CREEP AND FRACTURE IN CONCRETE STRUCTURES AT HIGH TEMPERATURE

Prof. Zdeněk P. Bažant

Northwestern University, USA

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Although the thermal effects on concrete creep and fracture have been studied for a long time, major progress has been taking place recently, facilitated by advances in computing power and driven mainly by problems of fire exposure of tall buildings and tunnel linings, decontamination of concrete walls and long-term radioactive waste storage. The lecture first reviews the modeling concepts of concrete creep and drying shrinkage at elevated and high temperatures, and the thermal effect on fracture energy, process zone size and scale effects in quasibrittle failure. A recent generalization of microprestress-solidification theory for concrete creep at variable temperature is summarized and explained, and the dependence of brittleness and size effect on temperature is pointed out. Then attention is focused on a comprehensive computational model for estimating the feasibility of decontaminating from radionuclides a surface layer of concrete wall, a few millimeters in thickness, and optimizing the decontamination process. The decontamination is achieved by using a powerful microwave blast, of several seconds in duration, strong enough to ablate a thin surface layer of the concrete wall. Electromagnetic power dissipation is calculated on the basis of Maxwell equations and the rapid evolution of the temperature and pore pressure field within the concrete wall is simulated computationally. Due to order-of-magnitude jumps in the sorption isotherms of concrete and in the dependence of permeability on temperature, the finite volume (rather than finite element) method must be used, in order to enforce the exact balance of water mass and heat. Short-time high-temperature creep is taken into account in calculating the thermal stresses produced by rapid heating, and the crack band model is used to capture the fracture mechanics aspects. It is concluded that ablation of the surface layer is driven mainly by high compressive stresses parallel to the concrete surface, while pore pressure serves only as a trigger of fracture but declines rapidly as a crack opens. This conclusion is similar to that previously made for explosive spalling of building walls or tunnel linings in fire. The lecture concludes by commenting on some profitable research directions.

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Podrobnější informace poskytne Prof. Milan Jirásek, tel. 224 354 481, Milan.Jirasek@fsv.cvut.cz .