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The effect of differences in the composition of Portland cement on the properties of hardened concrete

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This paper refers to the effect of differences in cement composition on the properties of hardened concrete. Samples were subjected to dry curing (20°C, 65% relative humidity) and wet curing (28 days under water). Thereafter the dry cured and the wet cured samples were stored under identical conditions (20°C, 65% relative humidity) up to the time of testing. Two of the properties tested were carbonation and oxygen permeability. These properties can influence durability with respect to corrosion of the reinforcement. The tests show significant differences for both these properties between dry cured and wet cured samples. Curing conditions seem to have an even greater influence than the differences in cement composition.

Storing conditions, at a constant 65% relative humidity, could be somewhat similar to conditions inside some buildings. However, concrete on the outside of buildings in Western Europe is subjected to daily and seasonal variations in relative humidity. Some surfaces are subjected directly to rain and snow; others to fog, damp air and condensation during cool nights.

Carbonation and oxygen permeability are not relevant to concrete on the inside of buildings. Due to lack of moisture, the reinforcement will not corrode whatever the depth of carbonation and the supply of oxygen. Carbonation and oxygen permeability can be important, however, for concrete on the outside of buildings. The outcome of the tests described, though, is not relevant to outside (storing) conditions in Western Europe. The dry cured as well as the wet cured samples should have been stored for 180 days under an outside relative humidity regime before testing—only then could relative conclusions have been drawn with respect to durability.

Recent research[1] has shown that the differences between dry cured and wet cured samples tend to vanish after storing under realistic outside climate conditions. Delayed reactions apparently take place between available moisture and cement particles. This has been observed for directly exposed as well as under-cover samples. The conclusion is drawn that in a Western European climate curing conditions are not as important as used to be thought, except, perhaps, with respect to surface texture.

Much research has been devoted to the effect of curing conditions on the properties of concrete. Almost without exception the samples are stored under some constant temperature and relative humidity regime after the various curing procedures. Such tests cannot lead to relevant conclusions for concrete on the outside of buildings and structures, because the storing conditions in the test do not represent the actual climatic environment to which the concrete in question will be exposed.

Reply by the authors

We would like to thank Professor de Sitter for the interest he has shown in our paper. We agree that concrete fully exposed to the weather in a typical Western European environment is likely to have sufficient available moisture to enable hydration of the cement to continue, so that the effect of initial cure and difference between cement types will be reduced.

We do not, however, agree that such differences are unimportant, especially for concrete in more sheltered environments, or that in such sheltered environments corrosion of reinforcement is not possible. Moreover, it should be remembered that one of the authors is from Israel, in whose climate premature drying and lack of hydration is a real possibility in the most exposed concrete. The extensive studies carried out by BRE on houses[2,3] have shown that over a fairly long period, reinforced concrete inside parts of a building where the humidity is higher than in the heated living space, e.g. the roof or wall cavity, can suffer serious corrosion. Similarly, corrosion of reinforcement is a real possibility in sheltered external environments; in such environments recent field studies by BRE[4] have found that, for example, concretes with high slag replacement levels are vulnerable to high rates of carbonation unless the curing is good.

We have recently compared the effects of various initial curing regimes on the carbonation of concrete stored for 2 years in either a sheltered external environment or in the laboratory at 65% relative humidity/20°C. Predictably, the initial cure had a major effect on the carbonation in concrete stored at 65% relative humidity. In the sheltered external environment the levels of carbonation were certainly less, but differences between the concretes subject to different initial cures were only slightly lessened.

Overall, then, we believe that there is a place both for studies in natural external environments and laboratory studies in controlled environments. The former are invaluable in showing the behaviour of real concrete, but because of the variability of the external environment can give very misleading results, especially in short-term studies, unless such variations are recognized and taken into account. The latter will enable precise comparisons between results obtained at different times and in different places, but must of course be correlated with behaviour in real environments.

References

1. *Carbonatatie, corrosie en vocht.* CUR, Gouda, The Netherlands. CUR rapport 90–3.
2. CURRIE D. *Carbonation depths in structural quality concrete: assessment of evidence from investigations of structures and from other sources.* Building Research Establishment, Garston, 1986.
3. *The structural condition of prefabricated reinforced concrete houses designated before 1960.* Building Research Establishment, Garston, 1984, information paper, IP10/84.
4. OSBORNE G. Carbonation and permeability of blastfurnace slag cement concretes from field structures. *Proc. 3rd Int. Conf. on flyash, silica fume, slag and natural pozzolana, 1989.* American Concrete Institute, Detroit, SP-114, Vol. 2, pp. 1209–1237.

Book review

Concrete radiation shielding

M. F. Kaplan

Longman, Harlow, 1989, 234 mm × 156 mm. 448 pp. Illustrated. Hardback. ISBN 0 582 03773 5.

Although concrete is ubiquitous and versatile, specialized applications arise that highlight its uniqueness. In this book, Kaplan presents just such a field of use, in a readable but quantitative and well-structured way that should appeal to the radiation specialist/designer and concrete generalist alike.

Fifteen well-referenced chapters and a good index comprise the volume, which begins with an introduction to atomic and nuclear structure, in particular the origination of radioactivity and its interaction with matter. The first paragraph of the first chapter leaves the reader in no doubt as to the importance of being respectful of ionizing radiation.

However, chapters 9 and 10, comprising about 40% of the book's contents, form its kernel. These chapters are concerned with the bulk and nuclear properties of concrete. Much tabulated information is given on concrete in both specific and general terms—a most useful source of reference. For example, thermal conductivity and expansion are dealt with together with shrinkage properties of a wide range of concrete types with aggregates such as serpentine, limonite, magnatite, and barytes, as well as various mixtures.

Concrete has to respond to both obvious and subtle effects. There is an interplay between composition and the ability to shield against radiation. Gamma and X-rays are contained by means of concrete density, but neutron radiation requires low molecular materials such as retained water in order to become attenuated. Some primary radiations, as a result of being absorbed, can themselves cause secondary high energy radiation. Interesting comments are offered about minimum water contents in relation to neutron shielding. The resulting high temperature causes water loss, therefore a reduction in shielding capacity must be considered when designing real and permanent installations. As well as thermal damage there can be invidious structural/compositional change, i.e. radiation damage. The author admits there is little information on this topic.

I suspect that the materials and concrete technologist will linger on these points, while the engineer will perhaps be more concerned with basic design requirements, costs, and seeking the practical compromise. Such items are dealt with in the two final chapters. Excellent well-worked examples are given.

The book retains its high technical level and consistency throughout, and is difficult to fault. Perhaps the references in chapter 8 are a little dated, and the use of angstrom units somewhat quaint, but these are minor niggles in what will be a standard reference text on this specialized topic. Although written with engineers in mind, this volume has a wider appeal, to scientists and students of concrete. It combines pragmatism with a clearly-presented scientific base. A very good work indeed.

PROFESSOR P. C. HEWLETT
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