MSE-424

Fracture of materials

Plummer John Christopher

Cursus	Sem.	Type
Materials Science and Engineering	MA1, MA3	Obl.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	2 weekly
Number of positions	

Summary

This course covers elementary fracture mechanics and its application to the fracture of engineering materials.

Content

The ideal strength, stress concentration factors, Griffith's (thermodynamic) analysis of fracture; *G* and *R*
Irwin's analysis; the stress intensity factor *K*, equivalence between Irwin's and Griffith's approaches to LEFM
Brittle fracture, Weibull statistics, subcritical crack growth in brittle solids
Influence of crack tip plasticity: small scale yielding, embrittlement of metallic materials, large scale yielding: COD and J-integral approaches, cohesive zones, *R*-curve behavior and its consequences for the onset of crack instability
Cyclic loading: parameters and cyclic plasticity; crack nucleation, crack growth, fracture mechanics applied to fatigue; Paris's law, damage tolerant design, crack tip plasticity under cyclic loading
Overview of testing methods for fracture toughness and fatigue crack growth
Large-strain ductile failure and the limitations of elastic-plastic fracture mechanics: the essential work of fracture (EWF): fracture of hyper-elastic materials and very soft materials
Kinetic and dynamic effects in fracture, rapid crack propagation (RCP) and crack arrest: high-speed fracture testing
Time-dependent fracture: viscoelastic fracture mechanics: special case of creep facture: slow crack growth in polymers under long-term static and dynamic loading: stress-corrosion cracking: thermal fatigue.
Fracture in highly heterogeneous and highly anisotropic media: bi-materials interfaces: specific test methods for rigid, viscoelastic and hyper-elastic substrates: testing of soft adhesives.

Learning Prerequisites

Required courses

Continuum mechanics, MSE-203, MX, Drezet
Materials mechanics, MSE-205, MX, Bourban
Deformation of materials, MSE-310, MX, Logé

Recommended courses

Surfaces and interfaces, MSE-304, MX, Ceriotti
Building materials + Laboratory work, MSE-322, MX, Boehm Courjault Scrivener Sofia
Ceramics, structures and properties + TP, MSE-231, MX, Damjanovic Stolichnov
Metals and alloys + Laboratory Work, MSE-236, MX, Drezet Weber
Composites technology, MSE-440, MX, Bourban Michaud
Materials selection, MSE-474, MX, Michler Siegmannm Vaucher
Polymères, structures, propriétés, MSE-230, MX, Plummer

Learning Outcomes

By the end of the course, the student must be able to:

- Decide on the structural viability of structures containing defects
- Deduce the largest defect that can be tolerated in a structure under load
- Predict the lifetime of structures susceptible to gradual crack growth
- Design tests to assess the resistance of materials to fracture
- Analyze causes for mechanical failure
- Assess / Evaluate how, and how often a structure should be checked for defects
- Hypothesize the mechanical performance of materials knowing their structure

Transversal skills

- Set objectives and design an action plan to reach those objectives.
- Access and evaluate appropriate sources of information.
- Collect data.
- Demonstrate the capacity for critical thinking

Expected student activities

Attendance at lectures, completion of exercices

Assessment methods

Written exam

Supervision

Office hours Yes

Resources

Bibliography

T.L. Anderson, Fracture Mechanics - Fundamentals and Applications, 2nd Ed., CRC Press, Boca Raton, USA, 1995.
J.M. Barsom et S.T. Rolfe, Fracture and Fatigue Control in Structures, 3rd Ed., ASTM/ButterworthHeinemann, 1999.
D. Broek, Elementary Engineering Fracture Mechanics, Martinus Nijhoff, Kluwer, Dordrecht NL, 1986.
T.H. Courtney, Mechanical Behavior of Materials, McGraw-Hill, New York, 1990.
G.E Dieter, Mechanical Metallurgy 3rd Edition, McGraw-Hill, 1986.
H.L. Ewalds & R.J.H. Wanhill, Fracture Mechanics, Edward Arnold, London, 1985, pp. 12 à 21, 28 à 55, 75 à 82.
D. François, A. Pineau et A. Zaoui, Comportement Mécanique des Matériaux, Volume 2 Hermès, Paris, 1993.
K. Friedrich, Application of Fracture Mechanics to Composite Materials, Elsevier 1989.
D.J. Green, an Introduction to the Mechanical Properties of Ceramics, Cambridge University Press, 1998.
R.W. Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, 3rd Ed., John Wiley & Sons, New York, 1989, pp. 237 à 246, 271 à 291.
J.W. Hutchinson, Non Linear Fracture Mechanics, Dept. of Solid Mechanics, Technical University of Denmark, Lyngby, Denmark, 1979 (reprinted 1989).
M. Janssen, J. Zuidema et & R.J.H. Fracture Mechanics, 2nd Ed., Spon Press, Taylor and Francis Group, London & New York, 2004.
M.F. Kanninen et C.H. Popelar, Advanced Fracture Mechanics, Oxford Eng. Sci. Series, Oxford, UK, 1985.
A. Kelly and N.H. MacMillan, Strong Solids, 3rd Ed., Oxford Science, Oxford UK, 1986.
A.J. Kinloch, Adhesion and Adhesives, Springer Science and Business Media, 2012
B. Lawn, Fracture of Brittle Solids, 2nd Ed., Cambridge University Press, 1993.
M.A. Meyers and K.K. Chawla, Mechanical Behavior of Materials, Cambridge University Press, 2009.
D.R. Moore, J.G. Williams and A. Pavan, Fracture Mechanics Testing Methods for Polymers, Adhesives

and Composites, Elsevier, 2001.
J.B. Wachtman, Mechanical Properties of Ceramics, J. Wiley & Sons, New York, 1996.
I.M Ward and J. Sweeney, Mechanical Properties of Solid Polymers, 3rd Edition, Wiley, 2012.
J.G. Williams, Fracture mechanics of polymers, Halstead Press, New York, 1984.

Ressources en bibliothèque

- Fracture Mechanics / Anderson
- Fracture and fatigue control in structures:applications of fracture mechanics / Barsom
- Mechanical behavior of materials / Courtney
- Mechanical metallurgy SI Metric ed. / Dieter
- An introduction to the mechanical properties of ceramics / Green
- Comportement mécanique des matériaux Vol.2 / François
- Advanced Fracture Mechanics / Kanninen
- Strong Solids / Kelly
- Adhesion and Adhesives / Kinloch
- Fracture of Brittle Solids / Lawn
- Mechanical Behavior of Materials / Meyers
- Mechanical Properties of Solid Polymers / Ward
- Deformation and Fracture Mechanics of Engineering Materials / Hertzberg
- Fracture Mechanics / Ewalds
- Elementary engineering fracture mechanics / Broek
- Application of fracture mechanics to composite materials / Friedrich
- Mechanical Properties of Ceramics / Wachtman