研究速報

Prediction of Rheological Properties of Mortar Using Neural Network

Quoc HUU DUY PHAN * and Taketo UOMOTO * *

1. INTRODUCTION

There have been many studies on rheology of concrete, mortar or cement paste. In most of these studies, the common methodology is to keep constant most of parameters of mixture and vary only one parameter, such as water by cement ratio, to check its effect on rheological properties. In this research, neural network was used to predict the rheological properties of mortar. Neural network is a data processing method simulating the structure and functions of human brain. Briefly, for a given matter with some available data, output parameters are correlated with corresponding input parameters. Then, ideally, with any new set of input parameters, it is possible to predict the outcomes without the need to perform the experiments.

2. ARTIFICIAL NEURAL NETWORK

Artificial neural network are relatively crude electronic models based on the neural structure of the brain. Fig. 1 shows the schematic structure of a neural network. A simple neural network consists of an input layer, one or more hidden layers and an output layer. In this study, the so-called supervised training was used in processing the data. In supervised training, both inputs and outputs are provided. The network then processes the inputs and compares its resulting outputs against the desired outputs. The least mean square algorithm is used to evaluate the error of training process. Errors are then propagated back through the system, causing the system to adjust the weights which control the network. Then the monitoring data are used to check the accuracy of the network.

*Uomoto Laboratory, 5th department
**Incede/Icus, professor

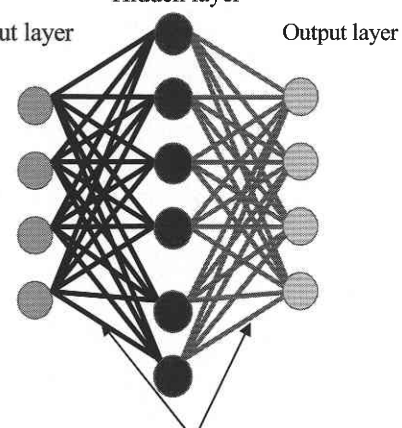

Fig. 1 Structure of neural network

3. RHEOLOGY OF FRESH MORTAR

In this research, it was assumed that rheological behavior of fresh mortar follows the Bingham's model. It means two parameters, yield stress and viscosity, are required to describe the rheology of a mixture. In this paper, the results of tests in which super-plasticizer was not used are reported.

4. EXPERIMENTS

Water by cement ratio, sand by cement ratio and filling ratio were varied from 0.38 to 0.55, 1.0 to 2.2, 0.454 to 0.767 and from 5 to 90 (minutes), respectively. Filling ratio is calculated by dividing sand volume to that of water and cement. Ordinary Portland cement was used in all the tests. The same kind of sand with constant surface water contents was used. B-type viscometer developed by Tokimec Corp. was used. In this test, a rotor is deepened and rotated at different velocities in mortar when the corresponding torque value recorded.

Temperature of materials and testing room was maintained at 20 degrees Celsius during the experiment. The volume of each mixing batch was 1.6 litters. Cement was mixed with sand for 30 seconds. Then, water was added and mixture was again mixed for 90 more seconds. Rheological tests were performed at 5, 25, and 45 minutes after mixing. Rheological tests were also performed at 65 and 90 minutes after mixing in some cases. In all cases, shear rates were varied (by varying the speed or the rotor) from 1.34 to $5.36s^{-1}$ while corresponding torque value recorded. Yield stress and viscosity were obtained by linear fitting the recorded data for each case.

5. RESULTS AND DISCUSIONS

In all cases of testing, fresh mortar followed the Bingham's model of linear relationship between yield stress and viscosity. As for the yield stress and viscosity, 36 cases of 11 mix proportions with different testing time were used. The neural network was trained with data from 33 cases and the remaining cases were used as monitoring data. The results are shown in Fig. 2 and Fig. 3 for yield stress and viscosity, respectively. In these figures, the circular points are training data, which means the data for supervised training of the neural network. Triangle points are the monitoring data, which means the data for evaluating the accuracy of trained network. The total mean square errors of training and estimating processes were of 0.127 and 0.0148, respectively. As can be seen in Fig. 2, the yield stress was well predicted by the trained network though two in three monitoring points were slightly underestimated. Similarly, in Fig. 3, viscosity of mortar was successfully predicted with total mean square error of 0.015. The reason for not using water reducing agent or super-plasticizer in tests of this paper lies on the difficulty in numerically expressing its effect on rheological properties of mortar. The authors are trying to include super-plasticizer as an input parameter of neural network. Above results prove that the neural network is a potential tool to quantitatively predict the rheology of mortar or cement-based fresh mixture. At the time being, this study enables the prediction of rheology from given water by cement ratio, sand by cement ratio, time and filling ratio. For the coming time, more efforts should be made to include the effect of other factors, such as surface water content and fineness modulus of fine aggregate, super-plasticizer, etc, so that the prediction of rheology of any given conditions becomes possible.

(Manuscript received, September. 10. 2002)

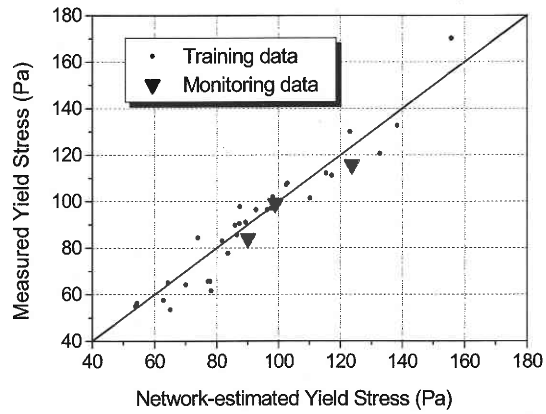

Fig. 2 Network-estimated Yield Strees (Pa)

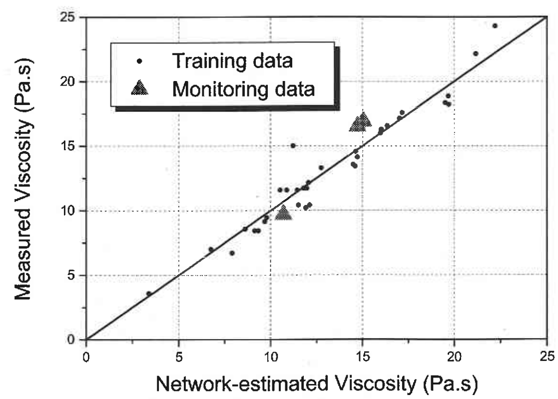

Fig. 3 Network-estimated Viscosity (Pa. s)