Karlsruhe Institute of Technology

Seminar series of the Graduate School GRK 2078

Referee: **Dr.- Ing. Natalie Rauter**
Substitute Professorship for Mechanics
Helmut-Schmidt-University /
University of the Federal Armed Forces Hamburg

Date: Thursday, March 2, 2023

Time: 10:00-11:00am

Location: Building 10.23, 3rd floor, seminar room 308.1
Please note that you can also participate in the event online

Title: **A stochastic material modeling approach by means of Gaussian random fields and its application to short-fiber reinforced composites**

Abstract

The mechanical properties of short fiber-reinforced composites are significantly shaped by the reinforcing elements and their finite length as well as the plastic characteristics of the matrix material. This leads to spatially distributed plastic material behavior at finite deformation. Therefore, to predict the structural response correctly these properties need to be included in the numerical model procedure.
One technique to incorporate such spatially distributed properties are second-order Gaussian random fields [1]. Their discretization by the Karhunen–Loève expansion is based on the correlation structure of the underlying random variables described by correlation functions, which can be sufficiently determined by numerical simulations [2]. Following this approach, the explicit representation of the microstructure on the component level is not required to incorporate locally varying material properties.
To include also the nonlinear material behavior, both finite deformation and plasticity are considered. This is done by utilizing a hyperelastic strain energy density function provided by Bonet and Burton [3] in combination with the multiplicative decomposition of the deformation gradient and perfectly plastic material behavior. The main object is the representation of the strain energy density function coefficients as well as the yield stress by second-order Gaussian random fields. Therefore, the apparent overall material properties of all involved parameters and the correlation structure are determined. With this information at hand, cross-correlated random fields can be discretized by the Karhunen–Loève expansion for multi-correlated stochastic processes [4].

Finally, the correlation length is determined by comparing experimentally obtained data of the spatial distribution with results of numerical simulations for different correlation lengths. Since the correlation length has a strong influence on the standard deviation of the distributed parameters, the correlation length for the representation of the material property distribution is given for the case, where the numerically and experimentally obtained values coincide best.

References:

[1] E. Vanmarcke, Random fields. Analysis and synthesis (Revised and Expanded New Edition). World Scientific Publishing Company, 2010.

[2] N. Rauter and R. Lammering, Correlation structure in the elasticity tensor for short fiber-reinforced composites. Probabilistic Engineering Mechanics, Vol. 62, pp. 103100, 2020.

[3] Bonet, J., Burton, A. J. "Correlation structure in the elasticity tensor for short fiber-reinforced composites", Computational Methods in Applied Mechanics and Engineering, Vol. 162, pp. 151-164 (1998).

[4] Cho, H., Venturi, D., Karniadakis, G. E. "Karhunen–Loève expansion for multi-correlated stochastic processes", Probabilistic Engineering Mechanics, Vol. 34, pp. 157-167 (2013).

You are cordially invited to take part in the event.

Prof. Dr.-Ing. Thomas Böhlke
(Spokesperson of GRK 2078)