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The Influence of Changes in Active Binder Content on the Control System of the Moulding Sand Quality

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Abstract

Artificial neural networks are one of the modern methods of the production optimisation. An attempt to apply neural networks for controlling the quality of bentonite moulding sands is presented in this paper. This is the assessment method of sands suitability by means of detecting correlations between their individual parameters. The presented investigations were aimed at the selection of the neural network able to predict the active bentonite content in the moulding sand on the basis of this sand properties such as: permeability, compactibility and the compressive strength. Then, the data of selected parameters of new moulding sand were set to selected artificial neural network models. This was made to test the universality of the model in relation to other moulding sands. An application of the Statistica program allowed to select automatically the type of network proper for the representation of dependencies occurring in between the proposed moulding sand parameters. The most advantageous conditions were obtained for the uni-directional multi-layer perception (MLP) network. Knowledge of the neural network sensitivity to individual moulding sand parameters, allowed to eliminate not essential ones.

Keywords: Quality management, Green moulding sand, Artificial neural networks

1. Introduction

Artificial neural networks usage is one of the modern methods of the production optimisation [1–6]. The networks owe their popularity to the fact that they constitute convenient tools of investigations. Molding sands and in particular their quality control methods significantly affect the quality of castings. The use of statistical analysis to support decision making on how to provide the required moulding sands properties is more and more popular.

Modern control systems are utilising changes of the selected sand properties for controlling its quality, mainly the sand compactibility [7]. Studies determining the usefulness of sand property changes for the estimation of the active binder content are available in the scientific literature [8].

The results concerning selected properties of moulding sands of the active bentonite content as well as neural networks models for the collected results, which constitute the continuation of the studies on the neural networks suitability in the process of the quality control of moulding sands were presented in earlier articles [9–12]. In this article the usefulness of selected artificial neural networks for estimation of active bentonite content in new-prepared moulding sands is presented.

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2. Researches

In the first part of the article, the influence of active bentonite content on selected properties of moulding sand as a function of moisture will be presented. Then, it will be described the model of the artificial neural network of the structure presented in [12] basing on the results presented in this article. In the next stage of the research, to the previously presented models new data was set to determine the suitability of these models if moulding sand is changed.

2.1. Influence of the active bentonite content on the selected properties of moulding sands

In order to determine the influence of the deactivation degree of the binder contained in the moulding sand on its properties, moulding sands of various contents of active and non-active binder were prepared (at the constant total amount of both binders, being equal to 8 parts by weight). Moulding sand preparation method was described in earlier work [12].
Influence of the binder deactivation degree on the compressive strength is presented in Figure 1. As can be seen, when the active binder content is higher the strength is also higher.

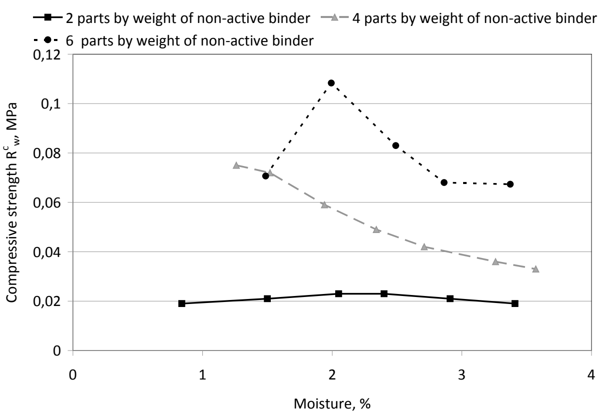

Fig. 1. The influence of water content on compressive strength R_c^w, for the moulding sands with different active bentonite content

The performed research of the influence of a non-active binder on permeability did not expose relevant permeability changes as a moisture function (Fig. 2).
The compactibility results are shown in Figure 3. An increase of sand moisture causes the increase compactibility, which obtains its maximum. An increased active bentonite content also causes the increased compactibility.
The Statistica 10.0 program was applied for designing the neural network models.

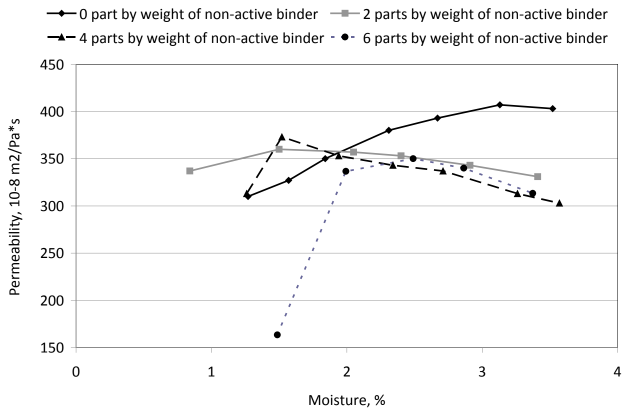

Fig. 2. The influence of water content on permeability for the moulding sands with different active bentonite content

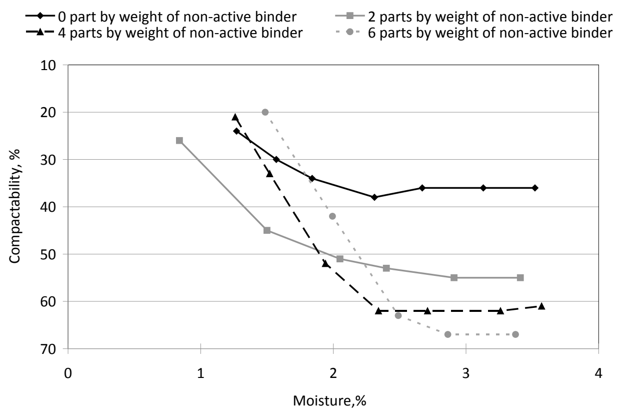

Fig. 3. The influence of water content on compactability, for the moulding sands with different active bentonite content

2.2. ANN modelling to determine active bentonite content in moulding sands

The results obtained for the model providing the best representation of the earlier experimental results of the compressive strength, compactability and permeability are shown in Figure 4 [12]. The continuous line shows real moisture values, while points indicate the data obtained as the deactivated bentonite content.

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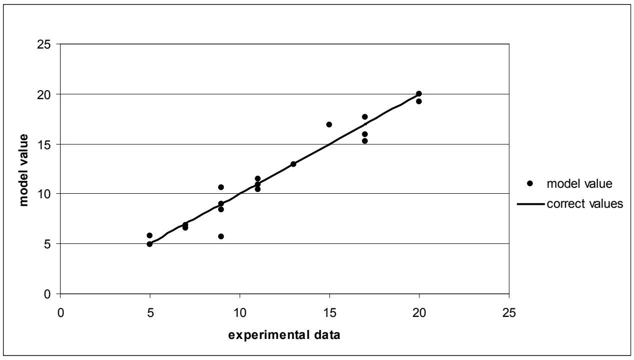

Fig. 4. Comparison of the distribution of data generated by the network and the experimental data (test data set), input data: compressive strength, compactability, permeability. output data: non-active binder, the network model: MLP 3-8-1, model quality: 0,9683 [12]

Table 1 and Figure 5 presents the predicted values results of activated bentonite obtained for the structure of the models calculated in previous research. These results indicate that the ANN structure ensures a good mapping for new data. This shortens the selection of an appropriate model as a tool supporting decision making process according to moulding sand quality.

Table 1.
Exemplary response ANN models of the structure 3-8-1

active bentonite content, %	ative bentonite - output_1	ative bentonite - output_2	ative bentonite - output_3	ative bentonite - output_4	ative bentonite - output_5
2,0000	2,1251	2,0000	2,0579	2,0879	1,2592
4,0000	3,9699	4,0000	3,7873	3,9309	4,7354
6,0000	5,8388	5,9997	5,6739	6,0091	6,2636

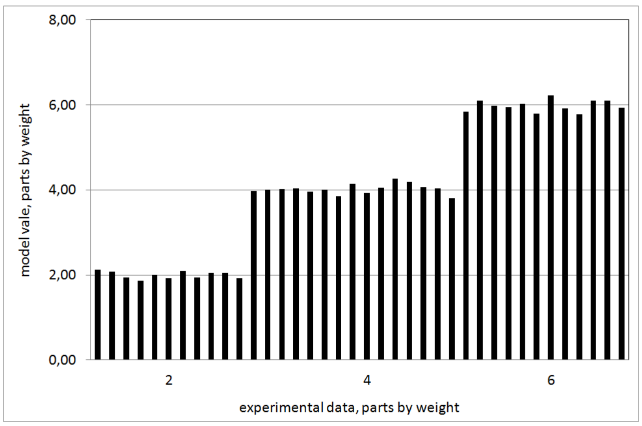

Fig. 5. Exemplary distribution of the output data values for 3-8-1 network structure

In the next stage of the research new moulding sand parameters were used. They were set to the previously selected models for various input parameters.
ANN response to new compactability data in relation to the actual values (solid line) are shown in Figure 6. The compactibility used as input data for network model achieved very poor mapping.

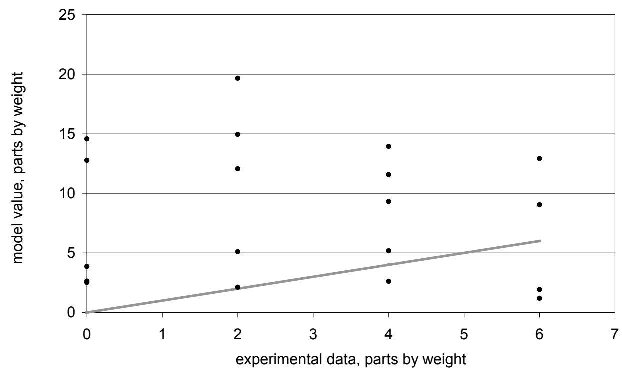

Fig. 6. Comparison of the distribution of data generated by the network and the experimental data, input data - compactability

The mapping problem results from the moisture influence on compactibility. For a constant amount of active bentonite moulding sand's properties were tested with variable moisture. Therefore, when entering data into the model, contents of bentonite is characterized by different compaction values which causes the problem to determine a proper value by ANN.

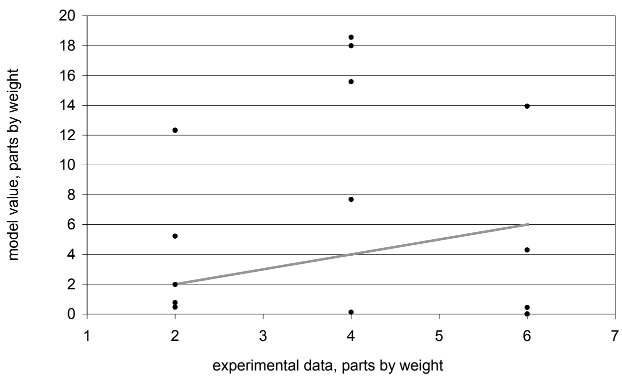

Fig. 7. Comparison of the distribution of data generated by the network and the experimental data (test data), input data: compressive strength, compactability, permeability

Then models that use as input three properties (compactability, compressive strength and permeability) were used. Also in this case the output results obtained for the value of a new moulding sand research, differ significantly from experimental data (Fig. 7).

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3. Conclusions

The analysis show that the determination of active bentonite content in moulding sand using the methods of data mining is very complicated. Neural network models developed for given moulding sand, even if they predict well the required properties, in the case of change in moulding sand are not always useful.
Development of a model that can be applied in different conditions requires further detailed studies.

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