AE 737 - MECHANICS OF DAMAGE TOLERANCE

LECTURE 23

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SCHEDULE

- 19 Apr - Damage Tolerance, Homework 8 Due
- 21 Apr - Exam 2
- 26 Apr - Exam Solutions, Damage Tolerance
- 28 Apr - SPTE, AFGROW, Finite Elements
- 3 May - Finite Elements
- 5 May - Non-Destructive Testing, Composites, Final Project Due May 10

OUTLINE

1. special topics
2. review
3. damage tolerance
4. inpsection cycle

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- Composite certification
- Other questions?

REVIEW

GROUP 1

Find the fatigue life of 2024-T4 aluminum ($\sigma_f' = 131$ ksi, $b = -0.102$) under the following load scenario

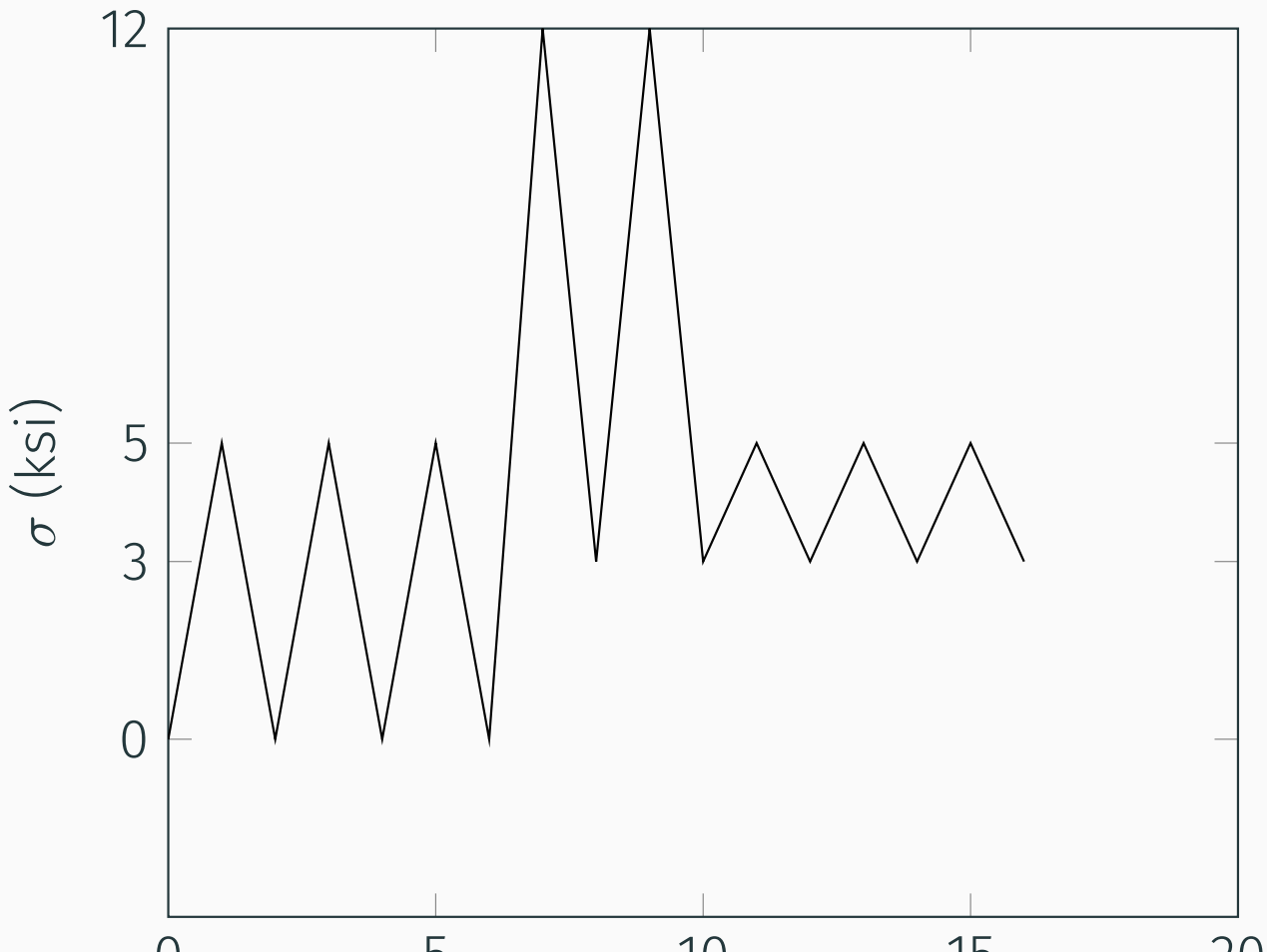
Stress Term	Min	Max
σ_x	0	15
σ_y	-5	10
τ_{xy}	5	15

GROUP 2

Show how to find the cycles to failure for 7075-T6 ($\sigma_f' = 213$ ksi, $b = -0.143$, $\epsilon_f' = 0.262$ and $c = -0.619$) with $\epsilon_a = 0.40$ and $\sigma_m = 15$ksi

GROUP 3

Use the Boeing method to find an equivalent load cycle for the following load spectrum. Repeat this calculation using two different "cycle counting" methods. Use material properties for 4340 steel ($p = 2.7$, $q = 0.84$, $M_T = 70.0$).



GROUP 4

For a wide, center-cracked panel with $C = 10^{-9}$, $n = 4$ and $a_0 = 1.5$ in. Assume $\sigma_{YS} = 70$ ksi.

1. Integrate to find the crack length after 10,000 cycles of $R = 0$, $\sigma_{max} = 10$ ksi loading
2. Calculate the plane stress plastic zone after an overload of $\sigma = 30$ ksi
3. Find the Wheeler parameter (ϕ) for the next cycle of $\sigma_{max} = 10$ ksi loading with $m = 1.5$

DAMAGE TOLERANCE

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  - Inspection cycles are set such that we can be sure crack will not become critical during regular operation

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- **Operating load** stress spectrum (used for crack propagation/fatigue)

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- Single load path - damage tolerant
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- Multiple load path - inspectable prior to failure

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- This often requires replacing parts pre-maturely

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- Many times this damage can be repaired to avoid replacing the part entirely
- Ideal for large, expensive parts that are easy to access (inspection and repair)

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- A secondary structure is inspectable
- The secondary structure can support a certain number of cycles after failure of the primary structure
- Secondary structure can be inspected to observe damage in primary structure

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- Otherwise same as externally inspectable structure

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    1. Determine loading cycle (or equivalent load cycle using Boeing method)
    2. Determine maximum crack length
    3. Determine initial assumed crack length (minimum detectable crack)
    4. Calculate number of cycles/flights until crack grows to maximum allowable size

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$$\sum_i (z\sigma_{max})_i^p \, N_i = (S)^p \tag{23.1}$$

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- Crack growth becomes unstable in Region III

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- Radiographic (X-Ray, nearly any material)

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- ΔN should be small enough to give converged solution

EXAMPLE