MSE 5315

FATIGUE OF ENGINEERING MATERIALS

Fall 2011

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Text Book	"Fatigue of Materials" S. Suresh. Cambridge University Press "Fundamentals of Metal Fatigue Analysis" J. Bannantine, J. Comer and J. Handrock. Prentice Hall		
Lectures	Tuesday Thursday	5:00 – 6:20 ; Rm. 221 Woolf Hall 5:00 – 6 .20 ; Rm. 221 Woolf Hall	
Office Hours	Thursday	2.00 –4.00 Rm. 335 ELB	
Homework	As and when given		
Examinations	Exam I Exam II	Oct. 27th, Dec. 1st ,	2011, 5:00- 6.20 pm 2011, 5:00- 6.20 pm
Grading	Homework Exam I Exam II Term Paper Presentation		15% 30% 30% 15% 10% --- 100% ---

American With Disabilities Act

The University of Texas at Arlington is on record as being committed to both the spirit and letter of federal equal opportunity legislation; reference Public Law 93112 - The Rehabilitation Act of 1973 as amended. With the passage of new federal legislation entitled Americans with Disabilities Act (ADA), pursuant to section 504 of the Rehabilitation Act, there is renewed focus on providing this population with the same opportunities enjoyed by all citizens.

As a faculty member, I am required by law to provide "***reasonable accommodation***" to students with disabilities, so as not to discriminate on the basis of that disability. Student responsibility primarily rests with **informing faculty at the beginning of the semester and in providing authorized documentation through designated administrative channels.** If you require an accommodation based on disability, I would like to meet with you in the privacy of my office during the first week of the semester to make sure that you are properly accommodated.

Academic Dishonesty

It is the philosophy of the University of Texas at Arlington that academic dishonesty is a completely unacceptable mode of conduct and will not be tolerated in any form. All persons involved in academic dishonesty will be disciplined in accordance with University regulations and procedures. Discipline may include suspension or expulsion from the University.

"Scholastic dishonesty includes but is not limited to cheating, plagiarism, collusion, the submission for credit of any work or materials that are attributable in whole or part to another person, taking an examination for another person, any act designed to give unfair advantage to a student or the attempt to commit such acts." (Regents' Rules and Regulations, Part One, Chapter VI, Section 3, Subsection 3.2, Subdivision 3.22)

OVERVIEW

Fatigue failures occur in many ways. Fluctuations in externally applied stresses or strains results in *mechanical fatigue*. Cyclic loads associated with high temperatures cause *creep-fatigue*. When both temperature and load fluctuate we have *thermo-mechanical fatigue*. Cyclic loading in a corrosive media causes *corrosion fatigue*.

The course aims to provide a comprehensive understanding of the fatigue process in materials and should appeal to a wide audience. This course will employ theoretical and practical examples. An understanding of the fatigue mechanisms can help us to answer some of the following questions

1) Why does fatigue occur?
2) How can we understand the development of damage due to fatigue?
3) What is the mechanism of fatigue crack growth?
4) How can we design components to minimize fatigue failures?

COURSE OUTLINE

1. **OVERVIEW AND INTRODUCTION TO FATIGUE**
   - Historical perspective of fatigue failures and their consequences.
   - What is fatigue?
   - General overview of terminology's used in fatigue.

2. **CUMULATIVE DAMAGE APPROACH**
   - Stress life approach.
   - Strain life approach.
   - Effect of mean stress
   - Comparison of both the approaches.
   - Cyclic strain hardening/softening in crystals.
   - Formation and development of Persistent Slip Bands.
   - Effect of Metallurgical variables.

3. **FATIGUE CRACK INITIATION**
   - Surface roughness.
   - Persistent slip bands.
   - Environmental effects.
   - Grain boundaries.
   - Material defects.

4. **FRACTURE MECHANICS**
   - Griffith Critera of Brittle Fracture.
   - Stress distribution and Stress Concentration Factors
   - Stress Intensity factor calculation and crack tip stress fields.
   - Linear elastic fracture mechanics and Elastic Plastic fracture mechanics.
   - K-Dominance and J-Dominance.

4. **FATIGUE CRACK GROWTH**
   - Microscopic stages of crack growth.
   - Near threshold crack growth.
   - Intermediate and high growth regime.
   - Factors that affect fatigue crack growth.
   - Mechanism of corrosion fatigue.
   - Crack initiation and growth at elevated temperatures.

5. **RETARDATION OF FATIGUE CRACK GROWTH**
   - Plasticity induced closure.
   - Oxide induced closure.
   - Roughness induced closure.
   - Viscous fluid induced closure.

- Phase transformation induced closure.
- Fatigue crack deflection.
- Crack bridging and shielding.

6. NOTCH SENSITIVITY

- Stress life approach.
- Fracture mechanics approach.
- Crack initiation and growth in cyclic compression.
- Short crack growth

7. VARIABLE AMPLITUDE FATIGUE

- Spectrum loading.
- Damage accumulation.
- Fatigue crack retardation following tensile overloads.
- Transient effects following compressive overloads.
- Overload sequence effects.

8. CORROSION FATIGUE

- Mechanisms of Corrosion Fatigue
- Nucleation and growth of corrosion fatigue cracks.
- Fatigue at elevated temperatures.

9. FATIGUE OF BRITTLE MATERIALS

- Mechanism of Fatigue
- Highly brittle solids
- Transformation toughened ceramics.
- Static Vs. Fatigue behavior
- Crack growth in cyclic compression.
- Cyclic Damage
- Fatigue crack growth

10. DESIGN CONSIDERATIONS AND CASE STUDIES

- Safe life and fail safe concepts.
- Cycle counting.
- Fatigue failure of aircraft structures.
- Failure analysis of electronic modules under thermal-mechanical stresses.
- Failure analysis of automotive components.