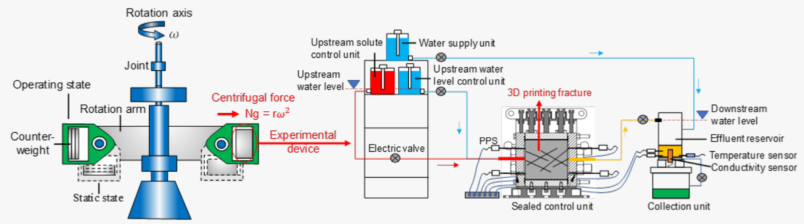
Geotechnical centrifuge modeling for simulating long-term radionuclide migration in large-scale fractured rocks

CHINA, October 20, 2023 /EINPresswire.com/ -- In a ground-breaking first, researchers have carried out hyper-gravity experiment of solute transport in 3D printed fracture network model with geotechnical centrifuge under hyper-gravity environment. This study not only validated the stability of contaminant transport in 3D printed fracture model under high hyper-gravity, but verified the feasibility of using geotechnical centrifuge modeling technique to evaluate the long-term barrier performance of low-permeability fractured rocks.



HOW HYPER-GRAVITY EXPERIMENT OF SOLUTE TRANSPORT IN 3D PRINTED FRACTURE NETWORK WORK.

Deep geological disposal is a globally recognized and safe method for long-term management of high-level radioactive waste (HLW). However, over extended periods of nuclear waste storage, there is the potential for the waste canister to experience leaks due to corrosion or alterations in the geological environment. This could lead to the eventual release of radionuclides into the surrounding fractured rock, posing a risk of migration into the biosphere. Therefore, we need to gain a deeper understanding of the transport of radionuclides or contaminants within fractured granite. However, addressing the long-term transport issues in such large spatial and long temporal with traditional field monitoring seems almost impossible—until now.

In a study recently published in the KeAi journal Rock Mechanics Bulletin, researchers from Zhejiang University outline a new method they have developed: an acceleration hyper-gravity experiment method designed to simulate the transport of radionuclides or contaminants through small-scale fractured rocks, utilizing geotechnical centrifuge modeling.

“The hyper-gravity experiment was used to simulate contaminant transport in soils since 1980s. We conducted a series of tests to gain some deeper understanding of contaminant transport behaviors in soils,” shared corresponding author Yingtao Hu. “We also used the method to predict the 50-year long-term barrier performance of clay or kaolin barrier by the hyper-gravity experiment.”

However, unlike soils, the similarity or hyper-gravity effect of contaminant transport in fractured rock under hyper-gravity conditions remains unknown. Furthermore, the team revealed that it was challenging to create a fracture network model with a complex structure and low permeability that closely mimics field conditions using traditional methods.

Undeterred, the researchers tapped the capabilities of 3D printing technology and introduced a unique structural design for creating fractured rock samples with adjustable permeability. Subsequently, they used the 3D-printed fracture network model in conjunction with a sealed control apparatus to conduct both a standard 1 g normal-gravity experiment and an N g hyper-gravity experiment. Consequently, the team devised a methodology for assessing the long-term barrier performance of low-permeability fractured rock using the hyper-gravity experiment.

According to Wenjie Xu, lead author of the study, this represents a breakthrough in deep geological disposal. “The hyper-gravity experiment also highlights its value in evaluating the long-term barrier performance of low-permeability fractured rock,” he said.

Going forward, the team hopes that their findings will inspire fellow scientists to delve deeper into the potential of utilizing hyper-gravity experiments in tandem with 3D-printed fracture networks to explore the long-term viability of deep geological disposal methods.

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