Fracture Mechanics and Applications

Semester I - 2004

Scope

For centuries structures have been known to fail in brittle fracture. The vast increase in the use of high strength metals and the reduction in design safety factors motivated a large number of researchers, mainly after World War II, to investigate these phenomena. As a result of the experimentally obtained data and the theories developed, *Fracture Mechanics* a new branch of materials mechanics has emerged. The fast evolution of this field in the past seventy years made Fracture Mechanics the primary approach to controlling brittle fracture and fatigue failures in structures. The present course has two aims:

(a) To provide the physical and the mathematical principles of Fracture Mechanics.

(b) To present various applications of this theory to practical problems of structural engineering.

Instructor

Prof. Mordechai Perl
Building Room
Phone: xxxxxx

Office Hours

Monday: 10:00-12:00
Wednesday: 10:00-12:00

Homework

Week assignments due on Mondays.

Exams and Grades

Homework assignments	25%
Final Exam	75%
	100%

Curriculum

Lecture No.	Topic	Ref.*
1	**Introduction to Fracture Mechanics** **Theory of Elasticity and Plasticity** a. Notion of stress b. Principal Stresses and Principal Coordinates c. Maximum Shearing Stress d. Hydrostatic and Deviatoric Stress Tensors e. Equilibrium Equations and Boundary Conditions	B-1.1, R-1.1 T-1, 2 T-74-79 T-12-13 T-84
2	**Theory of Elasticity and Plasticity (Continued)** f. Notion of Strain g. Compatibility Equations h. Generalized Hoke's Law i. General Formulation of Elastic Problem j. Principle of Superposition k. Strain Energy l. The Plane Problem of Elasticity m. Tresca's and von-Mises' Yield Criteria	 T-5 T-85 T-6-7 T-Ch-7 T-89 T-90 T-Ch-2
3	**Griffith's Fracture Criterion – the Energy Balance Approach**	B-1, R-2.2
4	**Irwin's Fracture Criterion – the Stress Approach**	B-3, R-2.1, 2.2

**** The notation in this column refers to:***

- T - ref. [1]
- B - ref. [2]
- R - ref. [3]
- KI and KII - the two parts of ref. [4]
- numbers refer to corresponding chapters (Ch) or articles.

Lecture No.	Subject	Ref.*
5	**Methods for Evaluating Stress Intensity Factors** 1. *Analytical Solutions* a. Exact Solutions b. The Energy Approach c. Green's Function d. Schwartz Alternating Method 2. *Semi-Analytical Solutions* a. Collocations b. Conformal Mapping	B-3.1-3.6 KII-5.7, 5.11 KII-5.8 KII-5.4 KII-5.2
6	**Methods for Evaluating Stress Intensity Factors (Continued)** 3. *Numerical Methods* a. Finite Elements (FE) b. Finite Differences (FD) c. Boundary Integral Equations (BIE) 4. *Experimental Methods* a. Compliance Method b. Photoelasticity c. Interferometry and Holography	KII-5.7, 5.11 KII-5.5 KI-Ch4 KI-Ch6 KII-Ch4
7	**(a) The Crack Tip Plastic Zone** **(b) Methods for Measuring Fracture Toughness**	B-Ch4 B-Ch7-8, R-Ch3
8	**(a) Fatigue-Crack Initiation** **(b) Fatigue-Crack Propagation Under Constant-Amplitude Load Fluctuation**	R-Ch7 R-Ch10, R-Ch8
9	**Fatigue-Crack Propagation Under Variable-Amplitude Load Fluctuation**	B-10.4, R-Ch9
10	**(a) Stress Corrosion Cracking** **(b) Corrosion Fatigue**	R-Ch10
11	**Dynamic Fracture**	B-Ch6
12	**Final TBA**	

Bibliography

Textbooks

[1] Timoshenko, S.P. and J.N. Goodier, "Theory of Elasticity", McGraw Hill (1970).

[2] Broek, D., "Elementary Engineering Fracture Mechanics", 4th edition, Martinus Nijhoff (1987).

[3] Rolfe, S.T. and J.M. Barsom, "Fracture and Fatigue Control in Structures, Applications of Fracture Mechanics", Prentice Hall (1977).

[4] Kobayashi, A.S. Editor, "Experimental Techniques in Fracture Mechanics", Vol. 1-2, The Iowa State University Press and SESA (1975).

[5] "A General Introduction to Fracture Mechanics", The Journal of Strain Analysis,vol. 10, (1975).

[6] Liebowitz, H. Editor., "Fracture" Vol. II, Academics Press (1980).

[7] Hellan, K., "Introduction to Fracture Mechanics" McGraw-Hill (1985).

[8] Broek, D., "The Practical Use of Fracture Mechanics", Kluwer Academic Publishers (1989).

Handbooks

[1] Tada, H., Paris, P. and Irwin, G., "The stress Analysis of Cracks Handbook" 3rd edition, ASME Pren (2000).

[2] Rooke, D.P. and Cartwright, D.J., "Compedium of Stress Intensity Factors", Her Majestys Stationery Office, London (1976).

[3] Murakami, Y. Editor in Chief, "Stress Intensity Factors Handbook", Pergamon Press (1988) (3 Volumes).

[4] "Damage Tolerant Design Handbook", WL-TR-94-4052, CINDAS/USAF Handbooks Operation, Purdue University (1994) (5 Volumes).