

MSE-424

Fracture of materials

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Cursus	Sem.	Type
Civil Engineering	MA2, MA4	Opt.
Materials Science and Engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	4 weekly
Lecture	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 fracture: 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 Siegmanna 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 exercises

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 / Ewalds](#)
- [Comportement mécanique des matériaux Vol.2 / François, Pineau, Zaoui](#)
- [Fracture Mechanics / Anderson](#)
- [Fracture and fatigue control in structures:applications of fracture mechanics / Barsom](#)
- [Elementary engineering fracture mechanics / Broek](#)
- [Mechanical behavior of materials / Courtney](#)
- [Mechanical metallurgy SI Metric ed. / Dieter](#)
- [Application of fracture mechanics to composite materials / Friedrich](#)
- [An introduction to the mechanical properties of ceramics / Green](#)
- [Deformation and Fracture Mechanics of Engineering Materials / Hertzberg](#)
- [Nonlinear Fracture Mechanics / Hutchinson](#)
- [Fracture mechanics / Janssen](#)
- [Advanced Fracture Mechanics / Kanninen](#)
- [Strong Solids / Kelly](#)
- [Adhesion and Adhesives / Kinloch](#)
- [Fracture of Brittle Solids / Lawn](#)
- [Mechanical Behavior of Materials / Meyers](#)
- [Fracture Mechanics Testing Methods for Polymers, Adhesives and Composites / Moore, Williams, Pavan](#)
- [Mechanical Properties of Ceramics / Wachtman](#)
- [Mechanical Properties of Solid Polymers / Ward](#)
- [Williams, Fracture mechanics of polymers \(disponible à l'ETH-Bibliothek\)](#)

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- <https://go.epfl.ch/MSE-424>