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Marble decay due to microcracking

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ABSTRACT

An actual degradation phenomenon of marble structures, i.e. microcracking, is examined via computer simulations with a microstructure-based finite element modelling. Crack initiation and crack propagation were characterized, as well their dependence on grain- shape preferred orientation (SPO), lattice preferred orientation (LPO), grain size and grain-boundary fracture toughness. Calcite is used as an illustrative example. Results are expected to be general for myriad marble microstructures, as the thermophysical properties of various marbles do not differ that much. Three SPOs were analyzed: equiaxed grains; elongated grains and a mixture of equiaxed and elongated grains. Six LPOs were considered: a random orientation distribution function (ODF); an ODF with strong directional crystal texture generated via March Dollase fiber-texture; and four types of actual marble texture as measured on marble samples with electron back-scattered diffraction (EBSD). Two different grain sizes were analyzed: fine grains range up to 200μm and medium size grains of approximate 1mm. The fracture surface energy for the grain boundaries was chosen to be 20 % and 40 % of the fracture surface energy of a grain, so that both intergranular and transgranular fractures were possible. Simulations were performed for both heating and cooling by 50 °C in steps of 1 °C. Microcracking results were correlated with the thermoelastic responses (indicators) related to degradation. Certain combinations of SPO, LPO, grain size, and grain-boundary fracture toughness have a significant influence on the thermal-elastic response of marble. For instance, thermal stresses and elastic strain energy are a strong function of the LPO. With increasing LPO the strain energy density and the maximum principal stress decreases. With decreasing grain size and increasing LPO and SPO, the area of microcracking is smaller and microcracking commences at a higher temperature differential.