SOLUTIONS TO CORROSION IN RAAC PANELS

Concrete Preservation Technologies (CPT) has been undertaking research on RAAC for four years with its partners in the NHS, independently at its laboratories and as a part of the prestigious Loughborough University RAAC Research Group. CPT has been focusing on the inspection, testing and corrosion risk appraisal of RAAC panels. **Christian Stone** reports.

TOP RIGHT:
Figure 1 – corrosion under the surface.

RIGHT:
Figure 2 – realkalisation confirmed with the application of phenolphthalein solution.

Reinforced autoclaved aerated concrete (RAAC) was introduced into the UK in the 1950s and was a popular building material for prefabricated elements up until the mid-1980s. Invented in Sweden in the 1930s, the use of this material spread through Europe and into the Middle East and Asia. Though in the construction community it was understood that the lifetime of aerated concrete would be less than traditional concrete (with around 30 years being commonly quoted), much of the post-war construction in the UK including RAAC is still in place 50–60 years on. Though only a handful of known failures have occurred, as may be expected in reinforced elements past their intended design life, age-based issues have become apparent.

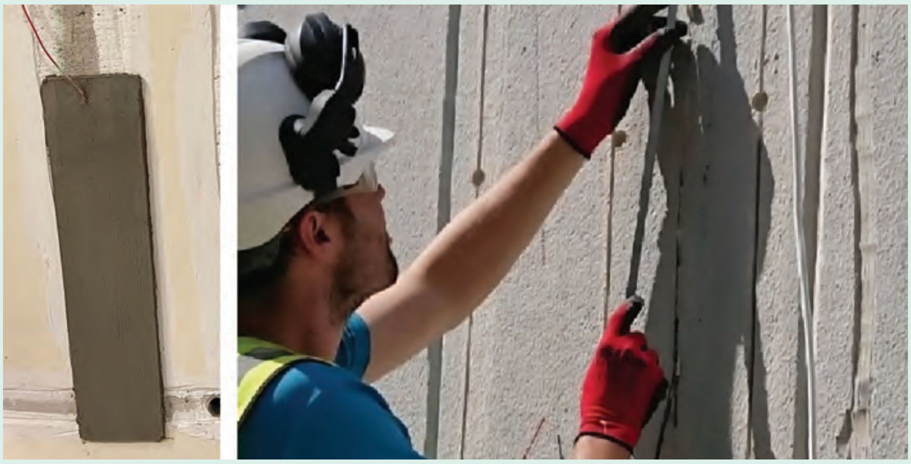
CORROSION INITIATION OF REINFORCEMENT

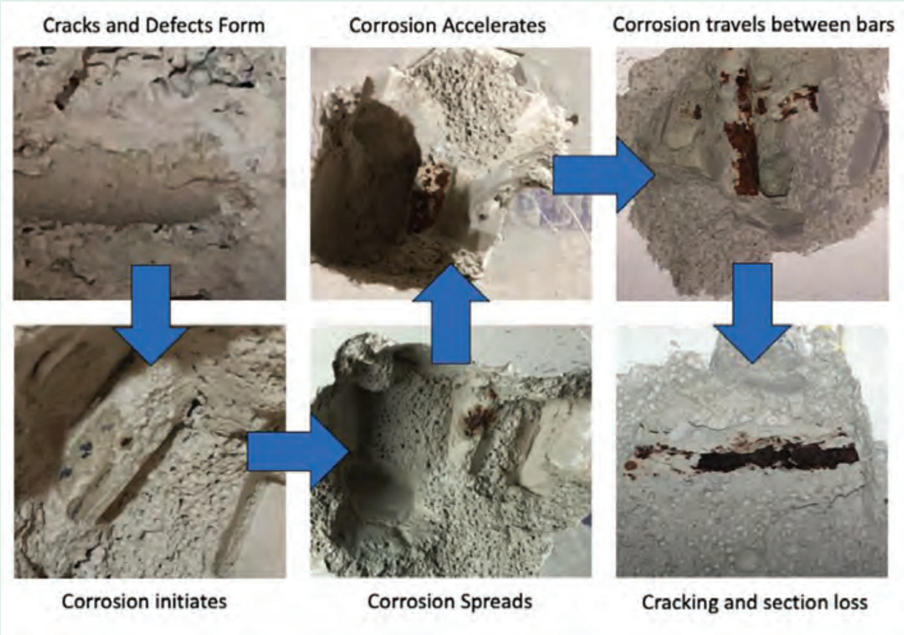
Aerated concrete does not itself offer much protection to the reinforcement from corrosion. The voids, typically making up half of the volume of the panels/planks, allow moisture and carbon dioxide to easily permeate the element. Carbonation therefore occurs throughout the autoclaved aerated concrete (AAC), reducing the pH and its ability to protect the steel. In order to combat this issue, manufacturers at the time coated the steel in a mixture of latex, fine aggregates and cement. However, the reinforcement coating found in RAAC in the 1980s may vary, with powder-coated steel being observed in one instance.

This latex-based coating is clearly visible on the steel, typically between 0.3 and 2.0mm thick and often a cream or grey colour. This coating is the primary protection for the reinforcement from corrosion and when intact is impervious to water, high in pH and adheres well to the surrounding concrete. However, over time the stresses likely caused by moisture, heat cycling, deflection and age-based shrinkage have begun to degrade the coating. Defects, carbonation, debonding from the steel and cracking are common issues found in these coatings.

Once the coating is degraded, corrosion can and does occur, exacerbated by the high humidity of RAAC; typically, approximately 6–14% moisture, but able to hold its own weight in water if waterproofing is poorly maintained. Moisture can also be an issue in places of high internal humidity. Bathrooms, kitchens or rooms with a kettle may have elevated moisture and therefore risk.

Corrosion issues also may be accelerated by chlorides, which have been commonly found in both roof planks and wall panels made of RAAC. Chloride at the steel interface interferes with the passivity of the steel interface. Once corrosion initiates, as it has in much of the RAAC surveyed from the 1960s and 1970s, it is only a matter of time before it accelerates and spreads.





LEFT:
Figure 3 – surface anode applied to RAAC; application of a strip anode into a RAAC wall panel.

BELOW:
Figure 4 – corrosion propagation mechanism in RAAC.

IDENTIFYING CORROSION

Corrosion within RAAC may not be as apparent as with reinforced concrete. Though rust is typically six to eight times the volume of steel and creates stress from its expansion, the AAC is not as robust as traditional concrete and can be crushed by the corrosion. Also, staining from rust is not as commonly seen in RAAC, even with severe corrosion. Due to these two factors, rust in RAAC can hide from plain sight until the stress builds up and large cracks appear, leading to spalling.

Further frustrating the surveying of corrosion in RAAC is that the coating on the steel does not degrade evenly. Different areas on a plank may have very different thicknesses of coating and may be suffering from different levels of both carbonation and debonding. This can frustrate half-cell mapping, which is a commonly used technique to assess corrosion risk as areas of steel. Steel surrounded by an intact coating will be highly resistive to external measurement and may suffer from oxygen depletion on the surface of the steel, which affects results.

INVESTIGATING CORROSION AND DEVELOPING SOLUTIONS

Scanning for corrosion is possible. By creating a scanning methodology that both identifies defects and then assesses their risk, corrosion can be found. Concrete Preservation Technologies Ltd (CPT) has scanned ten RAAC properties over the past four years and tested its methodology both in the laboratory and on-site. However, if the RAAC is from the 1960s or 1970s, and has been subjected to moisture recently, corrosion is almost inevitable from our data.

One of the best first steps is to keep the RAAC dry; upkeep of paint and waterproof coatings is critical to stopping corrosion initiation. However, traffic over the rooftop during maintenance and repair, heat cycling and deflection from loading roof planks of this age may degrade them further. Similarly, adding additional loads, such as HVAC systems, are detrimental. A structural engineer with knowledge of this material should be consulted before undertaking any works.

Corrosion is not the only concern. The location of the transverse steel reinforcement is not always well situated against the planks' bearing, leading to issues with shear failure. Also, moisture ingress can lead to leaching and loss of strength in the AAC as well as corrosion.

Roofs and walls with moisture ingress from rising damp, imperfect coatings or internal moisture are very likely to already have initiated corrosion. The aim in these cases is to manage the corrosion risk.

CORROSION RISK MANAGEMENT

CPT has been working with partners in the NHS for years to develop corrosion management solutions for RAAC. RAAC-Guard, a hybrid corrosion management solution has been implemented that is initially powered to realkalise the environment around the steel and halt any ongoing corrosion. Once the corrosion has been halted, zinc anodes are connected to the reinforcement within the RAAC. Being more electrochemically active, the zinc anodes corrode sacrificially to provide a reactive current, which delivers protection proportional to the amount of moisture and heat present. Any future water ingress will cause the anodes to corrode preferentially, delivering protective current to the steel and maintaining its passivity into the future.

Due to the fragile nature of some of these elements, systems were designed in consultation with structural engineers with experience with RAAC. Strip anodes installed into wall panels as well as surface-applied anodes for internal use and to protect the steel in roof planks have been developed, trialled and installed, which have minimal impact to the structural integrity of these structures. Importantly, these systems can only be implemented if the integrity of the RAAC is intact, ie, the reinforcement is correctly located and spalling is not widespread on the plank. C