# 6.1 Problems with weldments



before



#### Applied stresses not well known

#### Complex geometries

Sources of inherent scatter





The stresses which a structure may experience in service are not precisely known.

# Loading Conditions



Fatigue resistance depends upon loading condition

#### Service stresses generally unknown



#### Measurement of service history







# Strain gage location?





Stress concentrating effects of weld toe persist for as much as  $x/t \sim 0.3$ .

Less for bending and less for more generous weld toe radii.



# Variability in applied stresses



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#### Applied stresses not well known

# Complex geometries

Sources of inherent scatter















There is an endless number of weldment geometries.





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# Outline

- Applied stresses not well known
- Complex geometries
- Sources of inherent scatter
  - Weld quality
  - Mean, fabrication and residual stresses
  - Stress concentrations
  - Weldment size
  - Material properties

#### Scatter in weldment fatigue data





The geometry of a weldment may vary with location.

# Weld quality







Fatigue Life, N (cycles)





While the weldment may be simple, many different failure scenarios may exist.



# Welding Residual Stresses



Thermal contractions after welding generate yield point residual stresses

### Fabrication (residual) stresses



Subsequent welding may develop fabrication stresses which are superposed on the welding residual stresses.



Fatigue Life, N (cycles)





#### Weldment stress concentrations



**Unnotched Component** 

Component with a stressconcentrating notch

#### Weld toe is a stress concentration



# Fatigue failure starting at weld toe







Shorter Fatigue life





# Correlation between HAZ and BM hardness



Correlation between S<sub>y</sub> and hardness



# Correlation between hardness and strain-controlled fatigue properties



Variation in fatigue crack growth behavior of steels



# Predicted effect of S<sub>uBM</sub>



Trends in "Ideal" 1.0-in plate thickness, non-load carrying cruciform weldments fatigue strength.

- $\mathbf{R} = \mathbf{0}$
- Welding residual stresses = 50% of S<sub>YBM</sub>



- The variables influencing weldment fatigue life can be thought of as being only two:
  - the magnitude of the notch root stresses.
  - the properties of the notch root material.
- In this sense, the applied stresses, the degree of bending, the welding residual stresses, the fabrication stresses, the weldment geometry, the notch root weld defects all influence the magnitude of the notch root stresses.



- The fatigue behavior of a weldment is controlled by the local (notch root, hot-spot) stress strain history.
- For structural steel weldments: material properties are of minor importance except as they determine and limit the value of the residual stresses.