

The Ultimate Civil PE Review Course

Construction – Depth

Construction - Depth

<u>I. Earthwork Construction and Layout</u>	(10%)	<u>V. Material Quality Control and Production</u>	10%
A. Excavation and embankment (cut and fill)		A. Material testing (e.g., concrete, soil, asphalt)	
B. Borrow pit volumes		B. Welding and bolting testing	
C. Site layout and control		C. Quality control process (QA/QC)	
D. Earthwork mass diagrams		D. Concrete mix design	
<u>II. Estimating Quantities and Costs</u>	17.5%	<u>VI. Temporary Structures</u>	12.5%
A. Quantity take-off methods		A. Construction loads	
B. Cost estimating		B. Formwork	
C. Engineering economics		C. Falsework and scaffolding	
1. Value engineering and costing		D. Shoring and reshoring	
<u>III. Construction Operations and Methods</u>	15%	E. Concrete maturity and early strength evaluation	
A. Lifting and rigging		F. Bracing	
B. Crane selection, erection, and stability		G. Anchorage	
C. Dewatering and pumping		H. Cofferdams (systems for temporary excavation support)	
D. Equipment production		I. Codes and standards	
E. Productivity analysis and improvement		[e.g., American Society of Civil Engineers	
F. Temporary erosion control		(ASCE 37), American Concrete Institute (ACI 347),	
<u>IV. Scheduling</u>	17.5%	American Forest and Paper Association- NDS, Masonry	
A. Construction sequencing		Wall Bracing Standard]	
B. CPM network analysis			
C. Activity time analysis			
D. Resource scheduling			
E. Time-cost trade-off			

“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:

Disadvantages:

Process of Welding requires:

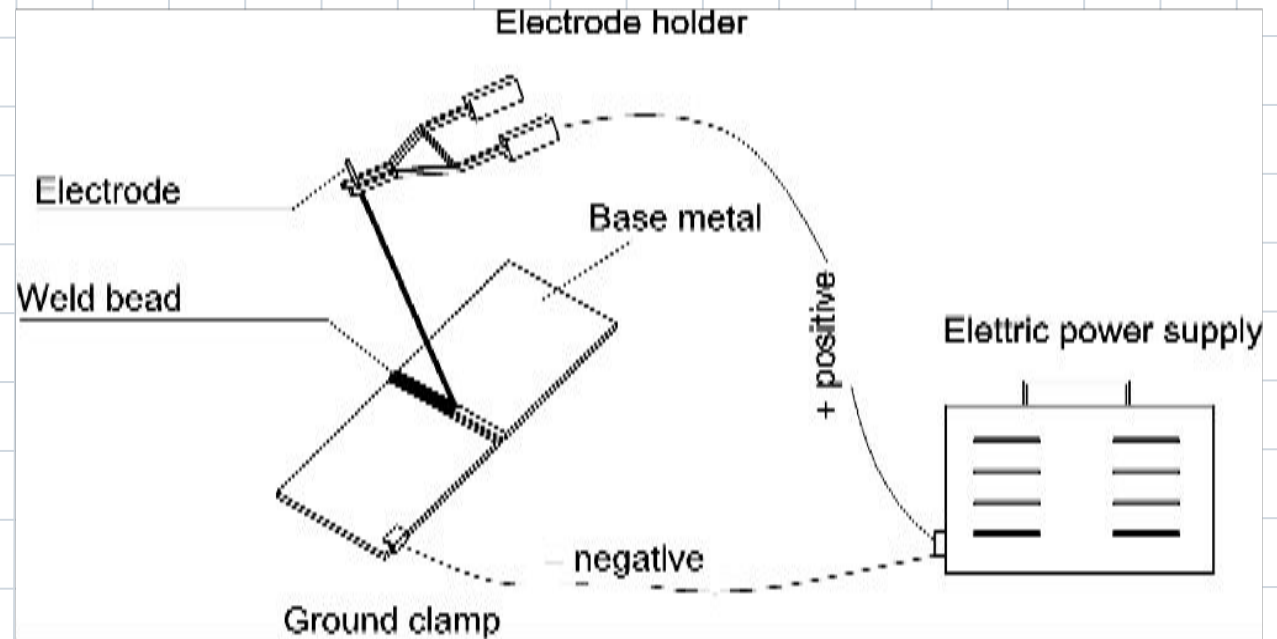
- Base Metal
- Filler Material
- Heat Source
- Protection of Weld Pool

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)

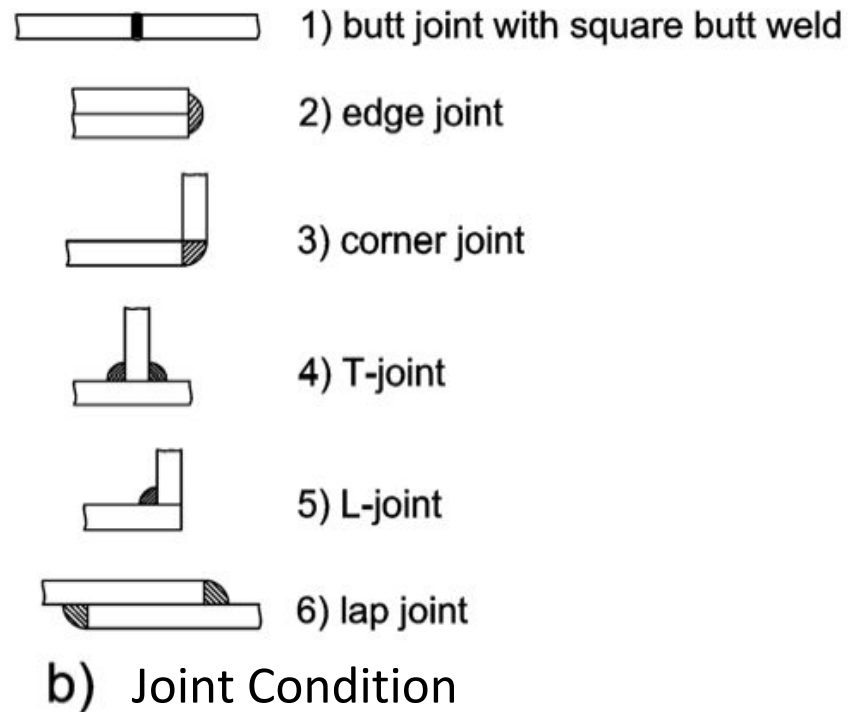
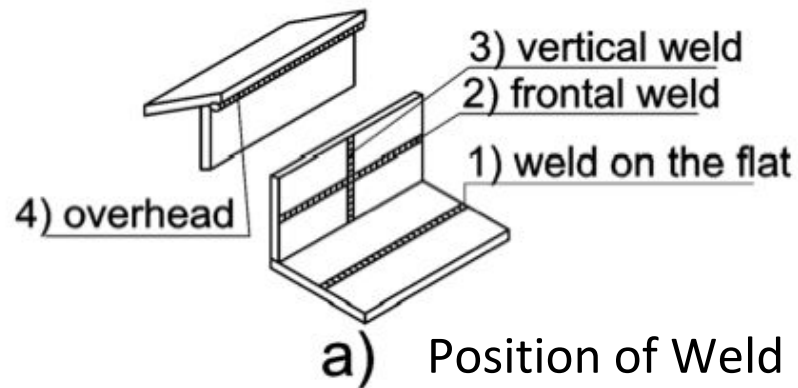
Welding Processes, Continued:

- Shielded metal-arc welding (SMAW)

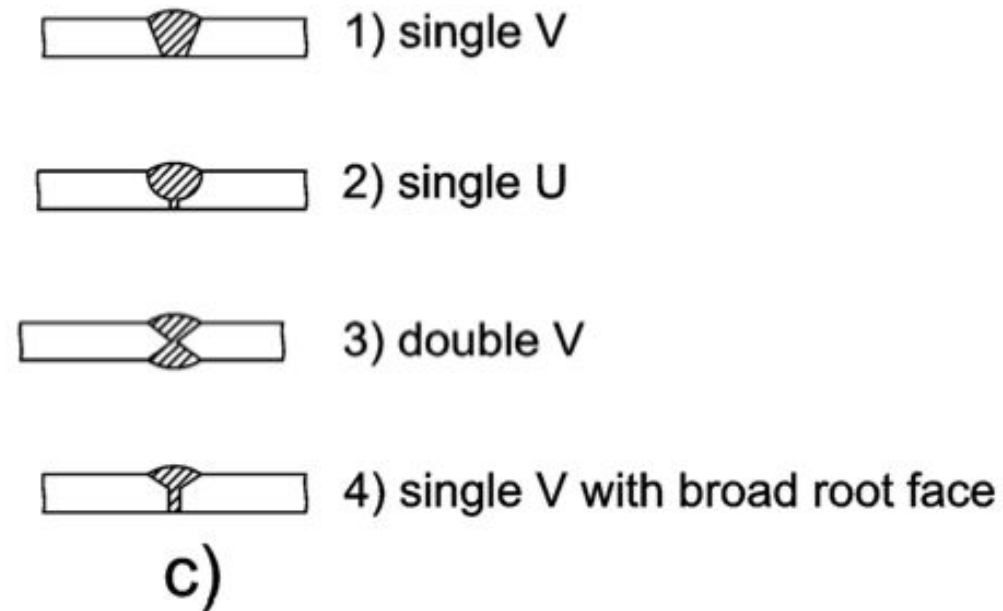


- Submerged arc welding (SAW)

Types of Welded Joints

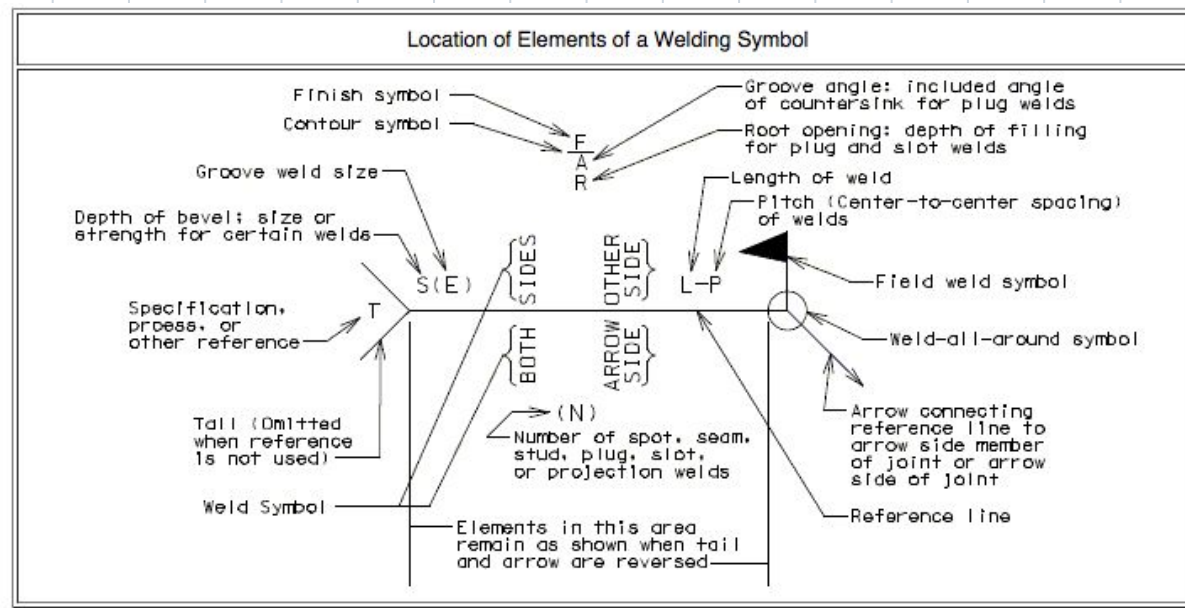


Butt Weld Types



Welding Symbols

Ref: 3



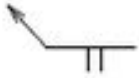



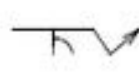

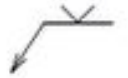

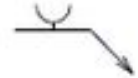
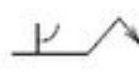
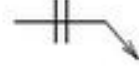


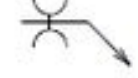
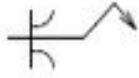
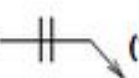
Standard Welding Symbols and Application of Symbols

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		

Supplementary Symbols

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

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

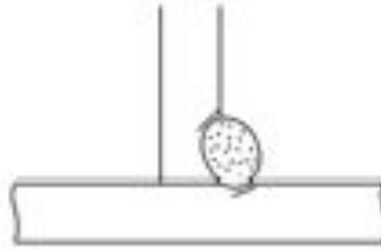
Cold Cracks

Hot Cracks

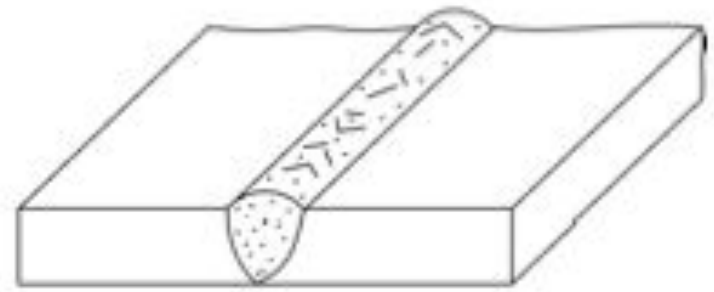
Lack of Penetration

Slag Inclusions

BlowHoles



a)



b)

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

Fabricator's Name: _____
Fabricator's plant location: _____

Required in-plant inspections: ☐ Steel Construction ☐ Cold-formed Construction ☐ Concrete Construction ☐ Wood Construction ☐ 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 conformance certificates	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic
Material identification	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic
Welder identification	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic
Fit-up groove welds	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic
Access holes	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic
Fit-up of fillet welds	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic

DURING WELDING (TABLE N5.4.2, AISC 360-10):

Use of qualified welders	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic
Control and handling of welding consumables	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic
Cracked tack welds	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic
Environmental conditions	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic
WPS followed	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic
Welding techniques	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic

FABRICATORS (IBC 1704.2.5)

<input type="checkbox"/> Approved Fabricator	Yes	No	<input type="checkbox"/> Unapproved Fabricator	Yes	No
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Fabricators Name:					
Fabricators plant location					
Required In-plant Inspections	<input type="checkbox"/> Steel Construction	<input type="checkbox"/> Concrete Construction	<input type="checkbox"/> Wood Construction		
	<input type="checkbox"/> Cold-formed Construction	<input type="checkbox"/> Other: _____	<input type="checkbox"/> 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	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic	Verify type and grade of material.
Material identification	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	
Welder identification	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	A system shall be maintained by which a welder who has welded a joint or member can be identified.
Fit-up groove welds	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify joint preparation, dimensions, cleanliness, tacking, and backing.
Access holes	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify configuration and finish.
Fit-up of fillet welds	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> 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	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify that welders are appropriately qualified.
Control and handling of welding consumables	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify packaging and exposure control.
Cracked tack welds	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify that welding does not occur over cracked tack welds.
Environmental conditions	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify win speed is within limits as well as precipitation and temperature.
WPS followed	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> 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	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify interpass and final cleaning, each pass is within profile limitations, and quality of each pass.



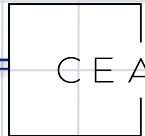
AFTER WELDING (TABLE N5.4-3, AISC 360-10):			
Welds cleaned	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify that welds have been propyl cleaned.
Size, length, and location of welds	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic	
Welds meet visual acceptance criteria	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic	
Arc strikes	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic	
k-area	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic	
Backing & weld tabs removed	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic	
Repair activities	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic	
Document acceptance or rejection of welded joint/member	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic	
NONDESTRUCTIVE TESTING (SECTION N5.5, AISC 360-10):			
CJP welds (Risk Cat. II)	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> 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)	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic	<i>A reduction in the rate of ultrasonic testing is allowed per Section N5.5e.</i>
Access holes (flange > 2")	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic	
Welded joints subject to fatigue	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic	

PRIOR TO BOLTING (TABLE N5.6-1, AISC 360-10):			
➤ <i>Not required if only snug-tight joints are specified [per Section N5.6(1) of AISC 360-10].</i>			
Certifications of fasteners	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> Periodic	
Fasteners marked	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify that fasteners have been marked in accordance with ASTM requirements.
Proper fasteners for joint	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify grade, type, and bolt length if threads are excluded from the shear plane.
Proper bolting procedure	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify proper procedure is used for the joint detail.
Connecting elements	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify appropriate faying surface condition and hole preparation, if specified, meet requirements.
Pre-installation verification testing	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Observe and document verification testing by installation personnel for fastener assemblies and methods used.
Proper storage	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify proper storage of bolts, nuts, washers, and other fastener components.
DURING BOLTING (TABLE N5.6-2, AISC 360-10):			
➤ <i>Not required if only snug-tight joints are specified [per Section N5.6(1) of AISC 360-10].</i>			
➤ <i>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].</i>			
Fastener assemblies	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify that fastener assemblies are of suitable condition, paced in all holes, and washers are positioned as required.
Snug-tight prior to pretensioning	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify that joints are brought to snug-tight condition prior to pretensioning operation.
Fastener component	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> Periodic	Verify that fastener component is not turned by wrench prevented from rotating.
Pretensioned fasteners	<input type="checkbox"/> Continuous	<input checked="" type="checkbox"/> 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	<input checked="" type="checkbox"/> Continuous	<input type="checkbox"/> 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

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

Concrete Mix Design



Concrete Mix Design



Concrete Mix Design

References

1. Theory and Practice of Steel Structures; 2013 Nunziata & Richardson.
2. State of Utah
3. Missouri DOT

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Construction Q&A

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