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Publication date

2019

Document Version

Final published version

Citation (APA)

Barnhoorn, A., Bakker, R., Douma, L., Pluymakers, A., & Bertotti, G. (2019). *Porosity controls the fracturing mode in rocks in unconfined compressive strength tests*. Poster session presented at EGU General Assembly 2019, Vienna, Austria.

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Porosity controls the fracturing mode in rocks in unconfined compressive strength tests

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Over the years we have performed a large number of unconfined compressive strength tests in our laboratory at Delft University of Technology on a wide variety of different rock types ranging from sandstones, limestones, shales, granites, basalts. Some rocks had a high porosity (up to 40%) whereas others had a very low porosity ($\sim 0\%$). Some of the rocks had a high unconfined compressive strength (>200 MPa) and others were relatively weak (10-20 MPa). The purpose of those experiments was to mechanically characterize the materials (Young's modulus, Poisson's ratio and strength) to be used in different application areas.

We have noted some recurring characteristics amongst the samples, independent of rock type and material strength, but instead seem to be controlled by the degree of porosity. All high porosity samples (porosity $>20\%$) formed a single oblique shear fracture (with an angle of $\sim 30^\circ$ to the loading direction) at the end of the unconfined compressive strength test. This happened irrespective whether the test was performed on a generally weak (few 10's MPa) or a generally strong sample (>100 MPa). In contrast, in all experiments performed on low porosity materials, near vertical fractures developed in the rock samples, interpreted to be axial splitting fractures. In addition, often those samples have multiple near-vertical fractures that form a connected network. This is not controlled by the strength of the material. For example, near vertical fractures were formed in weak siltstones and shales, but also in strong basalts, granites and limestones. It is not yet clear to us what can explain these observations, but it may indicate a different Mohr-Coulomb failure behaviour at low pressures, and a difference in fracture growth and coalescence within the microstructure of the rock. It must be noted that at sufficiently high confining pressures in triaxial tests all samples develop a shear fracture irrespective of the amount of porosity.