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Synthesis of multiscale simulations and 3d-scanning for the characterization of freeze-thaw damage in concrete

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Damage induced in concrete that are exposed to repetitive freezing and thawing processes in the presence of deicing salts is one of the severe deterioration processes in concrete pavements in cold climates. This deterioration process manifests as surface scaling and internal damage, and is influenced by the composition of concrete and the freezing liquid. These damage processes are governed by chemo-physical mechanisms that are active across multiple scales. In this contribution, we propose a synthesis of novel experimental measurement techniques and multiscale modeling for a data-driven model based characterization of freeze-thaw damage in concrete. Firstly, micrometer-level surface topographies of concretes of varying composition subjected to varying levels of freeze-thaw cycles in saline environments are extracted using high-resolution 3D surface scanning. Relative changes in the topographies are extracted using a global-local iterative closest point registration algorithm. This topographical dataset in addition to auxiliary experimental data associated with transport and mechanical properties is used to discover the parameters of a micromechanics based multiscale computational model[1]. Microcrack initiation and growth due to freeze-thaw processes is modelled using a combination of continuum micromechanics and fracture mechanics. Damage at the microscale is upscaled to the level of the specimen using multilevel homogenization[2]. The mechanisms involved in the deterioration process and the role of the concrete composition on freeze-thaw resistance is discussed based on the results from experiments and simulation.

REFERENCES

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