Book reviews

Concrete mix design, quality control and specification.

K. W. Day

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Concrete is the only primary structural material that can be manufactured at the point of use. Even when made remotely, for example at the ready mix plant, it is unique among materials for the diversity and variability of its constituents. In its historical and technological development, as soon as the nature of the factors affecting its properties and performance were established, users immediately sought to employ that knowledge in the reverse process of producing concrete of desired characteristics from available ingredients. Thus was born the art of the formulator. Having formulated a concrete for a job the next challenge was to ensure that the material produced over the lifetime of the project was sufficiently similar to meet the performance requirements. This brought forth the notion of quality control. Finally, clear and concise communication of requirements, backed up by enforceable criteria, is the province of the specification writer. This book deals with all three of these concepts.

I referred above to the formulator. Unlike the formulator of cosmetic products which in some cases contain 100 ingredients, concrete technologists are fortunate in dealing only with cements of a few types, aggregates, water and a limited number of aids like water reducing admixtures. In principle, then, the task should be simpler but in practice just the possible variations in particle size, shape, texture, mineralogy and density of aggregates alone gives rise to so many possible combinations that selecting a unique formulation becomes impossible without recourse to simplifying rules.

Formulation, referred to as mix design in many parts of the English-speaking world but as mixture proportioning in the USA, is the discovery and pragmatic adoption of those simplifying rules to the task of selecting the types and relative amounts of the various ingredients to produce concrete which achieves the required performance. This book assumes that the reader has the required knowledge of concrete behaviour and explores the ways and means of applying that knowledge to the problem of mix design. It reviews the historical development of the subject but concentrates on Day's own method, the so-called Conad system.

Conad is based on over 45 years of experience in five continents and reflects progressive development from, initially, tabulated processes to its current manifestation as a fully interactive piece of software, a demonstration of which is included as a CD-ROM with the book. It is based on specific surface area as the primary aggregate property of interest. This simplification restricts its validity slightly, as Day recognises, but this limitation is neatly overcome by using a feedback process to give correction factors. The approach is clearly set out in the book and amply supported by examples.

The second part of the book reviews the evolution of approaches to quality control and describes the Conad system, partner to the mix design system. It is based on multi-variable cusum graphing where a number of variables such as strength, slump density and concrete temperature are plotted continuously over time. Cusum is the cumulative sum of the differences between each

successive measurement and the previous running mean value. By definition the cumulative sum of the differences is zero provided the previous mean continues to be the new mean and the cusum graph shows temporary divergences but remains essentially horizontal. If the mean changes, however, each successive point will differ from the previous point by this amount. The graph will now deviate from the horizontal by an angle that is a measure of the change in the mean, and the point of intersection of the best straight line before and after the change will pinpoint the time of occurrence. Day's main contribution here has been to harness computer power to enable several variables to be monitored simultaneously and results processed rapidly to give automatic, prompt and reliable feedback. Thus changes can be detected earlier and corrections implemented promptly. He concludes this section of the book by raising the intriguing possibility of a self-regulating concrete batch plant: with his system such an installation seems credible.

The final part of the book deals with specification of concrete quality and discusses testing procedures that might be employed to establish compliance. Day is dismissive of specifications based on minimum cement content and contends that, typically, the decision to

accept or reject concrete is based upon tests representing such a large quantity of concrete and results that come so late after production that action is impracticable. Day's view is that specifications need to be readily enforceable and promote co-operation between suppliers and users and therefore he proposes a cash penalty as an alternative to the all-or-nothing approach currently adopted. He gives one example of where, if the strength of concrete supplied falls below the specified value, the supplier has the options of: (i) removing and replacing all the concrete at his expense; (ii) demonstrating that the concrete delivered is fully capable of carrying out its intended function in every respect; or (iii) accepting a cash penalty of 1% cost per 1% strength reduction. He avers that such a graduated penalty would be a positive step.

This is a well written and thought provoking book, written in direct and sometimes challenging language. It deserves to find its place on the desks and in the computers of producers and specifiers all over the world. If it does not then it will be an indictment of the conservative nature of the concrete industry of the world.

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