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PLENARY LECTURES

VIP001
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**My Professional Journey Through Mechanics Research:
A Personal Retrospective**

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This is a personal retrospective of the author's professional journey through mechanics research and education (http://mechanics.tamu.edu) began while the author was a Ph.D. student in USA in 1970. The publication of a seminal paper on 14 primal and dual variational principles [1] and the two books on mathematical theory of finite elements and variational principles with Dr. J.T. Oden (www.oden.utexas.edu/people/85/) provided the inspiration and paved the way for the author's professional journey through computational mechanics [2-6], composite materials and structures [7], least-squares finite elements models [3-6], higher-order shell finite elements [7], and non-local continuum theories. The lecture will begin with a brief childhood background of the author followed by an overview of the author's highly-cited shear deformation and layerwise theories for composite laminates [7], the penalty and least-squares finite element models of the flows of viscous incompressible fluids [4], a robust shell finite element [3], and non-local mechanics [8,9]. In addition, the graph-based finite element framework (GraFEA) suitable for the study of damage in brittle materials will be
discussed [10].

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VIP002
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Description of Quasi-Static and Dynamic Damage Processes in 2-Phase Ceramic Matrix and Metal Matrix Composites Reinforced by Ceramic Grains*)

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Quasi-static degradation of brittle composites exhibits different mechanical response under uniaxial tension and uniaxial compression. In this paper we analysed cracking processes and failure under quasi-static loading of 2 phase ceramic material made of alumina and zirconia mixture, subjected to tension and compression. Constitutive modelling of two phase ceramic composites obeys description of: (1) elastic deformations of initially porous material, (2) limited plasticity and (3) cracks initiation and propagation.
Modelling of polycrystalline ceramics at mesoscopic level under mechanical loading is related to analysis of a set of grains, which create so called Representative Volume Element (RVE). The basic elements of the defect structure inside polycrystal are: micro- and meso-cracks, kinked and wing cracks. To get macroscopic response of the material one can calculate averaged values of stress and strain over the RSE with application of analytical approach.

Dynamic degradation process was illustrated for 2 phase ceramic matix composite and cermet, which was subjected to short compressive impulse. The pulse duration was 10-7s and the applied pressure level - 480 MPa. In the proposed more advanced finite elements formulation of the cermet behaviour is was necessary to take into account the following data and phenomena revealing inside of the RVE: (1) spatial distribution of the cermet constituents, (2) system of grain boundaries/binder interfaces modelled by interface elemnets, (3) rotation of brittle grains. The cermet response due to pulse loading is significantly different in comparison to the quasi-static behaviour, i.e. the stress distributions and microcracking processes are quite different.

Keywords: ceramic matrix composites, cermet, quasi-static degradation, dynamic degradation, analytic model, numerical model.

*) This paper is devoted to prof. J.N.Reddy on occasion of his 75th BIRTHDAY.

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VIP006
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Multiscale Simulation of Multiphase Materials

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Many materials show a multiphase composition and have a distinct microscopic structure. Examples of multiphase materials are saturated or partly saturated porous material like soil, concrete but also steel and biological tissue like cartilage or bone. Their substructures are e.g. pores, fibres with different orientations or cells which can be influenced by bio-chemical reactions. The high complexity of those kind of material makes it reasonable to consider homogenization approaches and multiscale techniques in order to find an effective modeling access for the numerical simulation. This is even more the case since modern experimental methods as CT-scanning or MRI imaging give us the opportunity to get a deep insight into the microscale structure. Thus, we will present a combined multiphase-multiscale approach for the description of those kinds of materials. The method is based on the well-known Theory of porous media (TPM), a

continuum mechanical homogenization approach founded on the mixture theory in combination with the concept of volume fraction, cf. de Boer (1) and Ehlers (2).
Depending on the material, we will combine the TPM with reasonable multiscale techniques such as FE2, POD-ODE, or the Phase Field method, cf. Moj et al. (3) and Ricken et al. (4).

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VIP030
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Boundary Value Problems with Strain Softening Materials:
Ways to Ensure Physically SoundResults

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Local models of inelasticity formulated in the framework of classical solid mechanics are widely used for the analysis of engineering applications. In particular, geometrically nonlinear ductile damage models accounting for nonlinear phenomena, like isotropic, kinematic, and distortional hardening, are useful for the optimization of metal forming operations as well as crash-test simulations. Even more, models of combined creep-fatigue interaction allow one to estimate the lifetime of critical industrial components and to assess possible failure mechanisms. Unfortunately, finite-element computations for models with strain softening materials show pathological mesh dependence of the simulation results. The talk is devoted to several approaches which allow us to obtain well-defined solution procedures for such applications, even when dealing with strain localization on the macro scale. The discussed approaches include regularization by viscosity, implementation of non-local ductile damage models, and the use of advanced mesh-free discretization methods. The impact of the regularization methods on the strain localization is investigated. It is shown that numerous length scales may act as localization limiters thus bringing us closer to a physically sound solution.