TIME TABLE

TIME	Monday May 4	Tuesday May 5	Wednesday May 6	Thursday May 7	Friday May 8
9.00 - 9.45	Registration	Ganczarski	de Borst	Barlat	Werner
9.45 - 10.30	Altenbach	Ganczarski	de Borst	Barlat	Werner
11.00 - 11.45	Altenbach	Talreja	Altenbach	Talreja	Ganczarski
11.45 - 12.30	Altenbach	Talreja	Altenbach	Talreja	Ganczarski
14.00 - 14.45	Barlat	Ganczarski	de Borst	Werner	
14.45 - 15.30	Barlat	Workshop	de Borst	Werner	
16.00 - 16.45	Werner	Workshop	Barlat	de Borst	
16.45 - 17.30	Werner	Workshop	Barlat	de Borst	
18.00		Welcome Aperitif			

ADMISSION AND ACCOMMODATION

The registration fee is 600.00 Euro + VAT*, where applicable (bank charges are not included). The registration fee includes a complimentary bag, four fixed menu buffet lunches (on Friday upon request), hot beverages, downloadable lecture notes and wi-fi internet access.

Applicants must apply at least one month before the beginning of the course. Application forms should be sent on-line through the following web site: http://www.cism.it. A message of confirmation will be sent to accepted participants. Applicants requiring assistance with the registration should contact the secretariat at the following email address: cism@cism.it.

Applicants may cancel their course registration and receive a full refund by notifying CISM Secretariat in writing (by email to cism@cism.it) no later than two weeks prior to the start of the course.

Cancellation requests received during the two weeks prior to the start of the course will be charged a 50.00 Euro handling fee. Incorrect payments are also subject to a 50.00 Euro handling fee.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered lodging and/or board, if available, in a reasonably priced hotel or student guest house.

Requests should be sent to CISM Secretariat by **March 4, 2020** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

Information about travel and accommodation is available on the web site www.cism.it, or can be mailed upon request.

* Italian VAT is 22%.

For further information please contact:
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ACADEMIC YEAR 2020
The Erwin Stein Session

Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

ADVANCED THEORIES FOR DEFORMATION, DAMAGE AND FAILURE IN MATERIALS

Advanced School
coordinated by

Holm Altenbach
Otto-von-Guericke-Universität
Magdeburg, Germany

Artur Ganczarski
Cracow University of Technology
Poland

Udine ***May 4 - 8*** 2020

ADVANCED THEORIES FOR DEFORMATION, DAMAGE AND FAILURE IN MATERIALS

Numerical simulations are becoming an indispensable tool in many applications involving processing, manufacturing, and performance of metallic and composite materials. The corresponding tools are based on a number of fundamental relationships that were extracted from mechanics (and underlying physics). These relationships are universal with respect to materials but they are not adequate to solve boundary value problems in which constitutive descriptions of deformation and failure are essential.

The constitutive descriptions must not only account for the physical mechanisms but also for the input data needed for identification of the material coefficients. Thus, to accomplish this, the relationship between the variables and their rates must comply with the materials response within the framework set by mechanics and thermodynamic principles. A purely numerical description, which relates the state of a material to a set of data, is likely to be empirical. It leads to unreliable extrapolation of states, which are not included in the database.

Other considerations on constitutive models are the scale of the material features needed, the size of the structure and the associated computation time. The scale is dictated by the smallest microstructural information needed to characterize a product e.g., the grain size, which then enters simulations at the meso-scale. It is possible to envision cases were details at a finer scale are necessary, for instance for the manufacturing of micro-devices. Even if the idea of defining the constitutive description from the atomic scale is scientifically and philosophically very attractive, it is usually not practical.

The course will focus on descriptions of critical states for advanced metallic materials and composites. The approaches taken for this purpose can be categorized as follows: strongly based on Continuum Mechanics, incorporating knowledge of microstructure, and applying homogenization and other numerical approaches. The course will introduce the classical approaches and treat the new developments in a critical manner. Obviously, application of advanced materials rests on efficient and physically based constitutive relations.

The following specific topics will be covered: Plastic behavior at non-proportional loading incorporating the influence of relevant microstructural features, numerical simulation of metal forming of advanced high strength steels, termination of elastic range of pressure insensitive and sensitive materials, anisotropic vs. isotropic initial yield/failure criteria, structural components subjected to high temperatures, mechanical and thermal cyclic loads on the components under creep conditions, phase mixture model for simulating the mechanical behavior of tempered martensitic steels at high temperatures, but moderate mechanical loads, discretization methods for elasto-plastic solids, integration of plasticity models for finite loading steps, volumetric locking for fully developed plastic flow, mechanisms based modelling of failure in composite materials, basic aspects of fracture mechanics, and fracture and damage criteria.

The course is addressed to Master Course students of Mechanical and Civil Engineering as well as Computational Mechanics, PhD-students, young scientists, and research engineers.

PRELIMINARY SUGGESTED READINGS

K. Naumenko, H. Altenbach: Modeling High Temperature Materials Behavior for Structural Analysis, Part I: Continuum Mechanics Foundations and Constitutive Models (2016), Part II: Solution Procedures and Structural Analysis Examples (2018), Springer.

Altenbach, H.; Öchsner, A. (eds., 2014): Plasticity of Pressure-Sensitive Materials, Springer.

E.A. de Souza Neto, D. Peric, D.R.J. Owen (2008) Computational Methods for Plasticity - Theory and Applications, Wiley.

R. de Borst, M.A. Crisfield, J.J.C. Remmers, C.V. Verhoosel (2012): Non-linear Finite Element Analysis of Solids and Structures, 2nd Ed., Wiley.

Talreja, R., and Singh C.V. (2012): Damage and Failure of Composite Materials, Cambridge University Press.

Talreja, R., J. Varna (eds, 2016): Modeling Damage, Fatigue and Failure of Composite Materials, Woodhead Publ..

Talreja, R. (2014): Assessment of the Fundamentals of Failure Theories for Composite Materials, Comp Sc & Techn, 105, 190-201.

Talreja, R. (2016): Physical Modelling of Failure in Composites, Phil Trans Royal Society A, 374.

Teodosiu, C., Hu, Z. (1998): Microstructure in the continuum modeling of plastic anisotropy. In: Cartensen, JV et al. (eds.) Proc. Risø Int. Symp. Mat. Sci., Roskilde, Denmark. Risø Nat. Lab., 149–168.

Barlat, F., Ferreira Duarte, J., Gracio, J.J., Lopes, A.B., Rauch, E.F. (2003): Int. J. Plasticity 19, 1215-1244.

Barlat, F., Gracio, J.J., Lee, M.G., Rauch, E.F., Vincze, G. (2011): Int. J. Plasticity 27, 1309–1327.

Skrzypek, J., Ganczarski, A. (eds., 2015): Mechanics of Anisotropic Materials, Springer.

Skrzypek, J., Ganczarski, A. (2016): Constraints on the applicability range of pressure-sensitive yield/failure criteria: strong orthotropy or transverse isotropy, Acta Mechanica, 227, 2275-2304.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from the CISM web site. Instructions will be sent to accepted participants.

INVITED LECTURERS

Holm Altenbach - Otto-von-Guericke-Universität Magdeburg, Germany

5 lectures on: Creep and damage of materials at elevated temperatures

Components of structures that are subjected to high temperatures, but moderate loads are affected by creep deformations. Various models for simulation of such structures at quasi-static and cyclic loading conditions are discussed. As an example, a phase mixture model for simulating tempered martensitic steels i is presented.

Artur Ganczarski - Cracow University of Technology, Poland

5 lectures on: Anisotropic plasticity during non-proportional loading

Description of anisotropy influence on limit criteria (yield/failure) for modern homogeneous metallic alloys. Anisotropy of limit criteria, critical comparison of explicit vs. implicit approaches, discussion on physical interpretation and convexity of implicit approach are discussed.

Frederic Barlat - Pohang University of Science and Technology, Republic of Korea

6 lectures on: Anisotropic plasticity during non-proportional loading

Modeling of the plastic behavior during non-proportional loading using continuum theories with a top-down multi-scale approach to incorporate the influence of relevant microstructural features. Numerical implementation in finite element codes are discussed and illustrated with forming simulation results for advanced high strength steels.

Rene de Borst - University of Sheffield, UK

6 lectures on: Computational plasticity

Integration of plasticity models for finite loading steps, consistent tangent operator, volumetric locking for fully developed plastic flow, discretisation methods for elasto-plastic solids (finite elements, meshless methods, isogeometric finite element analysis).

Ramesh Talreja - Texas A&M University, College Station, TX, USA

4 lectures on: Mechanisms based modelling of failure in composite materials accounting for manufacturing defects

Five basic failure modes in unidirectional composites, Statistical simulation of fibre distribution irregularities and matrix voids, Energy based failure criteria and hierarchical failure progression, Failure under combined loading.

Ewald Werner - Technische Universität München, Germany

6 lectures on: Microstructure related aspects of fracture and damage of engineering materials

Basic aspects of fracture mechanics; stresses and strains ahead of cracks and notches; linear-elastic and elasto-plastic fracture mechanics; stress intensity factors; fracture and damage criteria; measurement of critical quantities (K_{Ic}, J-integral); influence of microstructure on fracture behaviour; fractography and observation methods; examples for fracture and damage of engineering materials.