Three-Dimensional Mesoscopic Numerical Study of Effective Thermal Conductivity of Cracked Concrete

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ABSTRACT

The pronounced decrease of effective thermal conductivity (ETC) due to the cracking behavior of concrete will change the temperature profile in concrete structures, indirectly inducing the redistribution of thermal stresses. To evaluate this phenomenon, a mesoscopic numerical method within the framework of finite element method is proposed to investigate the ETC of both tensile and compressive cracked concrete and this method is applied to obtain the quantitative relationships between tensile or compressive strain and ETC respectively. The main conclusions are drawn as follows:

（1） In the course of tensile failure process, the evolution between ETC, including T-ETCV (tensile cracked concrete ETC vertical to cracks) and T-ETCP (tensile cracked concrete ETC parallel to cracks), and strain can be divided into 3 stages. At the elastic stage, ETC has a little change. Then at plastic stage (80-100με) both the ETCV (23%) and ETCP(10%) has a significant reduction, while at the softening stage a very slight linear decrease appears.

（2） According to the compressive failure process the C-TECV (compressive cracked concrete ETC vertical to cracks) and C-ETCP (compressive cracked concrete ETC parallel to cracks) curves are made up of 4 stages. In the elastic period, tow curves have no change and are overlapped. Then at plastic drop stage, one can observe remarkable reductions in C-ETCV (30%) and C-ETCP(23%) and the bifurcation of the curves at 500με. As load increases both curves becomes stable temporally at the plastic steady stage, and at the softening stage begin to linearly decrease.

（3） It is the micro-cracks at ITZ rather than the macro-cracks that play the dominant role in this phenomenon. Aggregates whose thermal conductivity is commonly 2.5 times of that of mortar provides "heat bridges" for heat. The micro-cracks induced by the debonding of mortar and aggregates prevent heat flow into the aggregates which remarkably weakens the heat bridge effect. This is called interfacial thermal resistance (ITR) effect.

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