Scottish Construction Leadership Forum

Local Materials Case Study
BAM ground stabilisation

A treatment that turns loose local soils into strong, stable materials

Project: **University of Strathclyde, BAM Ritchies**
Contract value: **£521k**

Cementing relationships

The partnership between industry and academia that stabilises soil using bacteria

BAM Ritchies and the University of Strathclyde are working together to produce a low-carbon alternative to cement in ground works, river embankments and coastal defences.

The concept of using bacteria to solidify loose materials like soil and sand is being researched worldwide.

Among the leading research groups is the University of Strathclyde, which has for the past ten years been working on the use of microbially induced calcite precipitation (MICP) to solidify loose soils and surfaces. The University is now working in collaboration with UK ground engineering company BAM Ritchies to investigate the use of MICP to turn loose materials like soil and sand into sandstone at scale, and to assess its feasibility as a commercial process.

THE BACKGROUND

Concrete is the only material on the planet we use more widely than water. Unfortunately, unlike water, it comes with a massive carbon footprint - around eight per cent of the CO2 emitted into the atmosphere every year is a direct result of concrete manufacture. To put that into perspective, only China and the US emit more.

That's largely down to the carbon cost of creating cement, the key ingredient in the concrete mix. There are other costs too, in terms of waste generated, reusability, shelf life and transportation. Academia and industry all over the world are working to find alternatives to cement that would allow us to create a sustainable substitute that can reduce the need for concrete.

> *"We're creating a paradigm shift, showing people alternatives to the materials they've been using for decades."*
>
> Project lead **Professor Rebecca Lunn** MBE, BAM Nuttall/RAEng Research Chair in Biomineral Technologies for Ground Engineering

THE PROJECT

The University is now collaborating with BAM Ritchies to determine the feasibility of using the process in ground engineering works, and to create the UK's first large-scale field trial of the technique.

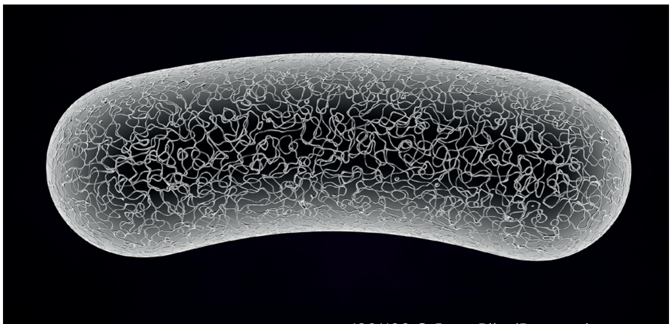
THE GOAL

The end goal is to develop a substance that can be used to create durable earth structures like embankments and coastal defences. It could, for example, be injected into crumbling cliff faces to increase their strength and prevent rapid erosion. It could replace the use of concrete in embankments, or reduce the requirement for concrete piles used as the basis for engineering structures. It could also be used for repairs to existing structures.

Right now, the partnership is working to scale up production. To date the process developed at the University has been used in the laboratory to create relatively small discs, roughly one metre in diameter and 30 cm deep. The current collaboration involves applying it to much larger volumes of soil material.

A PROCESS THAT WORKS WITH LOCAL MATERIALS

MICP involves taking harmless bacteria found naturally in soils and growing large quantities of them in a fashion similar to brewing beer. The bacteria are then injected directly into the soil volume to be treated, along with urea and calcium chloride.



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They use the urea as a food source, causing calcium carbonate to precipitate in the process. The calcium carbonate crystals grow around the edges of the loose particles, binding them into a solid, turning the soil into a material similar to natural sandstone.

Being the same viscosity as water, the bacterial solution can be injected via narrow holes that won't damage the area where it's being used. Which means it could treat natural environments like cliffs, dunes and seashores without having a highly visible aesthetic impact, and without damaging the natural environment.

PROMOTING THE USE OF LOCAL MATERIALS AND RESOURCES

A large proportion of the cement used in UK construction and civil engineering works is imported from other countries, which further increases both the embedded carbon and the financial costs. The advantage of the MICP system is that it works almost entirely with local materials.

The bacteria can be grown on waste products, like yeast, which are relatively easy to source or create at a local level. And they are then used in situ, so rather than replacing local soils, sands or other loose materials with imported concrete or other stabilising media, the process converts them into stronger, stable materials that can bear loads and resist erosion.

Concrete degrades chemically. That means it doesn't have to be damaged to lose structural integrity, it simply degrades as a result of everyday environmental exposure. Calcium carbonate does not. Unless it's exposed to extremely strong acids, it stays in place. It can be damaged, but the bacteria used in the MICP-based process have a secret power - they can come back to life. Simply feeding the bacteria reactivates them and restarts the precipitation process.

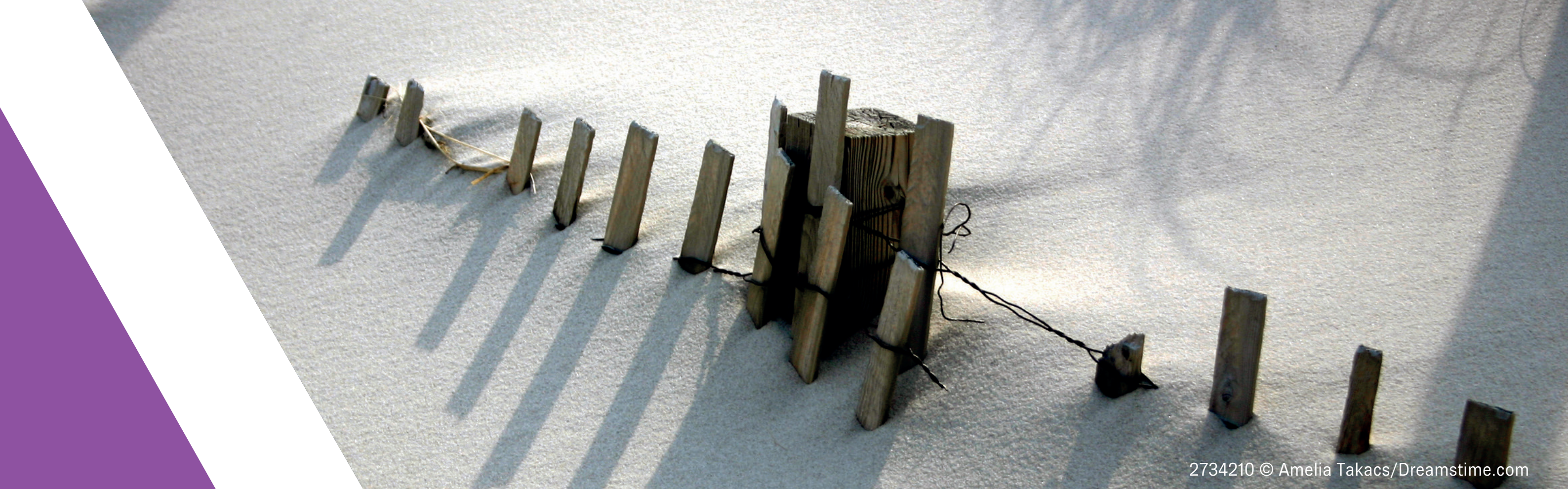
It doesn't end there. The University's research is currently exploring the potential for drying the bacteria and providing it as a powder. The theory is that the dried medium could be stored for far longer than a bag of cement, transported more easily, used by anyone on site and - importantly - remain useable even if works have to be delayed or suspended.

Concrete, once mixed, must be kept moving to prevent it from solidifying, and even it then remains viable for only a limited time. During the precipitation process, the bacteria become entombed within the calcium carbonate crystal and turn into spore form - almost like going into hibernation. If the crystal is then damaged or broken, even many years later, exposing the 'hibernating' bacteria, simply adding some food reactivates them and they begin to work again.

Even the solution's waste products have an application. The bacteria produce ammonium. This has to be extracted from the groundwater as part of the application process, however it can then be used as a fertiliser. So the system not only reduces waste enormously, but the waste it does create could be reused elsewhere.

> *"Sometimes on sites you'll see materials that are deemed as no use being removed and disposed of in landfill. Those materials could be put to use. So this isn't just about creating a cement alternative. It's about completely changing the way things are done."*
>
> **Dr Erica McLachlan**, Geotechnical Engineer, BAM Ritchies

MICP can solidify loose materials like sand



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OVERCOMING CHALLENGES

One of the main challenges the team now faces is ensuring the final product will create similar results at a much larger scale and in natural, less uniform soils. While lab results are very promising, the current project is scaling up the process by treating silty sand in a shipping container. In the final stage the team will conduct field research and pilot studies to examine how the solution performs in different natural environments.

Like all innovators in a field that has remained largely unchanged for a very long time, the team also has to persuade others to adopt innovation. Since some of the equipment currently used on construction and civil engineering sites has barely changed over the last 50 to 100 years, suggesting that there's a better alternative can be difficult.

There is, however, a steadily-growing demand from construction clients for new, cleaner, more sustainable construction technologies, and this, in conjunction with the support of industry practitioners like BAM Ritchies and industry bodies like CSIC, will help push the innovation agenda forward.

The process has the potential to help prevent coastal erosion

WILL USING LOCAL MATERIALS WORK?

At the time of writing, the project is focused on two key areas: reproducing lab results at scale and creating a viable product delivery system. To date the largest volume of solidified material has measured approximately 1m x 0.3m, and the lab has been testing 20 – 30 kilos of sand at a time.

The next step is to fill a structure approximately the size of a shipping container with 57 tonnes of sand, which will then be treated and solidified. The sides of the container can be removed, allowing the team to drill into the block to take test samples and assess their strength and stability.

BAM Ritchies is supporting commercialisation efforts and calculating the carbon impact, so that all processes can be aligned to ensure minimal or no significant carbon cost in production. Efforts to develop a commercially-viable transportation system that will allow the dried product to be easily delivered are being supported by the Industrial Biotechnology Innovation Centre.

"There are so many aspects of this process that are enormously beneficial to our environment,"

says **Professor Rebecca Lunn** from the University of Strathclyde, whose research group has been investigating and developing the use of MICP over the last ten years.

Project lead **Professor Rebecca Lunn** MBE

"We aim to grow it on a waste product. We use it to prevent CO2 emissions. We reduce transport costs and impact. It's simple to use and could be particularly useful for ecologically sensitive areas where transport of materials harms the environment, and where cement structures, which release high pH waters, will alter local soil properties and damage the surrounding ecosystem.

"Essentially what it allows us to do is work with our environment, rather than trying to dominate it."

CEMENT: THE NEED FOR AN ALTERNATIVE

- Cement production accounts for **8%** of world's carbon emissions
- Annual global production could reach **5 billion tonnes over 30 years**
- **2.6million tonnes** of cement imported to the UK (2018)
- 2018 imports cost **£78million**
- UK emissions from cement production: **4.4million metric tonnes/year**

*This case study was prepared by Construction Scotland Innovation Centre on behalf of the Scottish Construction Leadership Forum – **March 2021**.*

CONSTRUCTION SCOTLAND INNOVATION CENTRE