engineering mechanics

First Engineering Mechanics Symposium

23 - 24 November 1998
Rolduc, Kerkrade

Graduate School Engineering Mechanics
c/o Eindhoven University of Technology

PO Box 513, building W-hoog 0.143
5600 MB Eindhoven NL
Tel.: #31.(0)40.247 48 17
Fax.: #31.(0)40.246 14 18
E-mail: EMschool@tue.nl
Internet: http://www.em.tue.nl

Session 2:

New Trends in the Modelling of Material Nonlinearities

L.J. Sluys, M.G.D. Geers and A.H. van den Boogaard

Delft University of Technology. L.J.Sluys@ct.tudelft.nl
Eindhoven University of Technology, geers@wfw.wtb.tue.nl
Twente University of Technology, A.H.vandenBoogaard@wb.utwente.nl

The modelling of the mechanics of material nonlinearities has made a significant progress in recent years. Yet, many problems are still unsolved or insufficiently understood. The current headlines in the research on material nonlinearities can be sketched on the three-level model of a material: micro-meso-macro. Material science covers both the micro-level, which is the molecular or atomic level, and the meso-level, which is the scale of the microstructure (e.g. polycrystals in metals). Within this field, the underlying mechanisms which govern the behaviour of the microstructure are intensively studied (e.g. dislocation dynamics, crystal plasticity, micro-cracking). The adequate modelling of the microstructure has become an important subject, since many observed nonlinearities originate from this level. As a result of the ongoing miniaturization, ever thinner and smaller materials are used, which brings the applications on the scale of the microstructure, where classical theories fail to describe the observed mechanical behaviour. Modern material engineering now overlaps the meso-level and the macro-level. On the macro-level, many physical nonlinearities like damage and plasticity, cannot be analysed efficiently without the inclusion of a microstructural-dependent state variable, e.g. an intrinsic length scale. Evidently, these phenomena take place at the scale of microstructure which then becomes dominant. New higher-order theories are emerging to bridge this gap between the macro-level and the underlying microstructure. Complete microstructures are nowadays modelled and used in a multi-level finite element code as a substitute for classical constitutive models. These new approaches will provide us a better insight in the micro-macro relation. If links can be established between geometrical and mechanical properties of the microstructure and the macroscopically observed properties, material design is no longer illusory. A second major headline concerns the necessity for advanced macroscopic constitutive models for geometrical nonlinearities. The numerical analyses with these models are still cumbersome and difficult to deal with, especially if they are combined with physical nonlinearities or thermo-mechanically coupled. Forming processes in metals, large deformations in polymers are typical examples.

These new trends in the modelling of material nonlinearities are directly or indirectly the subject of most research projects in this field. An overview of the running and planned projects in the Netherlands will be given. Soils, concrete, metals, polymers, composites are being investigated with a variety of techniques. Emphasis will be given on the different approaches and the experimental facilities that are currently available in the country.