The Ultimate Civil PE Review Course

Construction – Depth

CEA

Construction - Depth

I. Earthwork Construction and Layout (10%)
- A. Excavation and embankment (cut and fill)
- B. Borrow pit volumes
- C. Site layout and control
- D. Earthwork mass diagrams

II. Estimating Quantities and Costs 17.5%
- A. Quantity take-off methods
- B. Cost estimating
- C. Engineering economics
  - 1. Value engineering and costing

III. Construction Operations and Methods 15%
- A. Lifting and rigging
- B. Crane selection, erection, and stability
- C. Dewatering and pumping
- D. Equipment production
- E. Productivity analysis and improvement
- F. Temporary erosion control

IV. Scheduling 17.5%
- A. Construction sequencing
- B. CPM network analysis
- C. Activity time analysis
- D. Resource scheduling
- E. Time-cost trade-off

V. Material Quality Control and Production 10%
- A. Material testing (e.g., concrete, soil, asphalt)
- B. Welding and bolting testing
- C. Quality control process (QA/QC)
- D. Concrete mix design

VI. Temporary Structures 12.5%
- A. Construction loads
- B. Formwork
- C. Falsework and scaffolding
- D. Shoring and reshoring
- E. Concrete maturity and early strength evaluation
- F. Bracing
- G. Anchorage
- H. Cofferdams (systems for temporary excavation support)
- I. Codes and standards

  [e.g., American Society of Civil Engineers (ASCE 37), American Concrete Institute (ACI 347), American Forest and Paper Association-NDS, Masonry Wall Bracing Standard]

VII. Worker, Health 7.5%

VIII. Other Topics 10%

→ "The knowledge areas here are not exclusive or exhaustive…" NCEES

V. Material Quality Control and Production

C. Quality Control Process (QA/ QC)

Quality: "The fulfillment of a series of actions and considerations during an engineering project" (As per AASTHO/ FHWA)

Quality Assurance: "All planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in its role (As per AASTHO/ FHWA)

Aspects falling under the umbrella of Quality Assurance:

- Quality Control
- Third Party Assessment
- Acceptance

Activities in a QA/QC program:

- Inspections
- Testing

Processes & Procedures in a QA/QC Program:

- Tracking
- Documentation
- Analysis

V. B. Welding and Bolting Testing

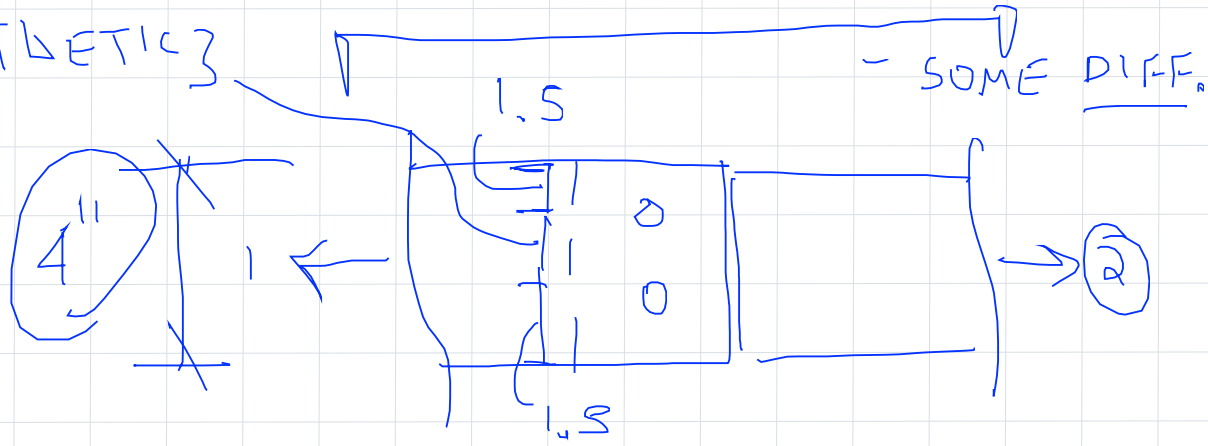
Welding is the process of fusing two metal pieces under the action of heat, with or without the contribution of metal material, in order to create a connection between the pieces. (Ref. Steel Structures by Nunziata & Richardson)

Advantages of Welding:

- NO NET LOSS OF SXN
- CAN BE CHEAPER
- LESS SPACE
- AESTHETICS

Disadvantages:

- SKILLED WELDERS
- TESTING
- SOME DIFF.

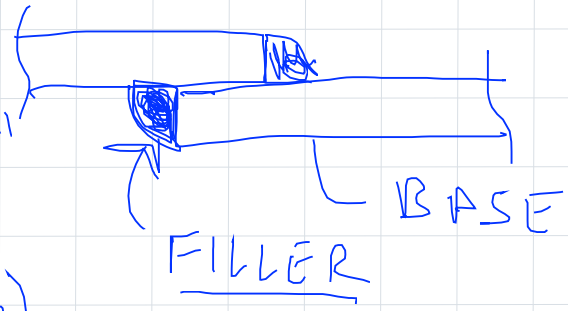


Process of Welding requires:

- Base Metal
- Filler Material
- Heat Source
- Protection of Weld Pool

Processes:

- Oxy-Acetylene (not common structurally)
- Shielded metal-arc welding (SMAW)
- Submerged arc welding (SAW)
- Gas-shielded metal arc welding (GMAW)
- Tungsten inert gas welding (TIG)

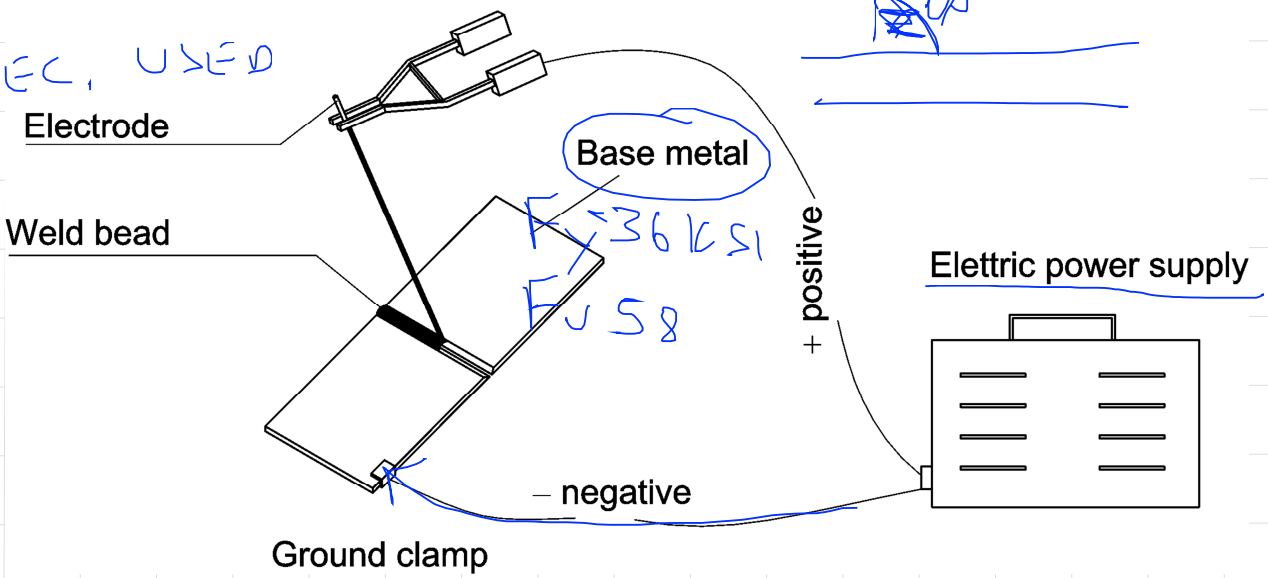


"STOP"

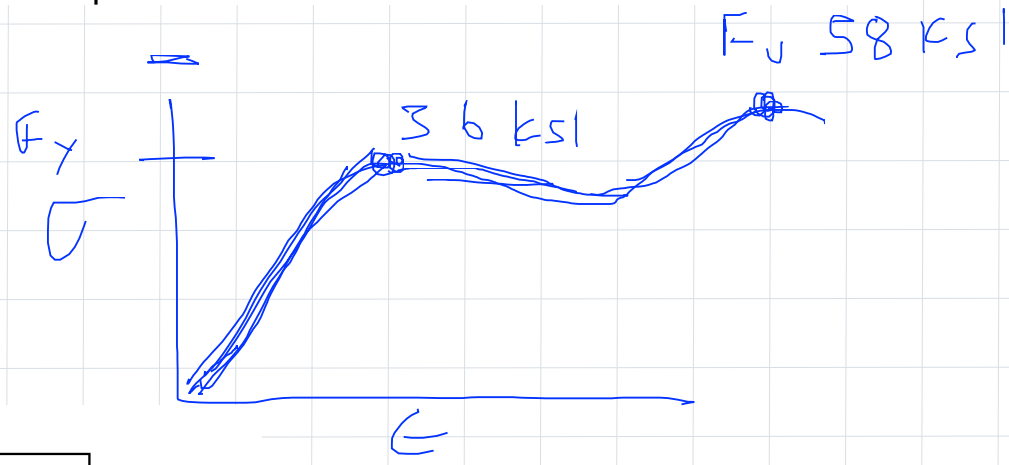
(MIG)

Welding Processes, Continued:

- Shielded metal-arc welding (SMAW)

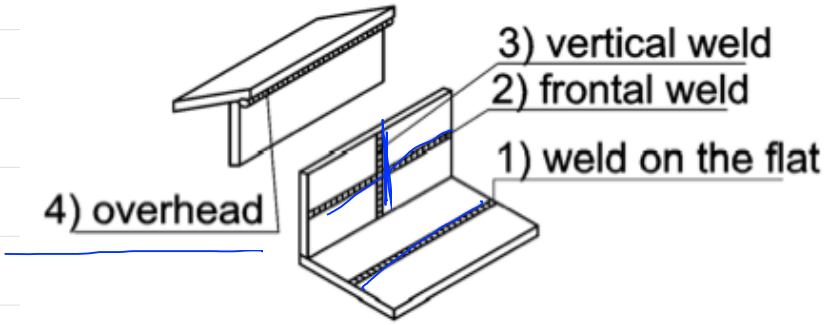


- Submerged arc welding (SAW)

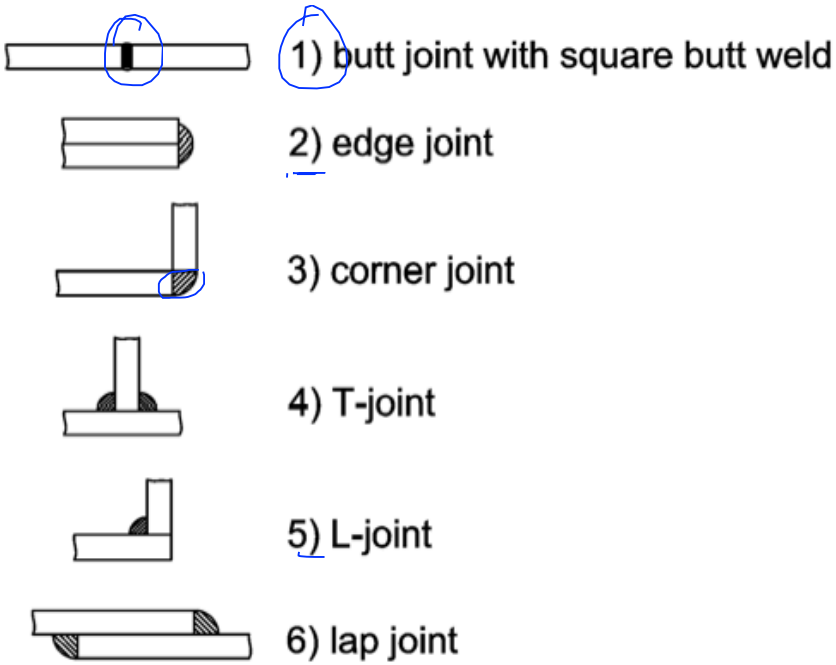


Types of Welded Joints

Ref: 2

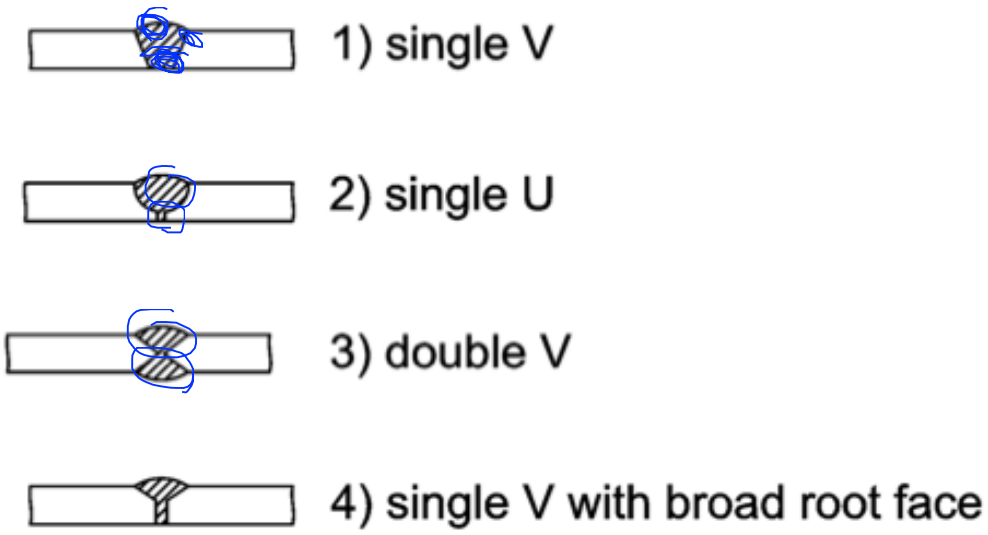


a) Position of Weld



b) Joint Condition

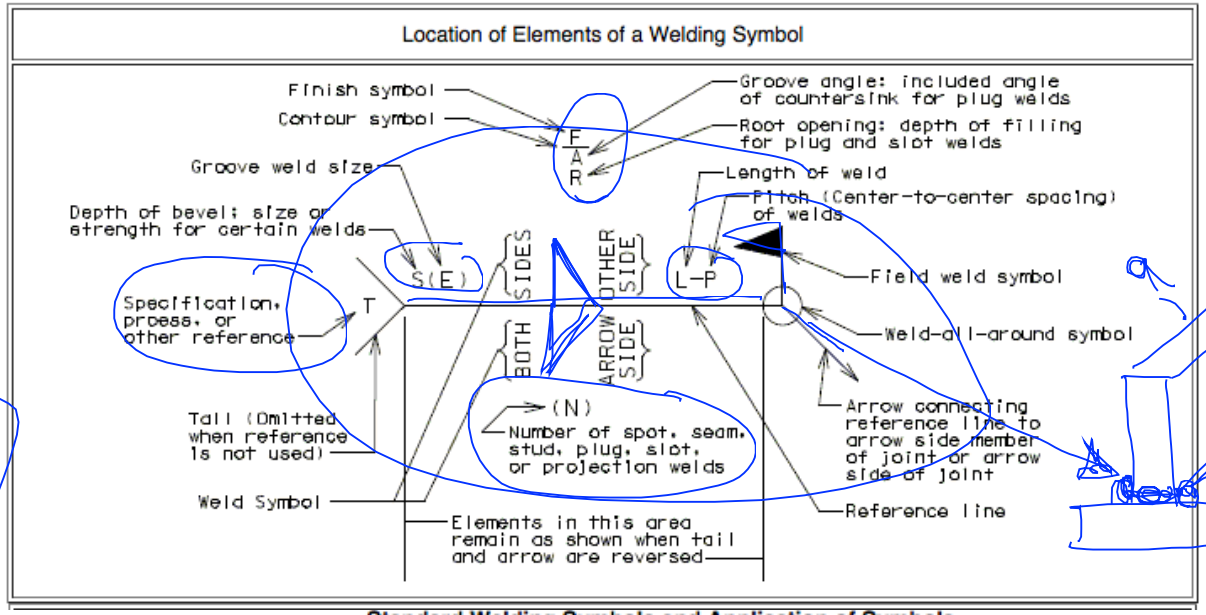
Butt Weld Types



c)

Welding Symbols

Ref: 3



Standard Welding Symbols and Application of Symbols

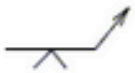
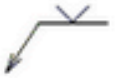
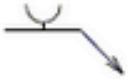
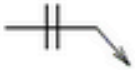
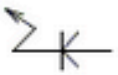
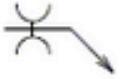
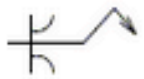
Basic Welding Symbols and Their Location Significance

Location Significance	Fillet	Plug or Slot	Spot or Projection	Stud	Seam	Back or Backing	Surfacing	Flange Corner	Flange Edge
Arrow Side									
Other Side				Not Used			Not Used		

Supplementry Symbols								
	Weld-All Around	Field Weld	Melt-Thru	Consumable Insert	Backing Spacer	Contour		
						Flush	Convex	Concave
Symbols								

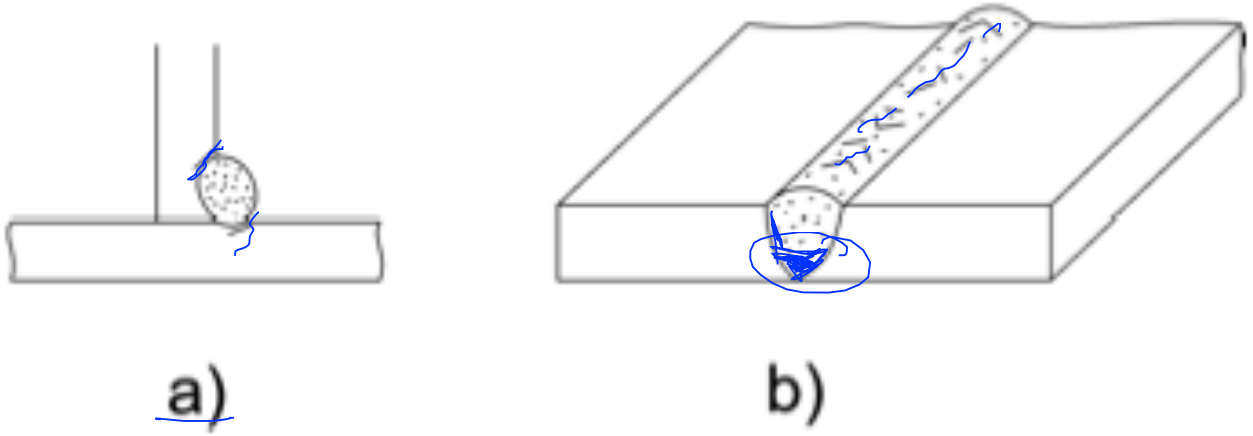
Welding Symbols

Ref: 3

	Groove				
Location Significance	Square	V	Bevel	U	J
Arrow Side					
Other Side					
Both Sides					
No Arrow Side or Other Side Significance	 (*)	Not Used	Not Used	Not Used	Not Used

Weld Defects

- Cold Cracks
- Hot Cracks
- Lack of Penetration
- Slag Inclusions
- BlowHoles



- VISUAL
- LIQUID PENETRANT
- MAGNETIC PARTICLE
- ULTRASONIC (UT)
- X RAY

SURFACE/ NEAR SURFACE

Bolting and Welding Inspections in the IBC

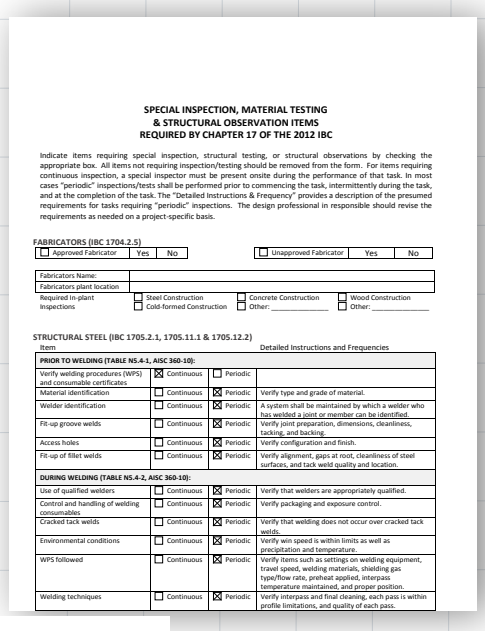
IBC references AISC 360 "Specification for Structural Steel Buildings" for Inspections requirements"

Note: IBC is not a reference for the PE Construction Depth, but this is noted for your knowledge.

The following table provides a good summary of bolting and welding inspections. (ref 2)

Welding inspections is dependent on

- *Certification of Fabricator*
- *Seismic Design Category*
- *Whether an item is a seismic component*



SPECIAL INSPECTION, MATERIAL TESTING & STRUCTURAL OBSERVATION ITEMS REQUIRED BY CHAPTER 17 OF THE 2012 IBC

Indicate items requiring special inspection, structural testing, or structural observations by checking the appropriate box. All items not requiring inspection/testing should be removed from the form. For items requiring continuous inspection, a special inspector must be present onsite during the performance of that task. In most cases "periodic" inspections/tests shall be performed prior to commencing the task, intermittently during the task, and at the completion of the task. The "Detailed Instructions & Frequency" provides a description of the presumed requirements for tasks requiring "periodic" inspections. The design professional in responsible should revise the requirements as needed on a project-specific basis.

FABRICATORS (IBC 1704.2.5)

☐ Approved Fabricator | Yes | No ☐ Unapproved Fabricator | Yes | No

Fabricators Name:	
Fabricators plant location	

Required In-plant Inspections: ☐ Steel Construction ☐ Concrete Construction ☐ Wood Construction ☐ Cold-formed Construction ☐ Other: _____ ☐ Other: _____

STRUCTURAL STEEL (IBC 1705.2.1, 1705.11.1 & 1705.12.2)

Item			Detailed Instructions and Frequencies
PRIOR TO WELDING (TABLE N5.4-1, AISC 360-10):			
Verify welding procedures (WPS) and consumable certificates	☒ Continuous	☐ Periodic	
Material identification	☐ Continuous	☒ Periodic	Verify type and grade of material.
Welder identification	☐ Continuous	☒ Periodic	A system shall be maintained by which a welder who has welded a joint or member can be identified.
Fit-up groove welds	☐ Continuous	☒ Periodic	Verify joint preparation, dimensions, cleanliness, tacking, and backing.
Access holes	☐ Continuous	☒ Periodic	Verify configuration and finish.
Fit-up of fillet welds	☐ Continuous	☒ Periodic	Verify alignment, gaps at root, cleanliness of steel surfaces, and tack weld quality and location.
DURING WELDING (TABLE N5.4-2, AISC 360-10):			
Use of qualified welders	☐ Continuous	☒ Periodic	Verify that welders are appropriately qualified.
Control and handling of welding consumables	☐ Continuous	☒ Periodic	Verify packaging and exposure control.
Cracked tack welds	☐ Continuous	☒ Periodic	Verify that welding does not occur over cracked tack welds.
Environmental conditions	☐ Continuous	☒ Periodic	Verify win speed is within limits as well as precipitation and temperature.
WPS followed	☐ Continuous	☒ Periodic	Verify items such as settings on welding equipment, travel speed, welding materials, shielding gas type/flow rate, preheat applied, interpass temperature maintained, and proper position.
Welding techniques	☐ Continuous	☒ Periodic	Verify interpass and final cleaning, each pass is within profile limitations, and quality of each pass.

FABRICATORS (IBC 1704.2.5)

☐ Approved Fabricator	Yes	No

☐ Unapproved Fabricator	Yes	No

Fabricators Name:	
Fabricators plant location	

Required In-plant Inspections

☐ Steel Construction ☐ Concrete Construction ☐ Wood Construction
☐ Cold-formed Construction ☐ Other: _____ ☐ Other: _____

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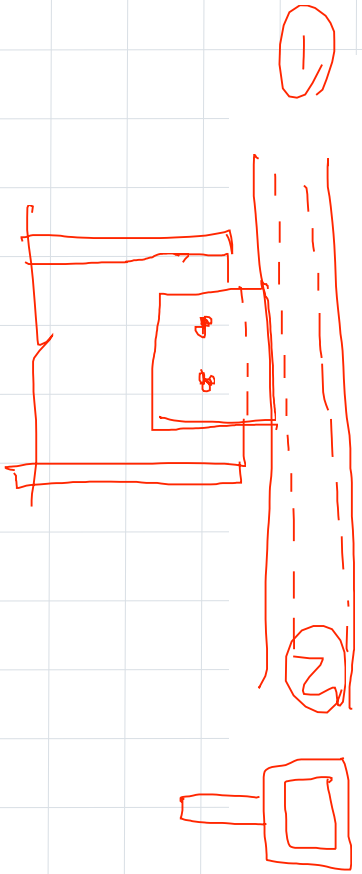
AFTER WELDING (TABLE N5.4-3, AISC 360-10):			
Welds cleaned	☐ Continuous	☒ Periodic	Verify that welds have been propyl cleaned.
Size, length, and location of welds	☒ Continuous	☐ Periodic	
Welds meet visual acceptance criteria	☒ Continuous	☐ Periodic	
Arc strikes	☒ Continuous	☐ Periodic	
k-area	☒ Continuous	☐ Periodic	
Backing & weld tabs removed	☒ Continuous	☐ Periodic	
Repair activities	☒ Continuous	☐ Periodic	
Document acceptance or rejection of welded joint/member	☒ Continuous	☐ Periodic	
NONDESTRUCTIVE TESTING (SECTION N5.5, AISC 360-10):			
CJP welds (Risk Cat. II)	☐ Continuous	☒ Periodic	Ultrasonic testing shall be performed on 10% of CJP groove welds in butt, T- and corner joints subject to transversely applied tension loading in materials 5/16-inch thick or greater. Testing rate must be increased if > 5% of welds tested have unacceptable defects.
CJP welds (Risk Cat. III or IV)	☒ Continuous	☐ Periodic	***A reduction in the rate of ultrasonic testing is allowed per Section N5.5e.***
Access holes (flange > 2”)	☒ Continuous	☐ Periodic	
Welded joints subject to fatigue	☒ Continuous	☐ Periodic	



PRIOR TO BOLTING (TABLE N5.6-1, AISC 360-10): ➢ *Not required if only snug-tight joints are specified [per Section N5.6(1) of AISC 360-10].*			
Certifications of fasteners	☒ Continuous	☐ Periodic	
Fasteners marked	☐ Continuous	☒ Periodic	Verify that fasteners have been marked in accordance with ASTM requirements.
Proper fasteners for joint	☐ Continuous	☒ Periodic	Verify grade, type, and bolt length if threads are excluded from the shear plane.
Proper bolting procedure	☐ Continuous	☒ Periodic	Verify proper procedure is used for the joint detail.
Connecting elements	☐ Continuous	☒ Periodic	Verify appropriate faying surface condition and hole preparation, if specified, meet requirements.
Pre-installation verification testing	☐ Continuous	☒ Periodic	Observe and document verification testing by installation personnel for fastener assemblies and methods used.
Proper storage	☐ Continuous	☒ Periodic	Verify proper storage of bolts, nuts, washers, and other fastener components.
DURING BOLTING (TABLE N5.6-2, AISC 360-10): ➢ *Not required if only snug-tight joints are specified [per Section N5.6(1) of AISC 360-10].* ➢ *Not required for pretensioned joints using turn-of-the-nut method with match-marking, direct-tension-indicators, or twist-off type tension control method [per Section N5.6(2) of AISC 360-10].*			
Fastener assemblies	☐ Continuous	☒ Periodic	Verify that fastener assemblies are of suitable condition, paced in all holes, and washers are positioned as required.
Snug-tight prior to pretensioning	☐ Continuous	☒ Periodic	Verify that joints are brought to snug-tight condition prior to pretensioning operation.
Fastener component	☐ Continuous	☒ Periodic	Verify that fastener component is not turned by wrench prevented from rotating.
Pretensioned fasteners	☐ Continuous	☒ Periodic	Verify that fasteners are Pretensioned in accordance with RCSC Specification, progressing systematically from the most rigid point toward the free edges.
AFTER BOLTING (TABLE N5.6-3, AISC 360-10):			
Document acceptance or rejection of bolted connections	☒ Continuous	☐ Periodic	

Problem

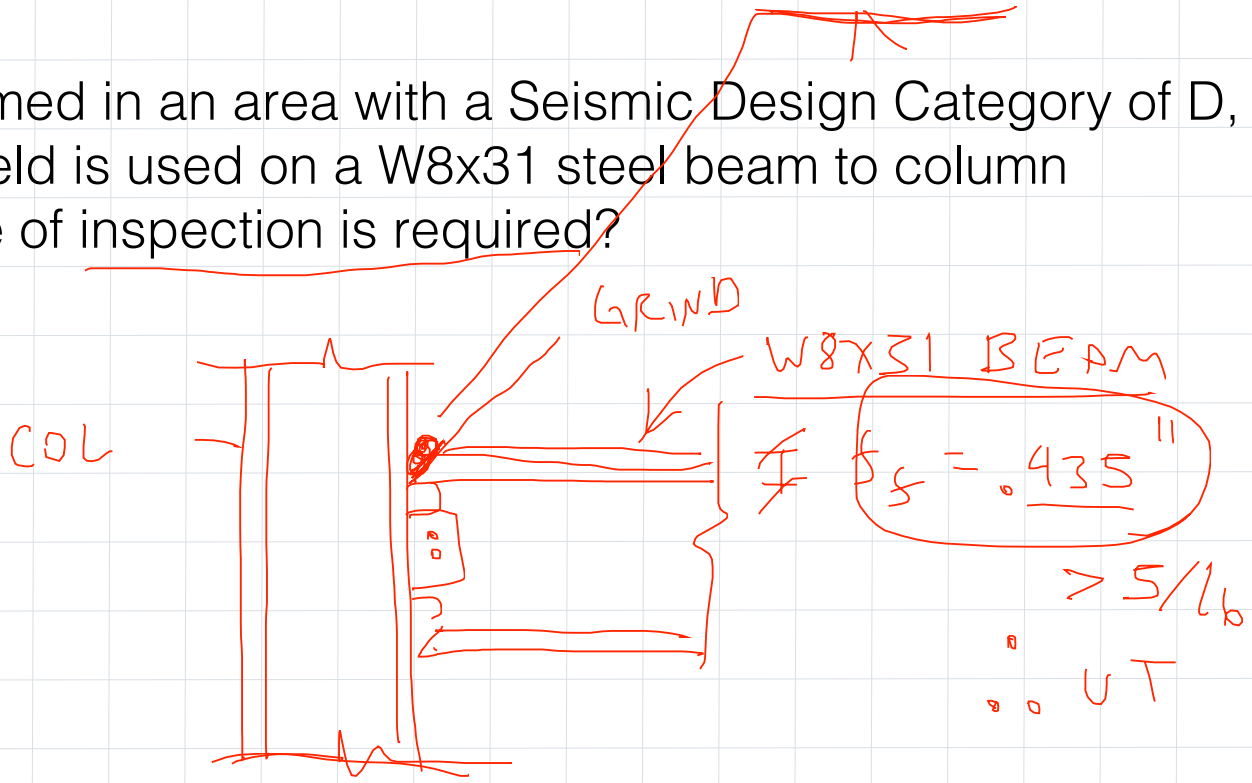
A weld is performed using a SMAW process, and the base material cooled too quickly. Which defect is most likely to occur?

A) Blowholes
B) Slag Inclusions
C) Hot Crack
D) Cold Crack

Problem 152

A weld is being performed in an area with a Seismic Design Category of D, and Full Penetration weld is used on a W8x31 steel beam to column connection. What type of inspection is required?

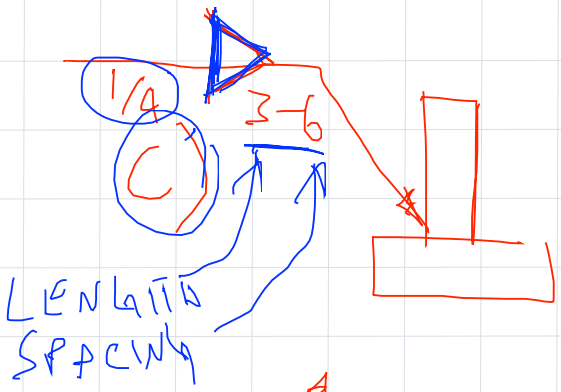
A) None
B) Visual
C) Radiographic
D) Ultrasonic



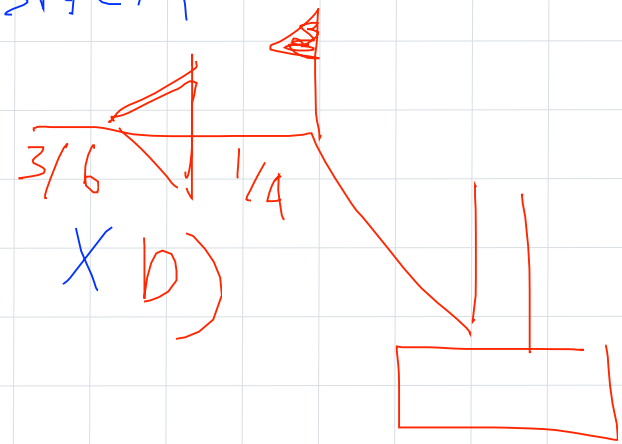
Problem 153

1/4" FILLET BOTH SIDES 6" ON CENTER
3" LONG

X A)



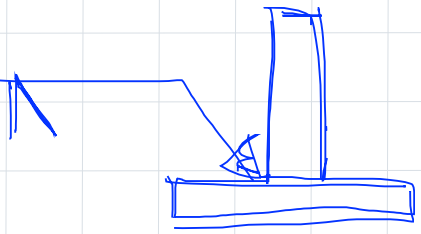
X B)



X D)

PROBLEM 154

SAW)



BEVEL WELD

A) SUBMERGED ARC WELD

B

1

References

1. Theory and Practice of Steel Structures; 2013 Nunziata & Richardson.

2. State of Utah

3. Missouri DOT

R_w (PER IN) $= (.3\, t_e\, F_u\, R_{OD})\, L$

$= (.3)(.707)(1/4)(70)(4)$

$= (3.71)(4)$

$= 14.84$ KIPS

$\frac{R_N}{\Omega} \geq T_{ALL}$

$\frac{R_N}{\Omega} = .928\, D\, l$

$(3.71)(4)$

$= 14.84$

#16 THS

[66.6] 1/2