

Book review

The rheology of fresh concrete

G. H. Tattersall and P. F. G. Banfill

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In keeping with the general trends of fairly recent years, concrete technology has been studied with increasing emphasis on materials science aspects, as distinct from traditional engineering approaches, in an attempt to understand more clearly underlying principles and their significance. Physicists and chemists, not unexpectedly, have had prominent roles in these studies and civil engineers have had to meet a challenge for which their academic (and, indeed, professional) backgrounds had not explicitly prepared them. Nevertheless some civil engineers have coped with the challenge with notable success, and there is no doubt that the study of concrete technology is much the better for it.

This book is by a physicist-chemist team, but each author is closely involved in the construction industry through his academic work in building science or building engineering; their approach and its expression throughout the book reflect their backgrounds in a way that is helpful and clear. Anyone who has had a serious interest in the behaviour of fresh concrete will have almost certainly been attracted by the fascinating field of rheology, its slightly exotic tone, the exciting prospects offered by its advocates and the insights awaiting the enthusiastic researcher; but there always loomed the shadow of dark complexity, for it was apparent that fresh concrete was a most complex material, confirmed many times by a myriad of experiments.

Dr Tattersall had, thirty years ago, clearly been

smitten by the challenge and has thus been able to build on long and fruitful experience. His infectious enthusiasm is well known and must have seen him through several difficult times in his researches. His younger co-author, Dr Banfill, while possessing perhaps less wisdom (at least of the sort that comes with age) presumably injected fresh enthusiasm and insight at appropriate times during their partnership. In any case, they bravely confronted the dark shadow and, collecting and generating evidence set out "to present a basis for progress in studies of concrete workability, in terms of the Bingham model, and to relate the results of laboratory work to practical methods of measurement and to practical problems at the plant or on the site". It is important to note the clearly stated restriction to the rheology because, of course, using the Bingham model, while posing sufficient problems of itself, allows progress to be made at a much faster pace and almost certainly provides the authors with the only path along which to tread through the otherwise apparently intractable obstacles. Even so their aim is a very ambitious one; the dichotomy between laboratory and site has been well known for years, so that attempts to heal (in the proper sense of making whole) are to be welcomed. There must be many civil engineers, suitably experienced in the nuances of fresh concrete behaviour, who have hesitated long and thought deeply before rejecting the healing role – and why not? The leap from laboratory to site practice would, for them, have

meant a fruitless struggle to cope with apparently irreconcilable objective and (largely) subjective procedures.

Not being civil engineers or concrete technologists has therefore probably helped the authors. They have boldly set forth, conscious of hazards, but not hampered by the set of prejudices buried deep inside most experienced and knowledgeable concrete technologists. (Of course, these prejudices are generally helpful to the latter, but would have made the rheological interpretations much more difficult for the former.) An impressive range of topics is covered, indicated by the following list of chapters (in the order as they occur).

The importance of workability; Introduction to rheology; The aggregate–cement–water system; The Bingham model; measurements using a coaxial–cylinders viscometer; Workability measurement based on power requirements in mixing; Theory of the two-point method; Calibration of the two-point workability apparatus; Experimental error in the measurement of workability; Workability expressed in terms of two constants; Workability and practical processes; Properties and proportions of mix constituents; The effect of chemical admixtures; The effect of cement replacements and of fibres; Workability measurement as a means of control of concrete production; The rheology of cement pastes.

These sixteen chapters are followed by four Appendices (Standard workability tests; Selected definitions of rheological terms; Glossary of chemical terms; Practical test procedures for concrete), a list of two hundred and forty-three references, an author index and a subject index.

The authors themselves note the seemingly strange inclusion of the chapter on rheology of cement pastes at the end of the book instead of early on where it might be expected to precede the discussion of concrete which, after all, is third in the list of materials (paste, mortar, concrete) of increasing heterogeneity. Characterizing the deformation and flow behaviour of cement pastes is extremely difficult and “the failure of the results of successive authors to agree either on a qualitative or quantitative basis” is a measure of the problem. Despite the need for a full understanding of cement paste rheology, in order to have a full understanding of fresh concrete, the authors have not allowed progress to be halted there and, sensible scientists as they are, have grasped at the opportunity presented by the fact that, within limitations (as with most phenomena), the flow properties of fresh concrete can be represented by the Bingham model. The nice, logical scientific progression is broken; elegant treatment gives way to practicality and everyone benefits. Because this

should mean much earlier and wider contact between concrete users and rheological principles than would otherwise have been the case, longer-term advances should benefit too. The alternative of leaving this information available but unpublished while researchers grappled with cement paste, eventually producing the unambiguous equations of flow which could complete understanding of fresh concrete flow might exemplify conventional scientific reporting, but would be a shocking waste.

The treatment of rheology throughout the book is very clear, and the development of the various equations is well presented (with one lapse in equation 4.37); non-mathematical summaries are given at the ends of four chapters. To many, the discussion of the aggregate–cement–water system, in particular the hydration of cement and the properties of suspensions, will be especially helpful. The discussion of the calibration of the two-point workability apparatus is most informative in its own right and will also be very helpful guidance to anyone in need of background to the careful process of calibration in general. Indeed the book as a whole is a good illustration of the careful study of and the methodical collection and treatment of experimental data required to supplement the analytical treatment of a particular problem.

Inevitably there are shortcomings. On page 148, use is made of published results, from five authors, of BS workability tests to check a proposed equation; the effect of the initial moisture conditions of the aggregates used on the measured BS workability value is well known, but in some of the data quoted it is not at all clear what this effect might be. This is not good practice. On page 179, values of g and h (the two constants analogous to the yield value and plastic viscosity) are given for a range of concretes which include, for example, an aggregate/cement ratio of 9:1, with 10 mm maximum size irregular gravel, 30% Zone 2 sand and water/cement ratios from 0.60 to 1.0. This must include mixes which, at the very least, have questionable compositions.

There will be other points which please, surprise, irritate, enlighten and educate the reader, depending on his interest, background and experience. There is much in the book to digest and discuss and much to which repeated reference can profitably be made. A number of areas are receiving current attention, the authors say, so further elucidation is awaited.

The book is nicely styled and printed. It costs £32.50, which will limit access for some potential readers. For the background work, discussion and conclusions it contains, it is well worth reading and studying and is a major addition to the literature on concrete.

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