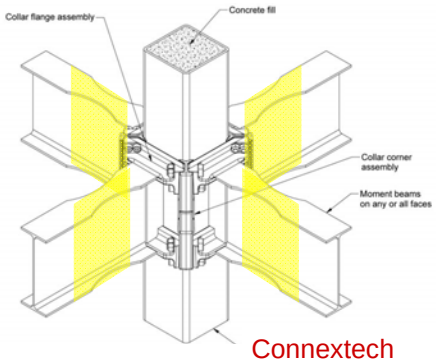
Flange Plate



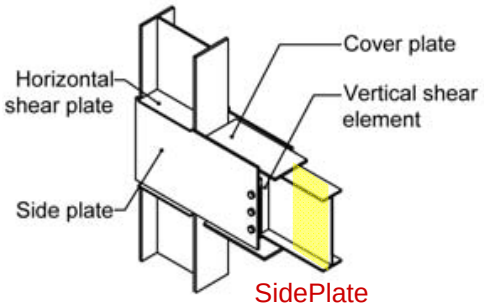
WUF-W



Kaiser Bracket



Connextech



SidePlate

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AISC 358s2-14 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.

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AISC 358s2-14 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.

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AISC 358s2-14 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 341-10 SEISMIC PROVISIONS

CHAPTER A

GENERAL REQUIREMENTS

A2. REFERENCED SPECIFICATIONS, CODES AND STANDARDS

American Welding Society (AWS)
AWS D1.8/D1.8M:2009 *Structural Welding Code—Seismic Supplement*

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AWS D1.8:2009
An American National Standard

Structural Welding Code—Seismic Welding Supplement

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Welded Connections for Seismic Service

OUTLINE

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

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AWS D1.8:2009 Seismic Welding Supplement

1. General Provisions
2. Reference Documents
3. Definitions
4. Welded Connection Details
5. Welder Qualification
6. Fabrication
7. Inspection

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Welded Connections for Seismic Service

OUTLINE: D1.8 Seismic Welding Supplement

- Overview
- Engineer's Responsibilities
- Heat Input Testing
- Restricted Access Welder Qualification
- Workmanship Details

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AWS D1.8:2009 Seismic Welding Supplement

1.1 Applicability

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 D1.8:2009 Seismic Welding Supplement

1.1 Applicability

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 D1.8:2009 Seismic Welding Supplement

1.1 Applicability (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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Welded Connections for Seismic Service

OUTLINE: D1.8 Seismic Welding Supplement

- Overview
- Engineer's Responsibilities
- Heat Input Testing
- Restricted Access Welder Qualification
- Workmanship Details

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AWS D1.8:2009 Seismic Welding Supplement

1.2 Responsibilities

1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

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AWS D1.8:2009 Seismic Welding Supplement

1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

(1) **Connection configuration,** material specifications, and part sizes required to provide the needed seismic performance (see 1.3)

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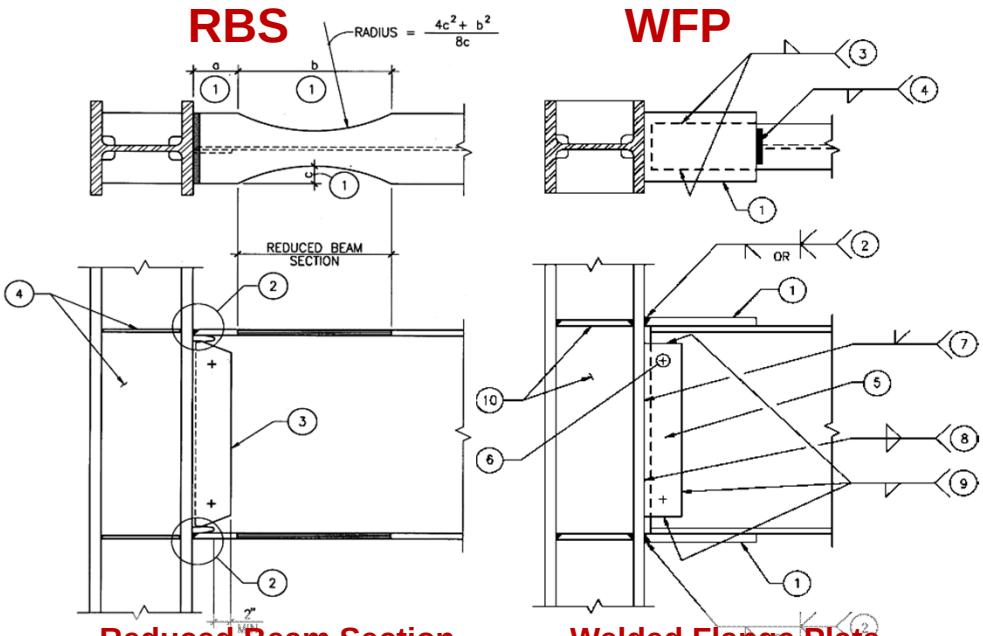

AWS D1.8:2009 Seismic Welding Supplement

1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

(2) Identification of members that comprise the Seismic Force Resisting System (SFRS) and that are subject to the provisions of this code (see 3.1)

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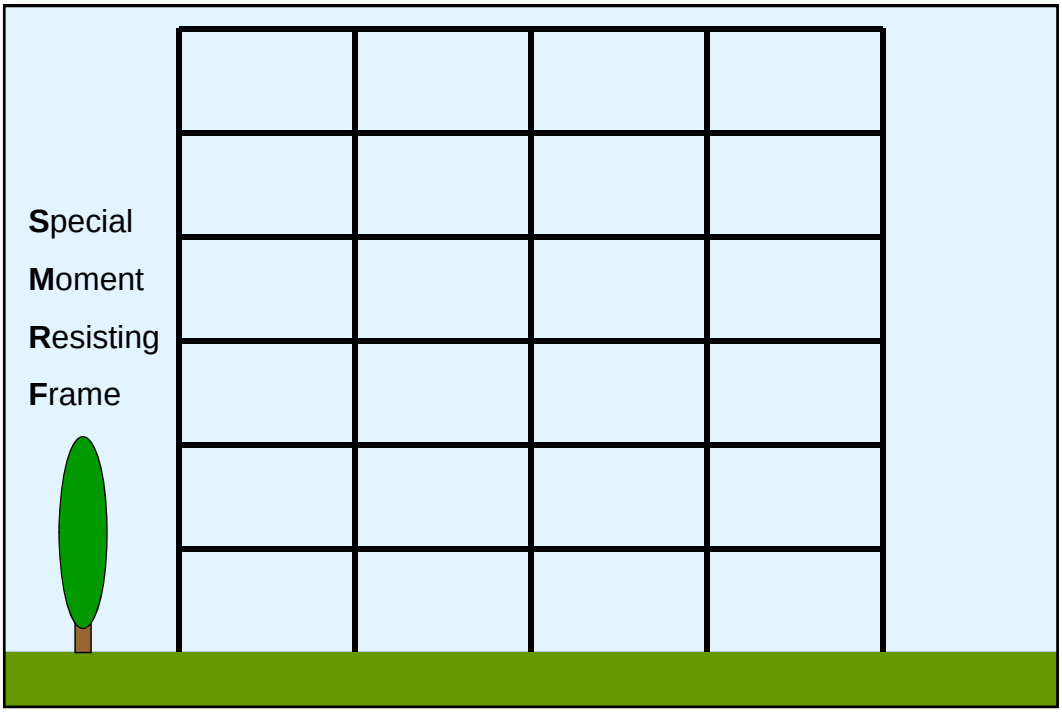
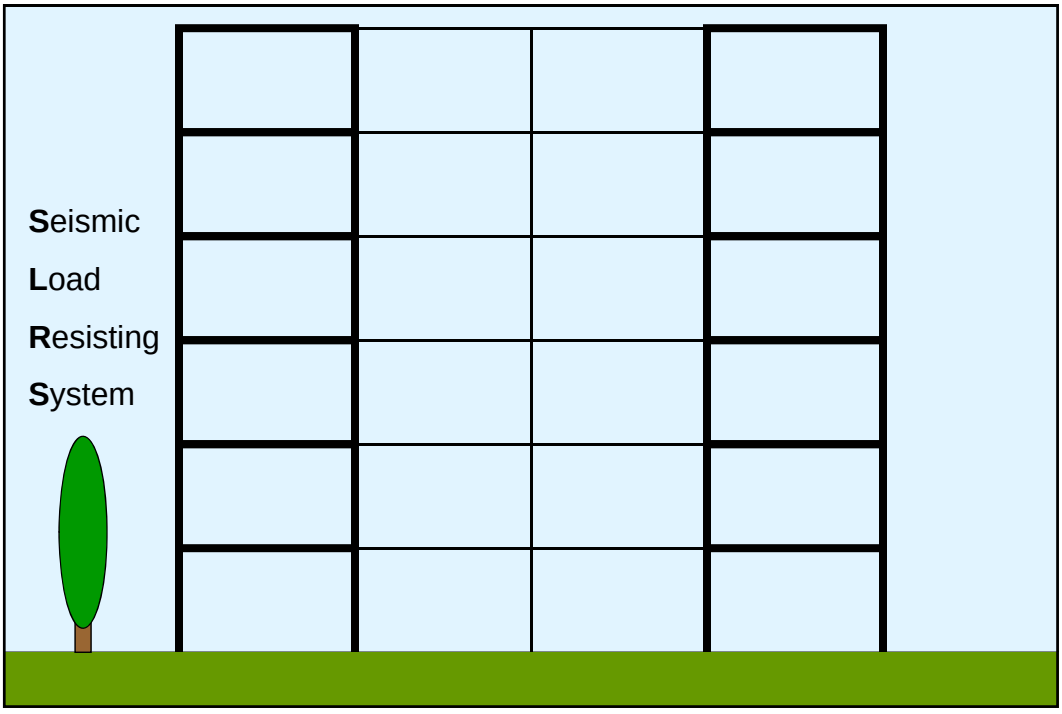
AWS D1.8:2009 Seismic Welding Supplement

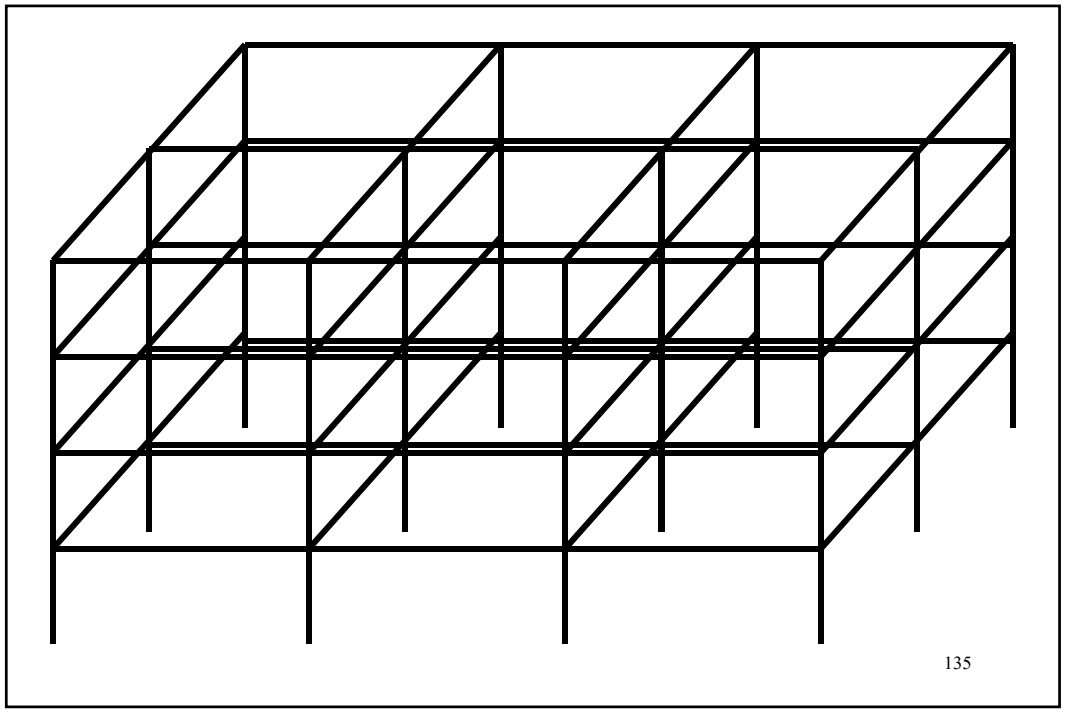
3.1 Seismic Force Resisting System (SFRS).

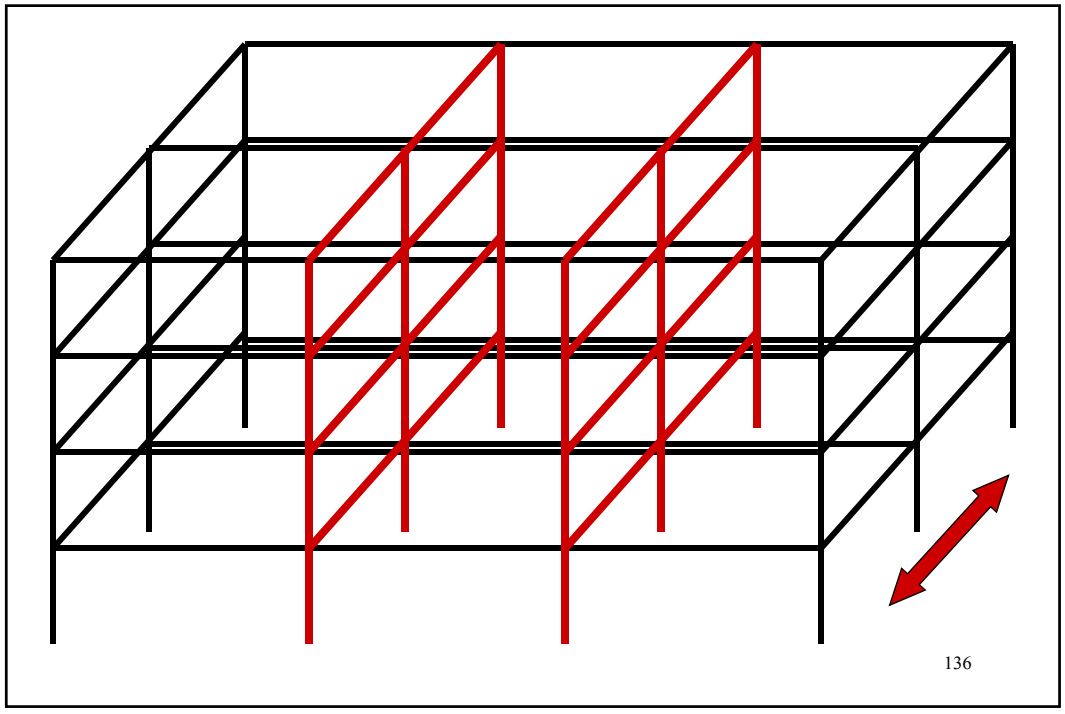
The assembly of structural elements in the building that resists seismic loads…. Included in the SFRS are the columns, beams, girders and braces, and the connections between these elements, specifically designed to resist seismic loads, either alone or in combination with other loads.

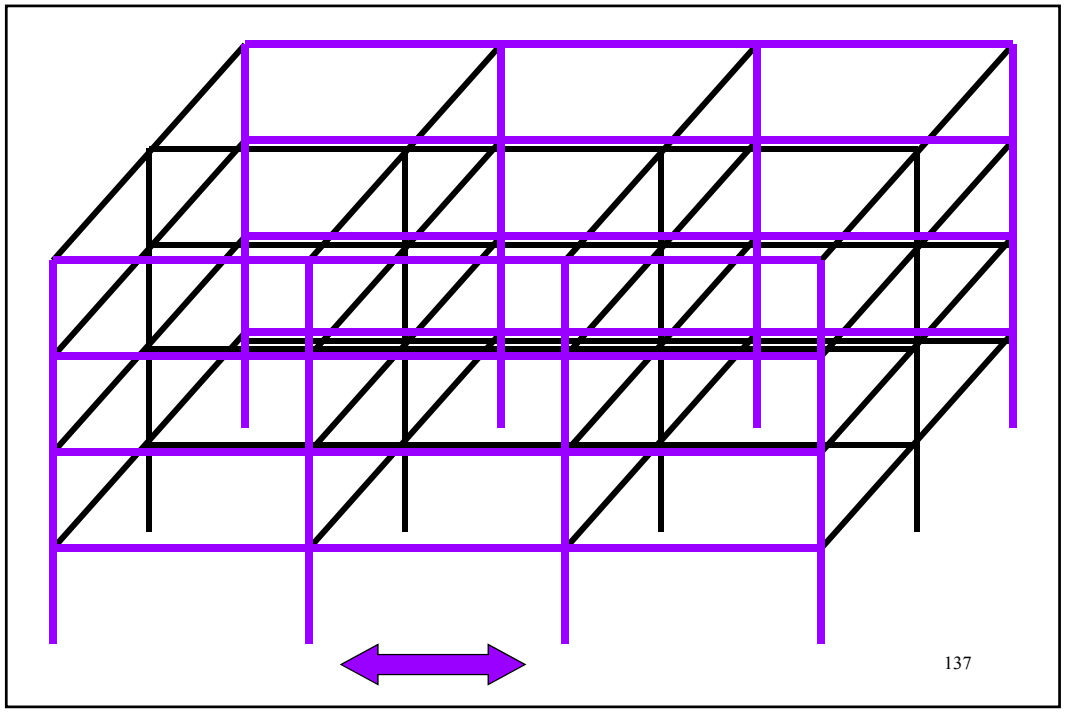
132

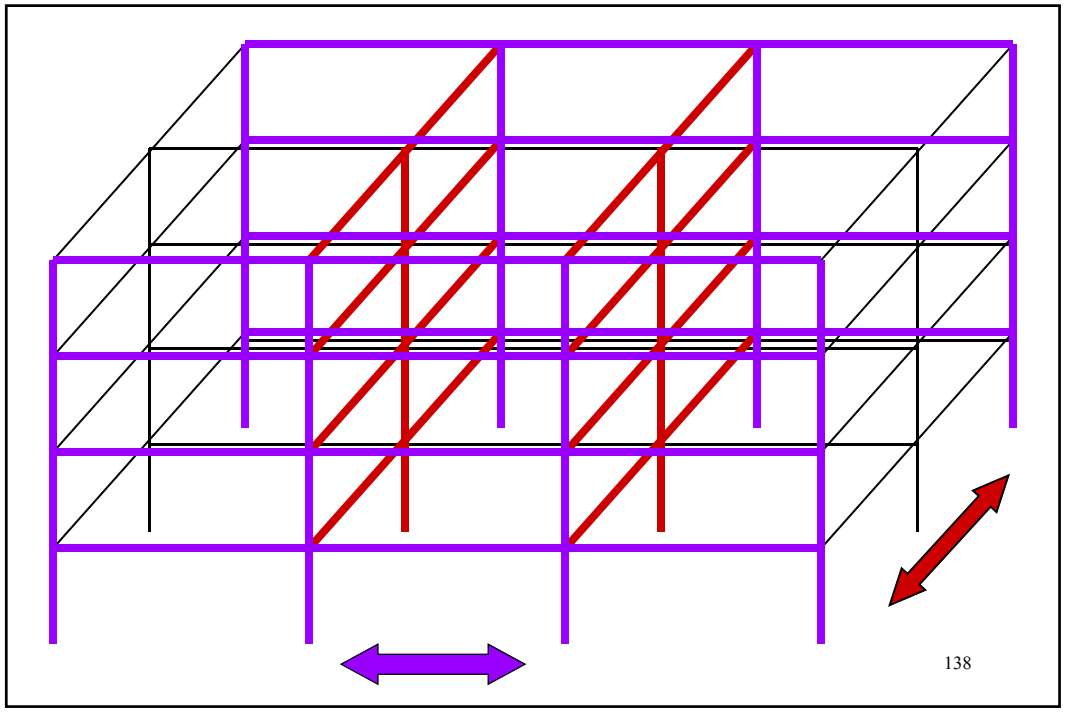


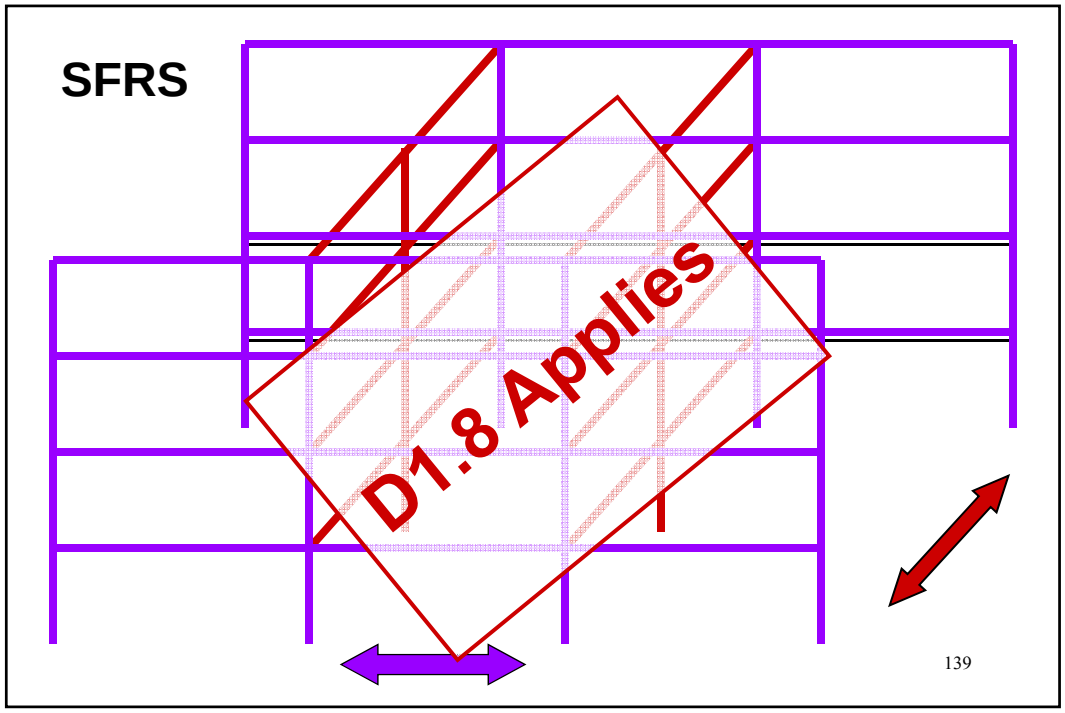


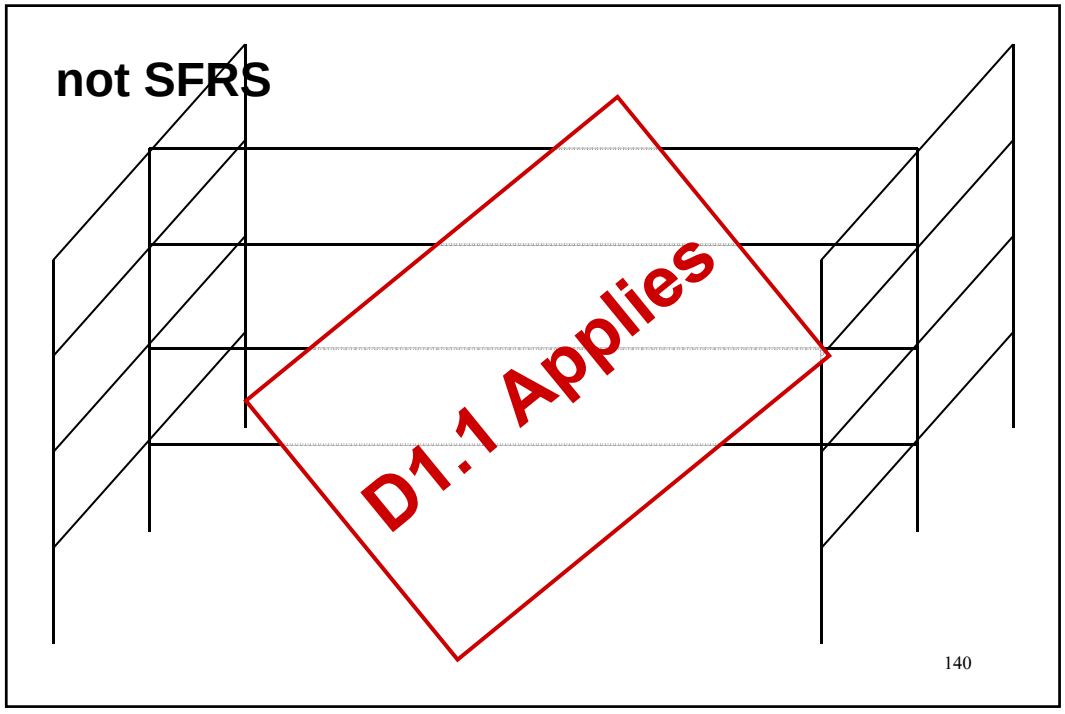












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1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

(3) The location of the Protected Zone for members of the SFRS (see 3.3)

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3.3 Protected Zone

That portion of a member of the SFRS, designated by the Engineer in Contract Documents in which inelastic straining is anticipated to occur and to which special limitations in these provisions apply with regard to attachments and fabrication.

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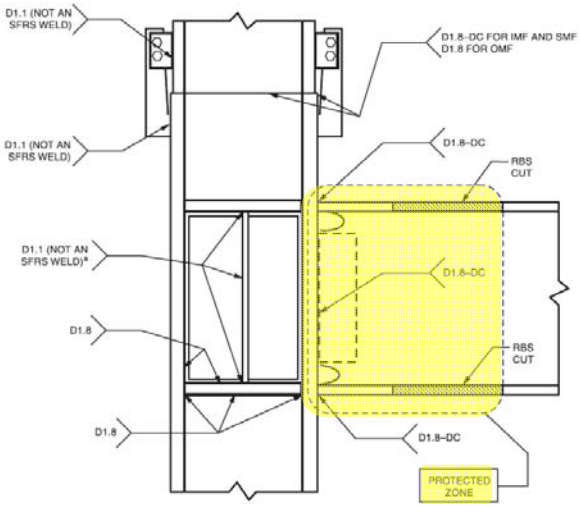

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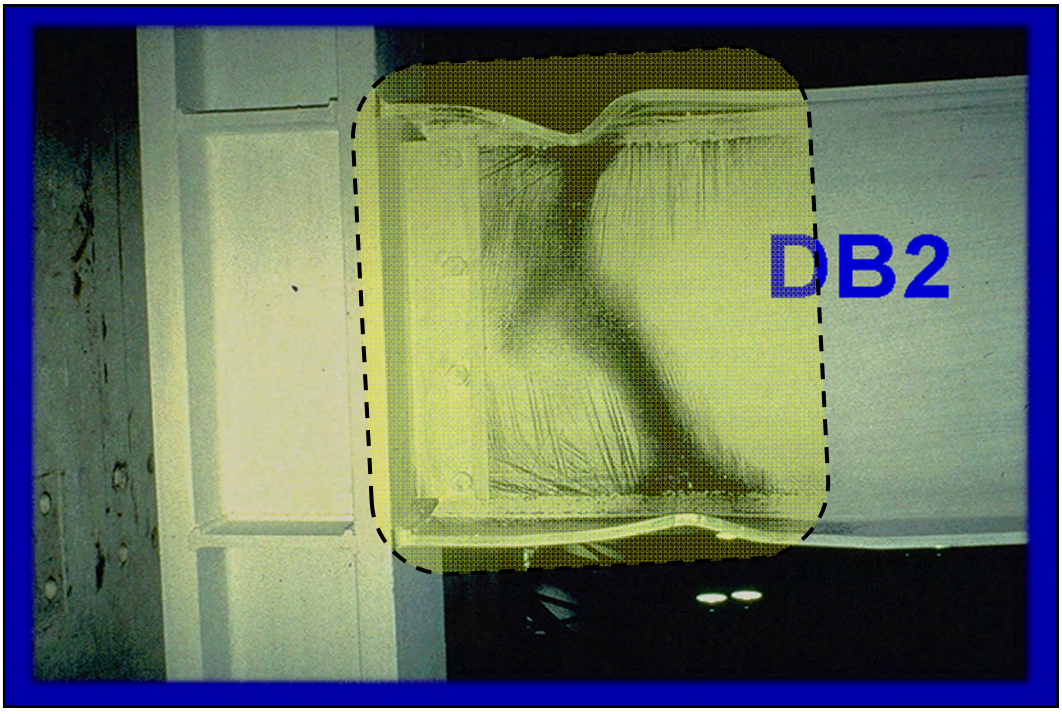
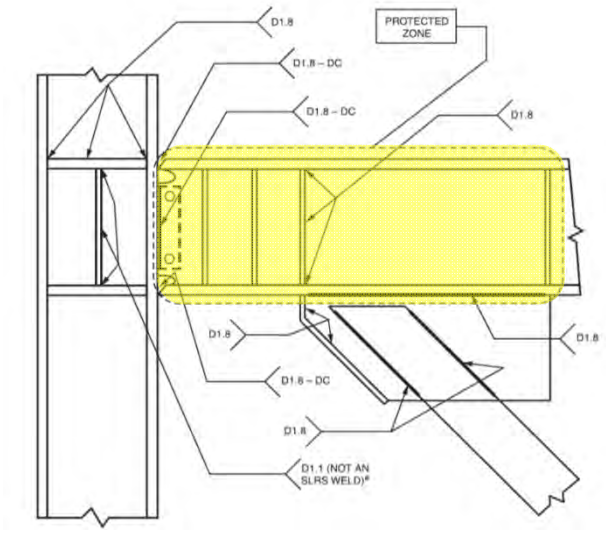


AWS D1.8:2009 Seismic Welding Supplement



145

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1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

(4) Welds designated as "Demand Critical" and subject to specific provisions of this code (see 3.2)

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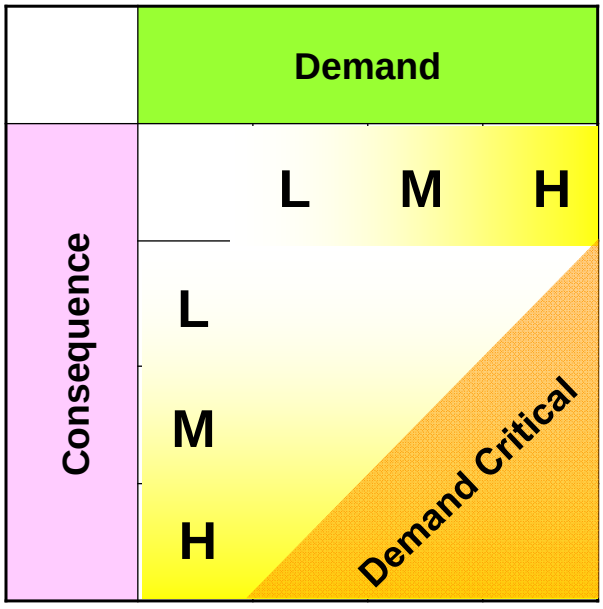
AWS D1.8:2009 Seismic Welding Supplement

3.2 Demand Critical Welds

Welds designated by the Engineer in the Contract Documents, and required to meet specific requirements of this code.

147



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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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AWS D1.8:2009 Seismic Welding Supplement

Welds: part of the SFRS

Table 6.1
Filler Metal Classification Properties

Property	70 ksi [480 MPa] Strength	80 ksi [550 MPa] Strength
Yield Strength, ksi [MPa]	58 [400] min.	68 [470] min.
Tensile Strength, ksi [MPa]	70 [480]min.	80 [550] min.
Elongation (%)	22 min.	19 min.
CVN Toughness, ft·lbf [J]	20 [27] min. @ 0°F [–18°C]	20 [27] min. @ 0°F [–18°C]

20 ft-lbs @ 0ºF

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AWS D1.8:2009 Seismic Welding Supplement

Demand Critical Welds

Table 6.2
Filler Metal Test Properties for Demand Critical Welds

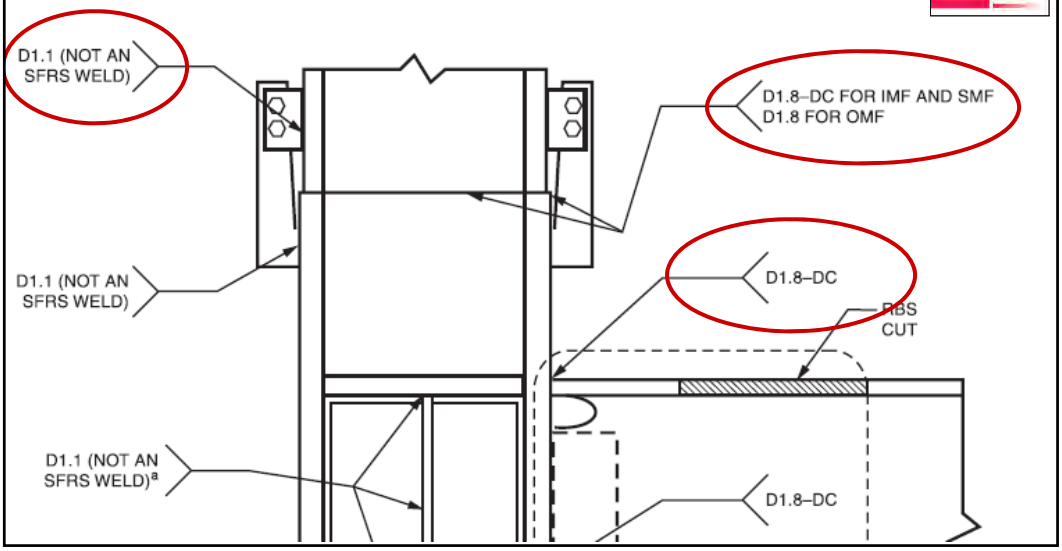
Property	70 ksi [480 MPa] Strength	80 ksi [550 MPa] Strength
Yield Strength, ksi [MPa]	58 [400] min.	68 [470] min.
Tensile Strength, ksi [MPa]	70 [480] min.	80 [550] min.
Elongation (%)	22 min.	19 min.
CVN Toughness, ft-lbf [J][a]	40 [54] min. @ 70°F [20°C]	40 [54] min. @ 70°F [20°C]

[a] For LAST of +50°F [+10°C] (see 6.3.6).

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

DEMAND CRITICAL

AWS D1.8:2009 Seismic Welding Supplement



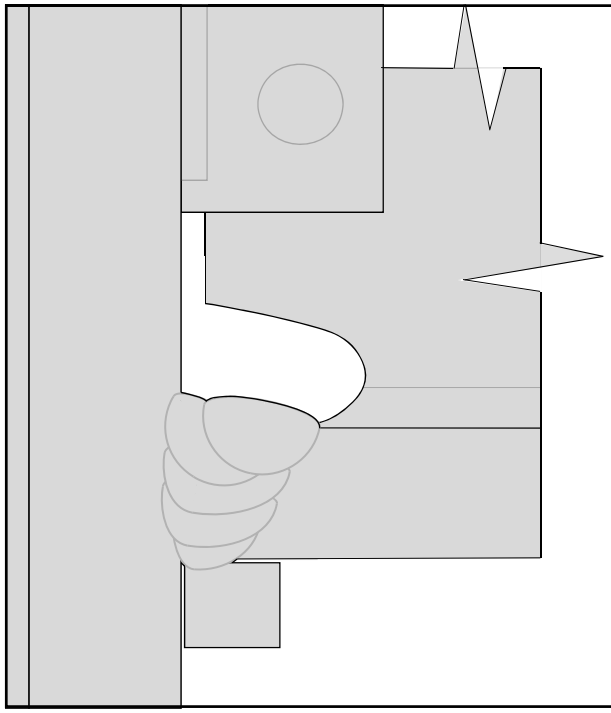
AWS D1.8:2009 Seismic Welding Supplement

1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

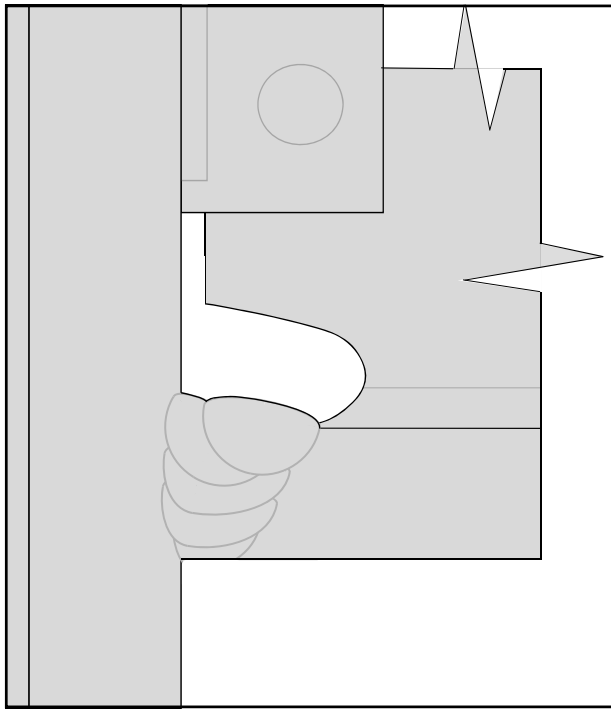
(5) Locations where the removal of backing is required

153



Benefits of Backing Removal

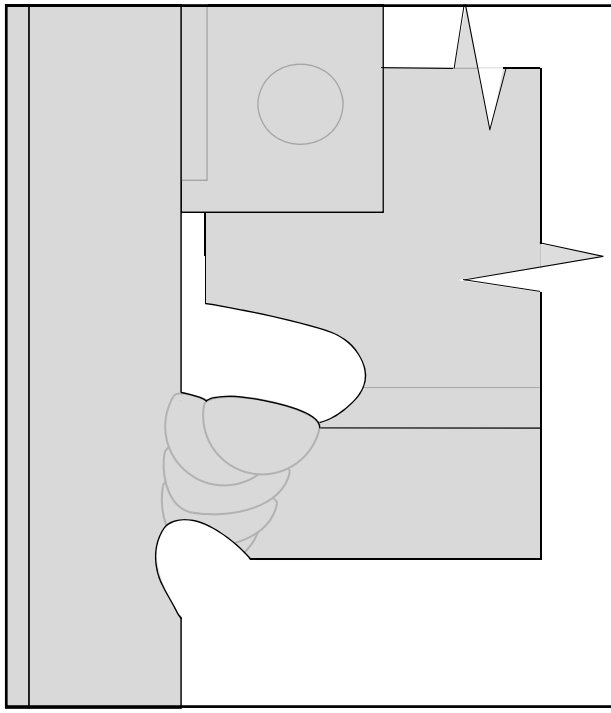
154



Benefits of Backing Removal

- Eliminates notch created by backing

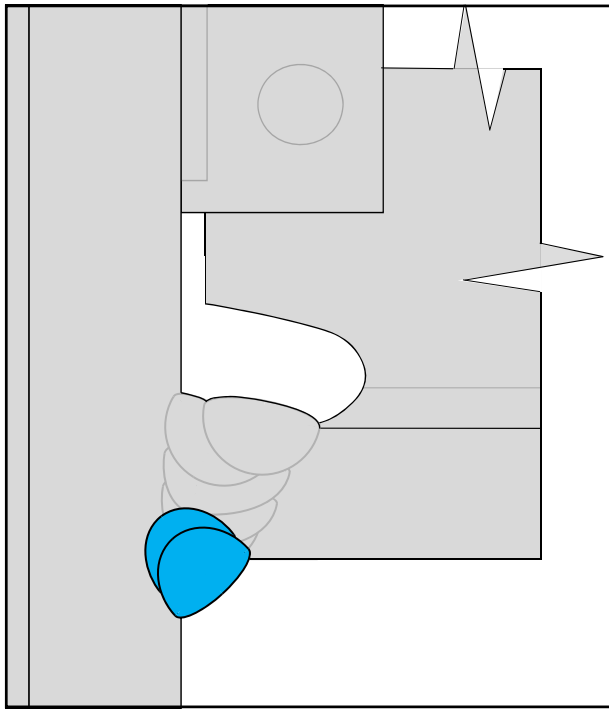
155



Benefits of Backing Removal

- Eliminates notch created by backing
- Eliminates root discontinuities (cracks, incomplete fusion, slag)

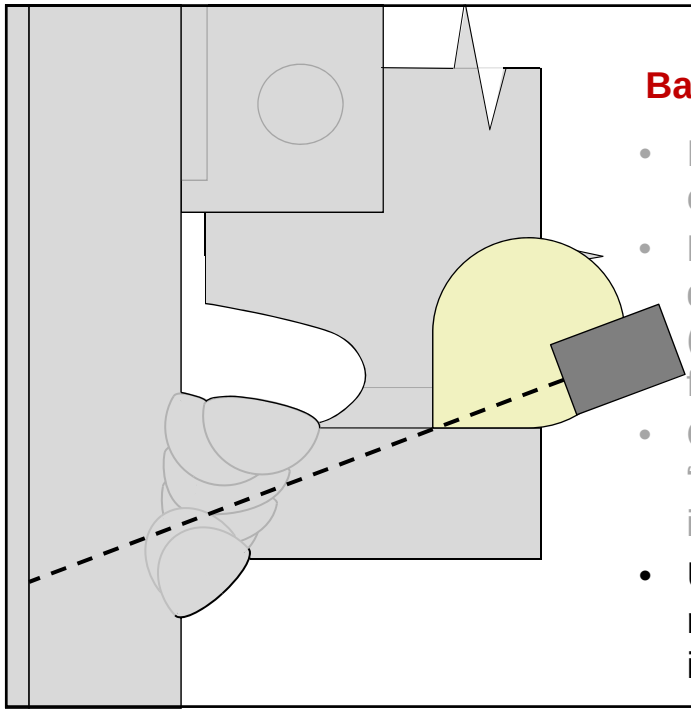
156



Benefits of Backing Removal

- Eliminates notch created by backing
- Eliminates root discontinuities (cracks, incomplete fusion, slag)
- Contouring fillet "softens" the 90º intersection

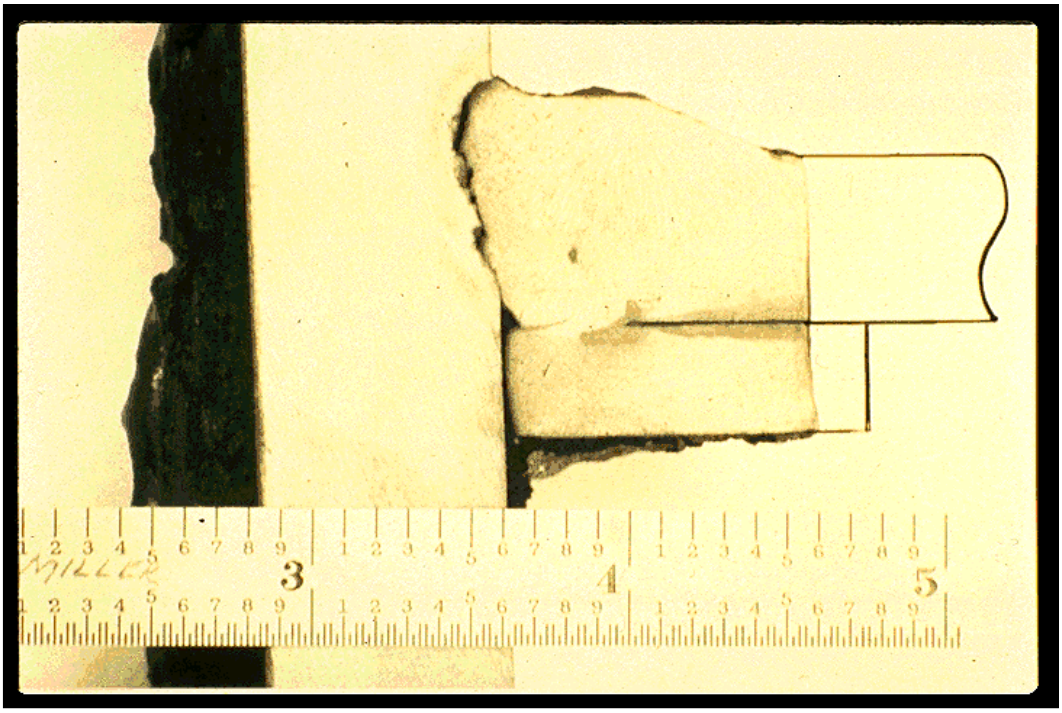
157



Benefits of Backing Removal

- Eliminates notch created by backing
- Eliminates root discontinuities (cracks, incomplete fusion, slag)
- Contouring fillet "softens" the 90º intersection
- UT inspection results are easier to interpret

158



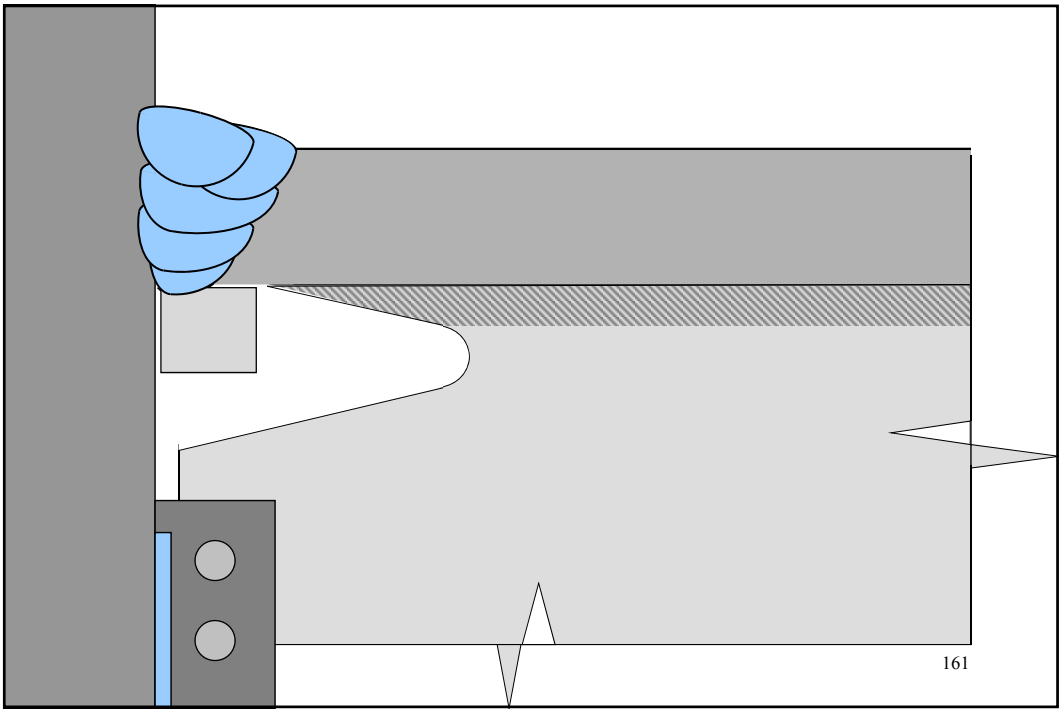
AWS D1.8:2009 Seismic Welding Supplement

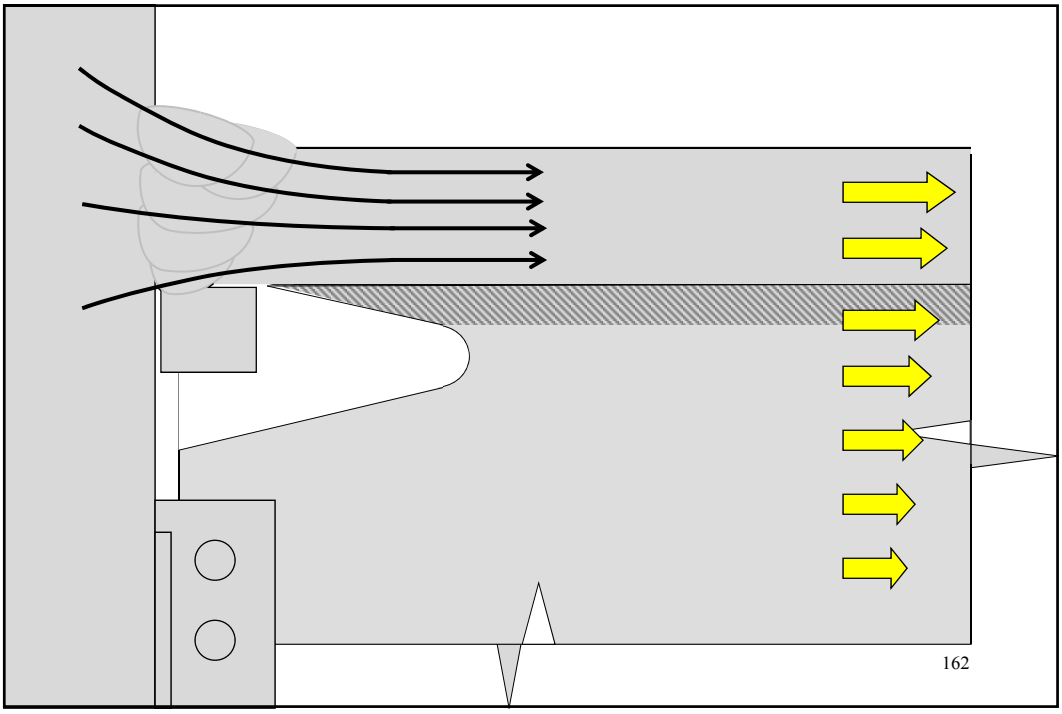
1.2.1 Engineer's Responsibilities.

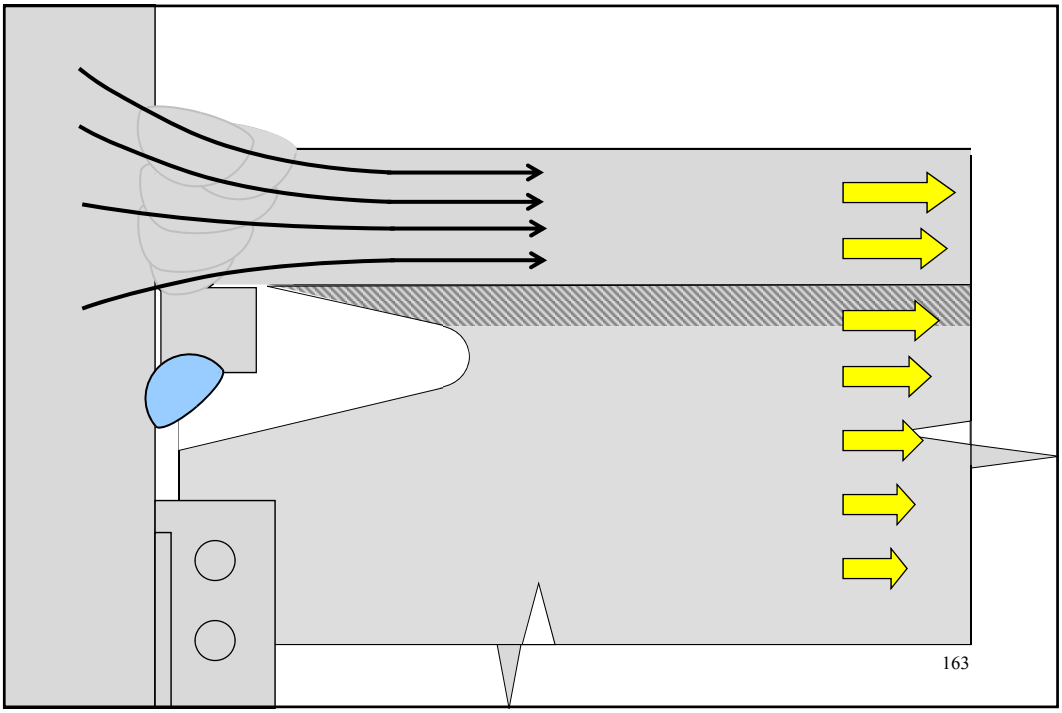
In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

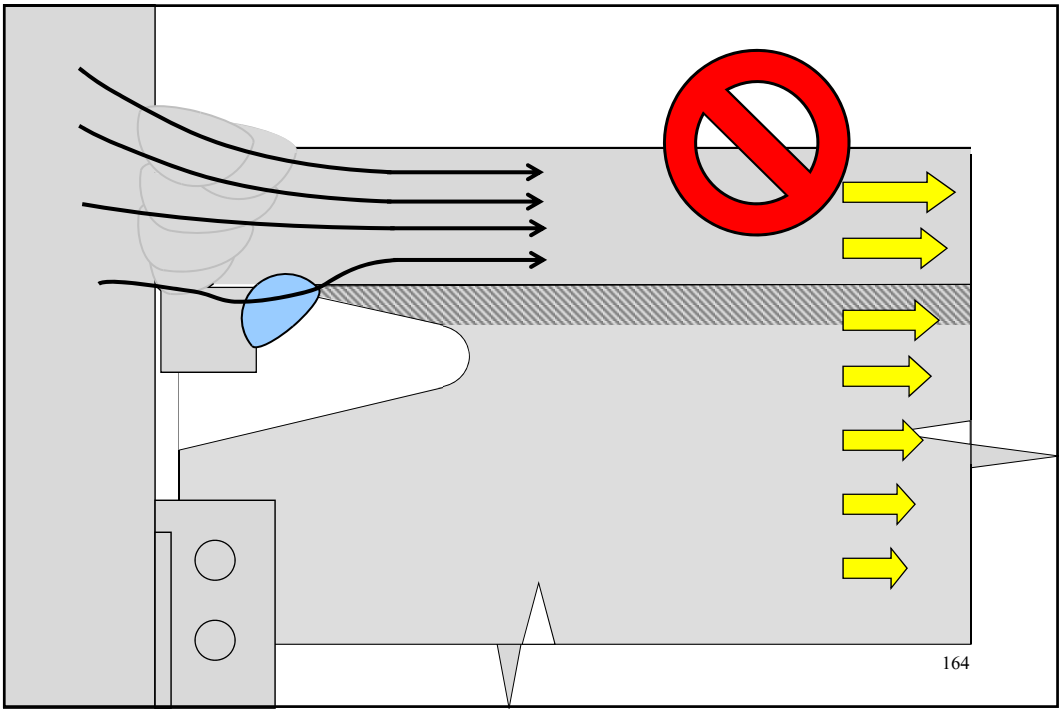
(6) Locations where fillet welds are required when backing is permitted to remain (see 6.9)

160









AWS D1.8:2009 Seismic Welding Supplement

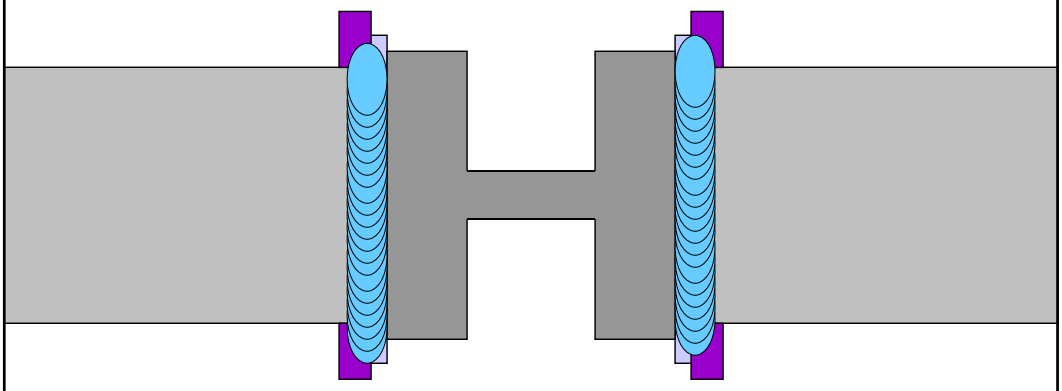
1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

(7) Locations where the removal of weld tabs is required

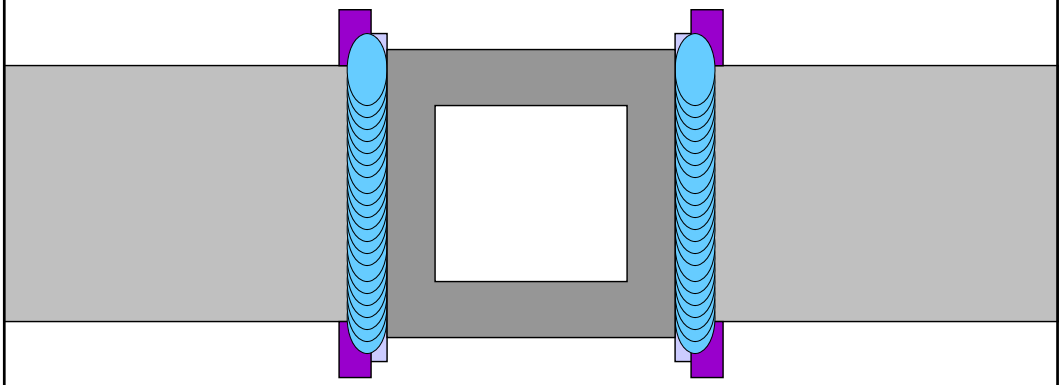
165

Weld Tabs



166

Weld Tabs



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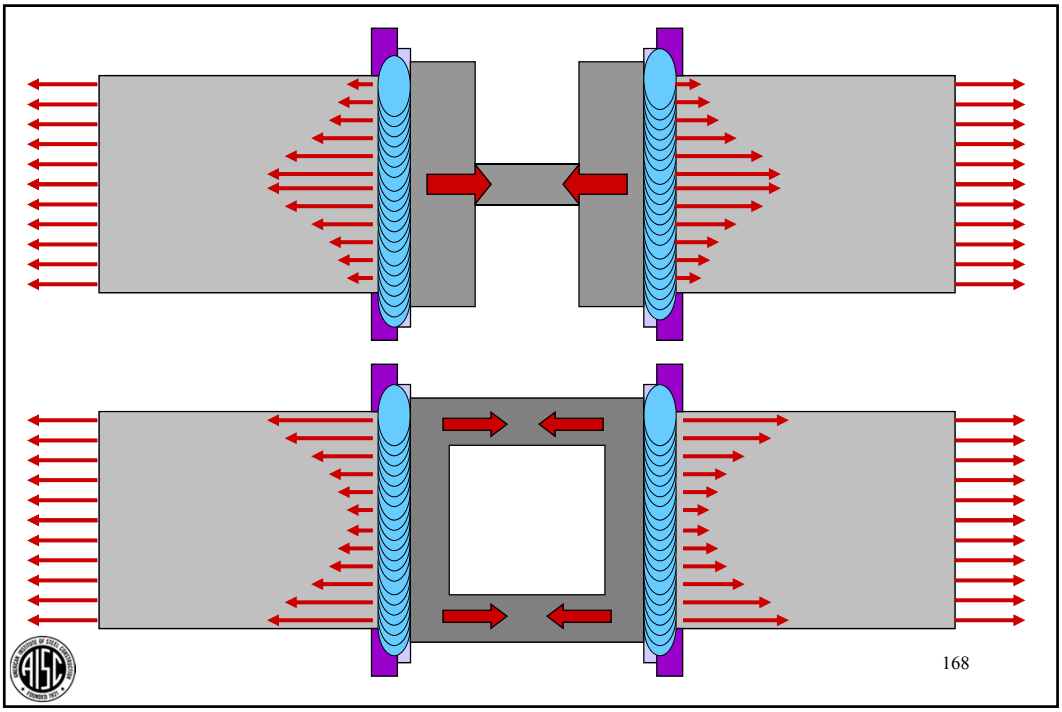

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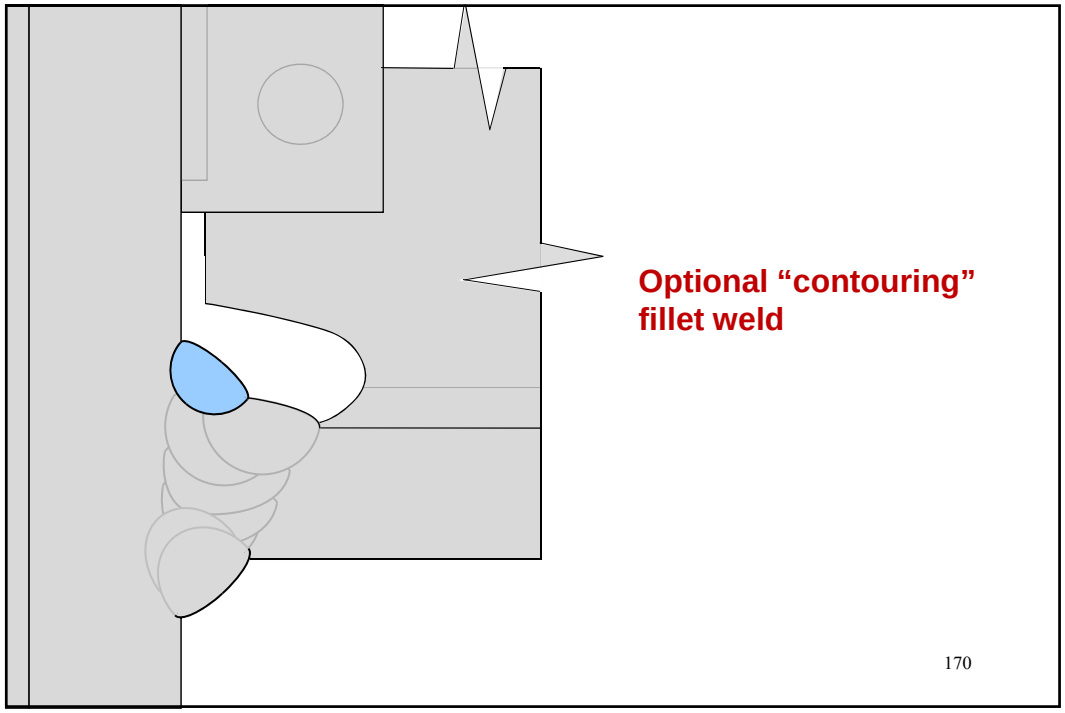
AWS D1.8:2009 Seismic Welding Supplement

1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

(8) Locations where fillet welds are required to reinforce groove welds, or to improve connection geometry

169



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AWS D1.8:2009 Seismic Welding Supplement

1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

(9) Locations of access holes and the required shape, whether standard AWS D1.1/D1.1M geometry, standard alternate geometry or a special geometry designated by the Engineer

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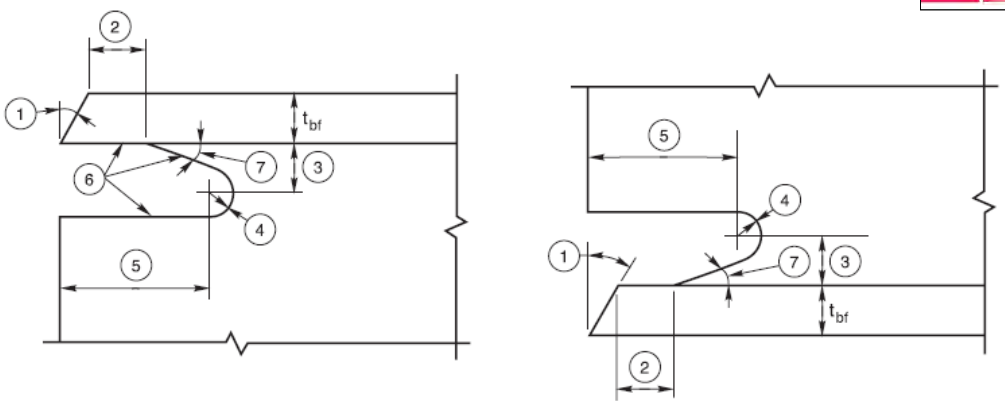
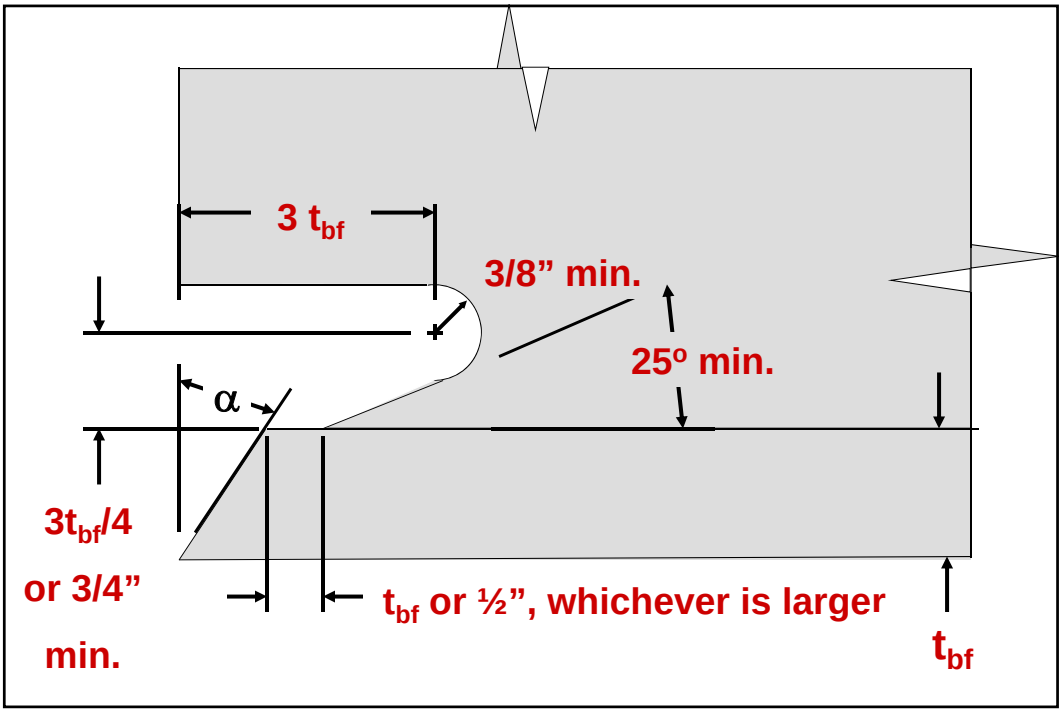
AWS D1.8:2009 Seismic Welding Supplement



172



AWS D1.8:2009 Seismic Welding Supplement

1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

(10) The Lowest Anticipated Service Temperature (LAST) of the steel structure for structures that are not normally enclosed and maintained at a temperature of 50°F [10°C] or higher (see 3.5 and 6.3.6)

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AWS D1.8:2009 Seismic Welding Supplement

3.5 Lowest Anticipated Service Temperature (LAST).

The lowest 1 hour average temperature with a 100 year mean recurrence interval.

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AWS D1.8:2009 Seismic Welding Supplement

1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

(11) Butt joints subject to tension where tapered transitions are required (see 4.2)

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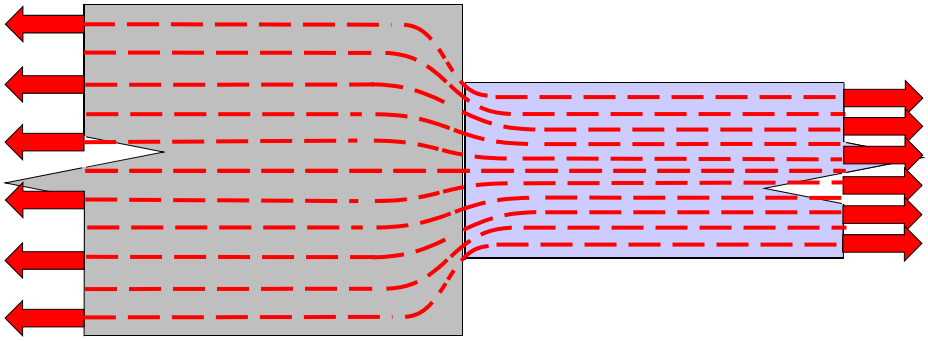
Details of Butt Joints

Butt Joint—different widths, same thickness



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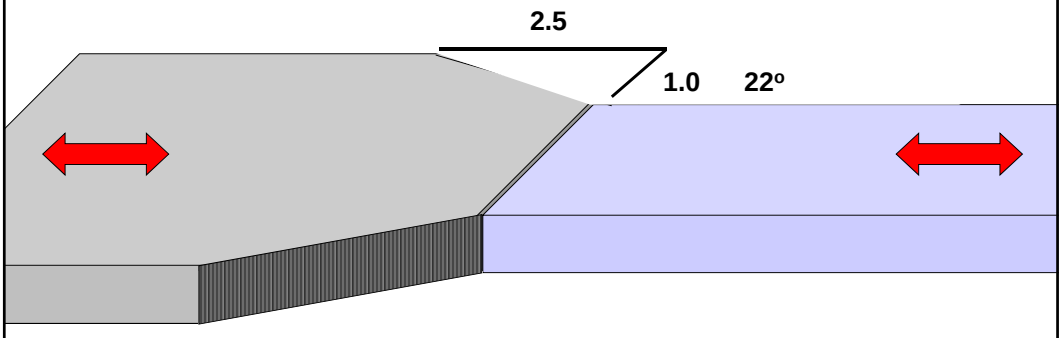
AWS D1.1:2010 Structural Welding Code--Steel

Butt Joint—different widths

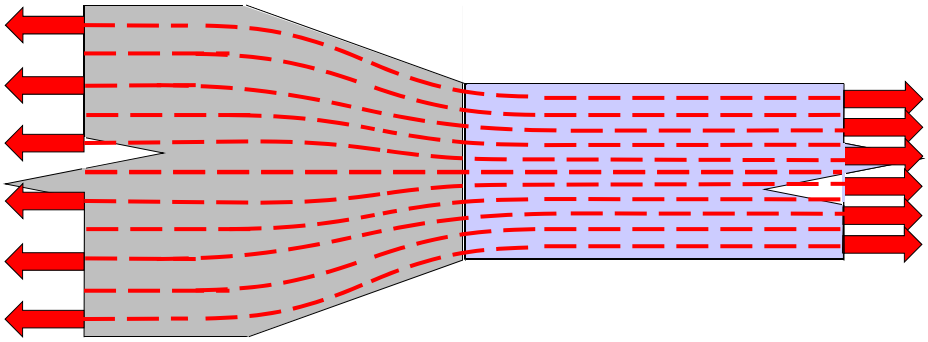


2.17.1.2 Provide transition for cyclically loaded members with width changes.

178

Details of Butt Joints

Butt Joint—different widths, same thickness



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AWS D1.8:2009 Seismic Welding Supplement

1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

(12) Those joints or groups of joints in which a specific assembly order, welding sequence, welding technique, or other special precautions are required (see AWS D1.1/D1.1M subclauses 2.2.3 and 5.21)

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AWS D1.8:2009 Seismic Welding Supplement

1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

(13) Quality Assurance Plan (QAP) for the project (see 3.4 and 7.1)

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AWS D1.8:2009 Seismic Welding Supplement

1.2.1 Engineer's Responsibilities.

In addition to the items listed in AWS D1.1/D1.1M, the Engineer shall provide the following information in the Contract Documents:

(14) Any additional provisions applicable to the specific project not governed by AWS D1.1/D1.1M or this code.

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Welded Connections for Seismic Service

OUTLINE: D1.8 Seismic Welding Supplement

- Overview
- Engineer's Responsibilities
- Heat Input Testing
- Restricted Access Welder Qualification
- Workmanship Details

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AWS D1.8:2009 Seismic Welding Supplement

Annex A (Normative)

WPS Heat Input Envelope Testing of Filler Metals for Demand Critical Welds

This annex is part of AWS D1.8/D1.8M:2009, *Structural Welding Code—Seismic Supplement*, and includes mandatory elements for use with this standard.

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

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 E70 filler metals shall conform either to ASTM A 36, A 572 Grade 50, or A 992. Plates for qualification of E80 filler metals shall conform to either ASTM A 36, A 572 Grade 50, ASTM A 572 Grade 65, or A 913 Grade 65, at the Contractor's option. Steel backing shall be of one of the five specifications and grades listed above, but need not be the same as the base

Heat Input

$$H = \frac{60EI}{1000S}$$

where

H = heat input in KJ/in [KJ/mm]
E = arc voltage
I = current (amps)
S = travel speed in inches/minute (mm/minute)

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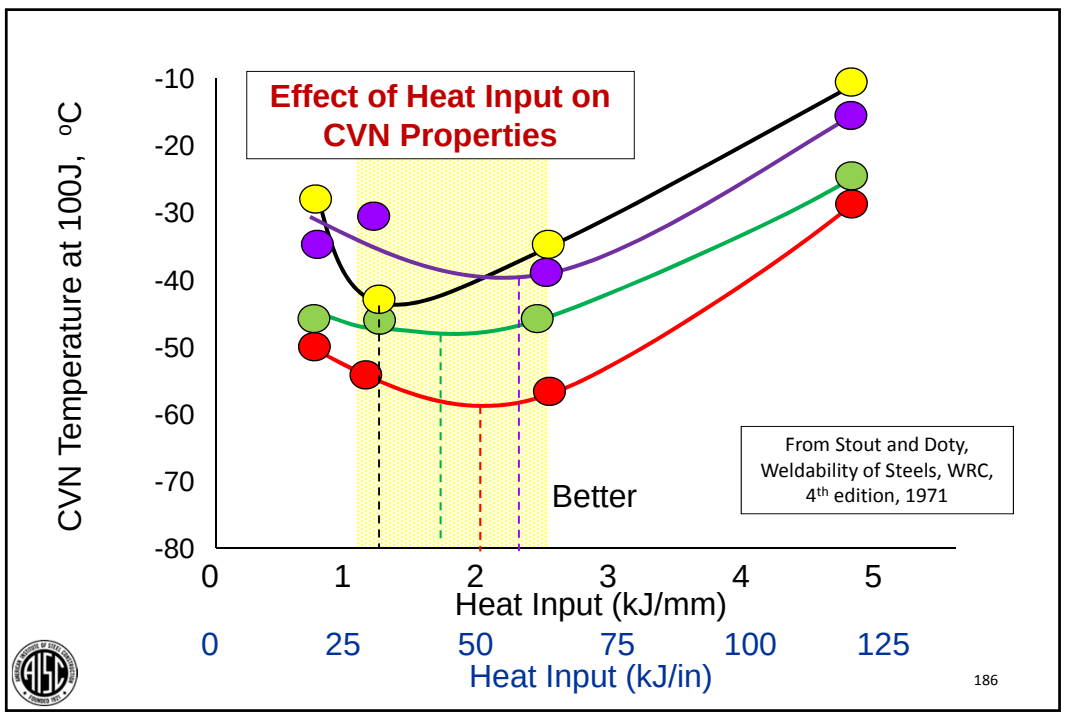

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AWS D1.8:2009 Seismic Welding Supplement

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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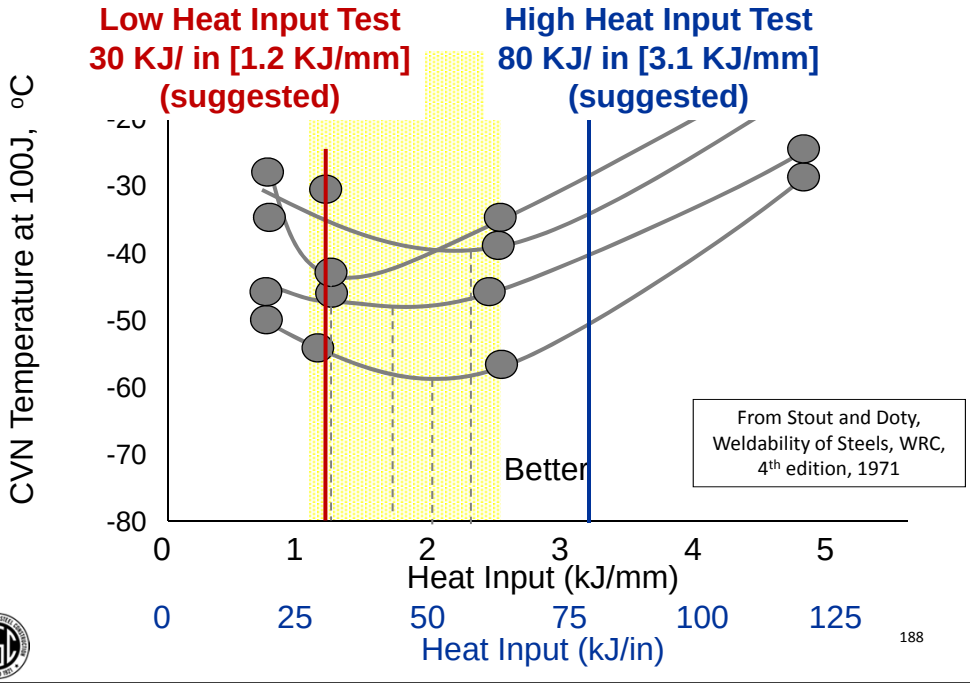

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Welded Connections for Seismic Service

OUTLINE: D1.8 Seismic Welding Supplement

- Overview
- Engineer's Responsibilities
- Heat Input Testing
- Restricted Access Welder Qualification
- Workmanship Details

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AWS D1.8:2009 Seismic Welding Supplement

Annex D (Normative)

Supplemental Welder Qualification for Restricted Access Welding

This annex is part of AWS D1.8/D1.8M:2009, *Structural Welding Code—Seismic Supplement*, and includes mandatory elements for use with this standard.

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.

the deposition rate used in the qualification test is equal to or greater than the highest deposition rate that will be used in production.

D3.1.3 Weld Passes and Interpass Requirements. The welder shall make all weld passes required to complete the assembly, and shall clean his or her own welds. The welder shall measure the interpass temperature to ensure compliance with the WPS.

D3.1.4 Test Specimen Preparation. The location of the web plate shall be clearly identified on the [illegible] plate so that, when the web plate is removed, the previous ori-

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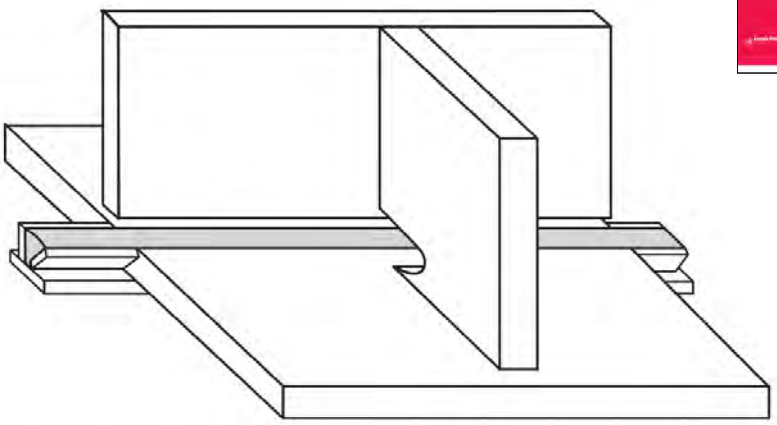

Notes:
1. The web location shall be marked on the test plates prior to disassembling the test configuration (see D3.1.4).
2. The web plate shall be centered on the test plate.

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

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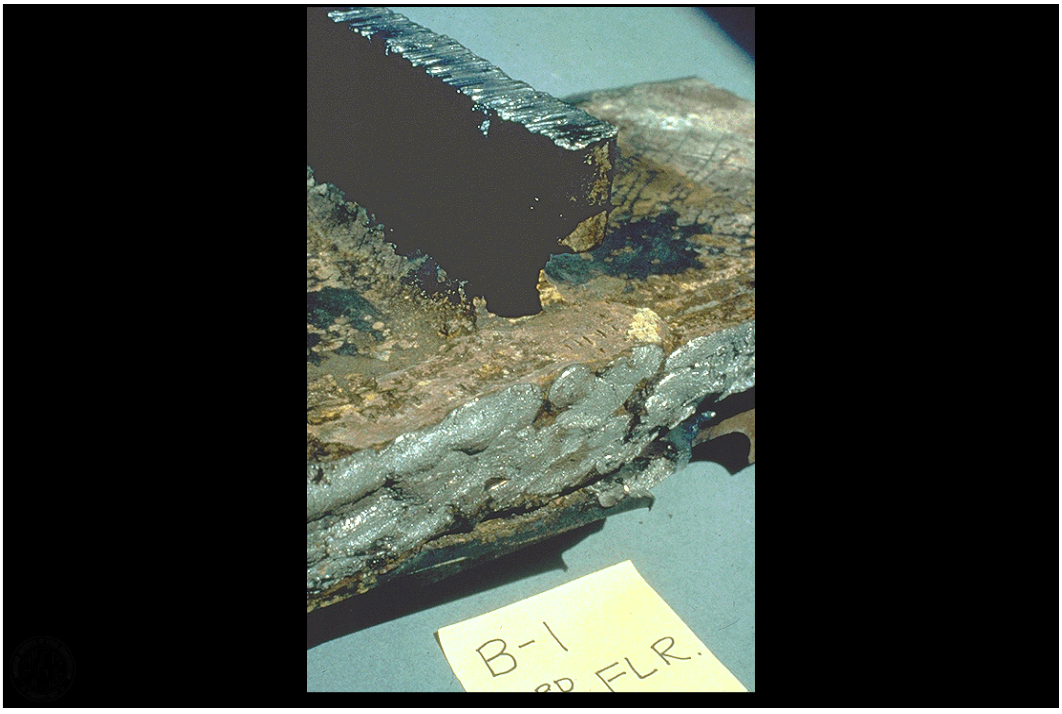

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D3.1.2 Welding Procedure Specification.

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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Welded Connections for Seismic Service

OUTLINE: D1.8 Seismic Welding Supplement

- Overview
- Engineer's Responsibilities
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6.11.1 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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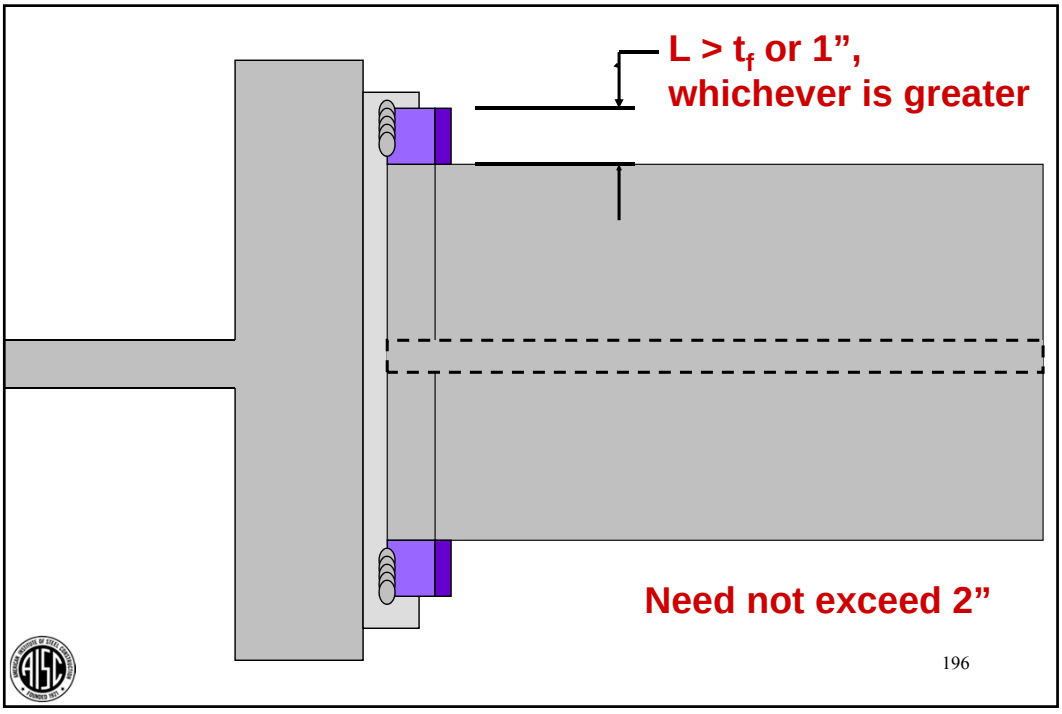

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6.6 Tack Welds to Steel Backing in the Protected Zone

Tack welds between backing and the beam flange outside the weld joint shall be prohibited. Tack welds that attach steel backing to groove welds in the Protected Zone shall be placed within the weld joint, when practicable, with the following exceptions: steel backing may be tack welded to columns for beam to column welds.

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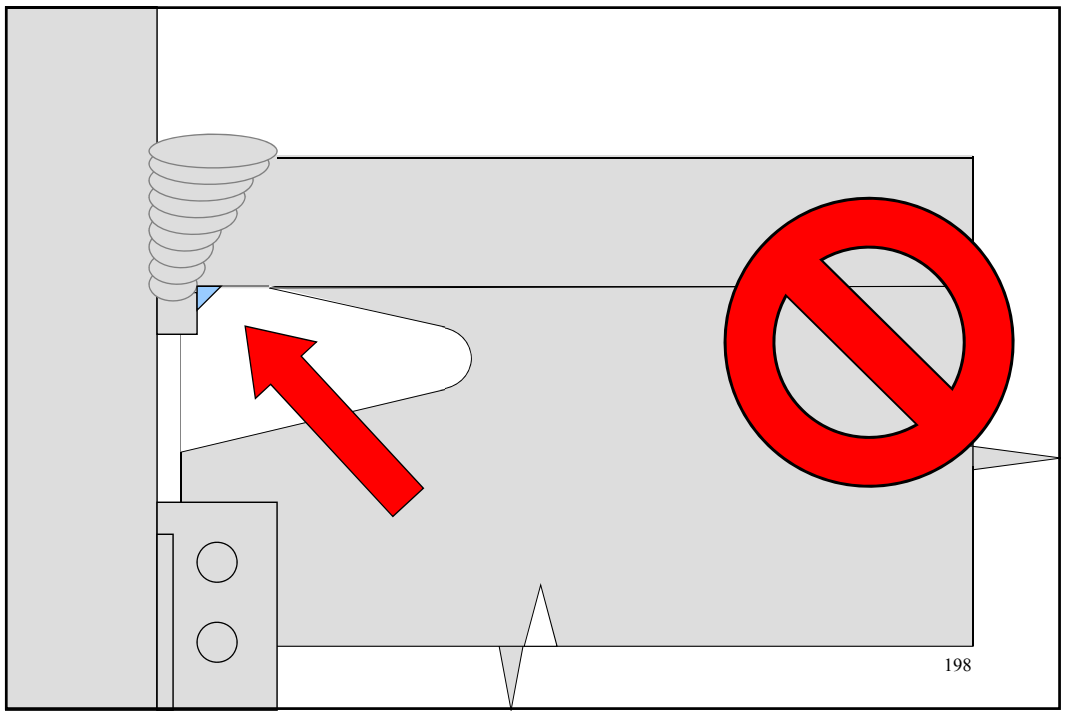

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AWS D1.8:2009 Seismic Welding Supplement

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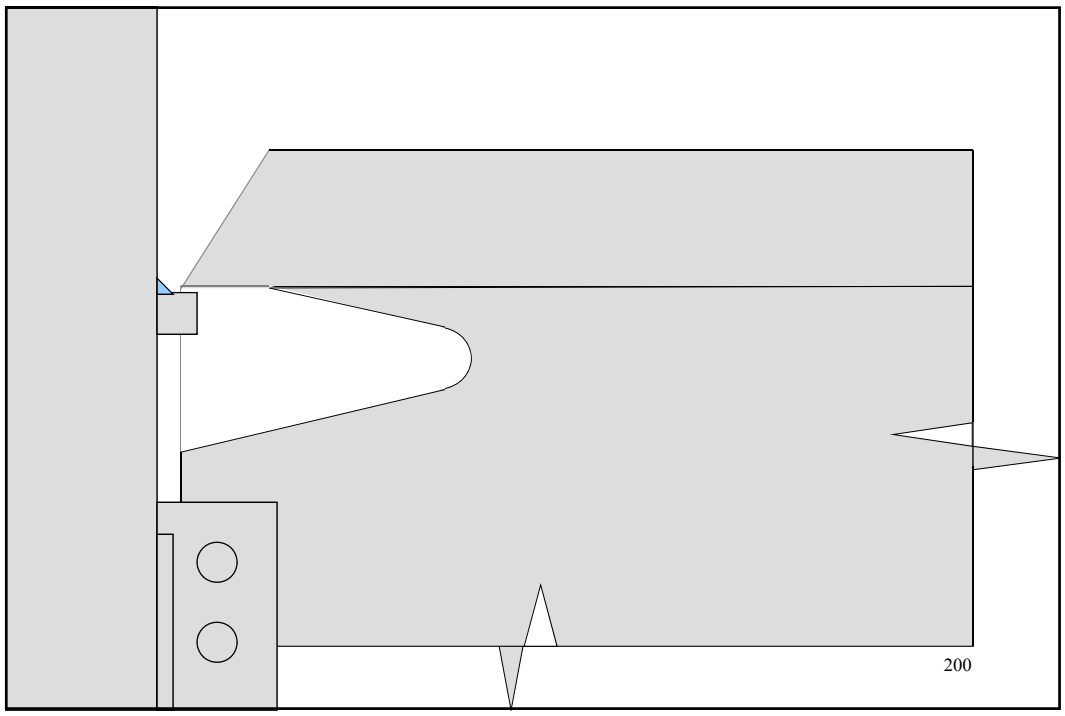
199



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6.15 Protected Zone

6.15.1 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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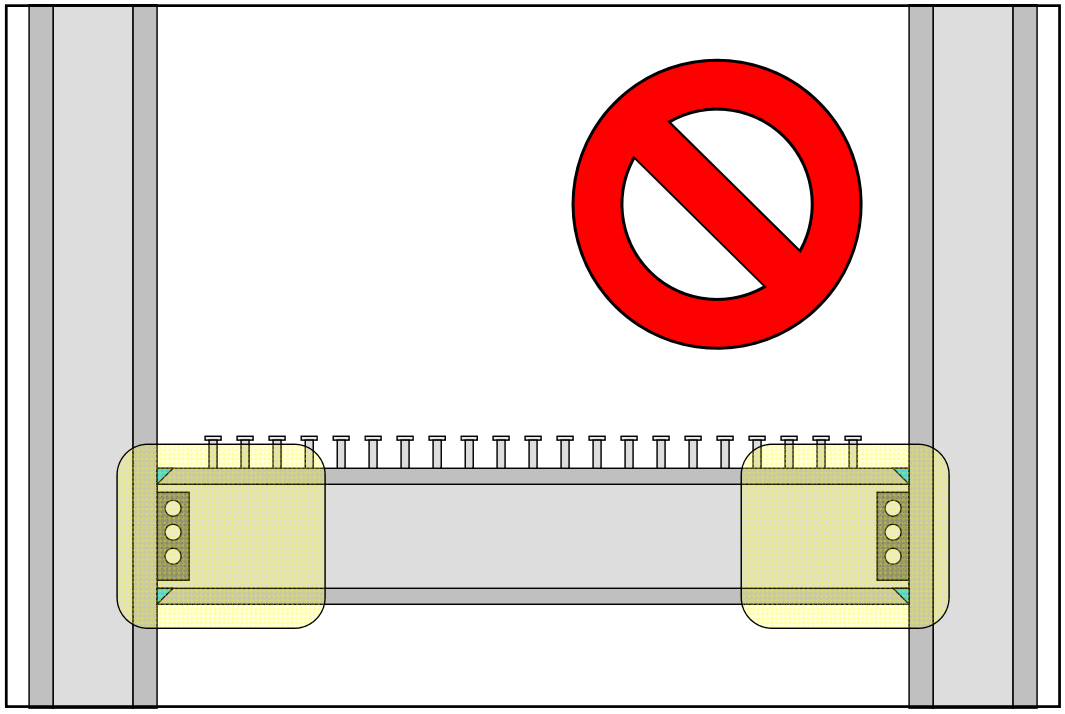

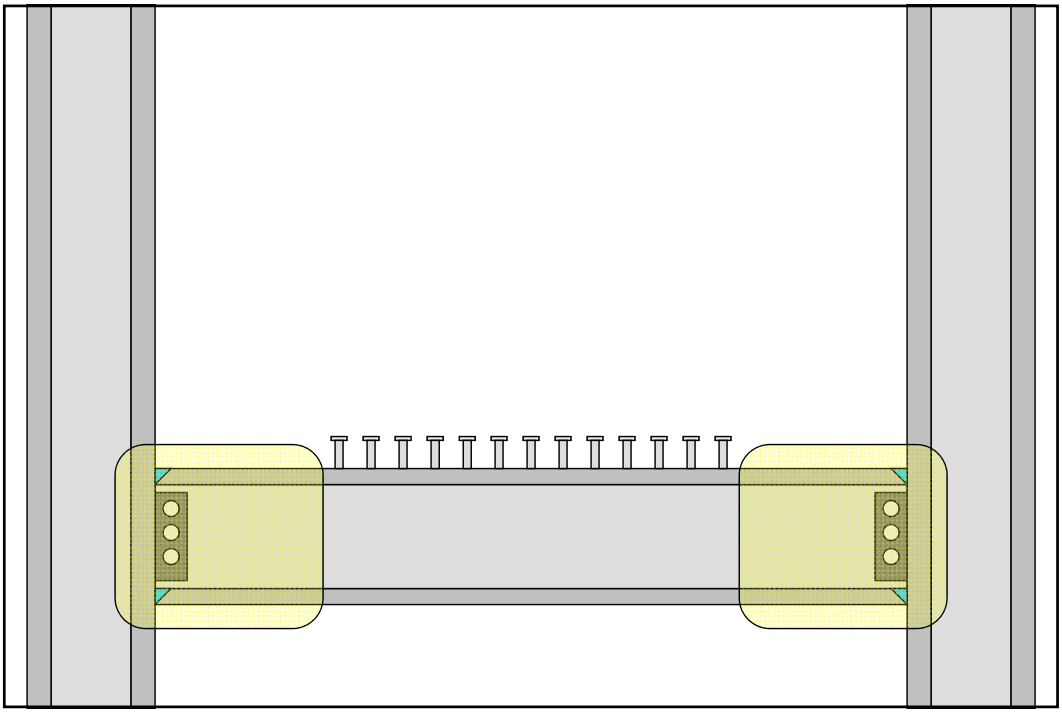

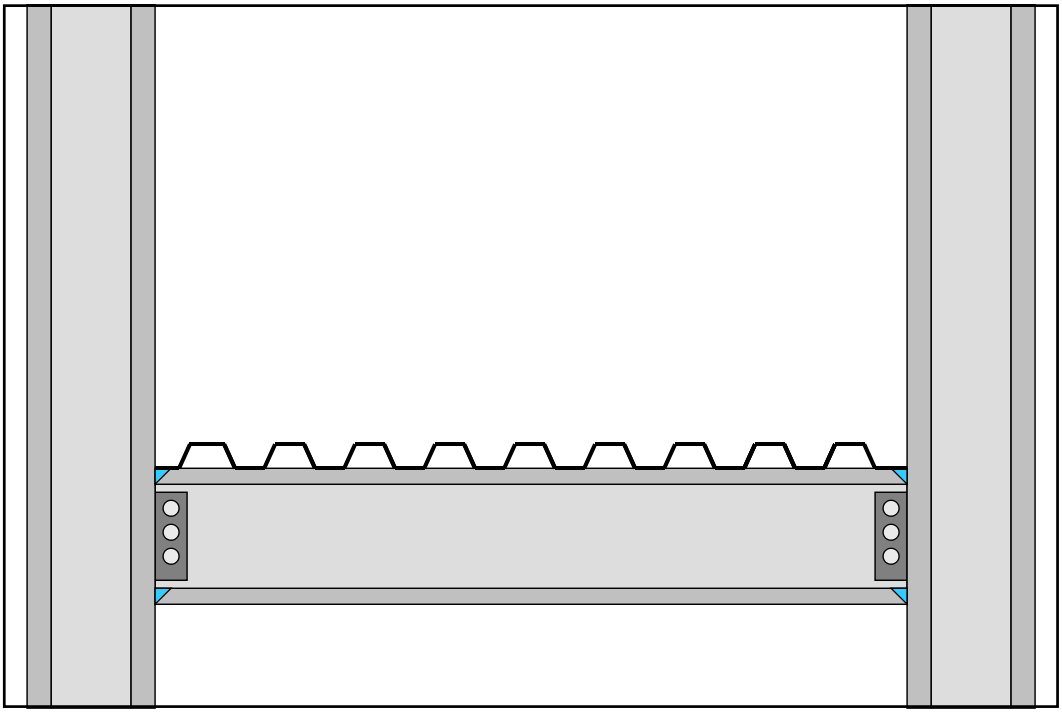

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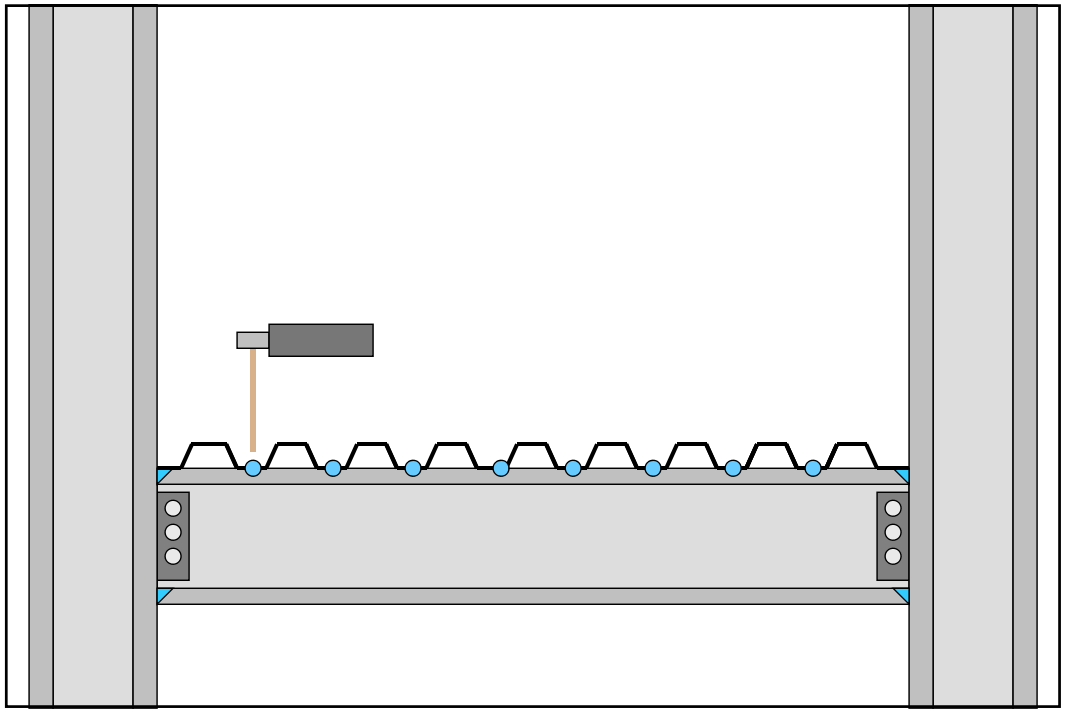

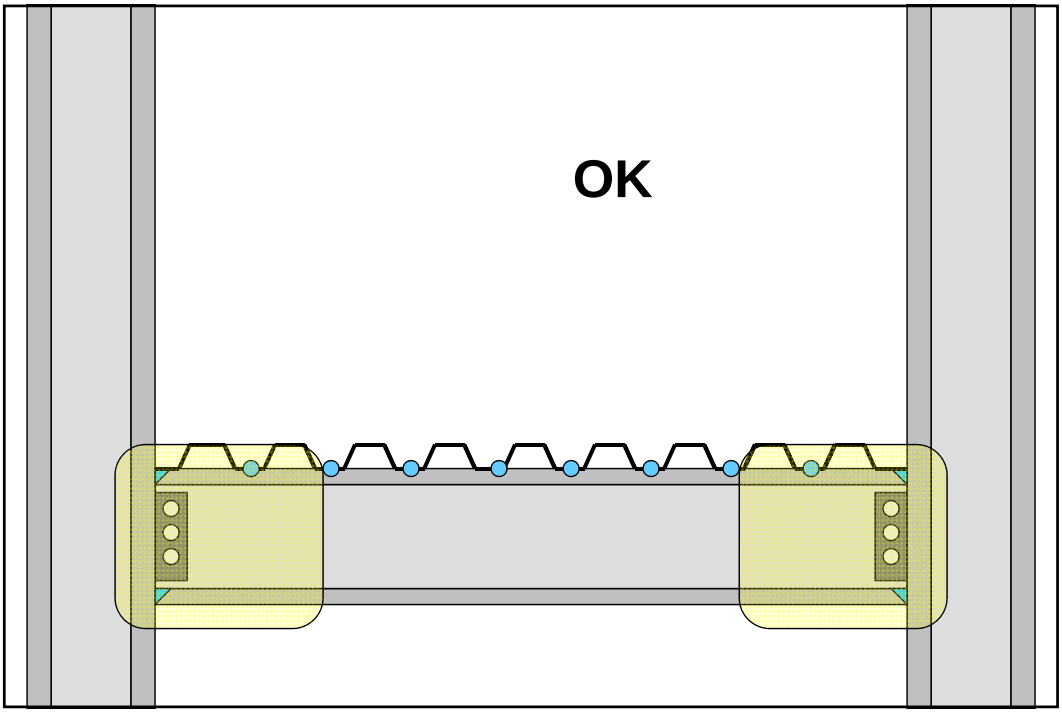

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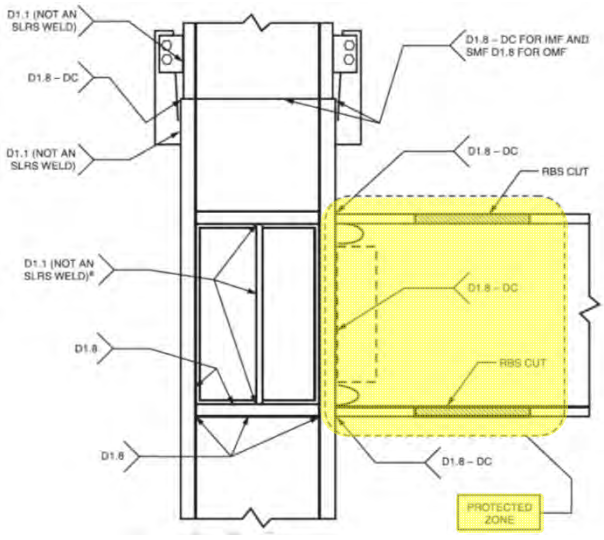

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6.15 Protected Zone (cont'd)

6.15.2 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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Welded Connections for Seismic Service

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- Overview
- Engineer's Responsibilities
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Welded Connections for Seismic Service

OUTLINE

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

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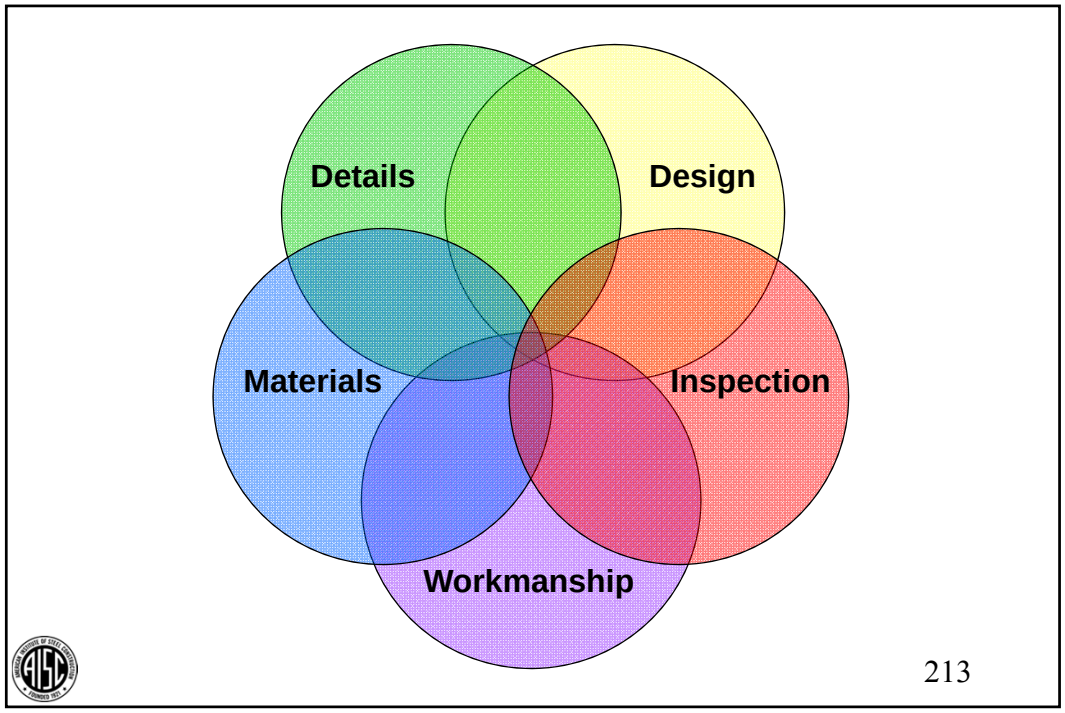

Ductile Design of Steel Structures

Bruneau
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Whittaker

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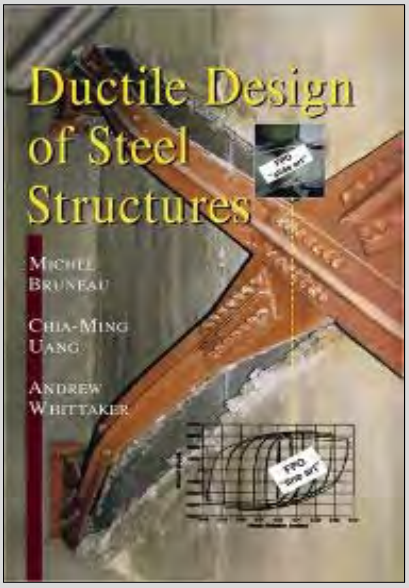

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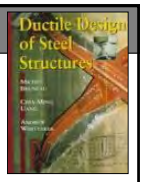
Ductile Design of Steel Structures



Preface

"Many practicing engineers have wrongly believed for years that the ductile nature of the structural steel material directly translates into inherently ductile structures."

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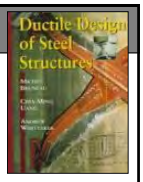
Ductile Design of Steel Structures



Chapter 1 Introduction

"However, there are many situations in which an explicit approach to the design of ductile steel structures is necessary because the inherent material ductility alone is not sufficient to provide the desired ultimate performance."

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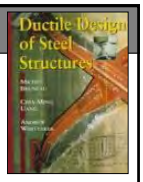
Ductile Design of Steel Structures



Chapter 1 Introduction

"To achieve this ductile response, one must recognize and avoid conditions that may lead to brittle failures and adopt appropriate design strategies to allow for stable and reliable hysteretic energy-dissipation mechanisms. This sort of thinking is relatively new in structural engineering."

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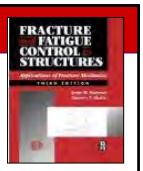
Fatigue and Fracture Control in Structures



Most structural materials exhibit considerable strain (deformation) before reaching the tensile or ultimate strength…However, under conditions of low temperature, rapid loading and/or high constraint (e.g., when the principle stresses σ_1, σ_2, and σ_3 are essentially equal), even ductile materials may not exhibit any deformation before fracture.

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Welded Connections for Seismic Service

OUTLINE

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

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Welded Connections for Seismic Service

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PDH Certificates

Within 2 business days…

- Reporting site (URL will be provided in the forthcoming email).
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PDH Certificates

One certificate will be issued at the conclusion of all 3 sessions.

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PROFESSIONAL DEVELOPMENT HOURS – If you watch a recorded session you must take quiz for PDHs.
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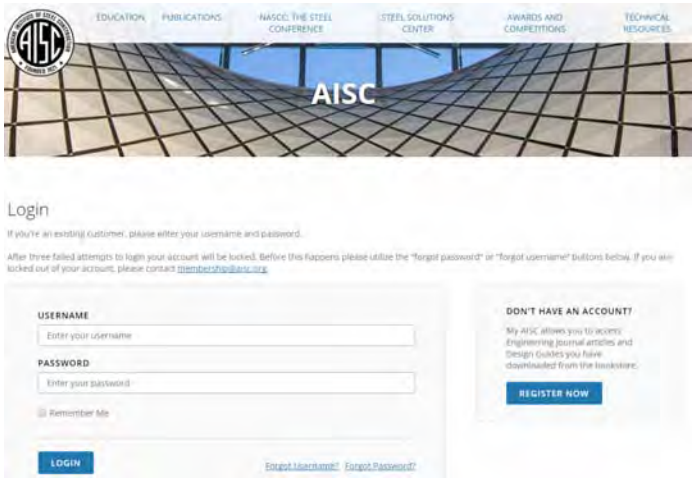

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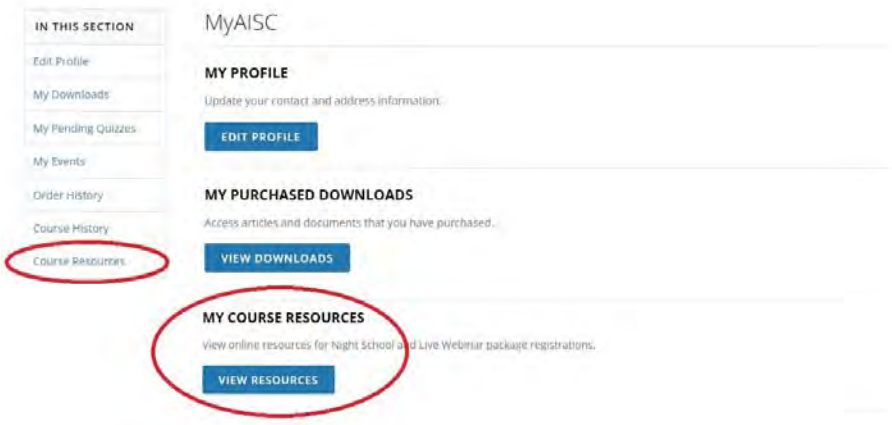

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Course Resources

Course Resources

Event	Start Date
Live Webinar - 3-Session Package: Welded Connections - A Three-Part Webinar Series	6/29/2017 1:30:00 PM
NS 14 8-Session Package-Night School 14 - Fundamentals of Stability	6/5/2017 7:00:00 PM
NS 13 8-Session Package-Night School 13 - Design of Industrial Buildings	1/30/2017 7:00:00 PM

3-Session Package Registrants
Course Resources

Welded Connections

3-SESSION PACKAGE RESOURCES

Event	Date	Handouts	Video	Quiz	Attendance
Part 1: Fundamentals of Welded Connections	Jun 29 2017 1:30PM EDT	Handouts	Available 07/01/2017 5pm EDT	Available 07/01/2017 5pm EDT	Pending
Part 2: Welded Connections for Seismic Service	Jul 6 2017 1:30PM EDT	Handouts	Available 07/08/2017 5pm EDT	Available 07/08/2017 5pm EDT	Pending
Part 3: Special Welding Applications and Field Fixes	Jul 13 2017 1:30PM EDT	Handouts	Available 07/15/2017 5pm EDT	Available 07/15/2017 5pm EDT	Pending

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EMAIL COMES FROM WEBINARS@AISC.ORG

All Registrants

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Webinar connection information:

- Can be found in your confirmation/registration receipt
- Reminder sent out Wednesday afternoon

Link to handouts also found here