# AE837

## Advanced Mechanics of Damage Tolerance

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Wichita State University, Department of Aerospace Engineering October 10, 2019

# upcoming schedule

- Oct 10 - Cohesive Zone
- Oct 15 - Fall Break (no class)
- Oct 17 - XFEM, Homework 4 & 5 Due
- Oct 22 - XFEM
- Oct 24 - Mixed-Mode Fracture, Project Abstract Due

# outline

- final project
- cohesive zone
- mixed mode cohesive law

# final project

# final project

- Model crack propagation in some real-life object
- Can be anything, including work you find in a literature review
- Abstract due Oct 24

# rubric

- Abstract - 5%
- Analytic Model - 20%
- Justification for Numerical Method - 20%
- Propagation Model - 25%
- Conclusions - 15%
- General presentation - 15%

# abstract

- 1-2 pages describing your idea for a project and why it will satisfy the requirements
- Think about a real crack propagation problem and what assumptions you might need to make to model it
- How will this project demonstrate your understanding of this material?

# analytic model

- Use methods described in class, as well as possibly some simplifying geometric assumptions, to model the strain energy release rate and/or the stress intensity factor
- You can use this as a check on your finite element model to make sure you have set up your boundary conditions correctly

# justification

- We have (and will) discussed several different numerical techniques for crack propagation
- Justify why the method you have chosen is the best approach for your problem

# propagation model

- You are not required to turn in the actual model with your project
- Instead, you will interpret the results and portray them in a report

# conclusions

- You should interpret the results from your model and make some conclusions
- What have you learned about crack propagation in this problem as a result of your work?
- Do you have any recommendations to improve this model or to improve this object?

# general presentation

- Organization
- Consistent formatting
- Spelling/grammar

# cohesive zone

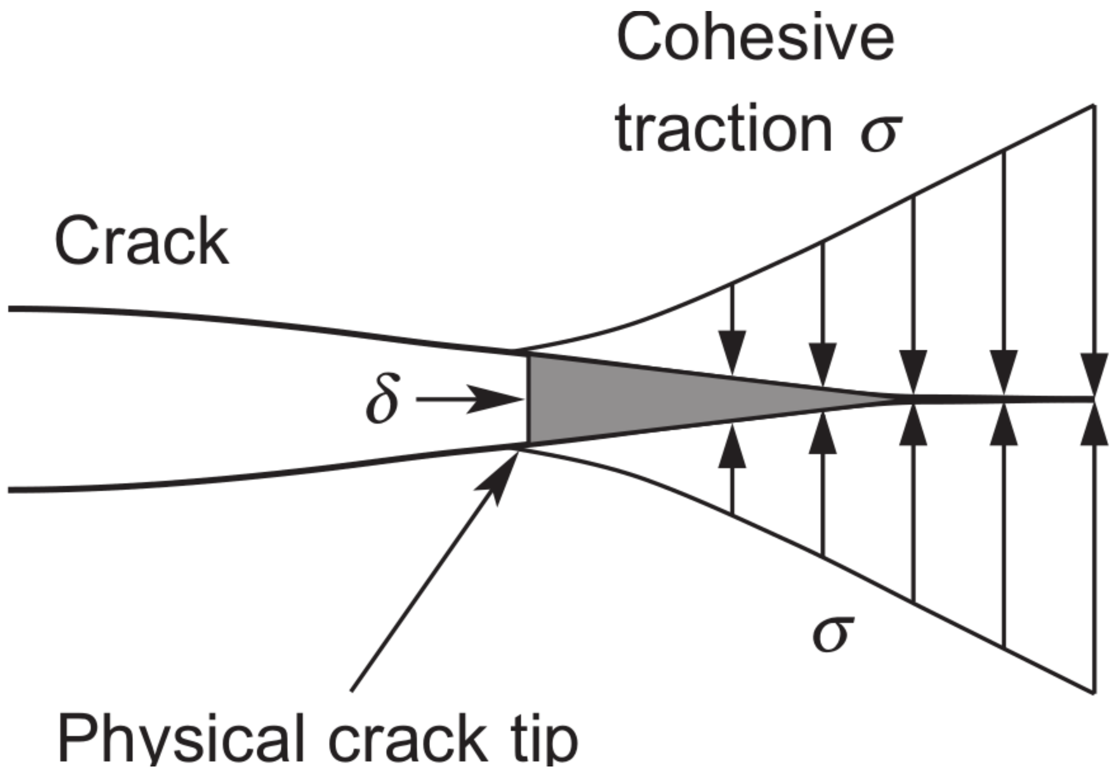
# cohesive zone

- Linear Elastic Fracture Mechanics is built on the continuum assumption
- This is appropriate at large scales, but inaccurate near the atomic scale
- As we consider the atomic scale, the concept of a stress singularity does not make sense
- The cohesive zone model was proposed to treat this

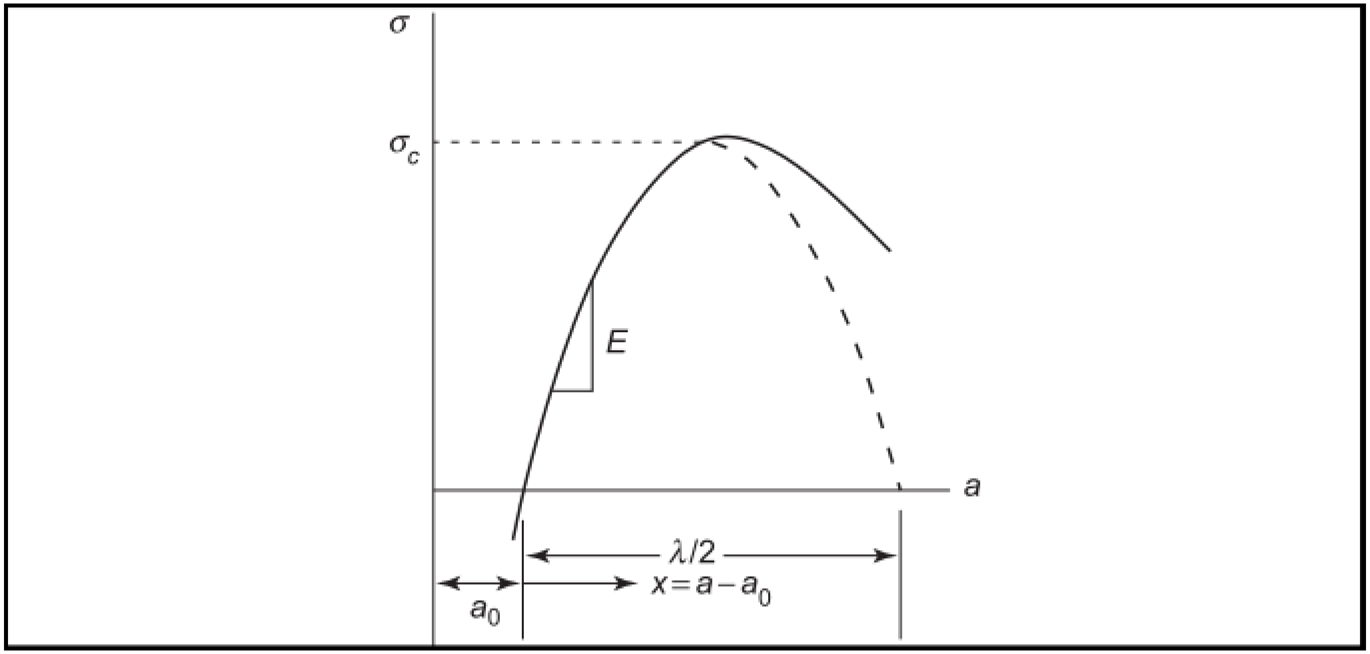
# cohesive zone

- There exists a zone near the crack tip held together by cohesive traction
- The size of the cohesive zone and magnitude of the cohesive traction are independent of geometry and external loads
- Stresses are finite everywhere, including the crack tip

# cohesive zone



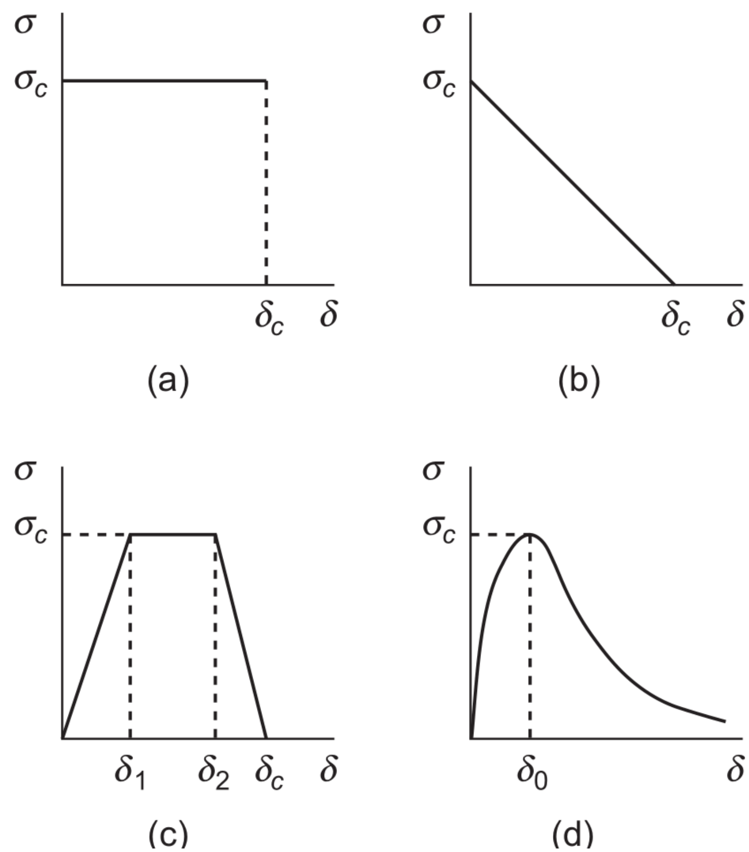
# cohesive zone



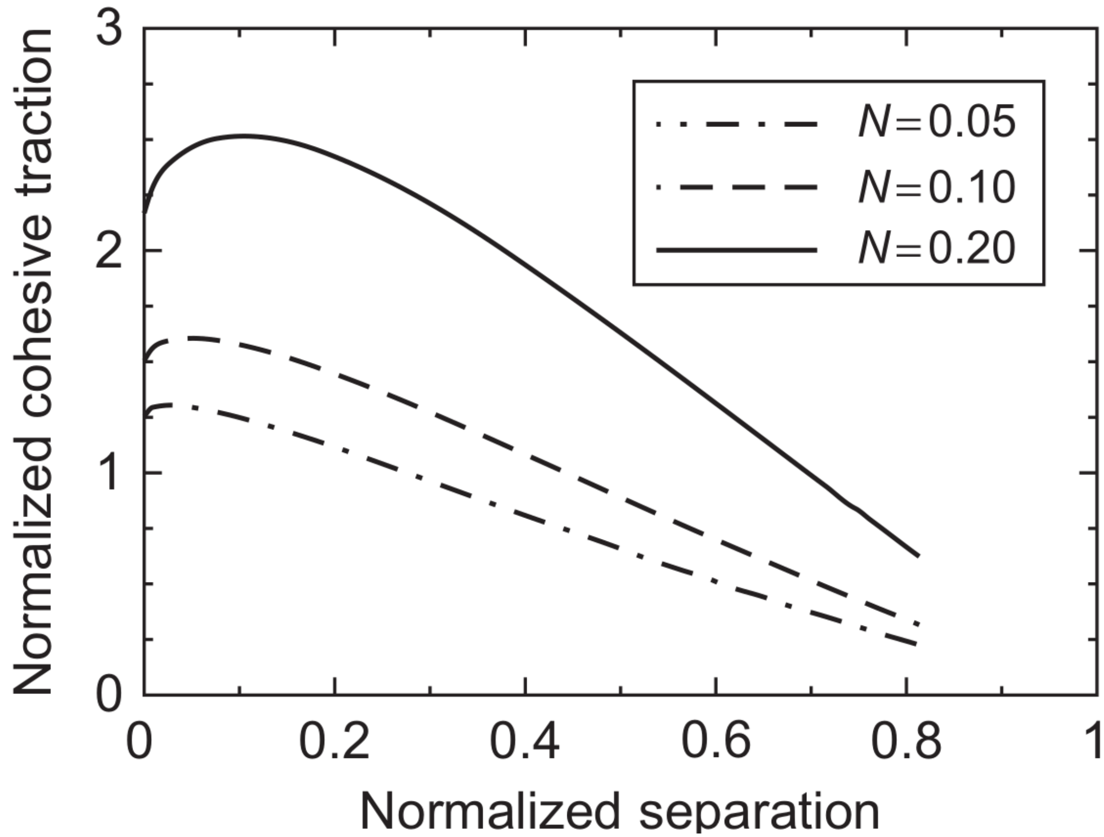
# failure models

- We can represent various failure models by incorporating different behavior in the traction-separation law
- Dugdale model for ductile materials
- Linear softening model for quasi-brittle materials (concrete and ceramics)
- Trapezoidal model combines both
- Expenonential form (based on atomic failure theory)

# failure models



# necking



Normalized cohesive traction
Normalized separation
0
1
2
3
0
0.2
0.4
0.6
0.8
1
N=0.05
N=0.10
N=0.20

# mixed mode cohesive law

# mixed-mode cohesive law

- Cohesive zones are often used to model an adhesive bond between two dissimilar interfaces
- Interfacial fraction is inherently mixed-mode due to the different material properties across the interface
- Therefore we must describe a cohesive law for mixed-mode conditions

# mixed-mode cohesive law

- If we consider a cohesive traction with both normal and shear components, $\sigma_n$ and $\sigma_s$
- And also normal and shear components of separation, $\delta_n$ and $\delta_s$
- We can define an effective traction and separation in terms of some parameter $\eta$

# mixed-mode cohesive law

$$\sigma_{eff} = \sqrt{\sigma_n^2 + \eta^{-2}\sigma - s^2}$$

$$\delta_{eff} = \sqrt{\delta_n^2 + \eta^2\delta_s^2}$$