Finding a cure for defective concrete

Chris Mahony takes a closer look at ASR and cathodic protection

For those of you who are tracking the Lafarge Cement UK incident, Lafarge has published a statement on its web site. The incident took place between 2002-04, and concerned the manufacture of cement at the company's Westbury plant in Wiltshire.

The incident affected the alkalinity of the cement being produced by Lafarge, which can lead to surface cracking in concrete structures. Lafarge and its customers are tracking down any projects that may have been affected and will endeavor to keep everyone informed.

Alkali aggregate reactions, of which alkali silica reactions (ASR) are only one variant, are relatively uncommon in construction in this country and tend to occur in civil engineering structures rather than conventional buildings. For most purposes it is sufficient to consider the risks of ASR in preference to the other forms of reaction, as these are not known to occur with most types of aggregate used in the UK.

Essentially, the problem occurs when certain types of reactive aggregate are affected by highly alkaline pore water within the concrete. The chemical reaction produces a gel, which imbibes water, expands and can cause the concrete to crack or disrupt. Sometimes a pattern of 'map' cracking occurs but in others small 'pop-outs' can occur. The durability of the concrete can be compromised and, in extreme cases, the tensile strength of the concrete component can be reduced.

For ASR to occur, three factors must be present:

- high alkalinity,
- sufficient moisture, and
- a critical amount of reactive silica in the aggregate.

Where the aggregate was sea-dredged, marine flint classified in accordance with current guidelines as being of normal reactivity (and most of the UK marine aggregates fall into this category) it would present no particular concerns when used in combination with highly alkaline cement, as supplied by Westbury.

Cathodic protection

Inspecting a building that has used concrete in its construction should trigger a number of questions in your mind.

One of the first things to ascertain is the way in which the concrete was formed, ie in-situ or pre-cast. This is not as easy as it may seem, as advances in in-situ concrete pouring and finishing are so well developed that what might appear to be pre-cast may in fact be in-situ. Assuming you've got this far, the associated potential (or actual) defects should be understood, ie corrosion of reinforcement, poor cover to reinforcement, shrinkage, admixtures, salts, spalling, carbonation and impact damage as well as high alumina cement (HAC) and ASR.

If your conclusions are that the concrete is in poor condition and needs repairing, what are the choices open to you ? One option is cathodic protection, so what is this and how does it work ?

Carbon steel, which is used in concrete reinforcement, will have a natural tendency to corrode due to the influences of water and oxygen. In other words, the steel rusts, expands and will spall the concrete surrounding the reinforcement. Cathodic protection is a principle developed as early as the 1820s in ship building, which makes something else corrode, instead of the steel. The sacrificial 'something else' is either linked via a dc current, or will create an impressed current of its own. For the technically minded, the steel becomes negatively charged and acts as a cathode, and the sacrificial material, such as aluminium, zinc or magnesium, is known as the anode. Perhaps the ship builders should talk to the car manufacturers.

Understanding the principals of cathodic protection is important, as it's an alternative to more traditional forms of repairing concrete. It's also true that you are likely to require the advice of a specialist who will help to determine if cathodic protection is viable, and will advise on the costs of design and installation. There are also several techniques available, including the application of specialist paints which contain active components. Clearly the system, once installed, will require monitoring and maintenance.

Understanding the principals of cathodic protection also make it easier to understand why good quality concrete with sufficient cover to the reinforcement is so important. Once reinforcement has been covered in concrete, it develops a protective film or passive layer of its own. This thin oxide film is a result of a reaction between the steel and the alkalinity of the concrete. When reinforcement has poor cover, moisture and oxygen will reach the reinforcement, causing it to corrode. Carbon dioxide in the atmosphere will combine with water to form an acid that will help to neutralise the alkalinity of the concrete which will also travel through the concrete – a process called carbonation – which can increase the risk of the steel corroding.

If you are aware of an emerging problem, the Building Pathology Working Group would be pleased to hear from you via the email at the end of this article. The group has a vacancy and would be pleased to hear from any members who would like to contribute. You may also wish to find out more about i-surv Building Surveying, the new RICS online information service on **www.isurv.co.uk**

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