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3D printing of rock analogs in sand: a tool for design and repeatable testing of geomechanical and transport properties

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Summary

Natural rocks can be heterogeneous due to complex diagenetic processes that affect mineralogy and pore architecture. Correlation of geomechanical and transport properties of rocks in three dimensions can lead to large variances in data when tested experimentally. 3D-printed rock analogs made from sand is a promising alternative for experimental testing that can be used to calibrate different variables during geotechnical testing [1-5].

Workflow

Natural rocks can be heterogeneous due to complex diagenetic processes that affect mineralogy and pore architecture. Correlation of geomechanical and transport properties of rocks in three dimensions can lead to large variances in data when tested experimentally. 3D-printed rock analogs made from sand is a promising alternative for experimental testing that can be used to calibrate different variables during geotechnical testing [6-9]. While 3D-printed sand is a homogeneous material, the parameters for creating grain packing, porosity and pore infill can be tuned to mimic specific geomechanical and transport properties [10-11].

Results and Conclusions

Initially, the 3D-printed specimens suffer from decreased density, uniform distribution of grains and lack of compressive strength. Herein, we detail our efforts at increasing the density through incorporating a roller in the printing process to compact individual layers. We also present how the density of rock analogs can be increased through incorporation of a more heterogeneous sand mixture that encompasses a wide range of grain size distributions, close to natural sandstones. Lastly, a relationship between binder saturation (that infills the pore space) of the 3D-printed specimens and the axial strength, dimensional control and porosity is described within.

Novel Information

3D printing of rock analogs is critical in pursuing rigorous destructive tests required for geotechnical and geological engineering because it can provide repeatable, controlled data on rock properties. The use of sand to create test samples for verification of experimental modelling is an unprecedented achievement that integrates geoscience and engineering. 3D-printed rock provides stakeholders with a tangible, physical specimen with repeatable properties for use in experimental studies.

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