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IDENTIFICATION OF THERMAL PROPERTIES OF HARDENING CONCRETE BY MEANS OF EVOLUTIONARY ALGORITHMS

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1 INTRODUCTION

The proper determination of the thermal properties of hardening concrete plays a key role in the building the correct models of concrete structures. High temperature gradients associated with the exothermic chemical reactions of cement hydration may occur between the interior and the surface at the early age of concrete, when its strength is low [1]. Cracks occur, when temperature gradients cause tensile stresses, which exceed the tensile strength of the young concrete. Thermal distortions have greater influence on stresses especially for massive structures [2].

Thermal characteristics of concrete described by: thermal conductivity, specific heat and heat of cement hydration (reaction of cement with water), are evolving during hardening and depend on the maturity of concrete. Such parameters in practice can be determined by means of different experimental measurements (e.g. calorimetric), hot plate apparatus and several transient dynamic techniques. Thermal characteristics, identified in the paper, are determined on the basis of temperature measurements only.

The evolutionary algorithms (EAs), as the global optimization technique for searching parameters, which describe thermal properties of hardening concrete are applied. Comparing to the use of conventional optimization methods, superiority of EAs manifest in many aspects, e.g.: fitness function has not to be continuous, information about objective function gradient is not necessary, choice of the starting point may not influence the convergence of the method, regularization methods in no needed [3,4].

2 FORMULATION OF IDENTIFICATION PROBLEM

From the mathematical point of view, the identification problem is expressed as the minimization of the functional. Following functional has been defined:

$$\min_{\mathbf{x}} \quad f(\mathbf{x}) = \sum_{i=1}^{n} \sum_{i=1}^{m} \left(T_{ij}(\mathbf{x}) - \hat{T}_{ij}(\mathbf{x}) \right)^2 \tag{1}$$

where: n is the number of sensors, m is the number of time intervals, T_{ij} and $\hat{T}_{ij}$ are vectors which contain measured and computed temperature values in particular point in time and space, $\mathbf{x}$ is vector of design variables.

Vector of design variables $\mathbf{x}$ contains over a dozen parameters, which define heat of hydration, specific heat and thermal conductivity. Identification problem is solved by finding the vector of design variables, minimizing the functional (1). In-house implementation of EA, with floating point gene representation is used. In order to calculate temperature in time and space, unsteady heat conduction equation, including proper definition of internal heat sources has to be solved. Numerical model of the hardening concrete specimen has been prepared and solved by means of finite element method (FEM) [5]. The obtained results have been compared with experimentally measured temperature in concrete specimens [6,7].

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