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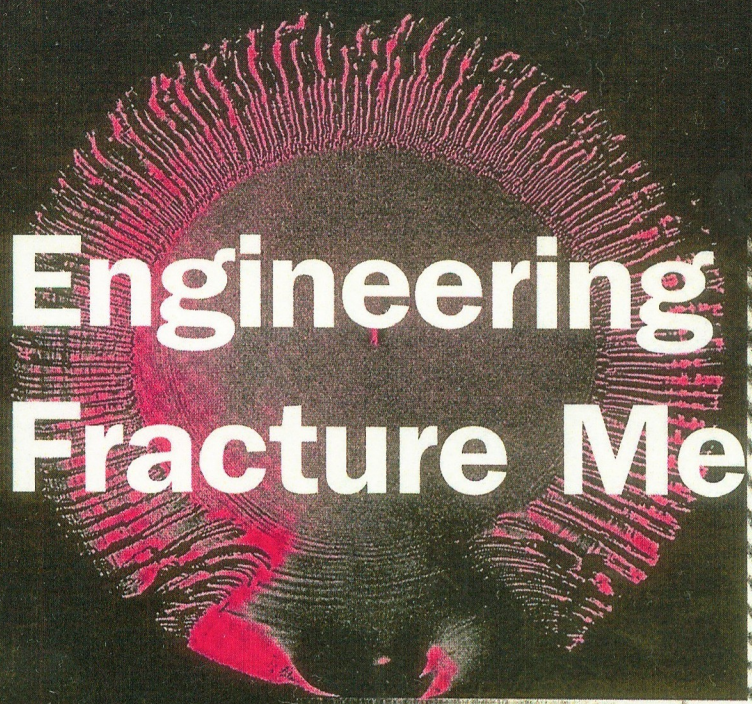

Engineering Fracture Mechanics

Editors: **A. R. Ingraffea** and **K.-H. Schwalbe**

Special Issue
Fracture of Concrete Materials and Structures
Guest Editors: **C. K. Y. Leung and K. Willam**

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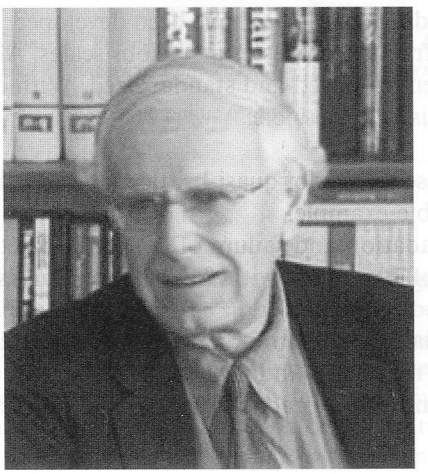
Editorial

Fracture of concrete materials and structures



This special issue is dedicated to Dr. h.c. mult. Zdenek P. Bazant, McCormick Institute Professor and W.P. Murphy Professor of Civil Engineering and Materials Science, Northwestern University. He is the founder of the International Association of Fracture Mechanics of Concrete and Concrete Structures, IA-FraMCoS, which was established to advance the area of concrete fracture that is evolving at different levels of observation. In 1992 he started a series of international conferences, FraMCoS-1 in Breckenridge, Colorado, which since took place every three years under the auspices of IA-FraMCoS in Zurich, Switzerland (1995), Sendai, Japan (1998) and Cachan, France (2001). The fifth FraMCoS-5 convened 184 attendees from 24 countries in Vail, Colorado from April 12–16, 2004. It was co-organized by Dr. Victor Li, University of Michigan, Ann Arbor, and Dr. KasparWillam, University of Colorado, Boulder. During the event, 160 papers were presented by researchers from academia and the cement industry. The conference papers were published in the form of two hardbound volumes of proceedings (1195 pages) edited by V.C. Li, C.K.Y. Leung, K.J. Willam and S.L. Billington. The over-arching theme of FraMCoS-5 was linking scales: from nanostructures to infrastructures. On April 16, 2005 the conference program concluded with an NSF sponsored workshop on 'Interface Problems in Cement-Based Materials' and a workshop on 'Connections between Steel and Concrete—Numerical Applications' held in parallel.

In summary, FraMCoS-5 provided an '*elevated*' forum for a lively exchange on fundamental issues related to material and computational issues of cement-based materials at different scales of observation.

The current issue of *Engineering Fracture Mechanics* features 19 full-size papers which were invited to be included in this special FraMCoS-5 volume on 'Fracture of Concrete Materials and Structures'. Considerable progress has been made in recent years in observing, characterizing and modeling progressive damage and fracture in cement-based composites and reinforced concrete structures. Concrete materials degrade by

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initiation and propagation of microcracks in the heterogeneous microstructure. Coalescence and propagation leads to fracture at the macro-scale of observation. In other terms, fracture of concrete is a multi-scale process which starts '*in the small*' and progresses '*to the large*'. At regions of high stresses, microscopic damage develops and forms a process zone, within which the interaction and coalescence of microcracks eventually leads to localization of a macroscopic discontinuity. Since the size of the process zone is of significant dimension compared to the member geometry, classical linear elastic fracture mechanics is no longer applicable to the analysis of concrete fracture. Indeed, due to the multi-scale nature of the failure process, what is considered as a '*crack*' has to be carefully defined, and the toughening mechanisms contributing to fracture resistance of the material need to be clearly understood and properly accounted for in the underlying formulation. Over the past few decades, theoretical approaches that are both physically sound and practically applicable have been developed for fracture analysis in concrete and concrete structures. Numerical methods for the effective computation of fracture behavior under various loading conditions have been developed. On the experimental side, techniques have been developed to investigate fracture processes at various scales. Also, methods for the determination of major fracture parameters have been proposed and standardized. With contributions by many researchers in this field of concrete mechanics, it is now possible:

(i) to explain and quantify the consequences of quasi-brittle material behavior at the structural level, with the size effect being the most notable example,
(ii) to analyze crack-induced degradation and failure of concrete structures, and hence predict the ultimate load capacity and durability of structures with fracture mechanics-based softening continuum and/or interface models,
(iii) to design crack-resistant materials based on fundamental understanding of concrete fracture, and develop practical applications for such materials, and
(iv) to apply fracture mechanics concepts to practical engineering problems related to non-destructive testing and structural repair.

The co-editors would like to thank the authors for their contributions to this special issue, as well as the reviewers for their thoughtful comments that have enhanced the quality of the papers. We hope that the *Engineering Fracture Mechanics* issue will provide an overview of current efforts on Fracture of Concrete Materials and Structures, and stimulate further work in this exciting research field.

P.S. In this special FraMCoS-5 volume, papers dealing primarily with computational fracture mechanics and numerical techniques have been excluded, because a separate special issue focusing on these aspects has been prepared for *Computer Methods in Applied Mechanics and Engineering* (Guest Editors: Ignacio Carol, Milan Jirasek and Kasper Willam). Interested readers should refer to this other special issue, which is currently in press.

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CONTENTS

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Contents continued on inside back cover

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Contents continued from outside back cover