08/22/2018

Wednesday, August 22, 2018 11:39 AM

http://rezaabedi.com/

http://rezaabedi.com/teaching/fracture-mechanics/

See the file

Detail of course topics

This file describes all the topics covered with specific references to books for different sections.

From <http://rezaabedi.com/teaching/fracture-mechanics/>

The slide

The main reference is:

1. T. L. Anderson, Fracture Mechanics: Fundamentals and Applications, 3rd Edition, CRC Press, USA, 2004 (**main textbook**).

Presentations can be downloaded from:

From <http://rezaabedi.com/teaching/fracture-mechanics/>

http://www.rezaabedi.com/wp-content/uploads/Courses/FractureMechanics/FractureMechancisME524.pdf

Two projects:

1. Term paper & presentation
2. Computing stress intensity factor using a commercial software

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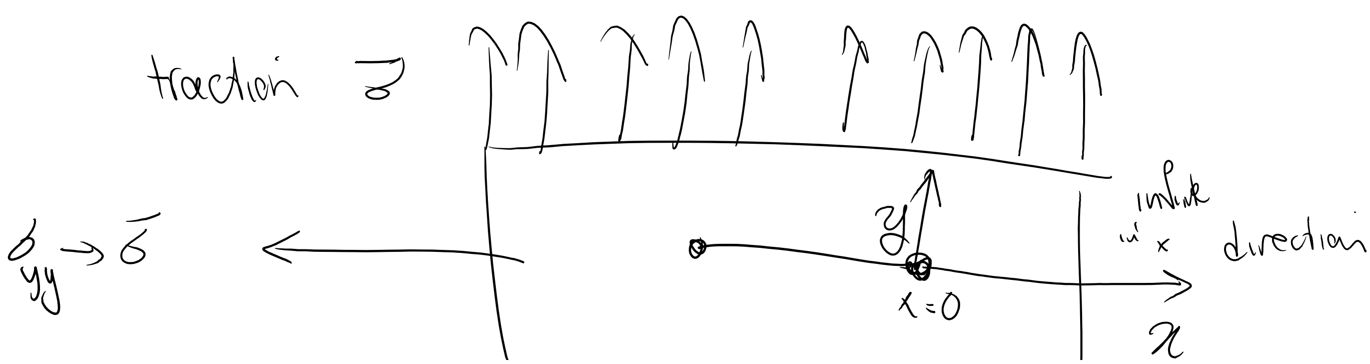
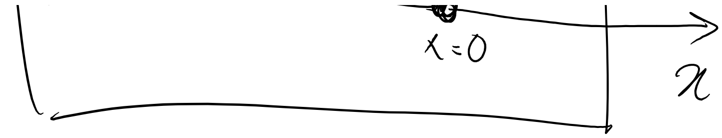
Course outline:

1. Brief introduction to fracture mechanics (ductile and brittle materials and transition between the two).
2. LEFM theory
3. PFM (plastic fracture mechanics)



yy



sym same as top

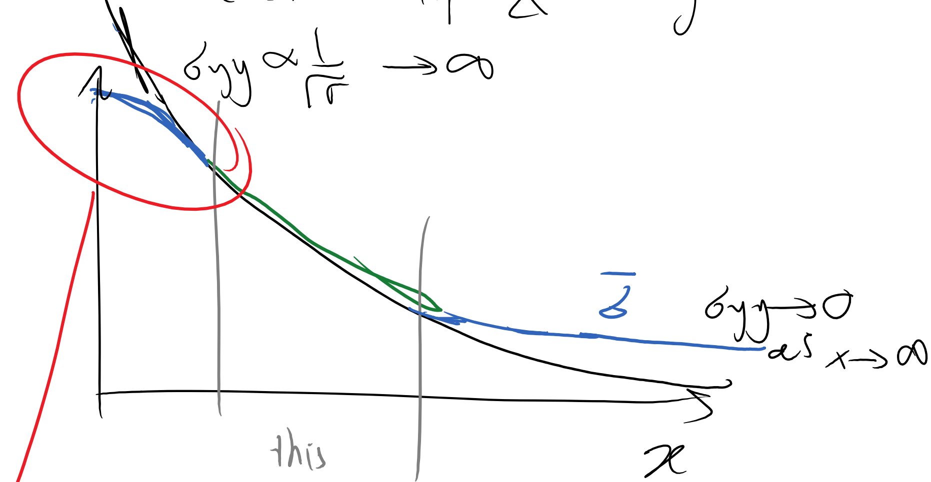
looking at stress at the crack tip & along x axis

stress intensity factor

$$\sigma_{yy}(x, y=0) = \frac{K_I}{\sqrt{2\pi x}}$$

$\sigma_{yy} \propto \frac{1}{\sqrt{r}} \to \infty$

$\sigma_{yy} \propto \frac{1}{\sqrt{x}}$

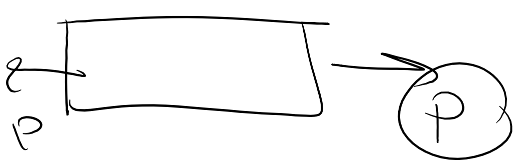


$\sigma_{yy} \to \bar{\sigma}$ as $x \to \infty$

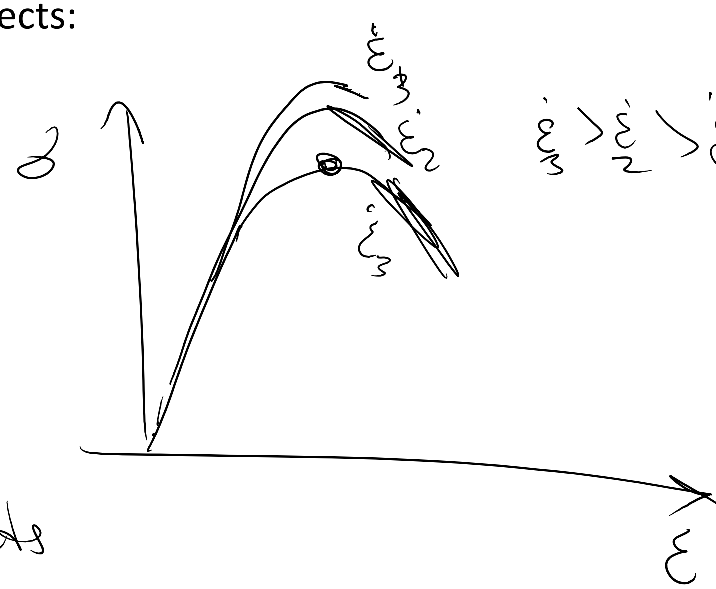
model solution with more accurate models, e.g. PFM

this distance range LEFM is a very good approximation

Dynamic fracture and rate effects:

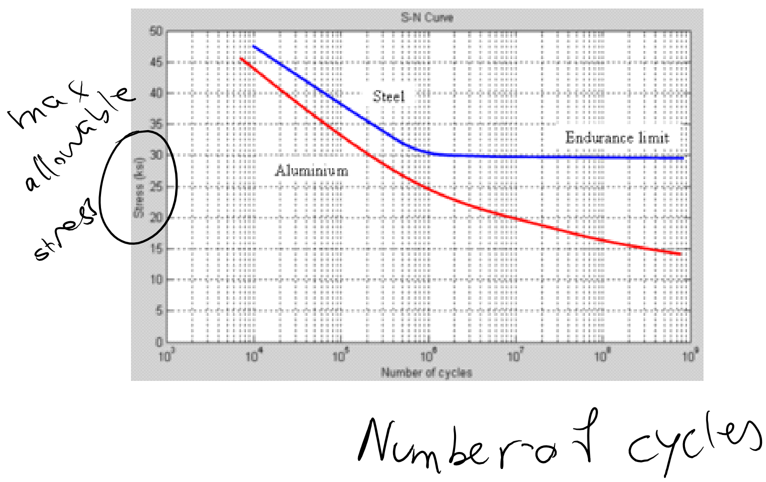


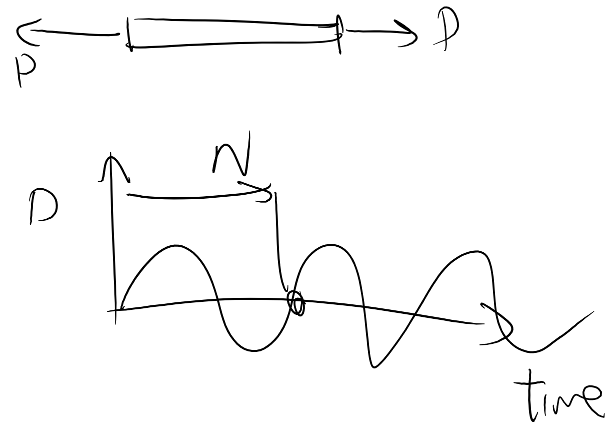
Pulling the ends with different speeds



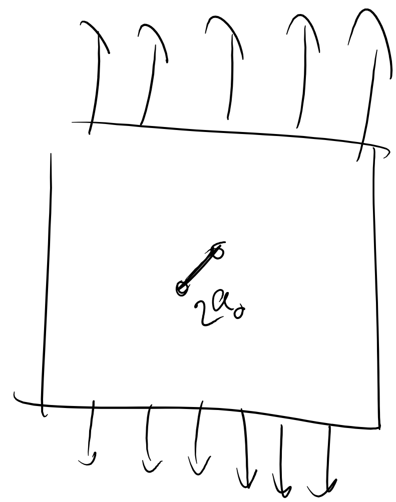
$\dot{\varepsilon}_3 > \dot{\varepsilon}_2 > \dot{\varepsilon}_1$

Fatigue:





The Paris law (modern way of looking into fatigue)



helps us understand how the crack length advances during the life of specimen going through cyclic load

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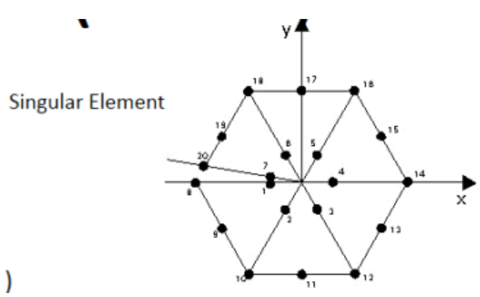
Differences between ductile and brittle materials

- Computational fracture mechanics
  Learn how to extract important fracture mechanics parameters from finite element (or other numerical method) solutions.



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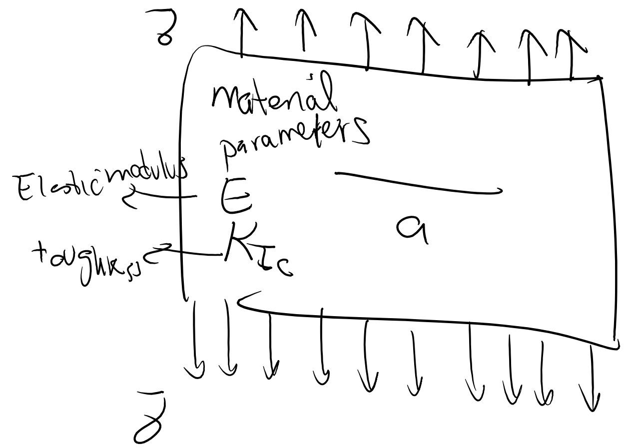
Goals: accurate solution around the crack tip and extraction of stress intensity factor, etc.

Three different problems encountered in fracture mechanics

1. Design loads σ
2. Material properties E, K_{IC}, ...
3. (in Fracture mechanics) defect sizes e.g. a



Design problems we have two need the third?

a. 1,2 are given -> what crack length is safe (fatigue analysis, …)
b. 1,3 are given -> what material is needed to withstand the given load and certain type of defect. (may not be practical -> expensive design, …)
c. 2,3 are given -> 1 want to find the safe design load (how much load can this structure take).

Design philosophies

- Safe life

  The component is considered to be free of defects after fabrication and is designed to remain defect-free during service and withstand the maximum static or dynamic working stresses for a certain period of time. If flaws, cracks, or similar damages are visited during service, the component should be discarded immediately.

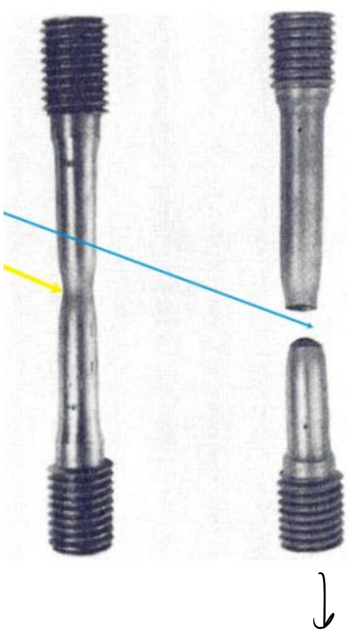
- Damage tolerance

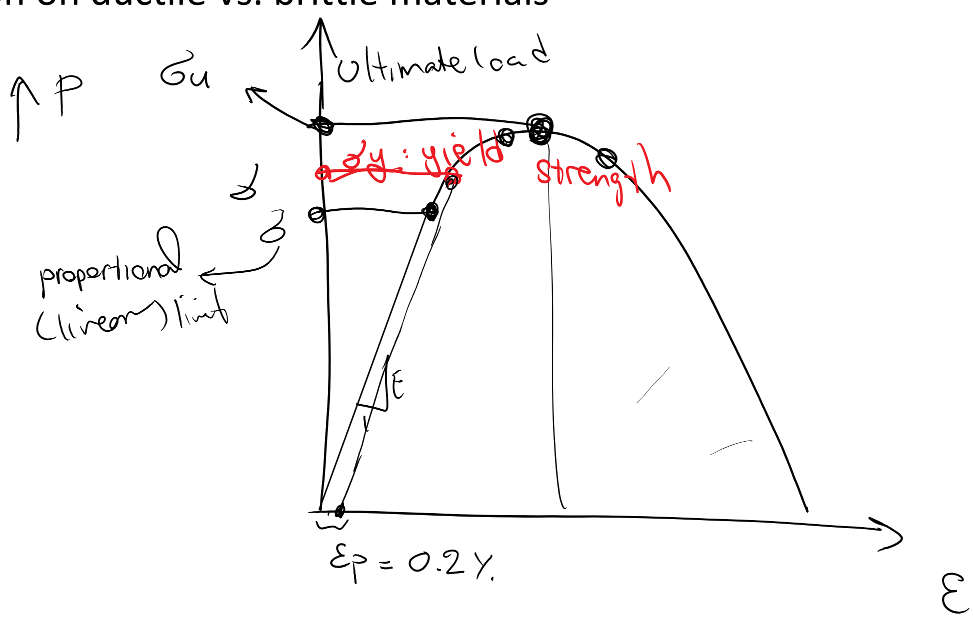
  The component is designed to withstand the maximum static or dynamic working stresses for a certain period of time even in presence of flaws, cracks, or similar damages of certain geometry and size.

Damage tolerance is the newer approach to design and typically results in more risk-informed and economical designs.

Starting the discussion on ductile vs. brittle materials

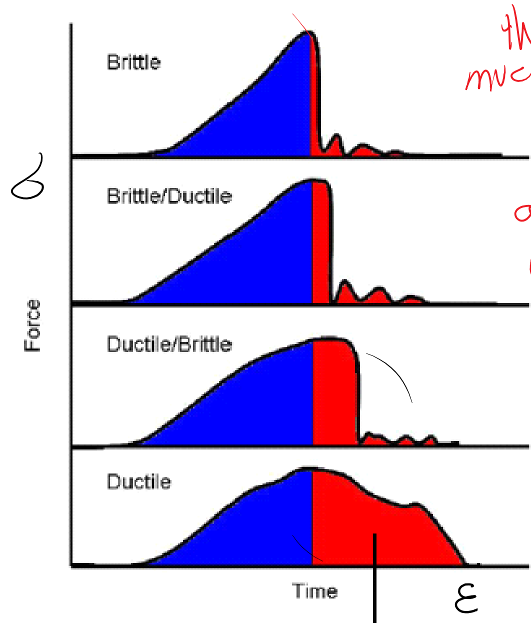
Stress-strain plot:





there is not much time left

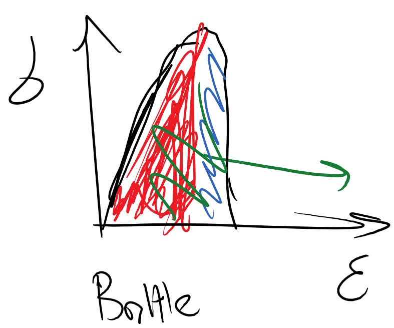
↓ P



there is not much time left

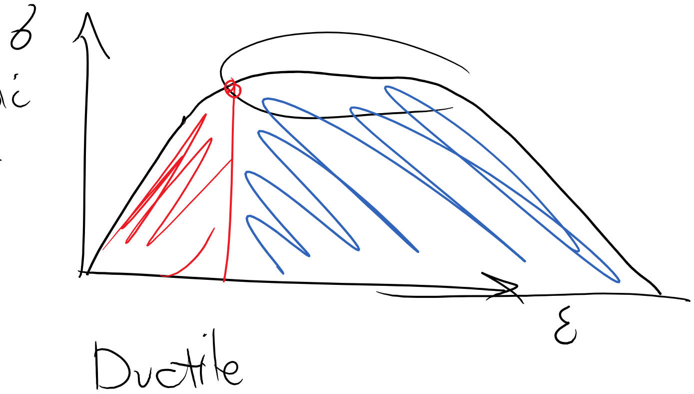
after reaching ultimate loading

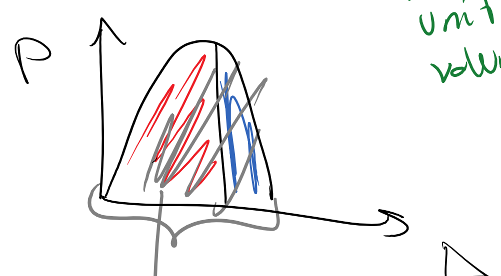
ε-σ

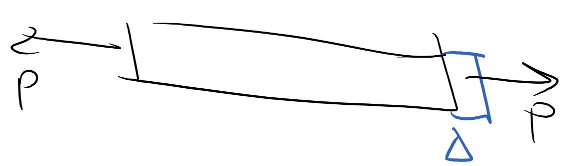


micro scopic level

energy dissipated per unit volume





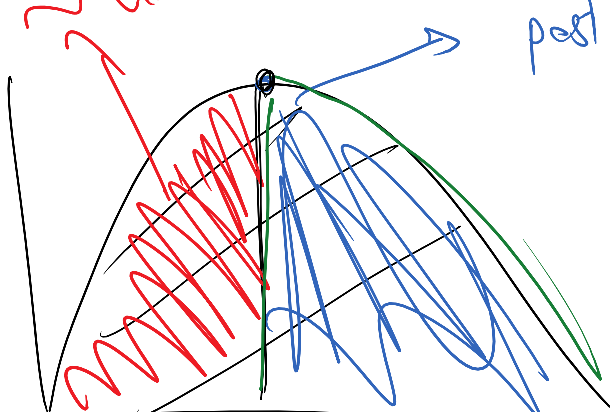


Energy dissipated (plasticity, fracture)

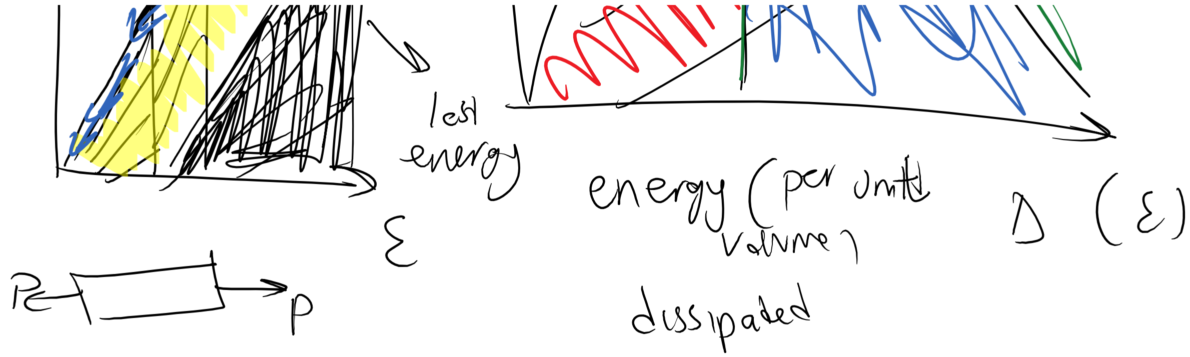
~ elastic

released energy

P(σ)



post ultimate load



Energy past ultimate load is very useful because in failure material dissipates more energy -> failure is less catastrophic