VI  Classifications of Weldments

Good

Bad
Outline

- TWI Classification system
- AISC classification system
- An alternative classification system
B - Longitudinal butt
C - longit. Butt w/ Reinforcement
C - Transverse Butt, Machined
D - Long. Butt w/ Start-stop
D - Butt weld w/ good toe
E - Butt weld w/ bad toe
F2 - Trans. butt in rolled section
F - Trans. Butt w/ backing strip
F - Attachments on plate face
F - Groove welded cruciform
G - Attachments near edge
F2 - Load carrying fillet weld
W - Fillet weld metal
TWI - Classification system
Application of TWI system
Application of TWI system
DESIGNING FOR FATIGUE LOADING

1. Use smooth shapes and transitions
2. Put welds in low stress areas if possible
3. Check weld joint classification
4. Check effect of possible weld defects, and if necessary define weld quality
5. Fatigue strength of welded steels does not depend on yield or tensile strengths of the parent metal
6. Improvement techniques can be used
7. Provide for inspection in service for fatigue cracks
Outline

- TWI Classification system
- AISC classification system
- An alternative classification system
AISC classification system
AISC category B and C

Fatigue life, N (cycles)

\[ S = 239.55 \times N^{-0.15296}, \quad r = -0.50264, \quad s = 0.13542 \]

\[ \log N = 8.1064 - 1.6518 \log S, \quad r = -0.45032, \quad s = 0.44503 \]

99% survival with 50% confidence

99% survival with 95% confidence

The good welds!
AISC category D and E

Fatigue life, $N$ (cycles)

$$S = 159.20 \times N^{-0.16648}, \quad r^2 = 0.173, \quad s = 0.1718$$

$$\log N = 6.8974 - 1.03751 \log S, \quad r = -0.2387, \quad s = 0.4293$$

99% survival with 50% confidence

99% survival with 95% confidence

The bad welds!
AISC category best fit lines to data

99% survival with 95% confidence
6.3 A Suggestion for the Classification of Weldments

Good

Bad
Weld stress concentrations

Termination
Ripple
Toe
Root

Personal view
Fatigue Life, N (cycles) vs. Nominal Stress Range, $\Delta S$ (MPa)
Groove welded butt joints

Fatigue Life, N (cycles)

Nominal Stress Range, $\Delta S$ (MPa)
Non-load-carrying fillet welds

Fatigue Life, \( N \) (cycles) vs. Nominal Stress Range, \( \Delta S \) (MPa) for different types of welds:
- Ripple Groove Welds
- Non-Load-Carrying Fillet Welds
- Load-Carrying Fillet Welds
- Terminations

The graph shows a scatter plot with data points for each category of welds, indicating the relationship between fatigue life and nominal stress range.
Transverse attachments

Fatigue Life, N (cycles) vs. Nominal Stress Range, ΔS (MPa)

- Ripple
- Groove Welds
- Non-Load-Carrying Fillet Welds
- Load-Carrying Fillet Welds
- Terminations
Longitudinal attachments

Fatigue Life, N (cycles) vs. Nominal Stress Range, ΔS (MPa)

- Ripple
- Groove Welds
- Non-Load-Carrying Fillet Welds
- Load-Carrying Fillet Welds
- Terminations
Good, bad, maverick
Fatigue Life, $N$ (cycles)

Nominal Stress Range, $S$ (ksi)

- Non-Load-Carrying Fillet
- Good
- Ripple
- Transverse Groove Welded Butt
- Bad
- Termination
- Partial Penetration Load-Carrying Fillet
- Mavericks

Nominal Stress Range, $S$ (MPa)

- Good welds, Bad welds, Mavericks
The good welds: weld toe failures

Detail #3
Kf = 1.87
2S design = 27.0 ksi.

Full-Penetration Groove Weld: Detail #10
Kf = 2.12
2S design = 23.3 ksi.

Non-Load Carrying Fillet Weld: Detail #25
Kf = 2.23
2S design = 22.1 ksi.
The bad welds: terminations

Load Carrying Fill et Weld:
Detail #20
$K_f = 3.12$
$\sigma_{design} = 17.5 \text{ ksi.}$

Weld Termination:
Detail #30
$K_f = 3.27$
$\sigma_{design} = 14.5 \text{ ksi.}$
Fatigue severity of terminations

- Starts and stops introduce weld discontinuities.
- Residual stresses very high.
- 3-D stress concentrations effects.
Examples of terminations
The mavericks: something undefined

- Partial penetration weldment. The amount of penetration is generally unknown.

- Undercut. Failure occurs at the undercut on wrap-around weld where the arris of the plate is melted. The amount of the undercut is generally unknown.
The mavericks: complex components

- Multiple failure sites. The stress distribution in the joint changes as fatigue cracks initiate and grow at various locations.

- Local stresses uncertain because of structural redundancy
Summary

- Viewed from the perspective of crack initiation site, weldments could be grouped into four categories: ripple, toe, root, and terminations.

- This classification scheme leads to the conclusion that there are “Good” and “Bad” weldments and “Mavericks” - weldments for which a critical piece of information is unavailable and hence their behavior is undefined.