# Water versus cement

## Measurement standards for NMR characterisation of cement

**Academic:** *Professor Peter McDonald*

**NMR techniques are increasingly used in cement research and development but lack a standardised means of measurement or analysis. The result is that data evaluation and comparison is problematic – a challenge addressed by two Surrey-NPL projects funded by the IAA.**

Cement is the glue of concrete and its production accounts for about 5 per cent of global man-made CO2 emissions, so industry is continually looking at ways of making more sustainable cements. Since a large proportion of concrete is used to repair existing structures, improving durability could also have a major impact on the environment. Understanding the role of water in cement is key to solving both problems.

Over the last two decades, academics in the University of Surrey's Department of Physics have been instrumental in developing an answer to this problem. As a member of Nanocem – a major consortium for cement research run out of École Polytechnique Fédérale de Lausanne (EPFL) – Surrey helped to pioneer the use of nuclear magnetic resonance (NMR) techniques, which are based on magnetic resonance imaging (MRI) technology commonly used for scanning in the healthcare environment. NMR was found to be an excellent way of measuring how much water there is in cement, how it is distributed among pores, and how water gets in and out of the cement.

Professor Peter McDonald, who has been involved in this research since its inception and leads the IAA projects, explains, "As more and more people started to use NMR – including cement manufacturers – it became clear that there was considerable variability in the results, depending on factors such as the sample preparation and the strength of the magnets used for scanning.

"We recognised that in the early days of MRI medical scanning, the community got together to develop standard protocols so that doctors receiving results knew what they were looking at. We therefore approached the National Physical Laboratory (NPL), as experts in metrology, to work jointly on a similar solution for the cement industry."

In an initial IAA project in 2014, the team successfully identified a stable reference material that mimicked cement in order to calibrate equipment. The current IAA project has built on this work by conducting round-robin trials of a proposed standard. This has involved the measurement of cement and reference samples on equipment at a range of cement and NMR equipment manufacturers' premises to ascertain the degree of variability demonstrated by different instrumentation.

While the cement manufacturers involved are informally adopting the standard already, following the completion of the current IAA project, NPL will begin to formalise this so that companies across the UK and globally can adopt the same common standard.

In the future the aim is that others will be able to buy a software add-on to adapt their existing equipment. In addition, the research points to the fact that there is a market for a much smaller machine than the currently used benchtop versions.

Professor McDonald explains: "We foresee the development of a scanner no larger than a can of baked beans. This would be relatively cheap to produce and simple to use, featuring a 'traffic light' system of green, amber and red lights to indicate that a sample is 'good', 'average' or 'bad'.

"A machine like this could be used in cement manufacturers' test labs beside a production plant. However, an even bigger potential market for this technology would be in the field, with consulting engineers who assess build quality or degradation."

Dr Roger Morrell of NPL comments:

**"The transient nature of cement cure and the wide variety of instrument types and test sample formats mean that it's vital to be able to make comparisons between different situations in order for the technology to move forward towards quantitative measurement."**