The optimization of waste material reuse in concrete using innovative combination method based on mathematical model and AI

Mahfoud BENZERZOUR - Mouhamadou AMAR - Nor-Edine ABRIAK

IMT Lille Douai, Univ. Lille, EA 4515 - LGCgE, Civil and Environmental Engineering Department, 59000, Lille, France
Université Lille Nord de France, LGCgE, Villeneuve d'Ascq, France
Keywords: Waste material, mathematical model, AI, mineral additions, prediction, formulation
Presenting author email: amar.mouhamadou@imt-lille-douai.fr

Abstract

The 21st century marks a remarkable stage of a widespread of various numerical techniques of calculation. In this study, artificial neural network (ANN) and mathematical model that find an optimal set of treatments respecting economical and legislative constraints are proposed.

This optimal solution is obtained by solving a non-linear mathematical model. The ANN model proposed is based on available experimental results for 1350 different mixture gathered from the 25 bibliographic sources for the learning process. The ANN model is built and trained in a Matlab platform using neural network module.

The specimens studied contain various type of mineral additions: metakaolin, silica fume, fly ash, limestone filler, marble waste, recycled aggregates, Ground granulated blast furnace slag and also superplasticizer in the admixture.

The results shows that, "hybrid" models, combining AI methods and mathematical models have strong potential for the optimization of waste material reuse and shown high precision and accuracy.

1. Scientific approach

The scientific approach used in this study is given in Figure 1. The main objective of this methodology is to design the beneficial use of waste material by combining AI methods and tradition mathematical models of optimization.

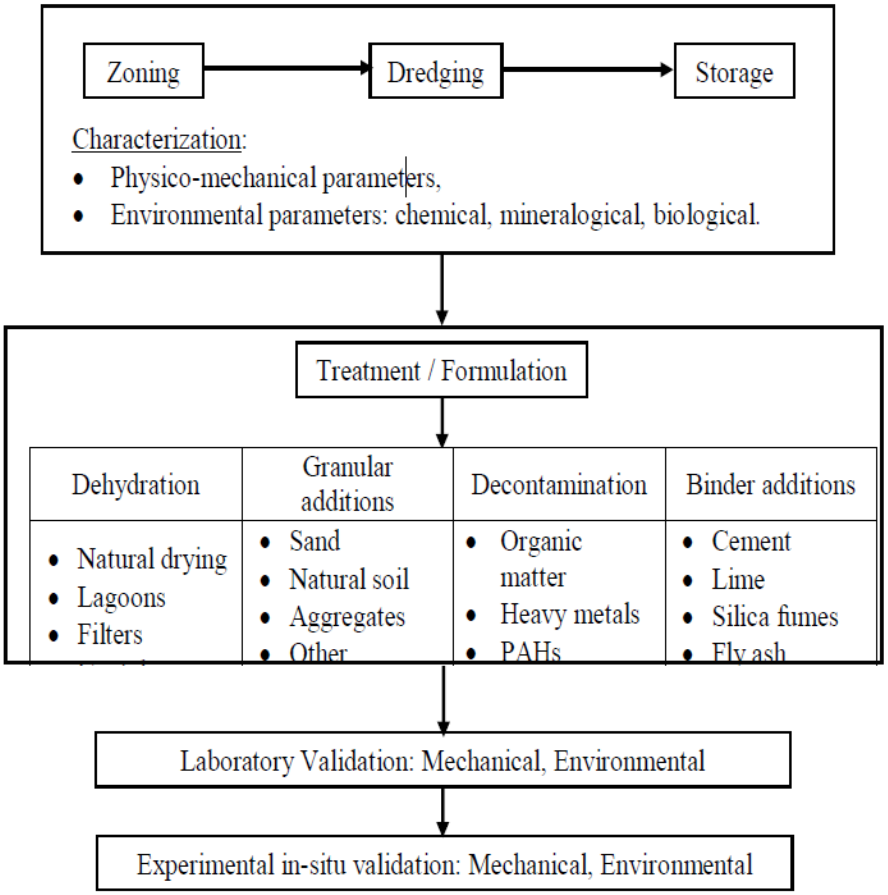

Figure. 1: Valorization process and methodology

2. Artificial neural networks

The general methodology used is described in Figure 2

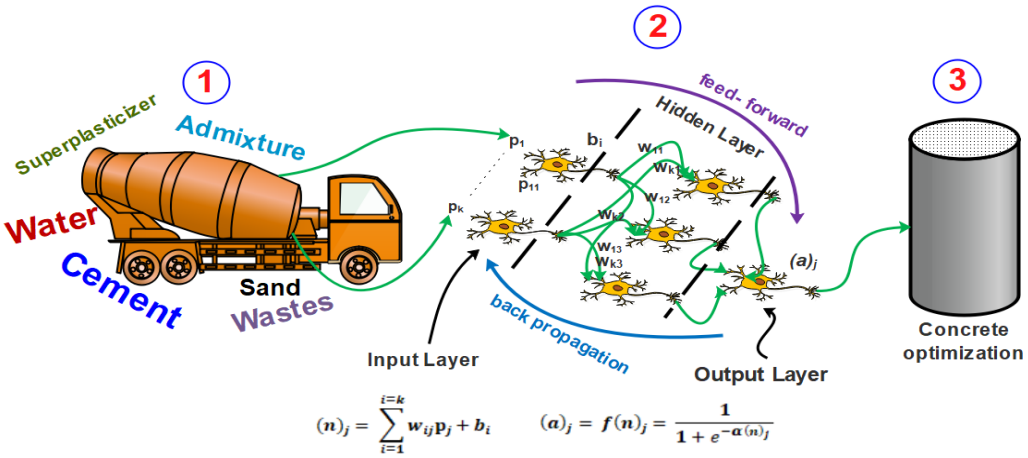

Figure. 2: AI methodology applied

The neural network models are developed using Neural Network Toolbox in MATLAB software (Abu Yaman, Abd Elaty, and Taman 2017; Saridemir 2009). The general characteristics for learning and training method is given in Figure 3 and Table 1. The method used in this study is based on a multi-layer perceptron (MLP) this method correspond to a gradient descent technique that minimize the error or cost of the process (Santosh Kumar and Rajasekhar 2017).

Table 1: General characteristics of the ANN model

Method type	Regulation technique	Learning method	Data division	Training method	Activation function
Feed-forward, back-propagation network	Gradient descent	Supervised	Random	Levenberg-Marquardt back-propagation algorithm (LMBPA)	Log-sigmoid

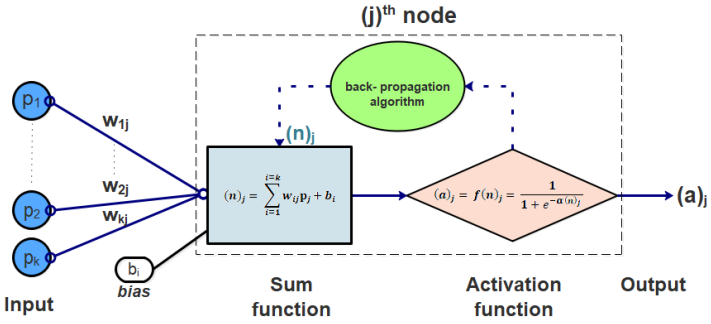

Figure. 3: Architecture of applied neural network

3. Mathematical model :

The objective of the mathematical model is to find an acceptable solution for a defined application with a minimum costs. That function can be expressed as in Equation 1:

$$Min \sum_{i=1}^{i=n} c_i^1 x_i + \sum_{i=1}^{|T|} c_i^2 T_t \qquad (1)$$

4. References

Abu Yaman, Mahmoud, Metwally Abd Elaty, and Mohamed Taman. 2017. "Predicting the Ingredients of Self Compacting Concrete Using Artificial Neural Network." *Alexandria Engineering Journal* 56(4): 523–32. https://doi.org/10.1016/j.aej.2017.04.007.

Santosh Kumar, Gottapu, and K. Rajasekhar. 2017. "Performance Analysis of Levenberg-Marquardt and Steepest Descent Algorithms Based ANN to Predict Compressive Strength of SIFCON Using Manufactured Sand." *Engineering Science and Technology, an International Journal* 20(4): 1396–1405. https://doi.org/10.1016/j.jestch.2017.07.005.

Saridemir, Mustafa. 2009. "Prediction of Compressive Strength of Concretes Containing Metakaolin and Silica Fume by Artificial Neural Networks." *Advances in Engineering Software* 40(5): 350–55. http://dx.doi.org/10.1016/j.advengsoft.2008.05.002.