

03 | Innovation

Developing novel encapsulation formulations for a **sustainable future**.

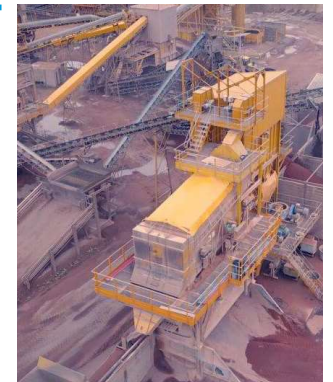


As part of NNL's environmental restoration work, we have been investing in innovation to find sustainable alternatives to existing encapsulation formulations. This has led to a promising collaboration with Clobury Quarry Ltd, which presents an exciting opportunity not just within the nuclear sector but also beyond.

As the UK and others across the world urgently address the climate crisis, the landscape within which industries and businesses operate is evolving. Changes are being made to the way we do things to drastically reduce carbon emissions.

The UK's commitment to end the use of coal power for energy by October 2024 represents a significant step towards decarbonisation, with the phase out of coal-fired power stations now nearly complete. But the ripple effects of this also need to be addressed, such as the loss of our UK production supply of fly ash, which is most commonly derived from coal combustion.

Fly ash and Ground Granulated Blast-furnace Slag (GGBS), which is also in diminishing supply given the national and global reconfigurations in the iron and steel industry, have been key components of the cement formulations we use to encapsulate and store the UK's legacy nuclear waste on behalf of the Nuclear Decommissioning Authority (NDA), in particular Sellafield Ltd. This needs to be done safely, securely and cost-effectively for the taxpayer.



Quality

Maintaining the highest standards as we adapt and innovate

Within the UK nuclear sector, we have stringent standards across everything we do to ensure that safety for workers and the public is unquestionable. This includes the management, encapsulation and disposal of used nuclear materials. The highest quality assurance for encapsulation materials is therefore needed in order to provide products of known and predictable quality.

Currently, we rely on a high-grade mix of cement and either fly ash or GGBS. This goes beyond the robust weight-bearing formulation of concrete used by other industries and gives it the special characteristics and reliability of performance that the UK nuclear regulatory bodies demand. In identifying a new sustainable encapsulation solution, therefore, we need to satisfy these same high

standards, whilst continuing to deliver efficiently for our end customers.

To meet the challenge, NNL put out a call as part of our Open Innovation programme. This asked potential collaborators to help us identify a replacement for fly ash that will retain all the existing qualities, standards and reliability of our current cement configuration.

Cloburn Quarry Company Ltd were one of the winning applicants for this work. It proposed the testing of Red Granite Dust (RGD) powder – a by-product of its rock processing activities – as an alternative material to traditional fly ash or GGBS. The powder has a chemical oxide composition similar to that of the fly ash specification for concrete and had been judged by the University of Sheffield's Chemical Engineering: Sustainable Materials and Processes Department as having the desirable qualities for further testing.

Cloburn Quarry were already looking to identify a viable long-term outlet for RGD that would have use, value and benefit to society, rather than requiring disposal. With 20,000 tonnes each year available for supply, this offers a viable long-term solution with the additional benefit of being a low-carbon footprint product across its whole life-cycle.

Our immediate focus has therefore been to progress the RGD powder from its current Technology Readiness Level of 3 to 4 for the proposed application of nuclear waste encapsulation, as a direct replacement of fly ash. This work has involved further testing to ensure the material generated by the quarry – which is initially wet – can be efficiently dried to powder form whilst retaining its low-carbon footprint properties.

Testing has proved promising so far. Once complete, the next stage of this process will be to scale up this formulation of this RGD-based conventional concrete mix and prove it at a large scale, with a view to successful implementation. Dependent on disposability acceptance by Nuclear Waste Services (NWS), and RGD being adopted by one of the UK's waste producers, this needs to be achieved within the next few years before fly ash is no longer available.

However, the RGD powder also presents a further, more pioneering opportunity. The properties of the material is such that it may prove to be a cement substitute, creating a material with the same strong qualities but with a low-carbon footprint.



Impact

Exploring sustainable solutions with far-reaching potential

This collaboration with Cloburn Quarry offers both environmental benefits and sustainability of supply for the UK. In the short term, RGD powder looks to present an almost immediate alternative to fly ash or GGBS. But the opportunity for RGD to form the basis of a novel encapsulation material would have even greater impact.

The production of cement is a highly intensive carbon generating process, yet it is a cornerstone of so many areas of our lives and industries. There is already wider work underway across the UK and globally to explore alternatives that reduce the environmental impact of conventional methods without losing the core properties of cement.

Given the scale of Cloburn Quarry's RGD supply, the nuclear sector would be a relatively niche market, should it implement either the new RGD-based conventional blended cement or novel material for nuclear waste encapsulation. However, by delivering on this research and development and proof of concept, this work will provide stronger foundations for its potential uses beyond nuclear.

For NNL, this fits within our remit as a national laboratory – not only driving innovation, skills and capabilities but benefiting society through nuclear science.



Talent

Sustaining and building UK skills and capabilities

At NNL, our world-leading expertise has been developed over decades, with environmental restoration acting as the proving ground for many of these skills and capabilities. This continues to be the case and helps us grow the next generation of nuclear specialists.

Innovation in novel encapsulation methods is the focus of a number of NNL's PhD and research programmes, allowing students and early career professionals to develop expertise in strategically important areas for the UK whilst delivering ongoing efficiencies for our customers. Longer-term programmes of research and development – such as exploring the viability of novel materials for the treatment of nuclear waste – also increase the likelihood of employees becoming Subject Matter Experts.

Partnerships

Leveraging collaboration to advance new techniques

This work is wholly underpinned by collaboration; working with another company, in another sector, to identify a solution that has a myriad of potential benefits for the UK's circular economy.

To progress this, partnership working with the University of Sheffield in particular has been vital. Harnessing NNL's world-leading specialist nuclear facilities and capabilities, we have been able to collaborate with academics to provide the fundamental underpinnings for further research and development.

As we seek to move new techniques and technologies up the Technology Readiness Level scale, it is this collaboration across academia and industry that is essential, and where national laboratories like ourselves are ideally placed to help bridge the gap.

