Design 2

Lesson Objectives

When you finish this lesson you will understand:

- Joint Design Terminology
- Prequalified Joint Selection
- Statically & Dynamically loaded Joints

Learning Activities

1. Read Handbook pp 149-158
2. View Slides;
3. Read Notes,
4. Listen to lecture
5. Do on-line workbook

6. Do homework

Keywords

Joint Design, Butt Joint, T Joint, Lap Joint, Corner Joint, Edge Joint, Square Weld, Fillet Weld, Bevel Groove, V Groove, J Groove, U Groove, Groove Angle, Bevel Angle, Root, Root Face, Land, Root Opening, Throat, Leg Length, Weld Face, Weld Toe, Flat, Horizontal, Vertical, Overhead, Tension, Compression, Bending, Torsion, Shear

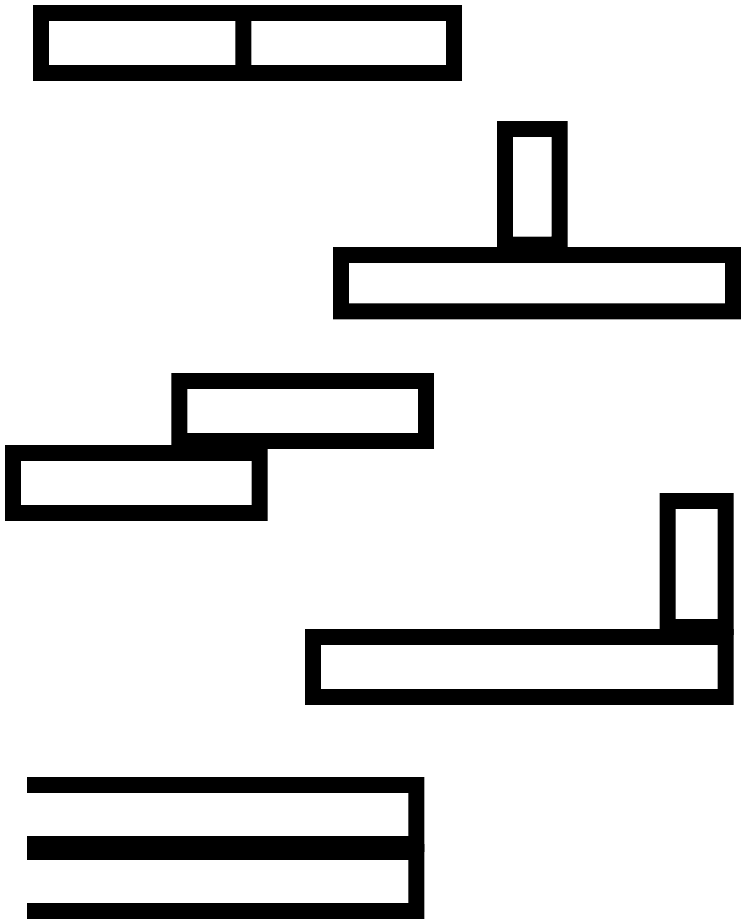
Welding Design

- **Welding design involves consideration of strength requirements, cost, and service conditions**
  - **Mechanical & Physical properties**
  - **Joint Design**
  - **Welding stress and distortion**

Welding Design

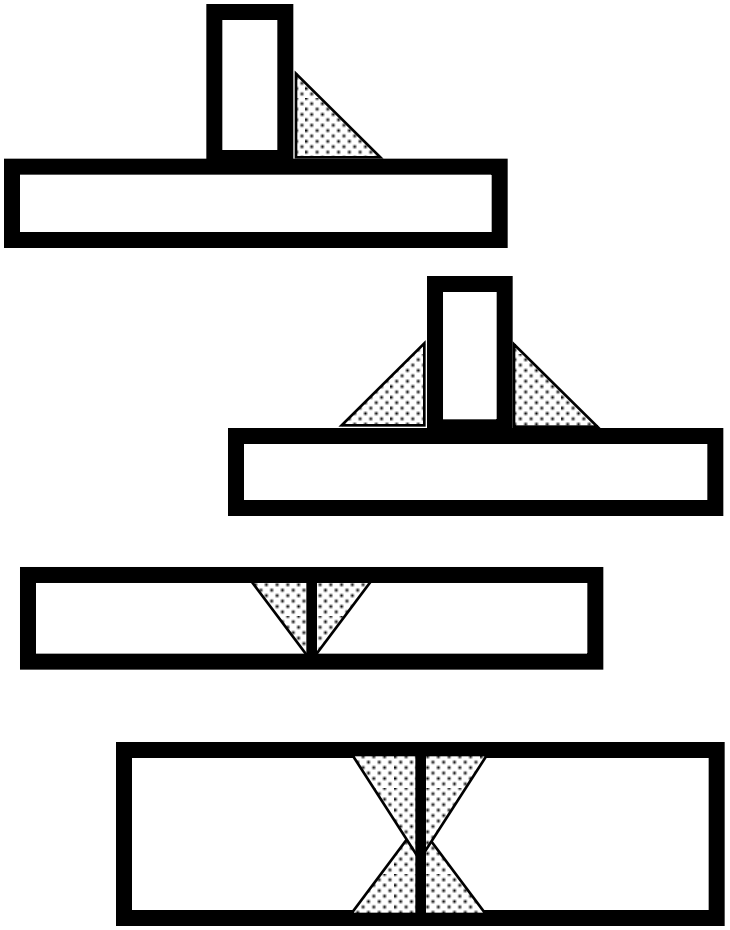
- Types of joints and welds
- Joint selection - AWS D1.1
- Fatigue design
- Residual stress and distortion

Joint Types



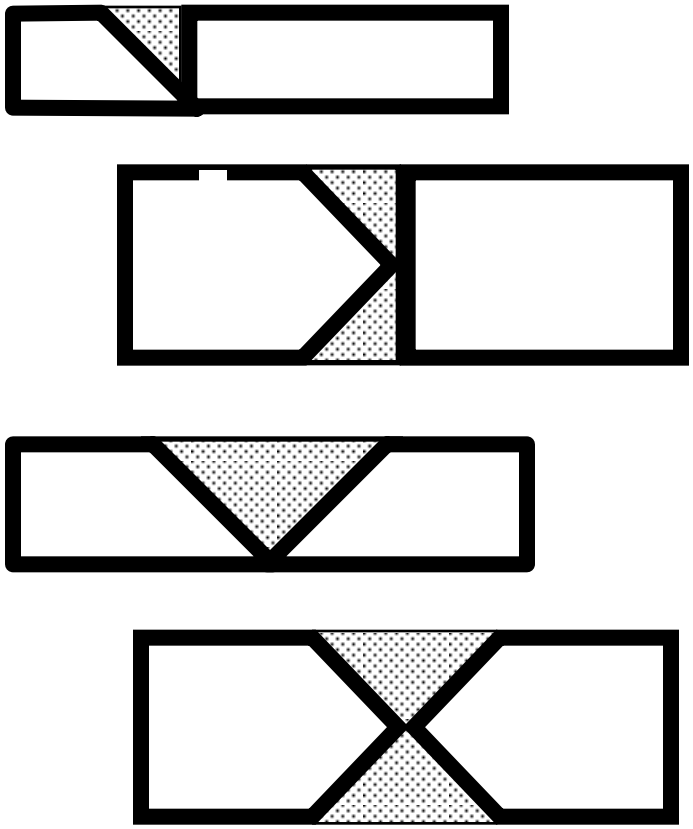
- Butt joint
  - Continuity of section
- T joint
  - Flanges or stiffeners
- Lap joint
  - No joint preparation
- Corner joint
- Edge joint
  - Two or more parallel, or nearly parallel members

Weld Types



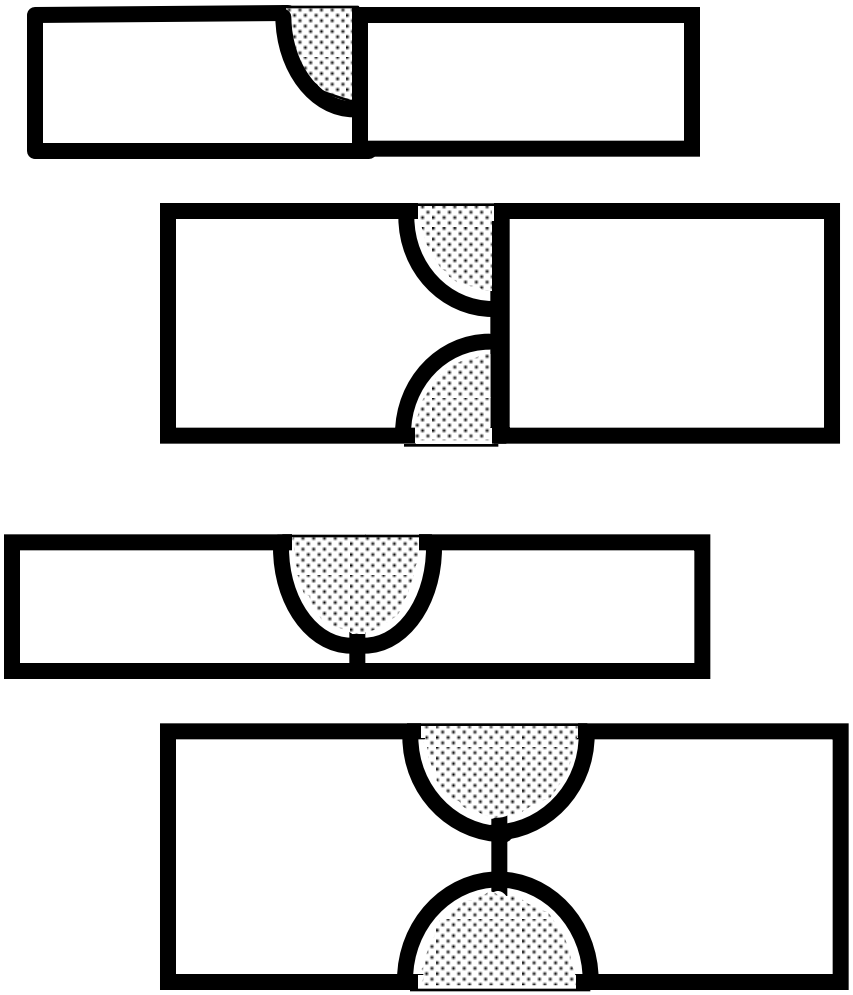
- Fillet weld
  - Approximately triangular
  - No joint preparation required
  - Most common weld in structural work
- Square Weld
  - Penetration difficult with single; double used to ensure strength
  - Sometimes root is opened and a backing bar is used

Weld Types



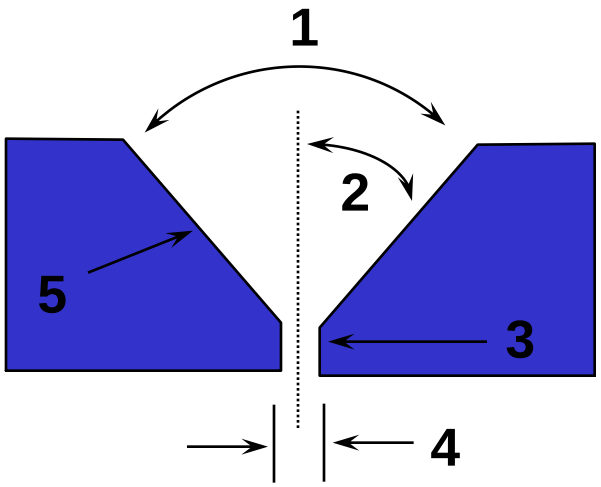
- Bevel groove
  - Single bevel is widely used
  - Double preferred if metal thickness >3/4
- V-groove
  - Both members beveled
  - Butt joints for plate thickness greater than 1/4 inch
- Double welds reduce distortion and require 1/2 the weld metal for a given plate thickness

Weld Types

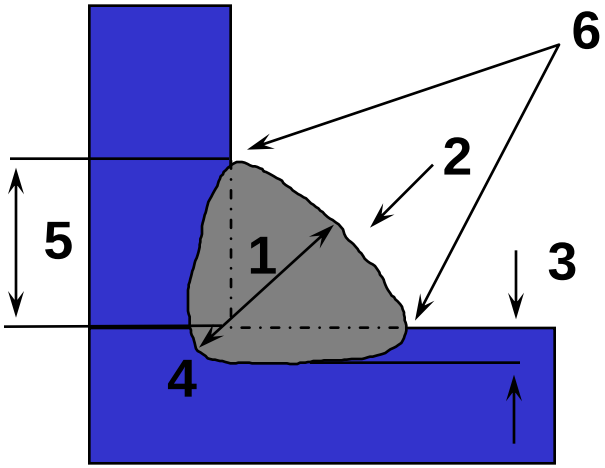


- J-groove
  - Single well suited for butted corner and T joints
  - Machined or carbon arc gouged preparation
- U-groove
  - Rounded base allows larger electrodes for narrower groove angles
  - Machined or carbon arc gouged preparation

Parts of a Weld Joint

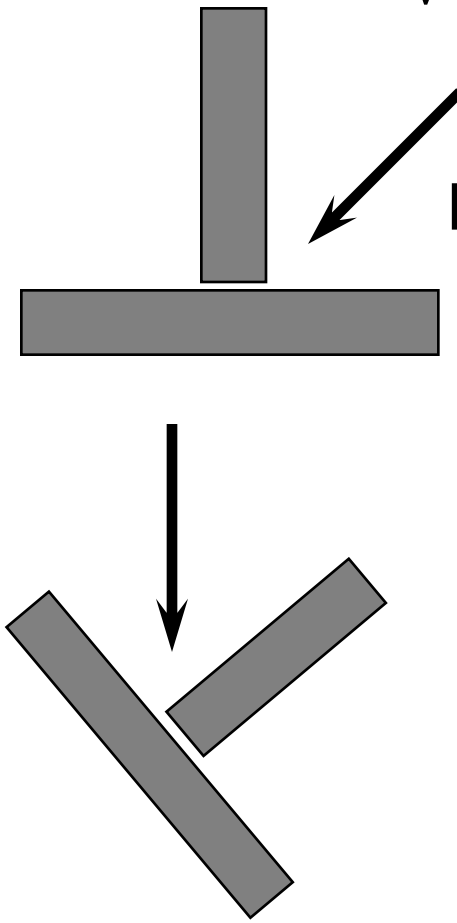


- 1 - groove angle
- 2 - bevel angle
- 3 - root face (land)
- 4 - root opening (root gap)
- 5 - groove face



- 1 - throat
- 2 - weld face
- 3 - depth of fusion
- 4 - root
- 5 - fillet leg length
- 6 - weld toe

Welding Positions



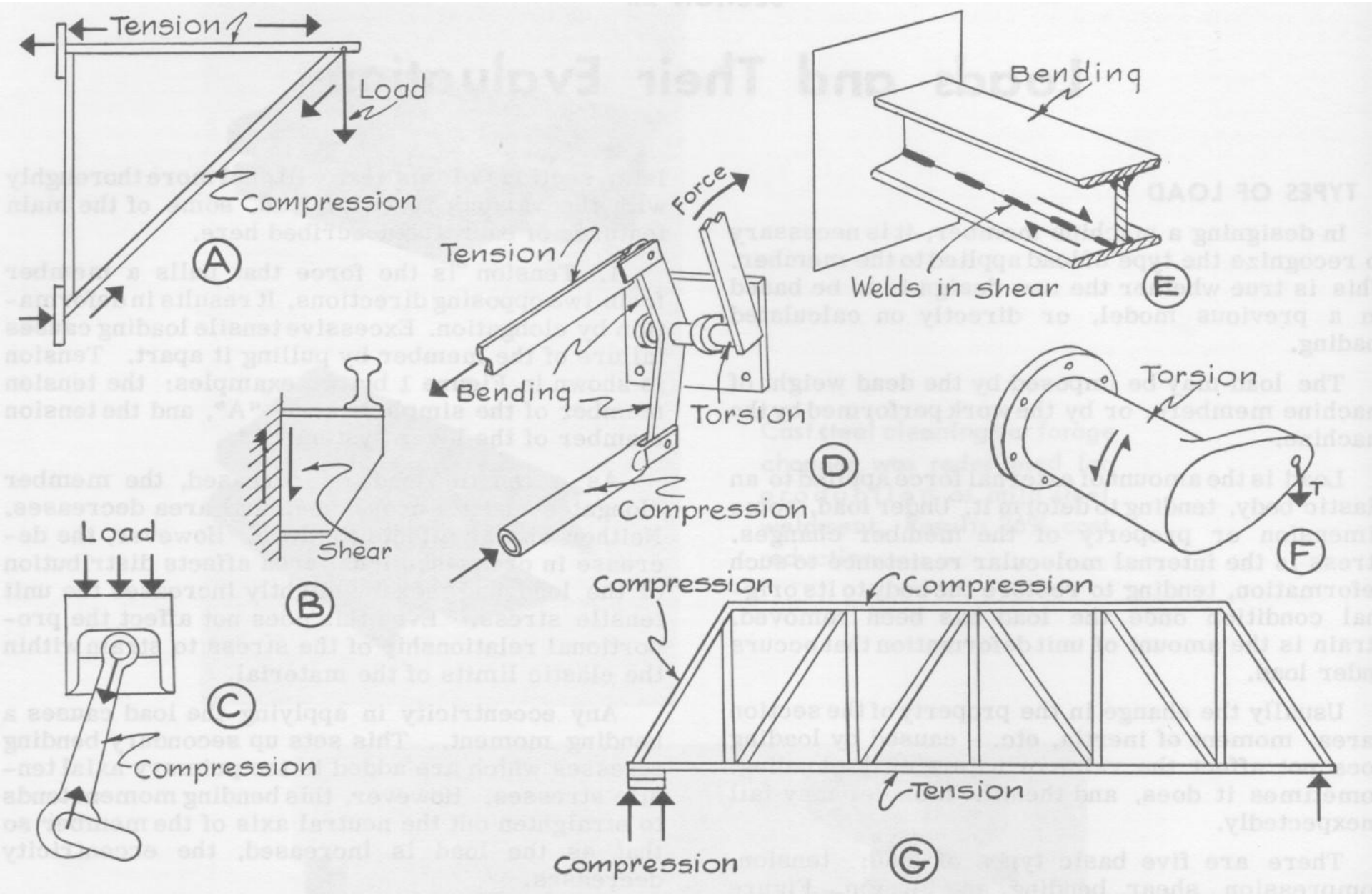
- 1 - flat
- 2 - horizontal
- 3 - vertical
- 4 - overhead
- F - fillet weld
- G - groove weld

Questions?

Turn to the person sitting next to you and discuss (1 min.):

• Do a calculation to prove that a double V groove requires ½ the weld metal than a single V groove with the same groove angel on the same thickness plate.

Loading of Joints



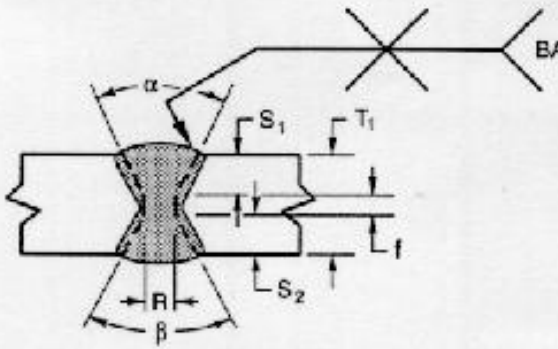
Blodgett "Design of Weldments" James F. Lincoln Arc Welding Floundation, 1976

AWS D1.1 Structural Welding Code - Steel

- Guidelines for design of welded joints, prequalified joint geometries
  - Statically loaded structures
  - Dynamically loaded structures
  - Tubular sections
- Details the processes used with particular joints
- How to qualify welding procedures and personnel
- Outlines quality and inspection in welded construction

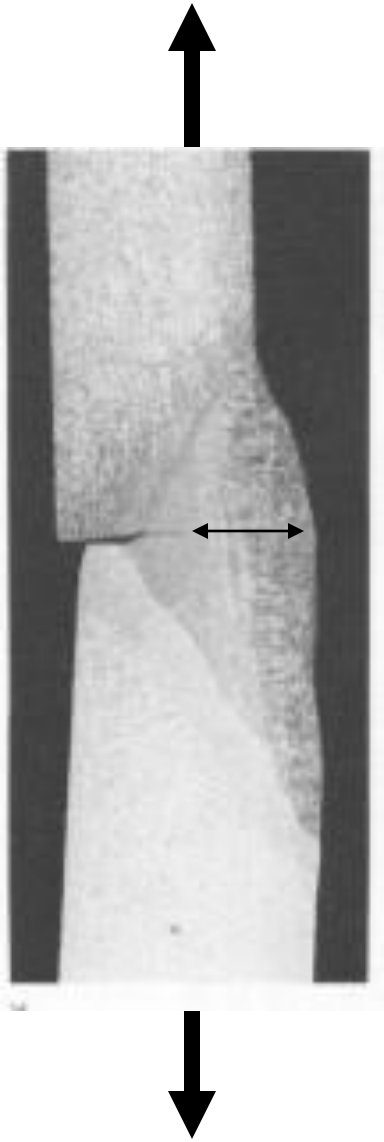
AWS D1.1 Prequalified Joint Geometry

Double-V-groove weld (3)
Butt joint (B)



For B-U3c-S only		
T_1		S_1
Over	to	
2	2-1/2	1-3/8
2-1/2	3	1-3/4
3	3-5/8	2-1/8
3-5/8	4	2-3/8
4	4-3/4	2-3/4
4-3/4	5-1/2	3-1/4
5-1/2	6-1/4	3-3/4
For $T_1 > 6\text{-}1/4$ or $T_1 \le 2$ $S_1 = 2/3\ (T_1 - 1/4)$		

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited) T_1	Base Metal Thickness (U = unlimited) T_2	Groove Preparation: Root Opening, Root Face, Groove Angle	Groove Preparation: Tolerances, As Detailed (see 3.13.1)	Groove Preparation: Tolerances, As Fit-Up (see 3.13.1)	Permitted Welding Positions	Gas Shielding for FCAW	Notes
SMAW	B-U3b	U	—	R = 0 to 1/8 f = 0 to 1/8 α = β = 60°	+1/16, –0 +1/16, –0 +10°, –0°	+1/16, –1/8 Not limited +10°, –5°	All	—	C, D, M, N
GMAW FCAW	B-U3-GF						All	Not required	A, C, M, N
SAW	B-U3c-S	U	—	R = 0 f = 1/4 min α = β = 60°	+1/16, –0 +1/4, –0 +10°, –0°	+1/16, –0 +1/4, –0 +10°, –5°	F	—	C, M, N
				To find S_1, see table above: $S_2 = T_1 - (S_1 + f)$					



$$\sigma = \frac{P}{A}$$

Questions?

Turn to the person sitting next to you and discuss (1 min.):

• We have already seen that some materials suffer mechanical property loss in the heat affected zone. How is this taken into account in the prequlified procedures?

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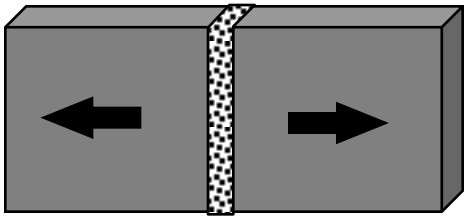
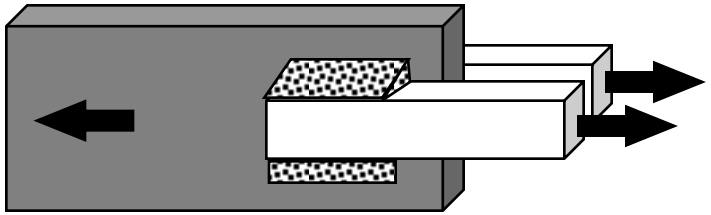
AWS D1.1 Fatigue Design



Class B



Class F - weld metal
Class E - base metal at ends of weld

- AWS D1.1 provides fatigue design guidelines for different weld types and loading configurations

AWS D1.1 Fatigue Design Lines

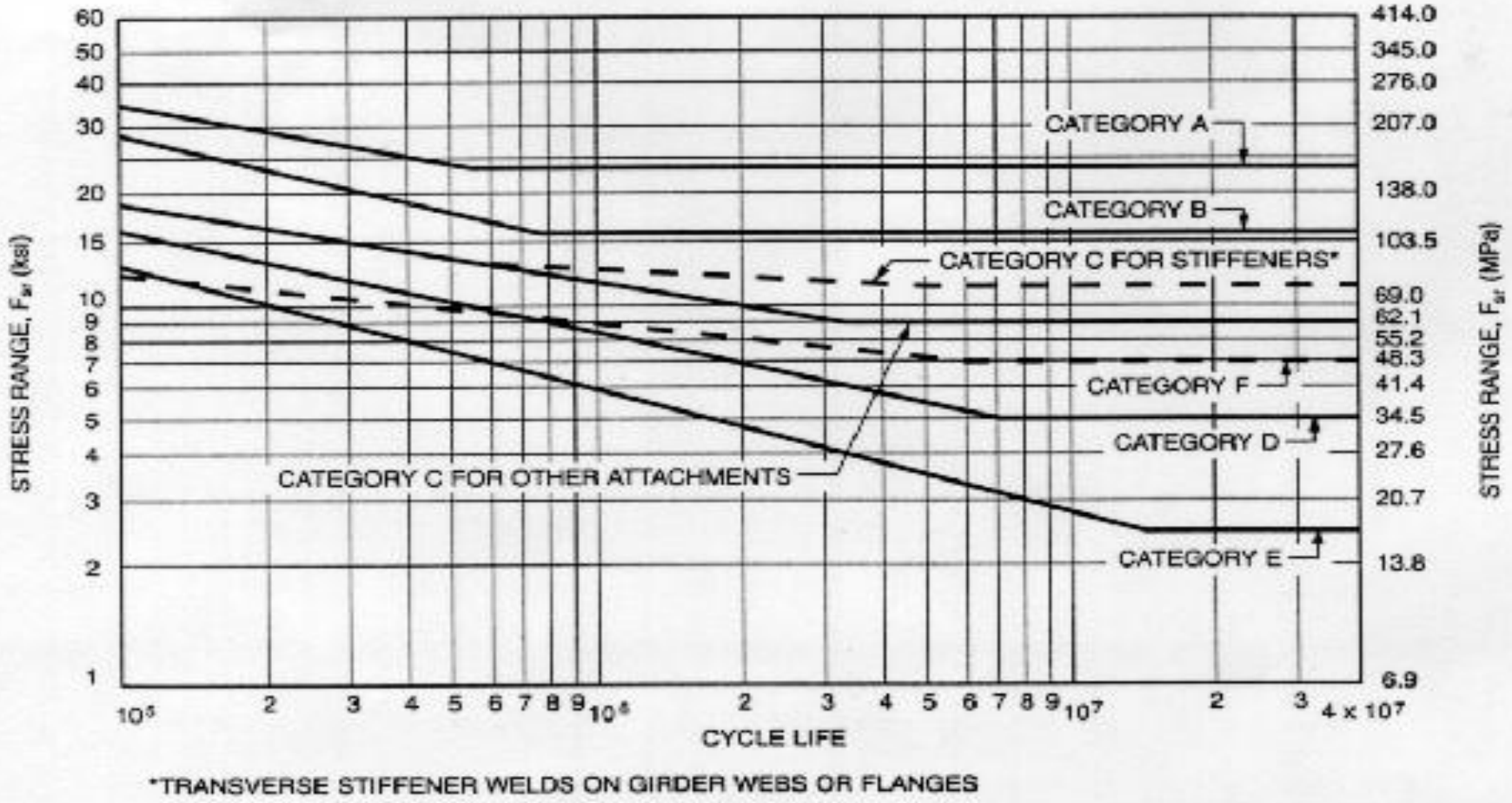


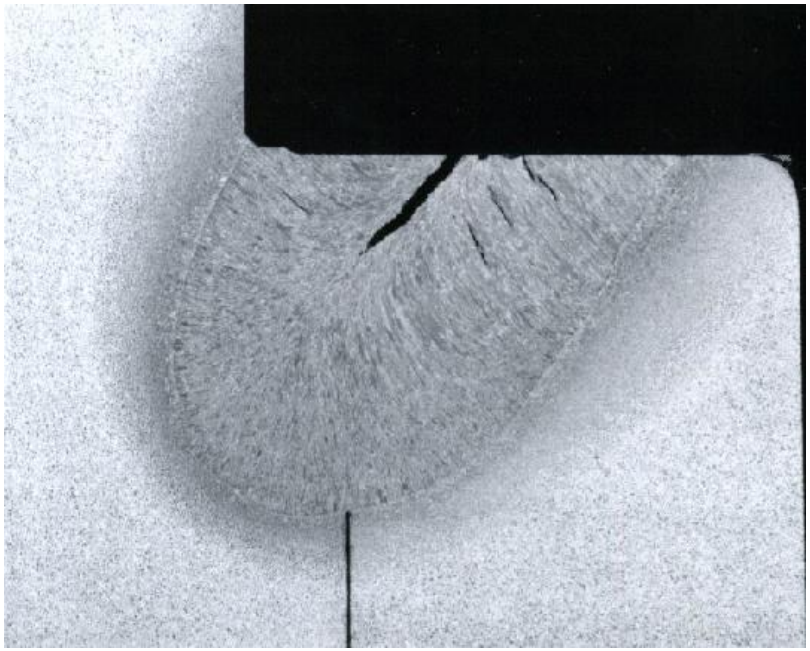
Figure 2.10—Design Stress Range Curves for Categories A to F—Nonredundant Structures (Nontubular) (see 2.24)

Questions?

Turn to the person sitting next to you and discuss (1 min.):

• The previous slide showed some fatigue design curves for a non-redundant structure design, that is if this part fails the structure fails. What might the chart look like for a part that is a redundant part?

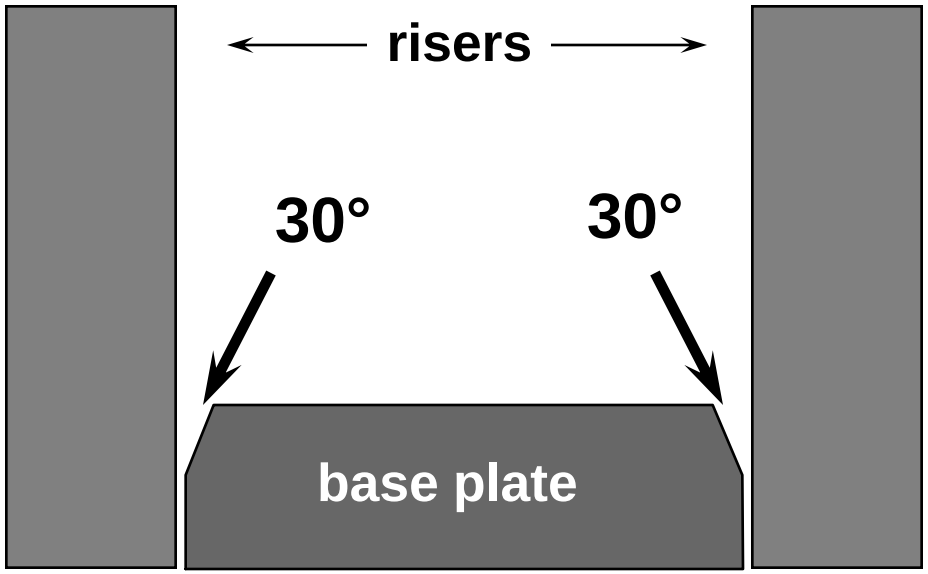
Case Study: Solidification Cracking



- Weld metal shrinks as it solidifies
  - Shrinkage causes stress
- Stress on hot weld metal
  - Metals have lower strength at high temperatures
- Weld metal cracks
- Affected by
  - Joint geometry
  - Impurity elements (S, P)

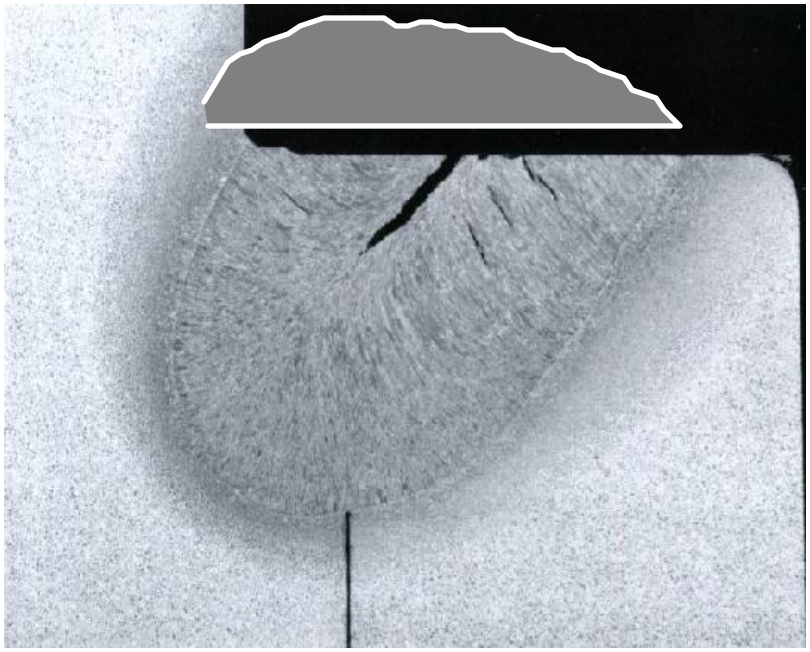
“Cocktail Napkin” Welding Procedure

- Submerged arc welding
- Corner joint, 30° bevel angle
- 1025 steel
- Saw-cut parts
- 900-1000 amps
- 35-36 volts
- 20-22 inches/minute



“The Weld Looked Great!”

Weld cap before machining



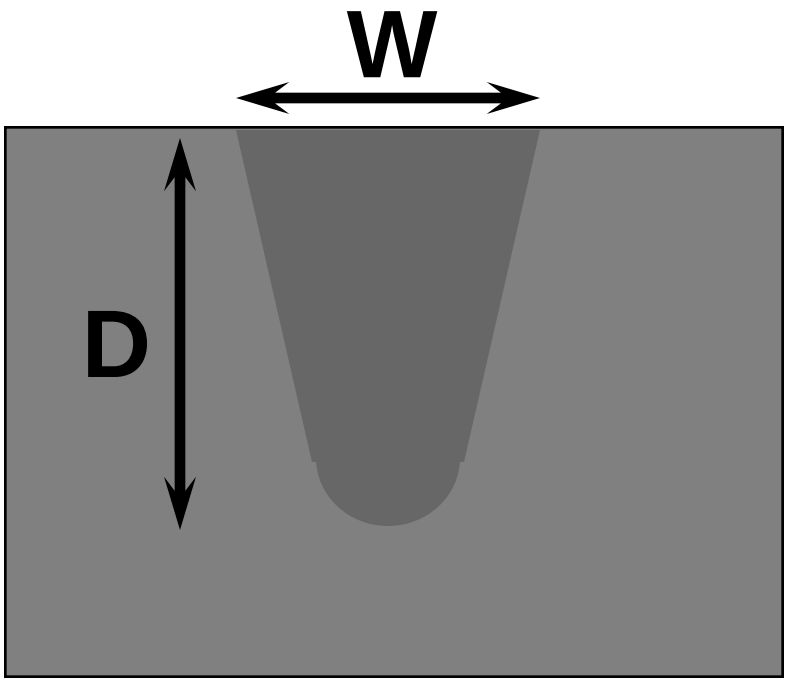
- Internal crack wasn’t visible after welding
- Weld cap removed during final machining
- Crack “appeared”

"The Welding Supplier Said Change the Wire/Flux"

- Weld metal strength is increased by adding more manganese
  - Select a wire/flux combination that adds manganese to the weld metal
  - Stronger weld metal is less susceptible to cracking
- Manganese scavenges out excess sulfur
  - Sulfur in steel can exacerbate solidification cracking

"Let's Look It Up in the Handbook"

- Solidification cracking in submerged arc welds occurs when the depth-to-width ratio exceeds 1.25

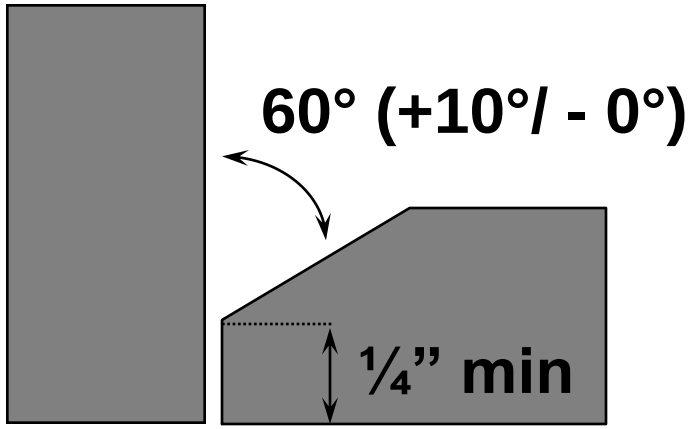


$$\frac{D}{W} < 1.25$$

to prevent cracking

"Check With AWS D1.1"

- Joint angle 60°-70°
- Extra width reduces D/W ratio to below 1.25
- Cracking disappears
- To consider:
  - More weld metal to deposit leads to lower productivity
  - Could weld in 2 passes at high speed; good depth/width ratio on each pass



Welding Economics

- Amount of weld metal
  - Cost of weld metal
  - Time required to deposit
- Joint preparation
  - Grooves are prepared by machining, grinding, gas cutting, gouging
- Accessibility
  - Poor access to joint adds to weld time