6.2 Classification 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
- AI SC classification system
- An alternative classification system
AISC classification system
AISC category B and C

S = 239.55 * N^{-0.15296}, \ r = -0.50264, \ s = 0.13542

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

99% survival with 50% confidence

99% survival with 95% confidence

The good welds!
AISC category D and E

The bad welds!

Fatigue life, N (cycles)

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

\[
\log N = 6.8974 - 1.03751 \times \log S, r = -0.2387, s = 0.4293
\]

99% survival with 50% confidence

99% survival with 95% confidence
AISC category best fit lines to data

99% survival with 95% confidence

Fatigue life, N (cycles)
Outline

- TWI Classification system
- AISC classification system
- An alternative classification system
Fatigue Life, N (cycles)

Nominal Stress Range, $\Delta S$ (MPa)
Groove welded butt joints

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

Fatigue Life, N (cycles) vs. Nominal Stress Range, \( \Delta S \) (MPa)
Non-load-carrying fillet welds
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

![Graph showing fatigue life vs. nominal stress range for different types of welds: Ripple, Groove Welds, Non-Load-Carrying Fillet Welds, Load-Carrying Fillet Welds, and Terminations. The graph illustrates the relationship between fatigue life (N, cycles) and nominal stress range (ΔS, MPa) on a log-log scale.]
Good, bad, maverick
Good welds, Bad welds, Mavericks

- Non-Load-Carrying Fillet
- Ripple
- Transverse Groove Welded Butt
- Termination
- Maverick

Nominal Stress Range, S (MPa)
- 500
- 100
- 50

Fatigue Life, N (cycles)
Nominal Stress Range, S (ksi)
The good welds: weld toe failures

- **Detail #3**
  - $K_f = 1.87$
  - $S$ design = 27.0 ksi.

- **Full-Penetration Groove**
  - Weld: Detail #10
  - $K_f = 2.12$
  - $S$ design = 23.3 ksi.

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

Load Carrying Fillet Weld:
Detail #20
$K_f = 3.12$
$2S \text{ design } = 17.5 \text{ ksi.}$

Weld Termination:
Detail #30
$K_f = 3.27$
$2S \text{ design } = 14.5 \text{ ksi.}$
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.
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

- Classification systems popular, simple and probably sufficient for many applications.

- However, the actual fatigue resistance of a weldment varies considerably with manner of loading, weldment size, and the state of the mean and residual stresses.....