Module Description, available in: EN

Fatigue Design

General Information

Number of ECTS Credits

3

Module code

TSM_FaDes

Valid for academic year

2025-26

Last modification

2023-09-22

Coordinator of the module

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Explanations regarding the language definitions for each location:

- Instruction is given in the language defined below for each location/each time the module is held.
- Documentation is available in the languages defined below. Where documents are in several languages, the percentage distribution is shown (100% = all the documentation).
- The examination is available 100% in the languages shown for each location/each time it is held.

	Lausanne			Lugano	Zurich		
Instruction				**X** E 100%			
Documentation				**X** E 100%			
Examination				**X** E 100%			

Module Category

TSM Technical scientific module

Lessons

2 lecture periods and 1 tutorial period per week

Entry level competences

Prerequisites, previous knowledge

- Mathematics, Calculus and Mathematical Analysis
- Linear algebra and analytical geometry
- Material Science and Engineering
- Solid Mechanics
- Basics of mechanics of composite materials
- Basics of computational mechanics, including finite element methods

Brief course description of module objectives and content

The course addresses fundamental and technical issues related to the design and maintenance of structures that shall not fail under cyclic loading. Students will be taught the principles of fatigue testing and fatigue failure analysis of mechanical structures, addressing the issues of how fatigue behavior is characterized, how fatigue failure is predicted, which physical mechanisms are responsible for the initiation and propagation of fatigue in various materials, with particular emphasis on metals and structural alloys, and how this behavior is related to the microstructure of the material. This course will also present the most important applications of fatigue design in industry, including failure analysis, fatigue life calculation, experimental techniques, destructive and non-destructive methods of damage detection and characterization.

Aims, content, methods

Learning objectives and acquired competencies

- Understand the theory of fracture mechanics applied to brittle, ductile and quasi-brittle materials;
- Learn experimental techniques for the characterization of the propertie affecting crack onset and propagation;
- Understand the fatigue phenomenon of materials, including factors that affect the residual life of structures under cyclic loading and analytical methods for fatigue strenght assessment;
- Use computational mechanics as a tool to solve fracture mechanics problems and prediction of fatigue life;
- Apply the knowledge of fatigue and fracture mechanics in the design of structures and to investigate possible causes of structural failure;

Contents of module with emphasis on teaching content

Introduction to Fracture Mechanics

Linear Elastic Fracture mechanics

- Griffith's analysis, 1st law of thermodynamics and crack growth, Energy release rate (ERR)
- Stress analysis and stress intensity factor (SIF). Failure modes (mode I, II and III)
- Relation between the SIF and ERR
- Mixed-mode propagation
- Plane stress, plane strain, R-curve, and stability of the propagation
- Experimental determination of the Fracture toughness: standard and non-standard methods

Elasto-plastic fracture mechanics

- Crack opening displacement (COD)
- J integral
- Relation between J-integral, COD and ERR

Fatigue of metals, plastic and composite materials

- Fatigue limit
- Factors affecting the crack propagation process
- Fatigue in brittle and ductile solids
- Low Cycle Fatigue and High Cycle Fatigue: application of strain- or stress-life approach in different scenarios
- Analytical and numerical methods for fatigue strength assessment
- Fatigue and random vibration analyses
- Fatigue of welded structures
- Fatigue of composite and plastic materials
- Experimental assessment of the fatigue behaviour
- Application of the theory concepts to the fatigue strength assessment in real industrial case studies

Computational fracture mechanics

- Determination of the SIF
- Determination of the J-Integral
- Virtual Crack Closure technique
- Cohesive elements

Teaching and learning methods

- Lectures in presence
- Tutorial in presence
- Self-study

Literature

Lecture notes and learning material will be distributed to students during the semester, along with references to books and scientific papers for the specific topics discussed.

Assessment

Additional performance assessment during the semester

The module does not contain an additional performance assessment during the semester

Basic principle for exams

As a rule, all the standard final exams for modules and also all resit exams are to be in written form

Standard final exam for a module and written resit exam

Kind of exam

written

Duration of exam

120 minutes

Permissible aids

Aids permitted as specified below:

Permissible electronic aids

Scientific calculator

WiFi off

Other permissible aids

The formula sheet provided by the module coordinator

Exception: In case of an electronic Moodle exam, adjustments to the permissible aids may occur. Lecturers will announce the final permissible aids prior to the exam session.

Special case: Resit exam as oral exam

Kind of exam

oral

Duration of exam

30 minutes

Permissible aids

Aids permitted as specified below:

Permissible electronic aids

Scientific calculator

WiFi off

Other permissible aids

The formula sheet provided by the module coordinator