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MATERIAL PARAMETERS IDENTIFICATION USING PARALLEL EVOLUTIONARY MULTI-OBJECTIVE ALGORITHM

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ABSTRACT

Concrete is one of the most frequently used materials in Civil Engineering. Nevertheless, as a highly heterogeneous system, it shows very complex non-linear behavior, which is extremely difficult to describe by a sound constitutive law. As a consequence, a numerical simulation of response of complex concrete structures still remains a very challenging and demanding topic in engineering computational modeling.

One of the most promising approaches to modeling of concrete behavior is based on the microplane concept [1]. It is a fully three-dimensional material law that incorporates tensional and compressive softening, damage of the material, supports different combinations of loading, unloading and cyclic loading along with the development of damage-induced anisotropy of the material. As a result, this material model is fully capable of predicting the behavior of real-world concrete structures once provided with proper input data [2]. The major disadvantages of this model are, however, a large number of phenomenological material parameters and a high computational cost associated with structural analysis even in a parallel environment.

This year, a procedure based on artificial neural networks (ANN's) [3] for the microplane parameter identification that is able to identify reliably all microplane parameters was developed. In particular, an artificial neural network was used to estimate required parameters. As the training procedure, the evolutionary algorithm-based method was used. However, the drawbacks of this methodology are a missing error control and a high computational cost of the identification algorithm. For instance, a suite of 30 uniaxial compression tests consumes approximately 25 days on a single processor PC with the Pentium IV 3400 MHz processor and 3 GB RAM. If we run tests in parallel on 7 computers, the needed time is less than 4 days.

In this contribution, the problem is solved by implementing a parallel multi-objective evolutionary procedure. The numerical analysis is implemented using the OOFEM - free finite element code with object oriented architecture [4]. The optimization procedure utilizes the Global parallel model [5]. More specifically, the program is divided into an optimization and an analysis part and in this way it is implemented in the cluster of PCs. As an optimization algorithm, the evolutionary method called SADE [6] is used. Management of several objectives is utilized by the Average Ranking procedure, see e.g. [7]. As objectives, errors among experimental and computed stress-strain curves are used.

The most pertinent conclusion is that using a multi-objective identification procedure the errors in identified parameters do not accumulate. Therefore, the values are identified with higher accuracy then those achieved by neural network-based inverse analysis [3]. Moreover, the parallel solution appears to be an appropriate tool how to tackle with enormous computational demand of the microplane material model. Obtained nearly-linear speedup together with possibility to use much more processors promise new interesting results and potential applications of the presented method in the future.

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