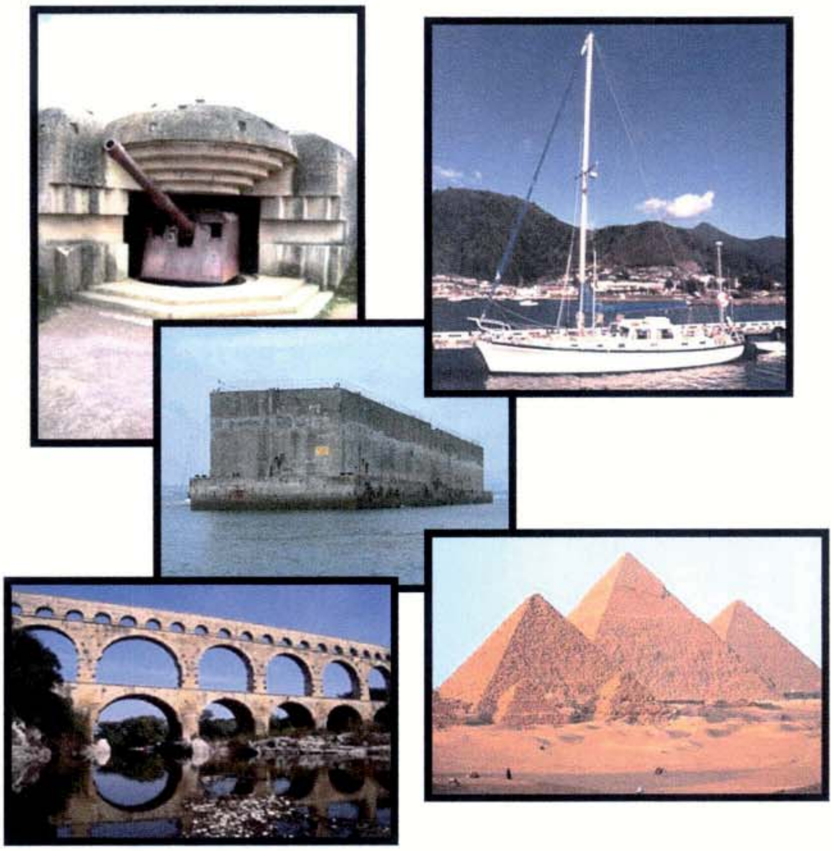
THE NEED FOR CONCRETE ANSWERS

MICHAEL NUGENT – MANAGING DIRECTOR OF THE CONCRETE AND CORROSION CONSULTANCY PRACTICE LTD takes a look at the methods available to Inspect and test concrete structures.



A History hard to beat

Concrete is believed to have first been introduced by the Egyptians as analysis of pyramids has identified a concrete type substance.

The Romans used concrete extensively and very successfully – they called it Opus Caementicium.

The Roman Pantheon is still to this day the largest un-reinforced concrete structure in existence.

On the positive side, concrete became the most widely used building material once it was reinforced as it could then be used on larger and taller structures.

On a slightly negative note however, at the point that such visionaries in their field as Louis Lambot discovered in the mid 1800's that by adding thin strips of metal he could greatly increase the strength of concrete – the future birth of the concrete repair industry was assured!

Concrete through the ages has found the most unlikely uses from aqueducts to the gun emplacements of two world wars and even one of the most unusual uses in world war two – the floating concrete mulberry units that locked together to form huge harbours for the D Day landings in Normandy.

Since wartime uses concrete has been used extensively for a huge range of buildings and structures from clinker concrete which first used the rubble of buildings destroyed by the blitz to make a crude concrete that could quickly clear the rubble and re-build Britain. Through to ferro concrete boats/yachts capable of travelling around the world – is there anything that it can't be used for?!

So where did it all go wrong?

There is no reason why a well designed concrete structure with a good standard/strength, well placed and compacted and with good cover to the steel reinforcement could not have a life expectancy of over 100 years.

Unfortunately, often not all of the factors above come together and that is where the problems start.

The ability of steel to remain un-corroded within concrete is due to the high alkalinity of portland cement concrete. In order to create this protective environment, portland cement is combined with aggregates and water, which once cured becomes concrete.

The high alkaline environment which is created as the concrete cures (approx pH12) gives the protection that the steel needs so as not to corrode.

This high pH level is known as passivity as it is in effect a passive layer of oxides and hydroxides on the surface of the steel reinforcement.

The passive oxide layer can last indefinitely if the high alkalinity is maintained, however the effects of carbon dioxide in the atmosphere can attack the layer, this process is known as Carbonation and the effects of chloride salts (chloride attack) are also a serious cause of distress.

Corrosion of the steel reinforcement, as with other forms of corrosion is an electro-chemical process.

Anodic and cathodic areas are present during the process, at the anodic area the metal oxidises and forms rust and at the cathodic area the steel will not rust.

The process causes the rust on the steel reinforcement to expand up to 10 times the original diameter causing the concrete around it to first crack and then spall.

The most common causes of distress

There are others but we will deal here with the two most common causes of distress.

Carbonation Induced Corrosion

Expansive corrosion of steel reinforcement contained within concrete can be caused by the carbonation front reaching the depth of steel and destroying the protective passive layer.

This process is normally caused by carbon dioxide in the atmosphere migrating as a gas into the pore structures of concrete elements. As the migration occurs the alkalinity reduces and becomes more acidic resulting in the lowering of the pH levels and the eventual loss of the passive (protective) layer around the steel.

Chloride Induced Corrosion

Chloride attack can be the more serious of the two forms of attack as it has a more aggressive 'cutting' effect through the steel.

Chlorides can enter the concrete through a number of ways:-

Through the use of marine aggregates or road de-icing salts (ingressed chlorides)

Or

By way of additives such as calcium chloride used extensively during the 1950's and into the 1960's for early cure/strength, found more commonly in pre-cast elements (cast-in chlorides)

Calcium chloride was however banned in the mid 1970's but many structures still exist that contain this additive.

Identifying the true cause and extent of distress

Of absolute vital importance when dealing with concrete distress is the need for accurate diagnosis and an understanding of both the cause/extent and technically correct methods of repair and protection.

Engaging consultants who are truly independent (not tied in any way to material manufacturers or contractors) is very important.

The consultants should have both the in-house capabilities and experience to not only access the structure but to also accurately diagnose the causes of distress, the extent of distress and be able to formulate a detailed, technically correct repair and protection strategy.

Only when in possession of all the relevant facts can this be achieved.

A range of diagnostic testing should be carried out with correlation across the different tests rather than reliance on a single test type made.

Procedures include:-

- Carbonation testing using phenolphthalein.
- Chloride content analysis in increments (including steel depth).
- Half-cell potential testing with results given in equi-potential colour contour plots.
- Cover-meter (cover and spacing of steel).
- Hammer testing including Schmidt.
- Petrographic and comprehensive strength.

There are other tests available but these are the main tests carried out.

The report should be a comprehensive document with a straight forward objective/deliverable – to identify the true cause of distress, the true extent of distress, with a technically correct remedial strategy and accurate budget costings.

Defect marked Auto-CAD drawings, defect schedules, photographic support and test results data are all important parts of the report.

In summary

Whether the distress is to a bridge, a jetty, a building and so on, the principal is the same for a long term repair strategy to be formulated – understand the cause to rectify. Always engage consultants who are truly independent and have a proven track record in diagnosis and cure of concrete distress.

Ideally the consultant will have these operations in-house including access depending on the structure, this can range from industrial roped access technicians for high-rise inspections through to dive teams for marine surveys.

Memberships to organisations such as the concrete society, the Association of Consulting Engineers and so on will all help to ensure you are selecting the right consultant.

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