



INSTITUT FOR MEKANIK & PRODUKTION
AALBORG UNIVERSITET

Ph.D. course

on

**Fracture Mechanics
for
Laminated Composite Structures**

18 – 22 May 2015

at

Department of Mechanical and Manufacturing Engineering
Aalborg University
Fibigerstræde 16, DK-9220 Aalborg, Denmark

Organized by

The Department of Mechanical and Manufacturing Engineering, Aalborg University
(www.m-tech.aau.dk)

Aalborg University
The Faculty of Engineering and Science
The Doctoral School of Engineering and Science
(<http://www.phd.teknat.aau.dk/>)

In collaboration with

DCAMM, Danish Center for Applied Mathematics and Mechanics
(www.dcammm.dk)

DCCSM, Danish Centre for Composite Structures and Materials for Wind Turbines

¹Associate Professor Esben Lindgaard (elo@m-tech.aau.dk)

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Course Content

This Ph.D. course will concentrate on theory and practice related to fracture mechanical problems for laminated composite structures, such as wind turbine blades. The classical approach to fracture mechanics will be presented and extended to anisotropic and bi-material problems via analytical and numerical methods including the framework of cohesive zone modelling. Furthermore, practical aspects of laboratory testing in relation to determination of fracture mechanical properties will be covered and included in the exercises for the course as experiments. The course consists of four parts; lectures, exercises, laboratory testing, and an informal poster session. The net work load corresponds to 5 ECTS. The exercises will consist of analytical problems solved using math programs such as Maple, numerical problems solved using the Finite Element Program ANSYS, and laboratory exercises conducted in the Lab of AAU. For the poster session all participants are expected to upload a poster of their own work, project or similar, which include discussion of how fracture mechanics apply. This poster should be uploaded to the organizers a week before the start of the course.

Topics include:

- Classical fracture mechanics
- Bi-material fracture mechanics
- Anisotropic materials
- Numerical estimation of fracture mechanical parameters with the finite element method (FEM)
- R-curve effects
- Crack bridging
- Cohesive zone modeling
- Numerical implementation of cohesive zone models in FEM
- Experimental estimation of fracture mechanical properties
- Fatigue properties of laminated composites

The aim of the course is to provide the participants with a toolbox of theoretical knowledge, experimental insight, and competencies in numerical analyses that can be applied in the participants own projects.

Lecturers

Associate Professor Esben Lindgaard (elo@m-tech.aau.dk)

Associate Professor Jens Henrik Andreasen (jha@m-tech.aau.dk)

Post Doc Brian Bak (brianbak@m-tech.aau.dk)

Invited lecturers from national and international research institutions:

Professor Bent F. Sørensen (bsqr@dtu.dk), DTU Wind Energy, Technical University of Denmark

Professor Henrik Myhre Jensen (hmj@ase.au.dk), Department of Engineering, Aarhus University

Associate Professor Albert Turon Travesa, Department of Mechanical Engineering and Industrial Construction, University of Girona, Spain

Invited lecturers from wind turbine industry:

Chief Engineer, PhD, Casper Kildegaard, LM Wind Power, www.lmwindpower.com

Course Language

The course will be given in English.

Teaching Material

Extensive course notes will be handed out to the participants.

Course Format and Work Load

The course will consist of a condensed session comprised of 5 full days of lectures, work on assignments, laboratory exercises, and discussions at AAU. After the course session the course participants (PhD students) are expected to solve and submit homework assignments. Diplomas will be issued on the basis of course participation and evaluation of homework assignments, and entitle Ph.D. students to 5 ECTS, corresponding to 125-150 hours of work load.

Participants

The participants are expected to have a basic knowledge in mechanics. The course is aimed specifically at Ph.D. students, but the course is also recommended for industrial engineers and engineering scientists. University staff and final year M.Sc. students are welcome as well. University staff, M.Sc. students and participants from industry may be exempted from the homework assignments and the course evaluation/examination.

Earlier Events

This course was first held in October 2012. News clips and pictures from that event can be seen on:

<http://www.en.m-tech.aau.dk/News/News//things-that-break....cid78481>

Research Internship

After the course it will be possible to have a research internship at the Department of Mechanical and Manufacturing Engineering. The number of internships is limited, and will be initiated on the basis of a separate application procedure.

Registration

Further information and registration:

<https://phd.moodle.aau.dk/course/index.php?categoryid=68>

Deadline for registration: 1 April 2015.

Course participation is free for national Ph.D. students and university staff. Participants from industry will be charged DKK 12,500 (DKK 2,500 pr. ECTS). International Ph.D. students and university staff get a discount of 50% and will be charged DKK 6,250.

For further information contact Associate Professor Esben Lindgaard, Phone (+45) 9940 7329, E-mail: elo@m-tech.aau.dk OR Associate Professor Jens Henrik Andreasen, Phone (+45) 9940 9316, E-mail: jha@m-tech.aau.dk.

Accommodation - Hotels

Aalborg offers a variety of accommodations. An overview over the city and the accommodations can be found at <http://www.visitaalborg.com>. The organizers have selected two places that are conveniently located and offer special rates for course participants. Please make your reservations directly with the hotel of your choice. In order to obtain the special prices, refer to "Department of Mechanical and Manufacturing Engineering, AAU" and ask for Aalborg University rates. The two selected hotels are listed below:

Cabinn Hotel Aalborg (<http://www.cabinn.com/english/aalborg/aalborg.html>)

Fjordgade 20, DK-9000 Aalborg

Hotel CABINN Aalborg is the newest hotel in the city opened i October 2009. The hotel is located in the centre of Aalborg.

Room rates: single/double wo/breakfast from DKK 495/625, breakfast DKK 70.

Phone: +45 9620 3000 , Fax: +45 96 20 30 01

E-mail: aalborg@cabinn.com

Radisson SAS Limfjord Hotel (<http://www.radissonblu.com/hotel-aalborg>)

Ved Stranden 14-16, DK-9000 Aalborg

Located right in the centre of the city facing the heart of Aalborg's famous nightlife.

Special room rates (mention affiliation with AAU and participation in PhD course): single/double w/breakfast, Monday to Sunday DKK 955/955 (single/double room) per night incl. breakfast.

Phone: +45 9816 4333, Fax: +45 9816 1747

E-mail: Limfjord@RadissonSAS.com