Materials and Design 32 (2011) 3966–3979

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Computer-aided design of the effects of Fe_2O_3 nanoparticles on split tensile strength and water permeability of high strength concrete

Ali Nazari *, Shadi Riahi

Department of Technical and Engineering Sciences, Islamic Azad University, Saveh Branch, Saveh, Iran

ARTICLE INFO

Article history:
Received 31 August 2010
Accepted 18 January 2011
Available online 21 March 2011

Keywords:
A. Ceramic matrix composites
E. Mechanical
E. Physical

ABSTRACT

In the present paper, two models based on artificial neural networks and genetic programming for predicting split tensile strength and percentage of water absorption of concretes containing Fe_2O_3 nanoparticles have been developed. To build these models, training and testing of the network by using experimental results from 144 specimens produced with 16 different mixture proportions were conducted. The data used in the multilayer feed forward neural networks models and input variables of genetic programming models have been arranged in a format of eight input parameters that cover the cement content, nanoparticle content, aggregate type, water content, the amount of superplasticizer, the type of curing medium, age of curing and number of testing try. According to these input parameters, in the two models, the split tensile strength and percentage of water absorption values of concretes containing Fe_2O_3 nanoparticles were predicted. The training and testing results in the neural network and genetic programming models have shown that every two models are of strong potential for predicting the split tensile strength and percentage of water absorption values of concretes containing Fe_2O_3 nanoparticles. Although neural network has predicted better results, genetic programming is able to predict reasonable values with a simpler method rather than neural network.

1. Introduction

Strength assessment of concrete is a main and probably the most important mechanical property, which is usually measured after a standard curing time. Concrete strength is influenced by lots of factors like concrete ingredients, age, ratio of water to cementitious materials, etc. The pore structure determines the transport properties of cement paste, such as permeability and ion migration. Permeability of cement paste is a fundamental property in view of the durability of concrete: it represents the ease with which water or other fluids can move through concrete, thereby transporting aggressive agents. It is therefore of utmost importance to investigate the quantitative relationships between the pore structure and the permeability. Through experimental studies and then numerical simulations of the pore structure and the permeability of cement-based materials, a better understanding of transport phenomena and associated degradation mechanisms will hopefully be reached [1].

Conventional methods of predicting various properties of concrete are generally based on either water to cement ratio rule or maturity concept of concrete [2]. Over the last two decades, a different modeling method based on neural networks (NNs) has become popular and used by many researchers for a wide range of engineering applications. NNs are a family of massively parallel architectures that solve difficult problems via the cooperation of highly interconnected but simple computing elements (or artificial neurons). Basically, the processing elements of a neural network are analogous to the neurons in the brain, which consist of many simple computational elements arranged in several layers [3]. The concrete properties could be calculated using the models built with NNs. It is convenient to use these models for numerical experiments to review the effects of each variable on the mix proportions [4–6]. Besides ANNs, genetic programming (GP) has begun to arise for the explicit formulation of the properties and the performances of concrete recently [7,8]. Genetic programming offers many advantages as compared to classical regression techniques. Regression techniques are often based on predefined functions where regression analyses of these functions are later performed. On the other hand, in the case of GP approach, there is no predefined function to be considered. In this sense, GP can be accepted to be superior to regression techniques and neural networks. GP has proven to be an effective tool to model and obtain explicit formulations of experimental studies including multivariate parameters where there are no existing analytical models [7,8].

The aim of this study is to predict split tensile strength and percentage of water absorption of several types of concrete with and without Fe_2O_3 nanoparticles by ANNs and GP. Totally 144 split

* Corresponding author. Tel.: +98 255 2241511; fax: +98 255 2241501.
E-mail address: alinazari84@aut.ac.ir (A. Nazari).

0261-3069/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2011.01.064