TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG

Life time prediction for rocks under static compressive and tensile loads

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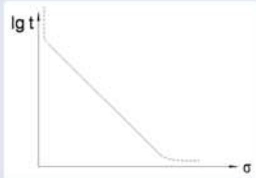
Idea

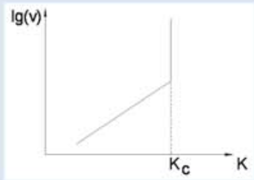
The proposed numerical model is based on subcritical crack growth using the linear elastic fracture mechanical approach and is implemented as a numerical cellular automata. The algorithm considers tensile and shear fracturing. Each cell contains a microcrack of random length according to a given probability function. Fracture growth is controlled by the Charles equation. Macroscopic cracks are the results of the coalescence of growing microcracks. Within the numerical approach elasto-plastic stress redistributions take place. If the stress intensity factors have reached the critical values or the microcrack has reached the zone dimension, the zone is considered as fractured and residual strength values are assigned. The proposed approach was applied to rock samples under uniaxial compressive and tensile loads (creep tests).

Subcritical crack growth is depending on stress intensity factors $v = CK^n$ and assumes superposition of the 2 fracture modes: $v = v(K_I) + v(K_{II})$

Life time is governed by actual crack length and stress state: $t_{Zone} = \int_{a_0}^{a_c} \frac{da}{CK_I^n + CK_{II}^n}$

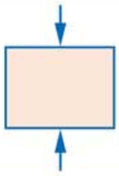


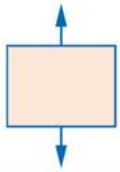
General relation between life time t and load for brittle solids

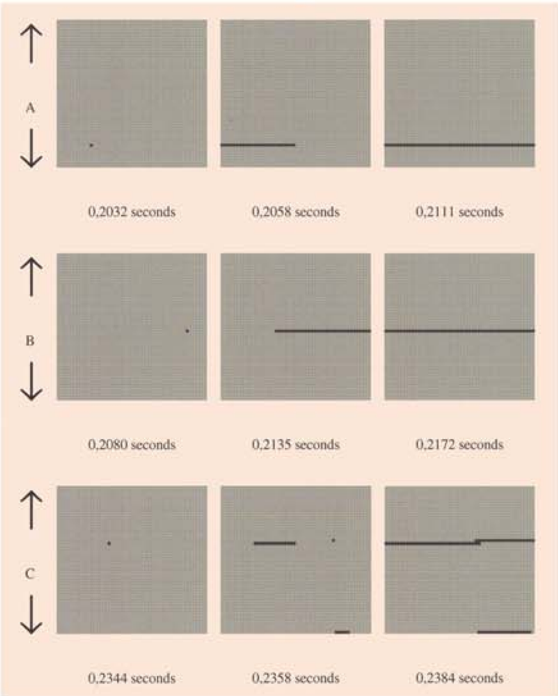


Principal sketch of the Charles equation, which relates the subcritical crack propagation speed v to the stress intensity factor K.

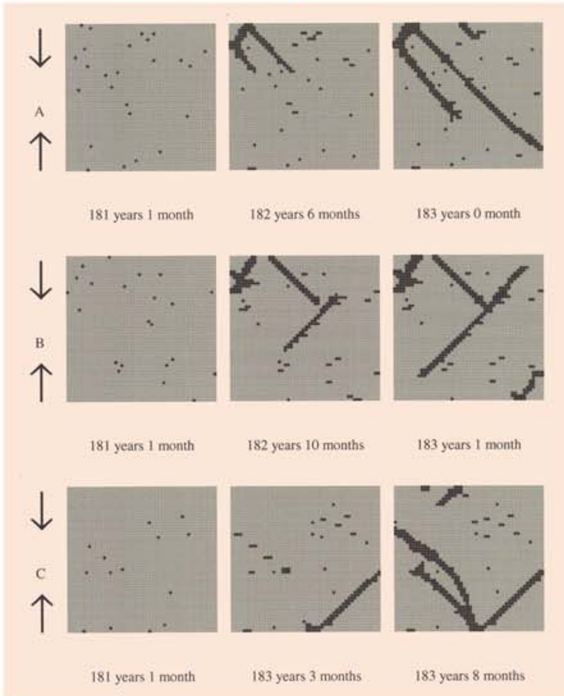
Results



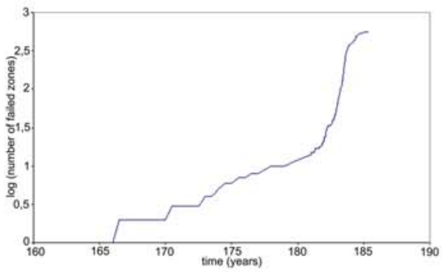


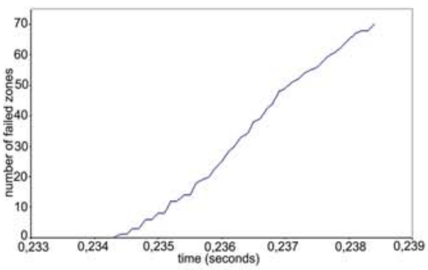


Uniaxial tensile tests under constant load on 3 different samples A, B and C with same distribution function of microcracks but different realisation.



Uniaxial compressive tests under constant load of 12 MPa on 3 different samples A, B and C with same distribution function of microcracks but different realisation.





Crack development versus time for model C with 12 MPa compressive (left) and 12 MPa tensile (right) loading.

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