AE 737 - MECHANICS OF DAMAGE TOLERANCE

Lecture 18

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SCHEDULE

- 31 Mar - Strain based fatigue, project abstract due
- 5 Apr - Crack Growth, Homework 7 due, Homework 8 assigned
- 7 Apr - Crack Growth, Stress Spectrum
- 12 Apr - Retardation, Boeing Commercial Method
- 14 Apr - Exam Review, Homework 8 Due
- 19 Apr - Exam 2
- 21 Apr - Exam Solutions, Damage Tolerance

OUTLINE

1. strain based fatigue

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- The strain-based method gives greater detail, and validity at lower cycles
- It is still valid for high cycle fatigue
- Does not include crack growth analysis or fracture mechanics

STRAIN LIFE CURVE

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- The test is run in strain control (not load control)
- Generally plotted on log-log scale

PLASTIC AND ELASTIC STRAIN

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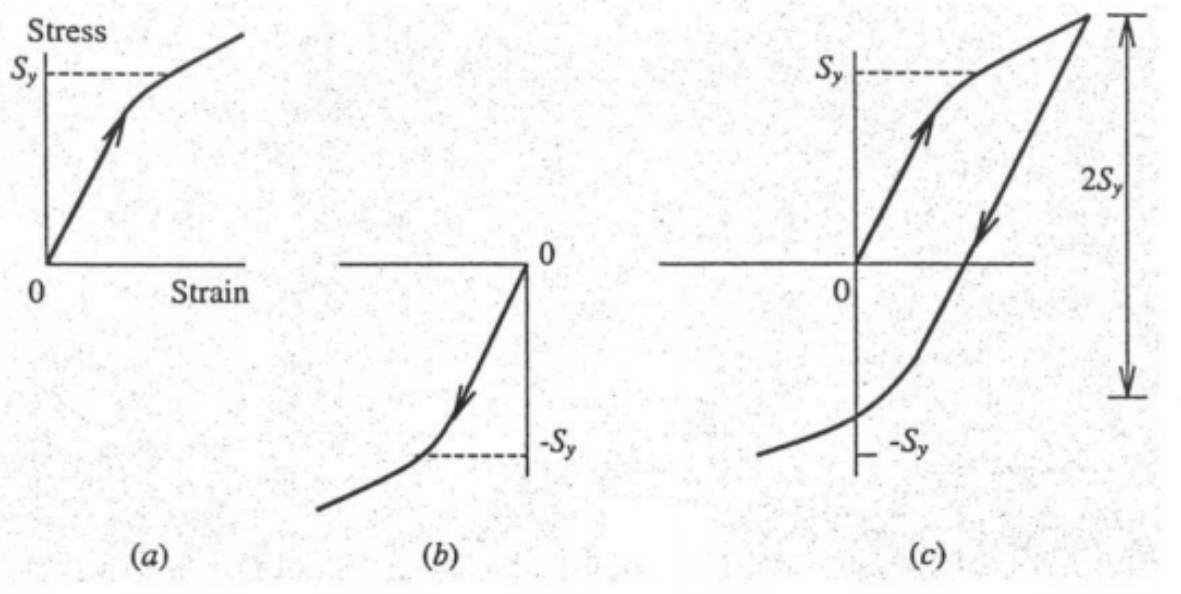
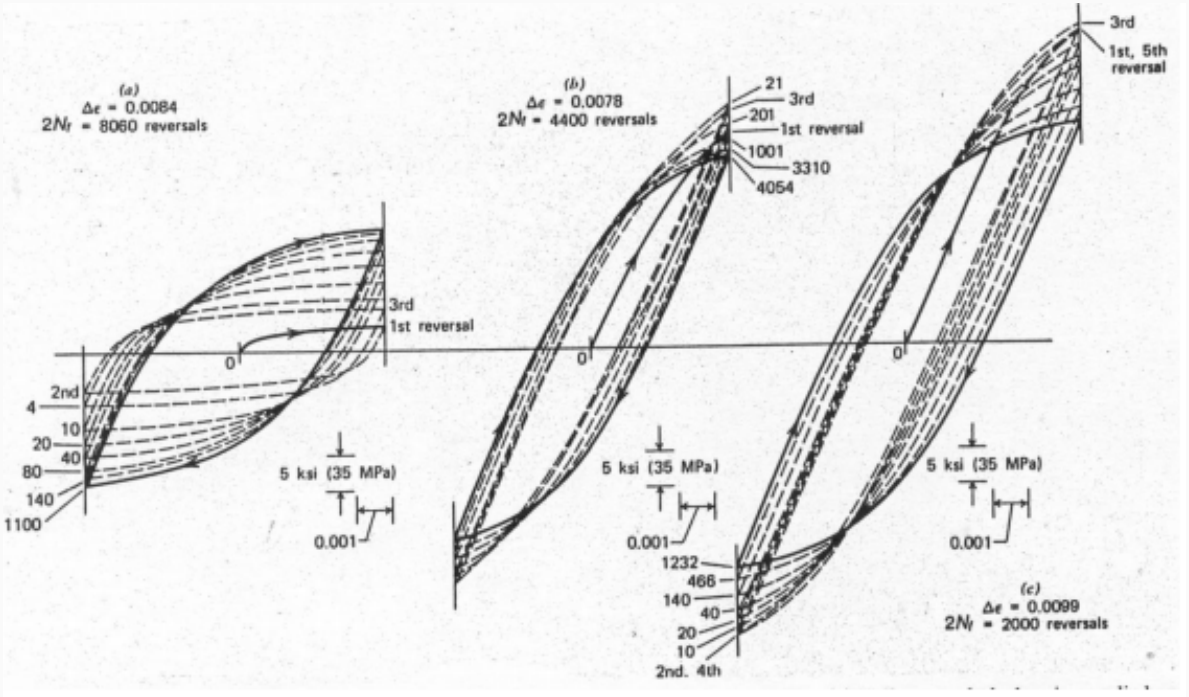
$$\epsilon_a = \epsilon_{ea} + \epsilon_{pa} \tag{18.1}$$

PLASTIC STRAIN



HYSTERESIS LOOPS



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$$\epsilon_a = \frac{\sigma_a}{E} + \left(\frac{\sigma_a}{H'}\right)^{\frac{1}{n'}} \tag{18.2}$$

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- Once for total strain, once for plastic strain, and once for elastic strain
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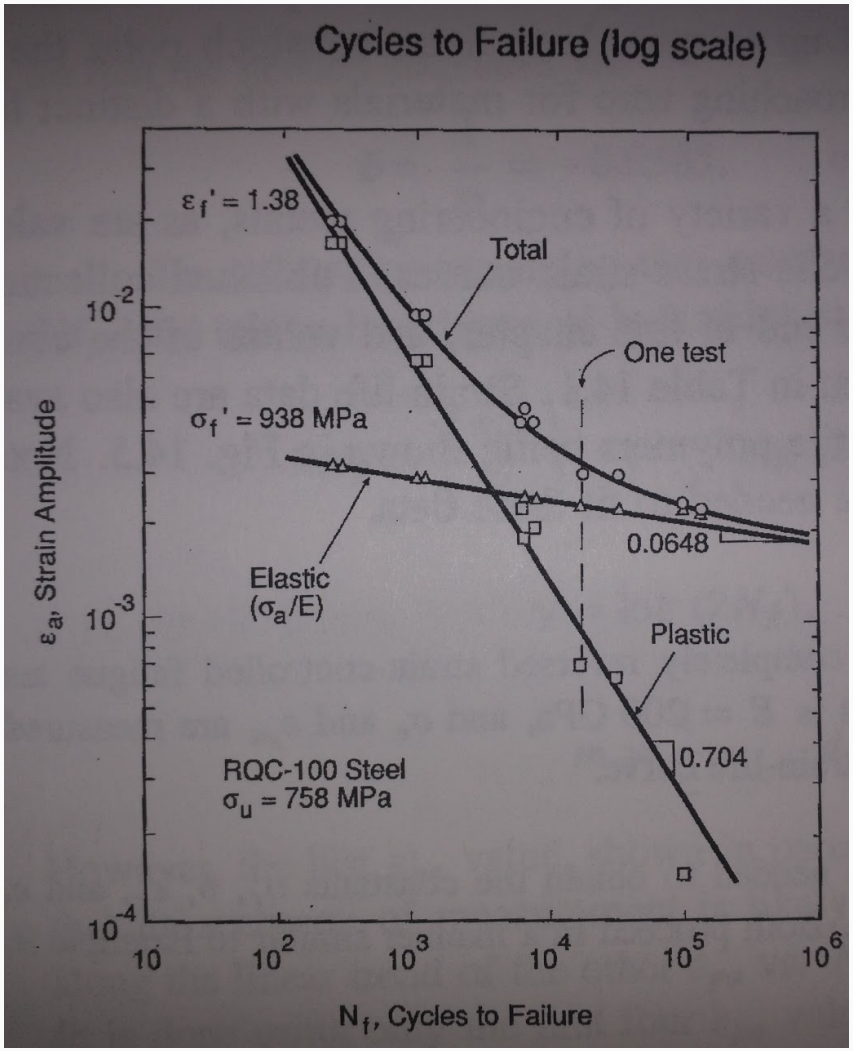
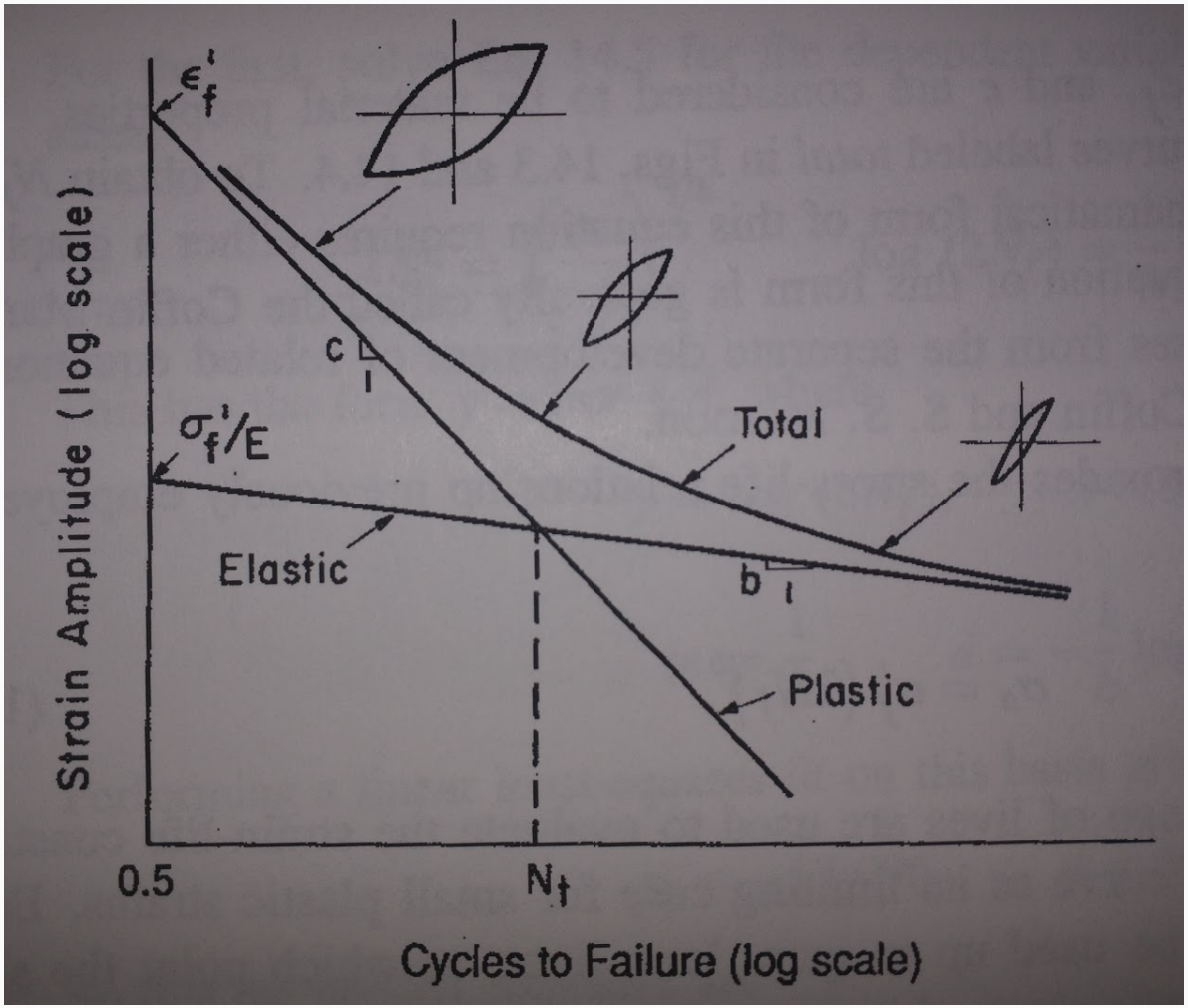
- This is considered representative of stable behavior

EXPERIMENTAL DATA



TRENDS


ϵ_f'
c
1
σ_f'/E
Total
Elastic
b
1
Plastic
Strain Amplitude (log scale)
0.5
N_t
Cycles to Failure (log scale)

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$$\epsilon_{ea} = \frac{\sigma'_f}{E} (2N_f)^b \tag{18.4}$$

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$$\epsilon_a = \frac{\sigma_f'}{E}(2N_f)^b + \epsilon_f'(2N_f)^c \tag{18.6}$$

EXAMPLE

Data from p. 270

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$$N_t = \frac{1}{2}\left(\frac{\sigma_f'}{\epsilon_f'}\right)^{\frac{1}{c-b}} \tag{18.7}$$

INCONSISTENCIES IN CONSTANTS

- If we consider the equation for the cyclic stress train curve

$$\epsilon_a = \frac{\sigma_a}{E} + \left(\frac{\sigma_a}{H'}\right)^{\frac{1}{n'}} \tag{18.8}$$

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- We can consider the plastic portion and solve for σ_a

$$\sigma_a = H'\epsilon_{pa}^{n'} \tag{18.9}$$

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- We then compare with 18.9 and find

$$H' = \frac{\sigma_f'}{(\epsilon_f')^{b/c}} \tag{18.12a}$$

$$n' = \frac{b}{c} \tag{18.12b}$$

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- However, in practice these constants are fit from different curves
- In some cases there can be large inconsistencies in these values
- One cause for this is data that do not lie on a straight line in the log-log domain
- For ductile materials at short lives, the true stresses and strains may differ significantly from engineering stress and strain