Ultrasonics 61 (2015) 103–113

Contents lists available at ScienceDirect

Ultrasonics

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

Prediction of ultrasonic pulse velocity for enhanced peat bricks using adaptive neuro-fuzzy methodology

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ARTICLE INFO

Article history:
Received 9 November 2014
Received in revised form 3 March 2015
Accepted 6 April 2015
Available online 15 April 2015

Keywords:
Peat
Ground improvement
Ultrasonic pulse velocity
ANFIS
Estimation

ABSTRACT

Ultrasonic pulse velocity is affected by defects in material structure. This study applied soft computing techniques to predict the ultrasonic pulse velocity for various peats and cement content mixtures for several curing periods. First, this investigation constructed a process to simulate the ultrasonic pulse velocity with adaptive neuro-fuzzy inference system. Then, an ANFIS network with neurons was developed. The input and output layers consisted of four and one neurons, respectively. The four inputs were cement, peat, sand content (%) and curing period (days). The simulation results showed efficient performance of the proposed system. The ANFIS and experimental results were compared through the coefficient of determination and root-mean-square error. In conclusion, use of ANFIS network enhances prediction and generation of strength. The simulation results confirmed the effectiveness of the suggested strategies.

1. Introduction

Researchers have shown growing interest in non-destructive testing techniques to measure the compressive strength of construction materials because of their evident advantages. Some of these techniques are pulse-echo [1], impact-echo [2], ultrasonic pulse velocity [3], resonant frequency measurements [4], wave reflection methods [5], and acoustic emission methods [6]. This paper introduces a novel approach to estimate propagation of the ultrasonic pulse velocity (UPV) in construction materials, such as peat bricks, using the adaptive neuro-fuzzy methodology.

In recent decades, the energy consumption has multiplied due to fast industrialization. In line with this, construction industry requires alternative materials to replace the conventional compositions. Especially, brickworks seek alternative materials over the inefficient conventional compositions. For example, brick manufacturers consider the peat with relatively high organic content as a sustainable alternative for the traditional materials (i.e. aggregates). The use of peat decreases the density, and increases the brick's porosity and permeability, which in turn reduces the production expenditure. Nonetheless, the compressive strength of peat bricks as the key performance indicator, still highly relies on the content of the cementation agents [7,8].

The use of UPV has been widely investigated for the non-destructive estimation of concrete quality. Many empirical equations were introduced to evaluate the compressive strength of the cementitious materials based on the non-destructive testing variables [9–11]. The old method for mathematical relationship using compressive tests and the UPV on cementitious material samples through regression analysis was not effective [12,13]. A correlation between compressive strength and UPV of concrete was reported for some combinations [14]. The study simultaneously measured the pulse velocity and compressive strength of 150-mm cubes at different ages from 1 day to 28 days and revealed a linear relation between the strength and velocity. Lin et al. [15] carried out an experimental study to establish mathematical models for predicting concrete pulse velocity based on aggregate content and water–cement ratio. Sahu and Jain [16] used the UPV as measure of concrete quality for different structural components, such as roof beams, crane girders, shell beams, columns, and shell roof.

The UPV has been mainly reported to predict the compressive strength of cementitious materials through linear regression analysis using few parameters. Notwithstanding, adaptation of soft computing methodologies to estimate the physic-mechanical

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http://dx.doi.org/10.1016/j.ultras.2015.04.002
0041-624X/