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Computing Method of Thermalviscoelastic Analysis of Asphalt Pavement Under condition of Cyclic Temperature Changing

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ABSTRACT

The low-temperature cracking is a main form of structural damage of asphalt pavements, so it becomes an important research task to quantitatively describe mechanical properties and inherent regularities for temperature cracking of asphalt pavement. Under the conditions of natural environment, the pavement is subjected to varying climate, which leads to a continuing time dependant and space dependant change in pavement's temperature field. Asphalt mixtures are a type of thermorheologically simple materials, so the study work on thermal stresses in asphalt pavements should be carried out beyond the scope of thermalviscoelasticity theory. Based on the reasons above, the research on the computing method of thermalviscoelastic analysis of asphalt pavement under the condition of cyclic temperature changing has very important significance.

Firstly, based on the engineering practice, two issues of thermal stress in asphalt pavement are presented and corresponding two mechanical analysis models are offered. According to the structure characteristics and actual working condition of asphalt pavement, several assumptions of mechanical models are given, in which asphalt mixtures are considered as a type of uniformity, isotropy and thermorheologically simple materials.

Secondly, taking thermalviscoelasticity theory as guide, simulating the viscoelastic property of asphalt mixtures with generalized Maxwell model, the test results are analyzed and the interrelated model parameters are fitted by use of the time-temperature transform principle of the thermo-rheologically simple materials. And the time-incremental thermalviscoelastic constitutive relation under nonconstant, nonuniform temperature condition is obtained from theory derivation by the incremental initial stress method.

Thirdly, the incremental-iterative finite element method taking displacement as the basic unknown quantities are used for calculating thermal stresses in pavement. The incremental thermalviscoelastic constitutive relation under the plane-strain condition is derived. Using the incremental constitutive relation, the form of thermalviscoelastic theory incremental-iterative plane strain finite element is provided. And several key issues of finite element numerical calculation are discussed, as following:

1) Aimed at some complex integral formulas of incremental constitutive relation, the Gauss Nesting Integral calculating method is proposed, which is used to solve problems in reason.
2) Step size calculating of incremental-iterative finite element has important infection to calculating precision. The time step size in finite element thermal stress calculating under cyclic temperature changing condition is analysed and the reasonable choice is found.
3) In incremental-iterative finite element method, initial condition setting has grate infection towards calculating result. Based on the research findings, the paper offers the reasonable setting method of thermalviscoelastic stress under cyclic temperature changing condition.

Finally, in order to validate the rationality for the thermalviscoelastic constitutive relation, the incremental-iterative finite element method is used to simulate one TSRST test process. The results show that the constitutive relation and numerical method both can be used for thermoviscoelasticitical calculation of thermal stress of asphalt pavement.

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