

AE 737 - MECHANICS OF DAMAGE TOLERANCE

LECTURE 23

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Last Updated: April 19, 2016 at 5:31pm

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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

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

SPECIAL TOPICS

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- Composite certification
- Other questions?

REVIEW

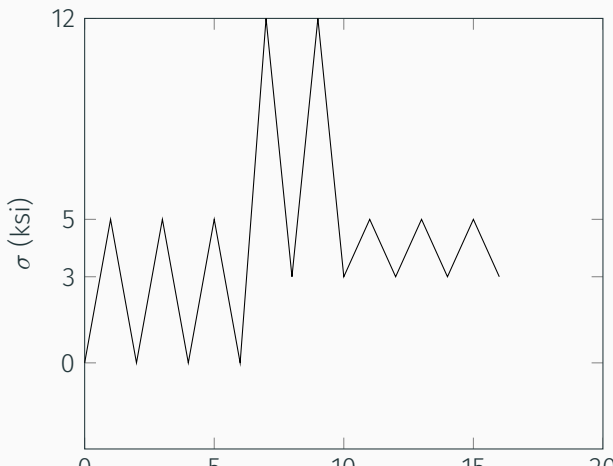
Find the fatigue life of 2024-T4 aluminum ($\sigma'_f = 131$ ksi, $b = -0.102$) under the following load scenario

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

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 ($p = 2.7$, $q = 0.84$, $M_T = 70.0$).



For a wide, center-cracked panel with $C = 10^{-9}$, $n = 4$ and $a_0 = 0.15$ 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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- **Damage tolerant**
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 - When cracks grow to a sufficient size, they are inspectable
 - 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)

- Single load path - safe life

STRUCTURAL CATEGORIES

- Single load path - safe life
- Single load path - damage tolerant

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

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- This often requires replacing parts pre-maturely

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- When the detectable crack size is much less than the critical crack length, we can safely inspect a part so that it is only replaced when damage is detected
- 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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- 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

- In this case the primary structure is inspectable

MULTIPLE LOAD PATH - INSPECTABLE PRIOR TO FAILURE

- In this case the primary structure is inspectable
- Otherwise same as externally inspectable structure

INPSECTION CYCLE

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- We have developed all the equations necessary to determine our own
 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

- Be sure to use a consistent cycle-counting method (rainflow or range-pair)

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

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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

