

best, but other worthwhile ones include a lengthy 'catalogue' of applications in the field of bridge decks and pavements (G. Hoff) and a rather more technical review of the same area (E. K. Schrader). Unfortunately the references are omitted from this latter paper. Other reviews deal with current applications (R. F. Zollo), micromechanical modelling (J. A. Mandel), flexural behaviour (V. S. Gopalaratnam and S. P. Shah), toughness (C. D. Johnston), use of steel fibres for shear reinforcement and ductility (G. B. Batson), bridge decks and building floors (R. N. Swamy) and durability (M. Schupack).

Some current commercial applications are described, including the Besab reinforced steel-fibre-reinforced concrete system, wet process shotcrete, tilt-up sandwich panels, the Ekebro AB fibre shotcrete system, precast products in Scandinavia, selection of steel fibre type and content, slurry-infiltrated-fibre-reinforced concrete (SIFCON), and advanced tunnel support. Aspects covered in the remaining papers are fracture

toughness (A. Hillerborg), fracture resistance (S. P. Shah and Y. S. Jenq) and steel fibre concrete for structural elements (M. Lorentsen). Finally, three papers deal with performance criteria and quality assurance.

The good impression created by the attractive and durable binding of the book is unfortunately spoilt on opening it. The typed papers from the seminar are reproduced with, apparently, little attempt being made to achieve consistency in terms of style, typeface or layout. A few are of reasonable quality, but too many are barely adequate, especially in the line drawings and half tones, and would have benefitted from rigorous editing. On the positive side, an index with about 500 terms is included.

Overall, the book is a useful compilation especially for the review papers, but it is only likely to be essential reading for the specialist in the field.

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Fracture toughness and fracture energy of concrete

Proceedings of the International Conference on Fracture Mechanics of Concrete, Lausanne, Switzerland, October 1-3, 1985

Developments in Civil Engineering, Volume 18

Editor: F. H. Wittmann

Amsterdam and New York, Elsevier Science Publishers B.V., 1986. 242 × 168 mm. pp. xiv, 699. Reproduced typewriting, illustrated, hardback. ISBN 0 444 42733 3 (Vol. 18). Price: Dfl. 350.00 (US\$ 155.50).

The International Conference on Fracture Mechanics of Concrete held in Lausanne in 1985 marked the end of the activities of the RILEM Technical Committee on Fracture Mechanics of Concrete (50-FMC). The first aim of the committee was achieved with the publication of a comprehensive state-of-the-art report on the fracture mechanics of concrete in 1983 (Fracture Mechanics of Concrete, Developments in Civil Engineering, Vol. 7, Elsevier, 1983). This earlier volume taken together with the book currently under review form an impressive resource for all those interested in fracture of concrete.

The book contains 72 papers sub-divided into the following chapters:

- Fracture process and mechanics of crack growth
- Damage theory
- Computer simulation and numerical studies
- Influences on strength
- Fracture process zone
- Fracture toughness
- Fracture energy
- Strain rate effects
- Fibre reinforced concrete

Applications and reinforced concrete

The cracking and fracture of concrete: An annotated bibliography, 1982-1985.

The contributors are drawn from 18 countries and, although several well-known researchers in this field are absent from the list, the papers give a good overview of current research into the fracture of concrete. As is inevitable with such a wide authorship, some papers suffer from transliteration. It is not possible in a review of this type to do justice to all the research included in the book and consequently a few general comments will have to suffice.

It is interesting to note the changes in emphasis between the volume produced by the same committee in 1983 and the current book. These changes are also reflected in the annotated bibliographies included in both books. The earlier research dealt largely with the question of whether fracture mechanics, and in particular linear elastic fracture mechanics (LEFM), was truly applicable to concrete. Because of the inconsistencies and contradictions in the experimental studies reported, the question was not properly answered. The latter book contains a general consensus that

fracture mechanics can, indeed, be applied to concrete although the majority of papers conclude that non-linear fracture mechanics concepts are more widely applicable than LEFM.

As a result of the increased confidence in the use of fracture mechanics the papers in the latter book concentrate on isolating the most appropriate fracture mechanics criteria for concrete and designing test techniques which may be standardised to provide values for fracture parameters. It is also significant that there are several papers dealing with the application of fracture mechanics to structures, of which those concerning concrete dams in China are especially noteworthy.

Those papers concerning the role of strain-softening in the fracture of concrete and the development of fracture process zones are of particular interest to the reviewer. In the papers by J. G. Rots (Strain-softening analysis of concrete fracture specimens) and by P. E. Roelfstra and F. H. Wittmann (Numerical method to link strain-softening with failure of concrete), plain concrete specimens are analysed using non-linear frac-

ture models, within the finite element technique. It is shown that the shape of the strain-softening curve has a significant effect on the load/deformation response and that a knowledge of the fracture energy and tensile strength alone is insufficient.

The observation of fracture process zones is a difficult experimental problem. The four papers on this subject describe four different techniques which have been used, however the results are by no means clear. What is demonstrated is that microcracking and the development of fracture zones are significant in the fracture of concrete. Further experimental work is required in this area.

The conclusions drawn in the different papers are often contradictory and the editor suggests that the book has been published in the middle of a transition period with non-linear fracture mechanics concepts growing in popularity. He hopes that this book will stimulate further development in this field. It is a pity, therefore, that the price will probably restrict its circulation to just a few libraries.

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