Multiscale computer simulation for improving technology in concrete industry

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Concrete performance and durability is affected by temperature and moisture history in many ways. With no regard to well-controlled laboratory conditions, the mixing, placing and curing of concrete occur worldwide under different environmental conditions. The understanding of underlying phenomena during maturing and concrete performance is rather a complex subject and presents a multiscale and interdisciplinary approach followed by material and civil engineers.

Temperature rise in hydrating concrete presents a formidable problem that may lead to significant acceleration of hydration kinetics, early-age cracking, and decreased durability. Multiscale formulation was developed, coupling a cement hydration model on the microscale with the finite element method (FEM) solving heat conduction problem on the macroscale. Although discrete hydration model predicts heat evolution controlled by macroscale temperature, the FEM satisfies heat balance equation during thermal conduction. 2D validations show reasonable temperature agreement with an access to the local quantities, such as a degree of hydration. Here, this multiscale and coupled model is validated against two in situ bridge constructions. The validation was carried out on a one segment of the bridge over the Oparno valley. The segment is located above the scaffolding in the bottom part of the arch. The bridge is located on the highway between Prague and Dresden. The arches span 135m. The presented transport and hydration model and its implementation into in house OOFEM software provides versatile tool for engineers. The analyses account for cement composition, concrete composition as well as for structural geometry and boundary conditions. Validation showed high capabilities of the developed tool.