Nanomaterials in Concrete

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This is an excellent research monograph which summarises some very interesting work done by the author over a number of years at Louisiana Tech. The methods which are presented offer the potential to improve the strength, durability and many other properties of existing concrete structures.

The term “nano” has been applied to many new technologies. In this book it generally refers to colloidal suspensions of particles in the size range 1-100 nm. To put this size in context, typical ions such as chlorides are in the range 0.1–1 nm, gel pores in concrete are 1-10nm and capillary pores are 10-1000 nm. The particles therefore enter the concrete through the capillary pores.

A wide variety of different materials were used. Colloidal silica, alumina coated silica and others are referred to and the author gives the names of the suppliers. The colloids were very concentrated in solution with stated values up to 50% by mass. Sodium silicate and calcium hydroxide solutions were also used.

The materials were driven into concrete using an electric field. The method is the reverse of the desalination that is used to remove salt from contaminated structures and can be used at the same time. Thus while negative chloride ions are being removed from concrete positive nanomaterials can be drawn in.

The main chapters of the book detail experimental investigations in which various properties are improved by this technique.

In chapter 2 the permeability of samples is reduced by up to three orders of magnitude by blocking the pores with nanoparticles. In chapter 3 the porosity is reduced by up to 75% and the strength increased by over 100%. In chapter 4 the issue of crack repair is addressed and it is shown how nanomaterials can overcome problems of bond between crack repair materials and the substrate. In chapter 5 pozzolanic nanomatrials (alumina coated silica) are introduced into chloride contaminated samples with reinforcing bars in them and the final corrosion current is shown to be two orders of magnitude lower than control samples which were just desalinated. In chapter 6 the same pozzolanic materials were used to achieve partial strength recovery and porosity reductions in samples with sulphate attack. In chapter 7 strength increases of 100% are reported for samples with freeze-thaw damage.

Chapter 8 gives guidance on methods that can be used to design repair systems and chapter 9 describes some advanced techniques in which particular chemical reactions are created by introducing sequences of different materials. An interesting experiment is also described in which organic polymer precursors were introduced which then formed fibres within the pores which reinforced the sample while reducing the permeability at the same time.

My only criticism of the book was that, as a European, I found the frequent juxtaposition of imperial and metric units (both cgs and MKS) confusing at times.