Thermal Integrity Analysis of Concrete Bridge Foundations Using COMSOL Multiphysics® Software

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Abstract

Concrete hydration is a highly exothermic process which, in large concrete structures, produces highly elevated temperatures. While this phenomenon has long been understood to be a negative side effect which can cause thermal stress cracking in concrete structures, a relatively new and innovative method known as Thermal Integrity Profiling (TIP) makes use of measured concrete hydration temperatures in underground bridge foundation elements (e.g. drilled shafts) to assess the quality and distribution of concrete placed underground where visual inspection is not available. The development and analysis of this type of technology, however, requires adequate understanding of the heat generation and thermal transfer properties of hydrating concrete, both of which are complex. This paper describes the use of COMSOL Multiphysics® to model the heat generation and thermal transfer behavior of hydrating concrete for the purpose of analyzing geometrical deformities and/or concrete quality degradation in bridge foundations. Therein a model was developed which combines the COMSOL® heat transfer module with two separate coefficient form PDEs - one which describes the concrete degree of hydration, and one which defines the concrete "equivalent age". From this, a 2-D parametric study can be performed to establish a relationship between temperature and shaft size, and a 3-D model is generated to analyze shafts with specific geometrical defects and/or spatial changes in boundary conditions.

Figures used in the abstract

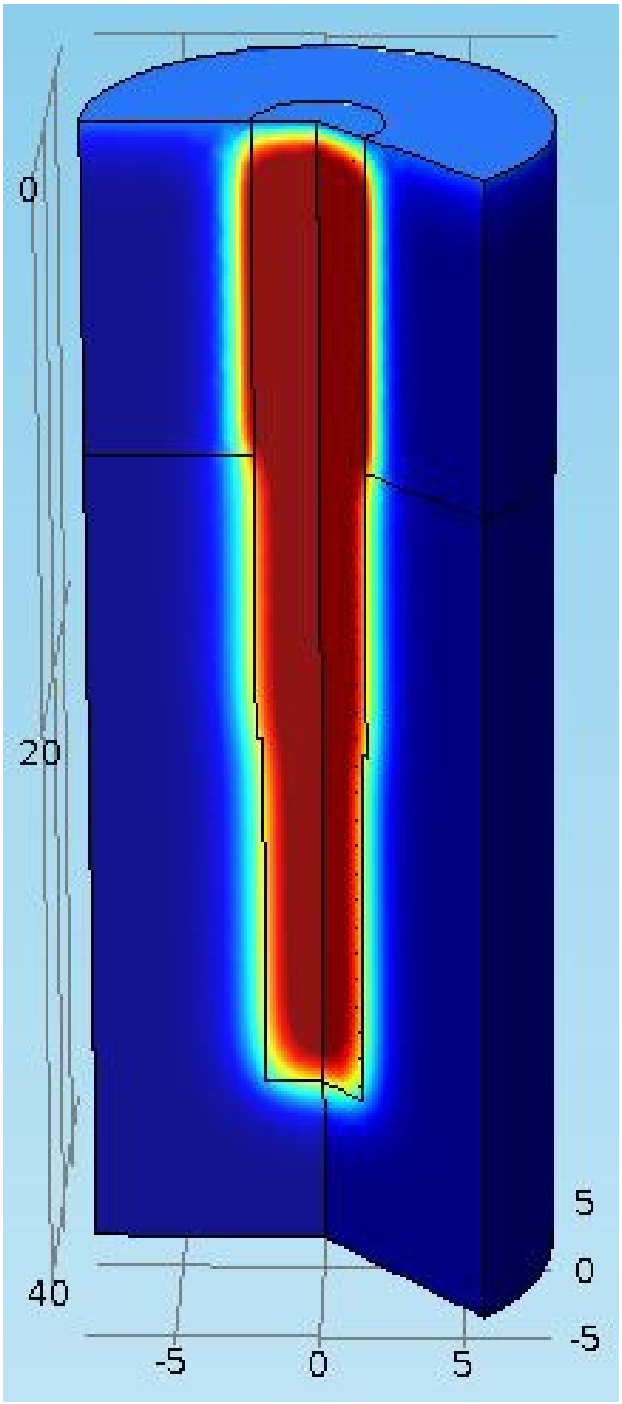

Figure 1: Heat distribution in a drilled shaft foundation during concrete hydration