

- the degradation of concrete properties with ongoing delayed ettringite formation
- the effects of DEF on lap strength
- the lap strength of multiple bars in multiple layers, where only the outer layer is enclosed by transverse reinforcement. ■

Reference:

1. BUCKBY, R. et al. Severe cracking in in-situ concrete substructures due to delayed ettringite formation. *CONCRETE*, Vol. 42, No. 2, March 2008, pp. 32–34.

Rust detection – the SciSite method

Figure 1: 10mm reinforcement with atmospherically-caused surface rust to the right hand side of the graph and cleaned to bare steel on the left hand side.

A unique non-destructive technology to detect rust has been introduced into the palette of techniques available to survey teams. The unique selling point is the direct measurement of rust through most other materials and so there is no longer any need to remove tarmac or other coatings. Corrosion can now, in many instances, be identified and defined with significantly reduced disruption and expense.

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Figure 2: Interpolated depth of cover plot.

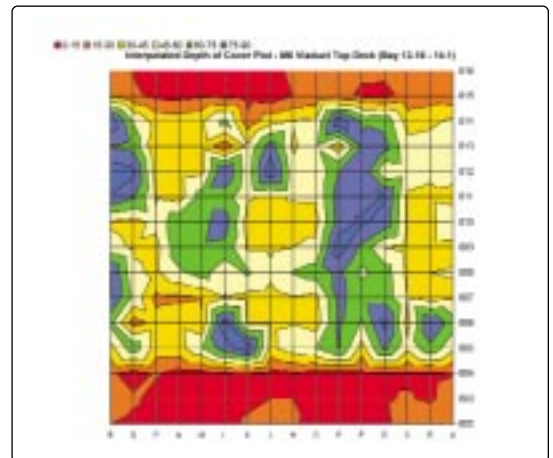
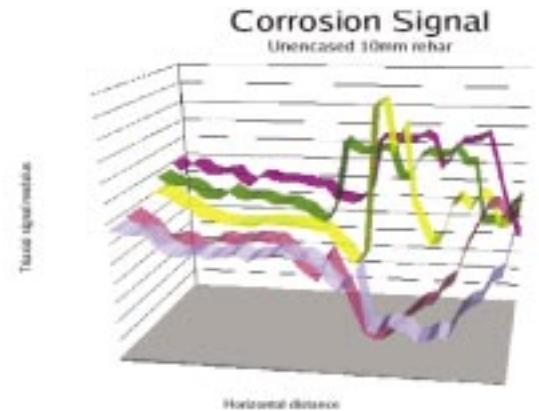
The demonstration models for this new technique have undergone extensive field trials with many leading industry experts including Network Rail, Mott MacDonald, CRL Surveys, Atkins and other leading consultancies; with a great deal of success on structures as diverse as reinforced concrete viaducts, multi-storey car parks and post-tensioned tanks, to masonry-clad steel-framed buildings. The most recent trials have been on the Continent, where there seems to be a lot of interest with projects including a prestressed viaduct in the Netherlands and underground car parks in Germany. Early negotiations are in progress on further corrosion surveys in Dubai and Italy.

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The next step is to commission a limited production run of fully ruggedised industrial prototypes and to introduce these into the market. SciSite has agreed to work together with CRL Surveys, part of Concrete Repairs Limited, to introduce the new method, with SciSite equipment available to augment CRL Surveys’ existing range of industry-standard techniques. This will enable clients to use the new technology either in isolation or alternatively as part of a full or partial CRL survey. CRL Surveys’ experience will be invaluable in making sure that the SciSite package meets all aspects of customer requirements, from getting on-site quickly, with the appropriate accreditation, to prompt reports. An additional advantage is that it will be possible to run traditional survey techniques in parallel with the new method and compare results.

The target for CRL Surveys/SciSite will be to complete validation of the method in as wide a range of scenarios as possible, with CRL Surveys supplying data for SciSite analysis and feedback for future developments.

Following this period, in addition to continuing to supply the survey service and specialised consultancy, decisions will have to be made on how best to service the market. The most common question from Europe to Japan and America is ‘When can we have a machine?’ Hence the opportunities range from equipment sales backed up by training, updates, etc, through to working with channel partners and franchisees to help extend the introduction



onto the Continent and worldwide.

Traditionally, the resolution of hidden corrosion has involved a range of variably indirect and subjective techniques, coupled with damaging intrusion for confirmation and a great deal of interpretation.

The SciSite method was initially developed to detect rust in reinforced concrete. However, the use of the technique has also been extended to include a range of steel structures meeting the key criterion of measurement of rust through anything except other steel. For example, although the method cannot be used to assess corrosion on tendons in steel ducts, the trend towards the use of organic ducts enables SciSite to survey the tendons. This could include post-construction surveys to establish the initial base data for subsequent monitoring of the development of any problems. The method has also been used to assess corrosion through brick and masonry, through air gaps and in marine structures soaked in salt water. The facility to survey through air gaps and to assess saturated structures is also new in the market. The accurate non-destructive assessment of structures in a number of areas will enable problems and potential risks to be quickly identified and any associated remedial work prioritised.

The SciSite corrosion probe uses a technique developed over ten years by leading materials scientists from

Keele University. SciSite was spun out from Keele University in April 2006 and key elements of the Intellectual Property patented by the University were then licensed exclusively to the company.

The SciSite corrosion probe uses a proprietary combination of electromagnetic signals to energise the steel and rust together. By taking a scan of the steel, applying an energising field, then scanning again, the rust is highlighted. The key features are:

- only where defects are present does the method detect a signal
- the scanning is rapid and can quickly cover large areas
- no connection to the steel is required
- scans through thick layers of tarmac, concrete or any non-ferrous material
- vertical or horizontal operation.

Example of application

CRL carried out a survey of M6 bay 14/1-13/8 (north-bound beyond junction 9). The collected data includes:

- half cell potential
- ferroskan cover readings (see Figure 2)
- chloride levels
- visual inspection.

SciSite took corrosion probe readings. Figure 1 shows a simplified image of the different signals.

The data analysis of the corrosion probe signal produces a false colour map of the area surveyed (Figure 2). The areas that indicate rust are the peaks of the colour scale (blue to white). Shades of green indicate the noise in the data or very small signals which do not indicate rust.

The corroded areas start at the bay edges and extend up to 2m into the bay (Figure 3). The horizontal striping over all areas of the map indicates the presence of fine horizontal detail in the enclosed steel work. This indicates a steel mesh internal to the concrete. There are horizontal features at the top and bottom edges of the bay which indicate the edges of the steel mesh in the bay, but which may reveal further information about rust on edge features. At 15–17m along and 5–6m across the bay the corrosion map shows a large patch of corrosion. This does not appear on the half-cell potential map but is shown on the bay diagram as an area of low or little concrete cover. In fact the concrete cover had been all but removed by the planing process, revealing steel bars at the surface. One limitation of the half cell potential test is that it cannot detect the onset of corrosion without good electrical conductivity through a layer of concrete.

On Figure 4, vertical features at 2, 5, 8 and 11 m across

the bay are surface rust on the steel I-beams which are underneath – and support – the section of motorway deck. This demonstrates that the technique is sensitive enough to detect surface rust at over 150mm distance. Overall, a good correlation is achieved between the corrosion probe survey and existing survey methods. In some areas the corrosion probe survey provides information not available from any other survey methods.

The specific advantages of the corrosion probe in this survey are:

- directly detect existing corrosion;
- detect existing corrosion through 150mm of concrete;
- corrosion detected in areas where half-cell potential will not work.

The results from the new method closely mirror the half-cell results but without the time-consuming and costly need to strip and plane the surface. In addition, the new method picks up additional rust spots and even the steel beams beneath.

Further details will be available from these data in the future, including:

- comparison with known corrosion signals to calibrate the plots to a known rust level;
- depth information, to tell the difference between rust patches at the top or bottom of the structure under test.

Concluding remarks

SciSite maintains close links with Keele University in order to ensure development of the next generation of the method. Three-dimensional visualisation is being developed to show where the rust is by depth as well as plan location. In addition, two PhD students are partly funded by SciSite.

The team has recently been commissioned to run a feasibility study for a major company on a new application of the SciSite method, which could potentially become an industry norm for monitoring certain types of structure. The company is also working with NPL in a research programme to evaluate a number of techniques for monitoring corrosion on a redundant bridge/walkway that has the advantage of being free for research and which ultimately will be dismantled to verify any findings.

The SciSite corrosion probe can be fitted to automatic scanning vehicles. It can be made only a few centimetres in diameter to fit into expansion gaps or inaccessible structures. Many probes can be used at once to scan large areas such as runways or road carriageways. Resolution can be as small as a few millimetres.

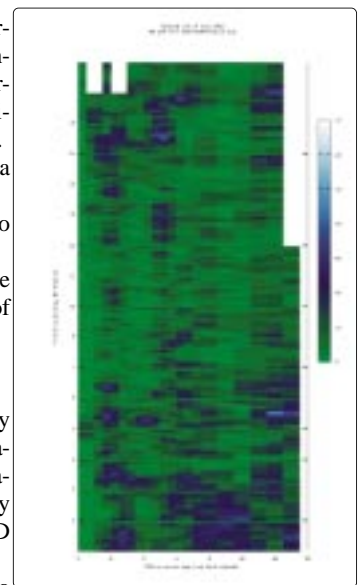
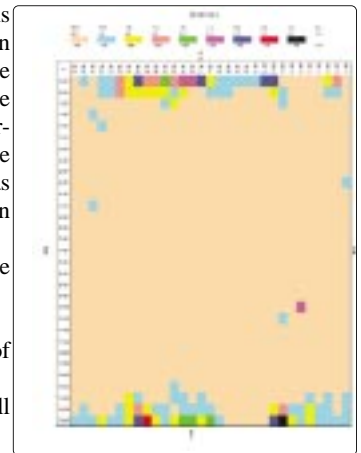


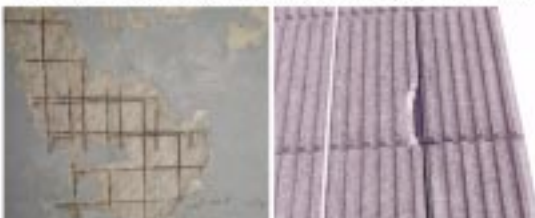
Figure 3 top: Standard half cell potential data for the area covered by the SciSite scan, for comparison between half cell and SciSite method, shown in Figure 4.

Figure 4 above: Graph showing the data from SciSite corrosion probe scan of the M6 bay.

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