Course and Instructor Information

Course Title: CE 5163
Credits: 3
Prerequisites: None
Instructor: Jeongho Kim

Course Description

Focuses on fundamental concepts and applications of fracture mechanics. Topics include linear elastic fracture mechanics, elastic plastic fracture mechanics, computational fracture mechanics, fracture mechanisms in metals and non-metals, fracture testing, dynamic and time-dependent fracture, fatigue crack growth, interfacial fracture, fracture in advanced materials, and engineering applications.

Course Objectives

By the end of the semester, students should be able to:

- Derive linear-elastic and elastic-plastic crack-tip fields for an isotropic homogeneous material
- Derive linear-elastic crack-tip fields for an isotropic bi-material with an interface crack
- Calculate stress intensity factors and the energy release rate
- Derive the path-independent J-integral and M-integral
- Apply energy domain integrals to calculate stress intensity factors using finite element methods
- Apply fracture mechanics concepts such as J and CTOD to laboratory testing specimens and real structures

Course Outline

Sections	Topics
1. Introduction	Overview & background Historical perspective Theoretical Cohesive Strength of Solids
2. Linear Elastic Fracture Mechanics (LEFM)	Inglis/ Griffith/ Irwin's work Basics of solid mechanics (Elasticity)
	Linear-elastic crack tip fields (Homogeneous) (Williams solution: In-plane modes and Mode III)
	Complex Variable Analysis
	Westergaard stress function (SIF & T-stress)
	Relationship between SIF and energy release rate (Irwin's crack closure analysis) Crack tip plasticity/ Plane stress & Plane strain/
	ASTM standard E-399/ K-dominance/ Interfacial Fracture (Bi-material)
3. Elastic Plastic Fracture Mechanics (EPFM)	Dugdale-Barenblatt model/ Yield criteria Theoretical Shear Strength of Solids/Lattice Defects/ Dislocation Theries/Macroscopic Plasticity Theories/ Mode-3 Fields in EPP Materials
	J-integral / The HRR fields (SSY)
4. Computational Fracture Mechanics	Basics of the finite element method (FEM) FRANC2D analysis
	Energy domain integrals – J-integral
5. Fracture Mechanisms	Metals
	Non-Metals

6. Fracture Testing of Metals	Deformation J, J_{IC} (ductile tearing), Jc (cleavage), J-R Curve, Constraint Effects on J-R Curve, ASTM Testing Standards
7. Fatigue Crack Growth	Fatigue essentials/ fatigue crack growth
	Crack closure/Overloads/Fatigue mechanisms
8. Dynamic and Time-dependent Fracture	Dynamic fracture and crack arrest
	Elasto-dynamic crack-tip fields
	Creep crack growth/Viscoelastic fracture mechanics
9. Engineering Applications and Other topics	Fracture in Concrete, Compression Fracture, Welded Structures, Failure Assessment Diagram

Course Materials: No Textbook Required