Colloidal Silica for Well Stabilisation during Borehole Sealing

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Key Words	**Hydrogel; Geotechnics; Hydrogeology; Borehole; Groundwater; Grout.**

Eligibility

A 4-year PhD studentship is available. This includes payment of home tuition fees for UK applicants and EU applicants with pre-settled or settled status and an enhanced stipend of £19,602 for academic year 2022/23, rising each year in line with UKRI rates. Candidates must have completed a Bachelor's degree in a relevant subject area (e.g. civil engineering, environmental engineering, petroleum engineering, geoscience, environmental science, chemistry, material science, physics) and have obtained a 2(1) or above. PhD funding is provided by the Engineering and Physical Sciences Research Council and Nuclear Waste Services Ltd.

Overview

This project is investigating the use of colloidal silica grout (which forms a hydrogel) in the long-term sealing of boreholes in the ground, to prevent subsequent upward fluid migration from rocks at depth to the surface. Successful borehole sealing is vital in many industries, including: deep borehole disposal of radioactive waste; oil and gas production and well decommissioning; carbon capture and storage; and hydrogen storage. For UK radioactive waste disposal, the preferred option for borehole sealing is backfilling with compacted bentonite, a clay which swells to form a tight, strong seal upon wetting. Prior to bentonite emplacement, it is necessary for the steel borehole casing to be removed. Recent field trials have exposed a problem with this method in weak or damaged rocks, where the borehole walls can collapse before the compacted bentonite is emplaced. This PhD project will investigate the potential for colloidal silica grout to provide short-term stabilisation of these weak rocks, prior to the bentonite emplacement. Figure 1 shows an example of a weak cracked material, into which colloidal silica has been injected to recover its strength. This PhD will use similar silica injection and imaging techniques. The final repaired rock will be investigated to optimise strength and durability.

Methodology

The project will be largely experimental, using equipment in the University of Strathclyde's geotechnical laboratories. Colloidal silica will be injected into samples of damaged mudstone and the resulting material will be tested for shear strength, erosion resistance and unconfined compressive

strength. The chemical and physical interactions between the colloidal silica and the bentonite will also be investigated to determine any long-term impacts on seal performance. Investigations will make use of the University of Strathclyde's Advanced Materials Research Laboratory, which hosts equipment such as Scanning Electron Microscopy, X-Ray Diffraction facilities and Micro X-Ray Computer Tomography (e.g. Figure 1).

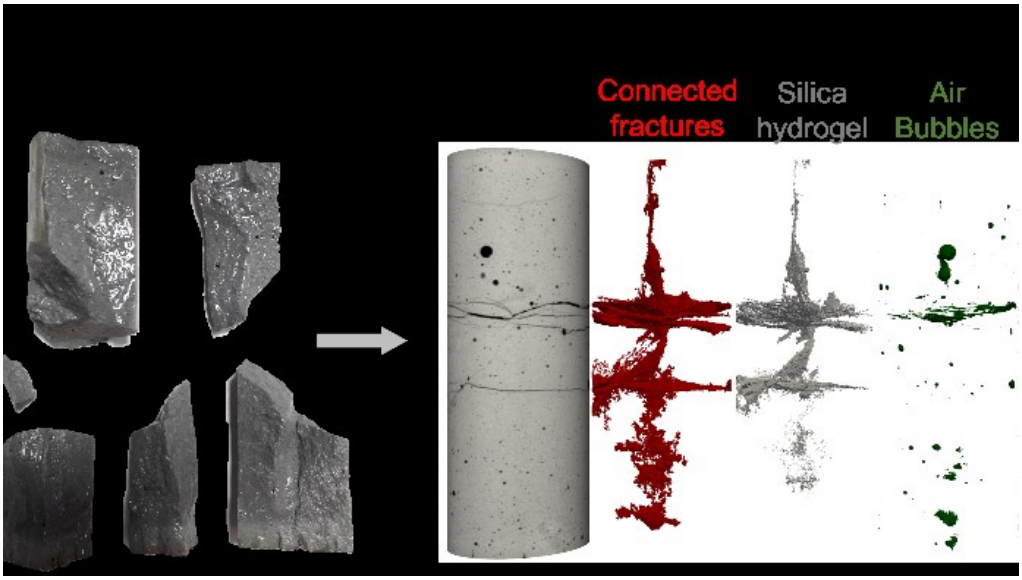

***Figure 1**. A fractured rock core repaired using colloidal silica. Figure shows Micro X-CT Images of: the original fracture network; the silica grout in the sample after injection; the remaining air-filled voids.*

Training & Skills

This project will suit a student interested in geotechnics, rock mechanics, geochemistry and/or material science using experimental techniques. You will learn basic laboratory techniques and will be trained on regularly used analytical equipment.

As a PhD student at the University of Strathclyde, you will also complete the University of Strathclyde's acclaimed Research development program, acquiring cross-disciplinary skills to broaden career prospects in various industries.

The candidate will also undertake a short secondment to gain work experience at Nuclear Waste Services Ltd.

Make an Application

Candidates can apply at:
https://www.strath.ac.uk/studywithus/postgraduateresearch/yourapplicationoffer/

Further Information
For further information on the application process, please contact: Morag.McIntosh@strath.ac.uk

For further information regarding the project please contact Prof Rebecca Lunn or Dr Gea Pagano (rebecca.lunn@strath.ac.uk arianna.pagano@strath.ac.uk)