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Book reviews

Radar testing on concrete structures. Concrete Society technical report No. 48.

Concrete Society

Concrete Society, 1997. 64 pp. ISBN 0 94 6 69161 4. £105.00

This report, prepared by a Working Party of the Concrete Society, under the chairmanship of Professor Bungey, is a guide to the non-destructive testing of concrete by the use of radar. It illustrates what radar can detect, and, more importantly, what it cannot. Radar can usefully penetrate concrete to a depth of 10–20 wavelengths, and has a resolution of about half a wavelength; at a typical frequency of 500 MHz, the wavelength is about 200 mm, so there is plenty of penetration for most concrete structures, but resolution may be a problem if small features are being sought. There are also problems caused when some elements, such as steel bars, shield features that lie further away.

There is a chapter on the underlying theory, which is supplemented by a useful appendix which gives some of the relevant equations and numerical values. There is a short chapter on signal processing, which could usefully have been supplemented by a section covering ongoing research, since it is in this area that future developments will lie. Some of the techniques used with other imaging systems should be applicable to radar. There is much relevant work in the medical imaging world of ultrasonics, CT and NMR scanners that allows the reconstruction of complete three-dimensional structures; this gets no mention at all. Presumably there is research going on in this field, and we should have been told what developments were in the pipeline. As it stands, the examples in the report give fairly bland two-dimensional representations of the sort of images that are to be expected; funny squiggly lines that 'clearly' show the presence of holes or bars or cracked concrete.

The report has guides to planning and reporting surveys, and how to draw up specification clauses in contracts. These hint at the possible underlying reason for producing this report; it has been drawn up by the professionals so that the rest of us can be better clients. There is enough detail in the theory to make it complicated and there are enough special cases to make it a black art, so we must employ an expert, but there are also enough tempting examples to show that we might get something useful from the technique.

The book shows signs of having been put together by a committee, with different parts being written by different people. For example, we are told some things several times, such as the effects of incomplete hydration of the concrete. There are also several places where black and white photographs are placed in the text, and are then reproduced in a separate colour section.

Taken as a whole, this is a useful introduction to the theory, practice and application of the use of radar to test concrete. It would make sensible reading for a client before getting involved in a discussion with the specialists, or for students learning about this new technique.

C. J. BURGOYNE

Penetration and permeability of concrete: barriers to organic and contaminating liquids.

H. W. Reinhardt and H. E. Reinhardt (editors)

E & F N Spon, 1998. ISBN 0 419 22560 9. £65.00

This book is a state-of-the art report prepared by members of RILEM Technical Committee 146—TCF dealing with 'tightness of concrete with respects to fluids'. This work started some 6 years ago, and the report is both pertinent and timely, taking regard of current interest in the durability of concrete structures and in particular of those that act as containment for fluids as well as barriers against them.

The interplay between the porosity of a material and its ability to assist or impede the passage of fluids through it is well established, both practically and theoretically, in fields such as oil well production, but is much less understood for concrete, and yet the durability of this material has its roots in such criteria.

The book presents ten chapters in all, although Chapter 2 is subdivided into four sections. The contributions come from four countries, namely the UK, France, Germany and Canada. The first chapter introduces the subject, and Chapters 2, 3 and 4 deal with the fundamentals of fluid transport. Chapter 5 is concerned with a classification of fluids with respect to transport and chemical attack, whilst Chapters 6, 7 and 8 present a wealth of experimental results relating to concrete, and Chapters 9 and 10, the shortest in the book, deal with knowledge transfer to practical engineering and identifying research needs. I would like to have seen these two chapters substantially larger in relation to concrete, and the fact that the two comprise only seven pages in all is an indicator of the need to develop this subject further.

Chapter 2 is subdivided into four sections dealing with the review of fluid transport theory, microstructure and models based upon it, and unsaturated displacement of immiscible/miscible liquids. The connection between direct measurement parameters rather than microstructural properties, the connection between liquid and gas flow as well as saturated and unsaturated flow as in capillary absorption and desorption are dealt with in detail. Some useful engineering formulae covering transport properties are given for sorbtivity and diffusivity. It is acknowledged that the link between porosity and permeability is difficult to establish for concrete, resulting from its complex internal structure. We have to remember that the flow of water through concrete reflects both cement's residual reactivity and the inherent reactivity of water itself. This can change the properties whilst they are being measured. In this regard the subchapter admits to the limitations of the present state of knowledge.

Some of the text dealing with connectivity and tortuosity are dealt with thoroughly, but perhaps more from the viewpoint of the physicist than the concrete technologist. The authors admit to limited success covering the models for porous media and those that relate to concrete, although it is hoped that the application of fractal analysis may yield more promising information. It is interesting to note the anomalous behaviour of water as far as sorbtivity is concerned compared with organic liquid counterparts. Deviations from expected performance are again due to the inherent mutual reactivity of both the medium and the liquid flowing through it. The reader becomes aware on occasions that perhaps the authors are predisposed towards appreciating complexity when perhaps a macro explanation might be sufficient: for instance, the effect of the migration of fines on the measurement of permeation properties. The somewhat esoteric style carries over to Chapter 3, which deals with transport in composite media and covers the role of aggregate, both sorbtive and non-sorbtive. However, no account seems to have been taken of the aggregate/matrix interface, often regarded as contributing substantially to the permeation properties of concrete.

Concrete under load undergoes internal cracking, and such pathways assist liquid transportation through the material and can far exceed the flow of liquids through the hydrated matrix. Quantifying the relationship between stress and permeability is difficult. And statements such as 'the crack (if wide enough) contributes to an increase in flow' may, to some, sound like a profound statement of the obvious. The contribution of cracking gives rise to considerable complexity and disparities between theoretical and actual measured properties that can be accounted for by invoking a 'simple scalar parameter'. It may be difficult for some readers to appreciate the physical reality of such abstract factors. This particular chapter, whilst thought provoking, at this stage of development has limited practical application.

Chapter 5 takes account of chemical and physical interactions, in particular the role of surface tension and viscosity. Considerable data are presented relating these aspects to fundamentals such as molecular weight and chemical functionality of the liquids passing through the concrete. Accommodating chemical interaction between the liquids, water and others requires further research before reliance can be placed on the predictive information.

Chapter 6 presents a thorough examination of available testing methods, some familiar to the concrete technologist such as the ISAT, but it is useful to see details of permeameters such as the Hassler cell as well

as a very simple vapour diffusion test. Future researchers in this field would do well to study this chapter thoroughly. Chapters 7 and 8 are the most substantial, comprising 111 pages in all and containing over 90 references, 99 figures and some 28 tables of information dealing with the transport properties of concrete, both cracked and uncracked. Inevitably there is some repetition of the chapters that have preceded these, but that is not a bad thing if the book is going to be used as a reference work. Evidence is tabled that establishes the role of autogenous crack healing in concrete and a means of measuring permeation properties whilst inducing cracking does appear to be established. A great deal of information is presented in these two chapters dealing with concrete that has cracked both in compression, tension and bending as well with reinforced and unreinforced concrete. Cracking does not appear to have the same impact on diffusivity as on permeation.

The last two chapters are a little disappointing, with the author admitting to being surprised by how special concrete is! Water has a special place compared with non-aqueous fluids due to the latent reactivity of water with the base material. No surprises for the average concrete technologist to hear this view, and I think it reflects that studies are being carried out by individuals and institutions that perhaps should liaise closer with the concreting fraternity. There is a need for both sides to get together in order to establish the underlying permeation and sorbtive principles in order to link these with predictions of durability and general performance. It was interesting to note that the specification for fluid-type concrete in Germany at least (FD Beton) is covered by a third party overseeing the making and placing of the concrete—lessons for us all here.

I would certainly recommend the purchase of this modestly priced book because it is truly a state of the art report, but it is not without some limitations. For instance, there is a very limited keyword index and no author index. Some closer editing of the text would have made it easier to read, and there are a number of typographical errors and some inconsistencies. Notwithstanding these reservations I recommend it for the bookshelves of those concerned with researching the topic of concrete durability and endeavouring to relate the established technologies in other fields and linking that beneficially to the needs of concrete.

P. C. HEWLETT

Waste materials in concrete manufacturing.

Satish Chandra (editor)

Noyes Publications, 1997. 651 pp. ISBN 0 815 51393 3

This book of 651 pages is a compilation of contributions from an international body of authors, dealing with a wide range of waste materials with potential uses in concrete production. With a few exceptions, each chapter deals with a single waste. Whilst the book's scope is not exhaustive, and the main emphasis is on materials suitable for use as binders, chapters dealing with chemical admixtures and aggregates are also included.

Broad overviews are given of the more established materials, such as pulverized fuel ash, ground granulated blastfurnace slag, silica fume, by-product gypsum and lignin-based substances. Additionally, however, wastes whose use in concrete is less commonly encountered, including red mud and fluidized bed coal combustion residues, are also covered. One of the most thorough chapters is an examination of the principles of, and strategies for, recycling municipal and industrial wastes as both feedstock and fuel in cement manufacture. As well as providing a detailed discussion of the influence on the clinkering process of various elements likely to be encountered in waste streams, the chapter also covers environmental pollution control techniques and changes in plant procedure necessary to carry out such practices.

In general, this book acts as an excellent introduction for engineers who are new to the subject of waste recycling in concrete and who wish to obtain an understanding of the current international scene. Moreover, all the chapters are extensively referenced, and offer an ideal starting point for those requiring some background information before facing the often overwhelming body of literature available on many wastes.

R. K. DHIR

Strength and related properties of concrete.

S. Popovics

Wiley, 1998. 535 pp. ISBN 0 471 14903 9. £75.00

The book contains a huge amount of data on almost every aspect of concrete related to strength and stiffness. There are well over 1000 references, of which about 100 are to Popovics' own publications. The author has brought together in one volume an excellent description of most of the complex interactions between concrete components which affect concrete strength and elastic properties. The book contains six chapters and a software disk to assist the reader in some of the numerical computations.

Chapter 1 consists of 100 pages devoted to methods of determining the compressive strength of hardened concrete. Destructive and non-destructive procedures are described in detail, together with empirically based predictive equations. Statistical procedures for assessing variability and compliance are also described. Chapter 2 follows a similar format for other types of strength, including flexural, tensile, torsional, shear, bond and impact strengths. This is followed by more fundamental work related to fracture mechanisms and failure criteria. Chapters 3 and 4 concentrate on the strength development and structure of cement paste and concrete. Hydration processes are discussed in detail, with extensive data on the effects of temperature on concrete strength. Again, a large number of models are described for predictive purposes Chapter 5 devotes nearly 100 pages to predicting the relationships between composition and the strength of concrete. A major part of this chapter is devoted to the determination or prediction of the three coefficients which are necessary in the formulation of the exponential function for Abrams' law. Chapter 6 is mainly concerned with models which may be used to predict the elastic properties of concrete.

A significant disadvantage for much of the potential readership is that more than three-quarters of the figures in the book are in non-SI units, with the majority of strength values being quoted in ksi or psi. Thus, reference to much of the literature published outside the USA during the past 20 years is missing.

Also, the empirical equations are generally based on non-SI systems. This emphasis on non-SI units inevitably reduces the value of the book in areas outside the USA. The software supplied is provided with solutions to some of the equations in three systems of units, including SI. However, to take full advantage of its power, the reader is advised to read the user's manual, which is not provided.

Because of the detailed nature of much of the text and the wide variety of the empirical equations presented, the book is not appropriate for undergraduates but is more suited as a library general reference text for the specialist researcher or specifier. In this respect it provides a useful summary of the development of some aspects of concrete technology during the first three-quarters of this century, but it is not 'state of the art' because of the lack of attention to recent developments outside the USA in the last quarter of the century.

D. J. Hannant