Conférence plénière

Evolving discontinuities in solids and structures

René de Borst

Regius Chair of Civil Engineering and Mechanics - University of Glasgow

Abstract:

Evolving discontinuities can be modelled in a truly discrete sense, or in a smeared or continuum manner. Within the class of discrete models, cohesive-surface approaches are very versatile, in particular for heterogeneous materials. However, limitations exist, in particular related to stress triaxiality, which cannot be captured well in standard cohesive-surface models. We will therefore discuss an elegant enhancement of the cohesive-surface model to include stress triaxiality, which preserves the discrete character of cohesive-surface models. Subsequently, we will outline how the cohesive approach to fracture can be extended to multi-phase media, in particular fluid-saturated porous media.
Whether a discontinuity is modelled via a continuum model, or in a discrete manner, advanced discretisation methods are needed to model the internal free boundary. Level sets, extended finite element methods and isogeometric analysis are important and promising tools in this respect. Examples will be given, including delamination in layered shells and fracture in fluid-saturated media.
In smeared approaches to fracture higher-order spatial gradients typically evolve. Here, isogeometric analysis offers advantages by virtue of the smoothness of its basis functions, as will be demonstrated at the hand of a gradient-enhanced continuum damage model. In addition to approaches like NURBS that exploit tensor products for multi-dimensional generalisations, Powell-Sabin B-splines seem to be versatile, since they are defined on triangles, and thus share the ease and flexibility of mesh generation that characterises standard triangular finite elements.
Another development in continuum approaches to fracture is the phase-field theory. We will discuss the formulation for brittle fracture, including its relation to gradient damage models, and extend the phase-field approach to cohesive fracture-surface models. We conclude with a concise discussion of the advantages of phase-field theories for damage and fracture.

Key words: Discontinuities, fluid-saturated porous media, shells, fracture, damage, extended finite element methods, isogeometric analysis.

Biography:

René de Borst received an MSc degree in civil engineering in 1982 from Delft University of Technology. Thereafter he worked as an R&D engineer at TNO, the Netherlands Organisation for

Applied Scientific Research, in the Institute for Building Materials and Structures. He obtained his PhD in 1986 at Delft University of Technology.

In 1988 he was appointed as a part-time professor in Computational Mechanics at the Faculty of Civil Engineering of Delft University of Technology, and combined this with his TNO position for the next five years. In 1993 the university created a full-time professorship for him, which he combined with a part-time professorship in Damage Mechanics at the Faculty of Mechanical Engineering of Eindhoven University of Technology. In 1999 he moved to the Faculty of Aerospace Engineering to occupy the newly installed professor position in Engineering Mechanics and was appointed Distinguished Professor in 2000. In 2007 he became Dean of the Faculty of Mechanical Engineering and Distinguished Professor at Eindhoven University of Technology, and in 2012 he was appointed as the Regius Professor of Civil Engineering and Mechanics at the University of Glasgow. He has held visiting professorships at a number of places, including Albuquerque (New Mexico), Minneapolis, Tokyo, Barcelona, Milan, Stuttgart, Cachan, Metz, Lyon, and Lublin.

He is active in a number of scientific journals: editor-in-chief of the International Journal for Numerical Methods in Engineering, the International Journal for Numerical and Analytical Methods in Geomechanics, the Encyclopedia of Computational Mechanics, associate editor of the Aeronautical Journal, and member of the editorial board of another twenty journals.

His work has been recognized by a large number of honours and prizes, including the Composite Structures Award, the Max-Planck Research Award, the IACM Computational Mechanics Award, the NWO Spinoza Prize, the Royal Society Wolfson Research Merit Award, and the JSCES Grand Prize. He is a Fellow of the Institution of Civil Engineers, the International Association of Computational Mechanics, the International Association for Fracture Mechanics of Concrete and Concrete Structures, and a Member of the Royal Netherlands Academy of Arts and Sciences, a Fellow of the Royal Society of Edinburgh, a Member of the European Academy of Sciences and Arts, and an Officer in the National Order of Merit (France). He has published a book, edited twelve books, published over 200 journal articles and 27 book contributions. His work is widely cited.