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FORECASTING OF DURABILITY OF THE LAYER OF SUPERFICIAL PROCESSING OF ROAD COVERINGS ON THE BASIS OF THE MODIFIED BITUMENS WITH APPLICATION OF NEURAL NETWORKS

The opportunity of application of system of neural networks for forecasting durability of a layer of superficial processing of road coverings is considered. The offered technique of definition of efficiency of application of any additive intended for improvement of properties of bitumens at the device of layers of superficial processing of road coverings allows to receive the most authentic forecast of safety of a layer.

Keywords: systems of neural networks, forecasting of longevity layer surface of processing road covering, additives intended for improvement of bitumen characteristic at device of the layers of the surface processing road covering.

The main reasons for the low quality of the surface treatment performed both in a traditional way of separate distribution of materials, and with simultaneous distribution of bitumen and chip, are violations of the links in the system “traffic — chip-astringent — pavement”. We know that the durability of the layer of rough surface treatment (SHPO) in subsystems “astringent-chip” is influenced by several factors: temperature, type of modifier and its concentration in astringent, astringent discharge in the layer SHPO, the type of asphaltic concrete (including on hardness) and binder used for preparation, etc.

Thus, the prediction of durability of layer SHPO with the use of bitumen, modified by various additives is a complex multiple task. To solve the problem it is necessary to develop a methodology that allows for a certain optimal value of the critical factors and boundary (boundary) conditions under which the prediction of durability layer

SHPO would be most favorable. To develop such a technique it is very effective to use neural networks. To solve the complex and poorly formalized problem direction, which is called artificial neural networks exists. Artificial neural networks consist of neuron-like elements interconnected by a network [1, 2]. Note that the use of other mathematical methods of approximation of functions of several variables is a very difficult problem. There are static and dynamic strategic neural networks. In static neural networks change of the parameters of the system occurs on some algorithms in the learning process. After learning the network settings are not changed. In the dynamic neural networks mapping of external information and its formulation implements in the form of a dynamic process, i. e., in the process depending on time.

Neurons are organized into neural networks that perform different functions. At the core of an artificial neural network is an element that is an artificial neuron. Mathematical model of neuron represents an abstract element that has multiple inputs and one output.

For operating the artificial neural network the type of neuron must be selected, the configuration of the network must be determined and its training and testing on the existing set of training examples must be made.

At the entrance of network some of the known signals are made, while at the entry known output is expected. In doing so, the entire system setup consists in selecting weights of neurons input and displacements bi. These parameters are some numbers that one needs to pick up on the basis of the training so that at the well-known examples the system gives the correct answers in the form of the function at the exit.

The system modifies its parameters while presenting of her new examples in order to most accurately reproduce the output signal.

Such teaching of system is called teaching with the teacher. It is also possible to study without a teacher, when neural networks are offered different examples of data. It is important to understand the principal possibility to display complex data structure using artificial neural networks. Representability of continuous maps on the basis of three-layer neural networks is a consequence of a theorem of Kolmogorov — Arnold on the representability of functions of several variables as superpositions and sums of functions of one variable.

Task function E in the simplest case of a single neuron can be written in the form of ½ $(d—f(u))^2$, where d-the result of example, $f(u)$ — output of the neuron. In the training process parameters of the neuron must be chosen so as to get to the point d.

In practice, the neuron are trained so that the $E \to \min$. Different procedures for training are used, based on finding of the minimum functions. As a result, it is necessary to achieve that state when the difference between what gives the network and our data was a minimum (Fig. 1).

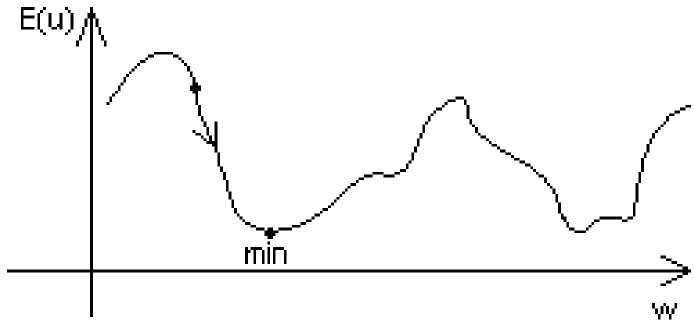


Fig. 1. A general view of the window of "masters" of program on the input of parameters to simulate the neural network

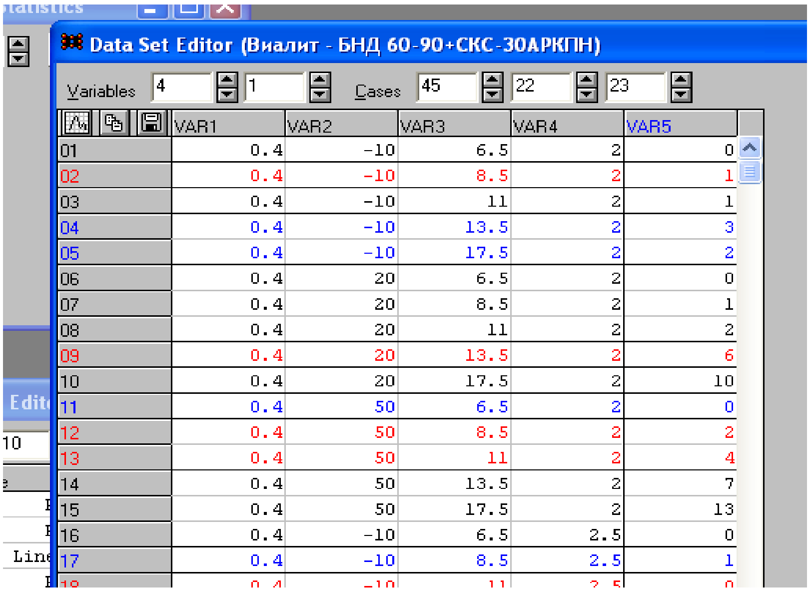
Thus, to examine the relationships in the subsystem "astringent-chippings" we need to get experimental a series of bitumen modified with polymer additives with different percentage of them, in a range of flow rate of binder, as well as with the use of all fractions of crushed stone, and under different temperature conditions for tests opportunities for structure formation of created neural network. Test results in the subsystem "astringent-chippings" are fixed on the outcome parameter — the number of bounced chip.

It is possible to get a pilot series in the considered subsystems that helps to build and train neural network, which will predict the output parameters in a number bounced chips not only for the values of parameters that were fixed in experiments, but also for other values of parameters which were not directly in these experiments, but were set both within the experimental range, and beyond it. Each type of binder (a modifier) and each system correspond to its own network of artificial neurons. In the end, to simulate the experimental results for the 15 considered compounds binder 30 small neural networks are needed.

The baseline data necessary for the formation of the neural model for one of these examples have the form of a table in which the first columns represent the input parameters, and the last column represents the value of the output parameter. Example of a matrix of data entry by the number of bounded chips for the binder, based on SCS-30ARKPN is shown in Fig. 2 (source array consists of 90 records). The process of constructing the algorithm of all possible variants of neural networks is performed with certain parameters determined by the user or an automatically generated using the wizard to build a network (Fig. 3).

Taking into account the nature of the theory of neural networks and experience of their application in solving of scientific-practical tasks, it can be said that the task of constructing a mathematical model for the processing of neural networks is not difficult and can be widely used in practice.

After all the parameters of the network have been set, run the algorithm of formation. In the performance algorithm of the program creates and remembers possible variants of network surfaces, and assessing each of the options on the basis of criteria, selects the best network.


Data Set Editor (Виалит - БНД 60-90+СКС-30АРКПН)

Variables 4 1 Cases 45 22 23

	VAR1	VAR2	VAR3	VAR4	VAR5
01	0.4	-10	6.5	2	0
02	0.4	-10	8.5	2	1
03	0.4	-10	11	2	1
04	0.4	-10	13.5	2	3
05	0.4	-10	17.5	2	2
06	0.4	20	6.5	2	0
07	0.4	20	8.5	2	1
08	0.4	20	11	2	2
09	0.4	20	13.5	2	6
10	0.4	20	17.5	2	10
11	0.4	50	6.5	2	0
12	0.4	50	8.5	2	2
13	0.4	50	11	2	4
14	0.4	50	13.5	2	7
15	0.4	50	17.5	2	13
16	0.4	-10	6.5	2.5	0
17	0.4	-10	8.5	2.5	1

Fig. 2. A general view of the original matrix experiment, after entering data on the results of tests on a method "Vialit" for binders based on the SDR-30ARKPN, crushed stone of various sizes, temperature and flow of binder

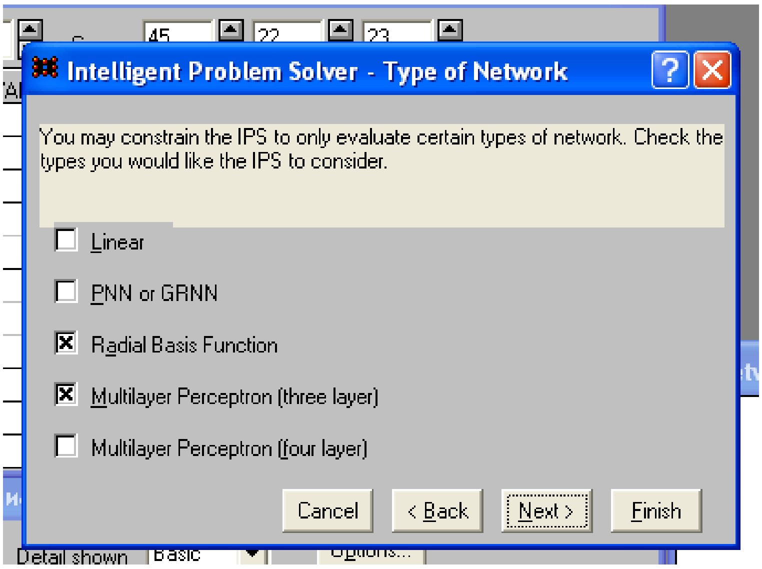


Fig. 3. A general view of the window of "masters" of program on the parameters input for modeling the neural network

As visual analysis of the reliability (the degree of adequacy) of constructed mathematical model can provide a table can be taken, in which calculated values of model function and corresponded target values are presented (Fig. 4). In analysed case table showed that the absolute deviations of no more than 3 units and no less than 2 units (in relation to the number of bounced chips) inclusive shall do not exceed 3.8 % of all results, and hence the absolute deviations with a value of no more than one present 96.2 % results. Hence the function constructed in this way will ensure reliability of the results of solving the problem of the number of bounced chips with security 96.2 % and an accuracy of one chip.

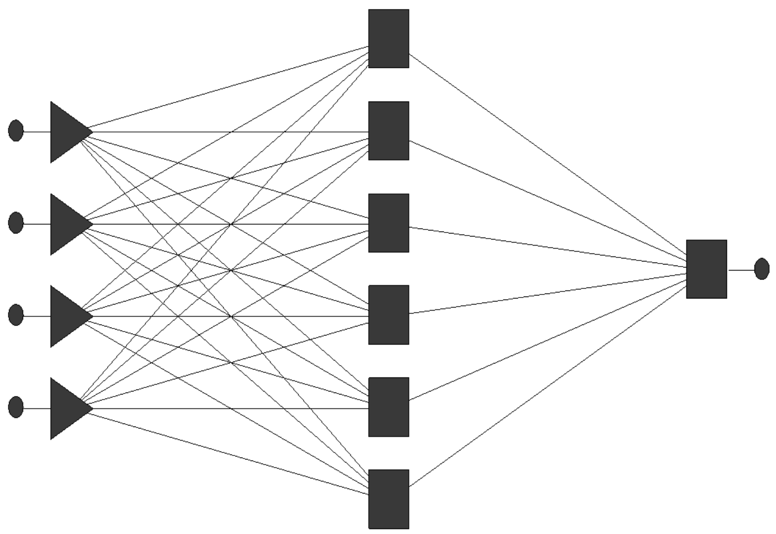


Fig. 4. Example of a neural network (context, inputs and outputs)
for the model of retention of capacity of binder on the basis of SCS-30ARKPN

The figure presents the main statistical characteristics of the selected version of the network and mean square and absolute error for a given sample.

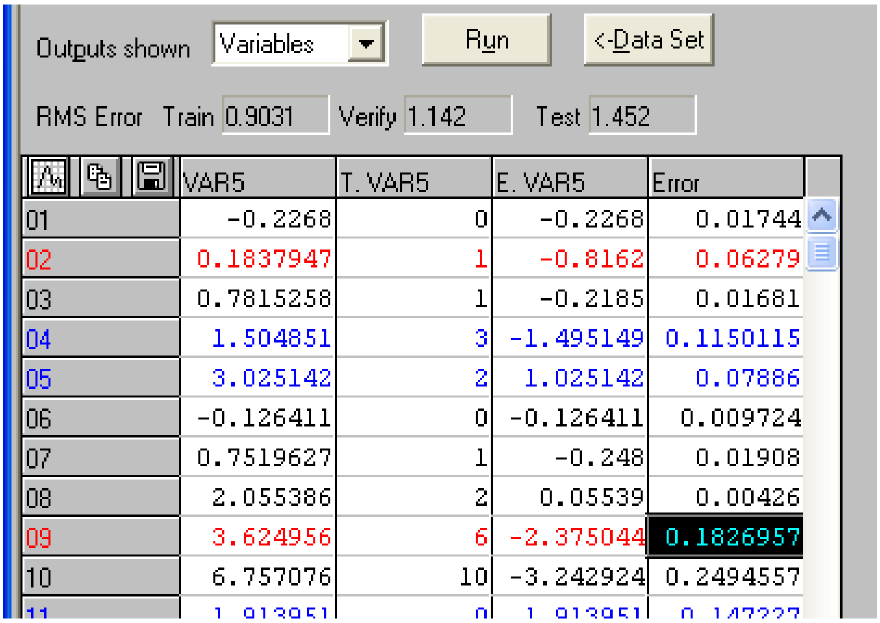
The main feature of the use of technology of neural networks as mathematical model, as well as its advantage in comparison with the analytic formula method is its obviousness (openness) and the availability for viewing parameters and assess the quality of the simulated network surface for all inputs and outputs constituting a nodal array of input data.

Thus, we are clearly aware of with what degree of accuracy network meets original array of data with any level of discretion, as well as the ease of calculating of the required number of intermediate values of the functions inside and outside experimental range, as well as the ease of finding solutions of problems of boundary conditions of simulated function.

Once the most adequate neuronet system was modeled, structure of its layers has the form presented in Fig. 5.

It is important to note that the modeled neural networks in each case (eg, the use of another modifier) can (and will) differ from the others and, therefore, have a different structure, including graphics. This is due to the characteristics of algorithmic principles of neural networks.

Ability to recognize visual images are far superior opportunities of computer algorithms, including neural networks. But unfortunately, they are limited only by two-, three-dimensional objects. In this case, consider the results of the work the neural networks we have modeled in bulk form, consistently releasing (by averaging the values) two inputs (input parameter), and receiving the corresponding response surface.



Outputs shown: Variables | Run | <-Data Set

RMS Error Train 0.9031 Verify 1.142 Test 1.452

	VAR5	T. VAR5	E. VAR5	Error
01	-0.2268	0	-0.2268	0.01744
02	0.1837947	1	-0.8162	0.06279
03	0.7815258	1	-0.2185	0.01681
04	1.504851	3	-1.495149	0.1150115
05	3.025142	2	1.025142	0.07886
06	-0.126411	0	-0.126411	0.009724
07	0.7519627	1	-0.248	0.01908
08	2.055386	2	0.05539	0.00426
09	3.624956	6	-2.375044	0.1826957
10	6.757076	10	-3.242924	0.2494557
11	1.913951	0	1.913951	0.147227

Fig. 5. The calculated intermediate values of function, target values,
the corresponding mean square and absolute errors for the values of the original sample

Consider the simulated response surface (Fig. 6), describing the holding ability of binder (tested on “Vialit”). Parameters X (Var (i)), Y (Var (j)) — this are inputs, and as Var (i), Var (j) parameters Var (1) (this flow of binder, Var (2) — test temperature, Var (3) the average of ficator of astringent) are used. Where Var (4) is not involved in the construction of a surface formed neuronet model does not require this input (input variable).

Considering the dependence of preservation of layer SHPO on the basis of tradition bitumen note that the largest number of bounced chips, i. e. the worst safety in the subsystem layer “astringent-chippings” is observed at the lowest flow rate of binder, the largest average size of chip in the area and the temperature +50 °C.

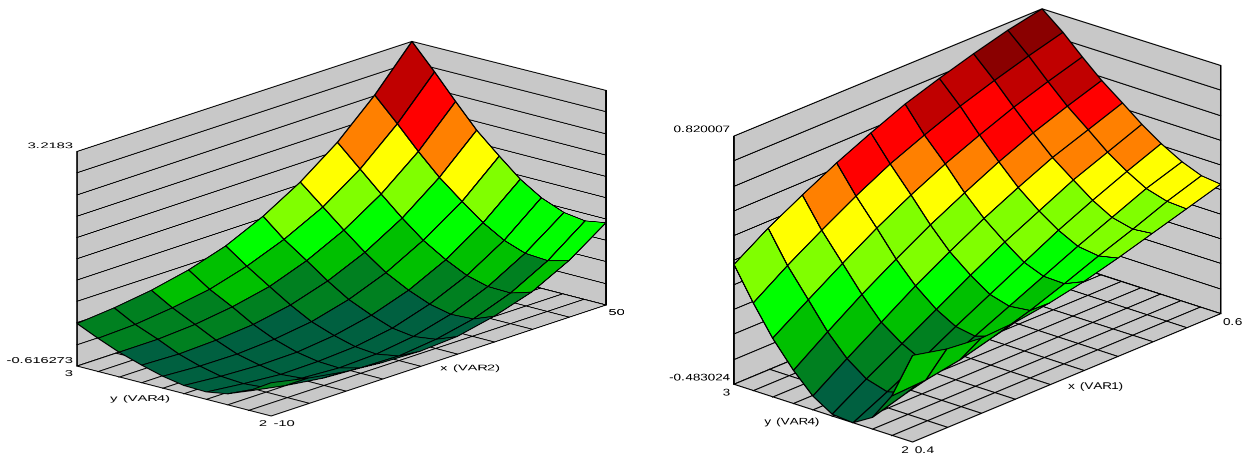


Fig. 6. A general view of the response surfaces for the binder
based on SCA — 30ARKPN for Var1, Var2, Var3, Var4

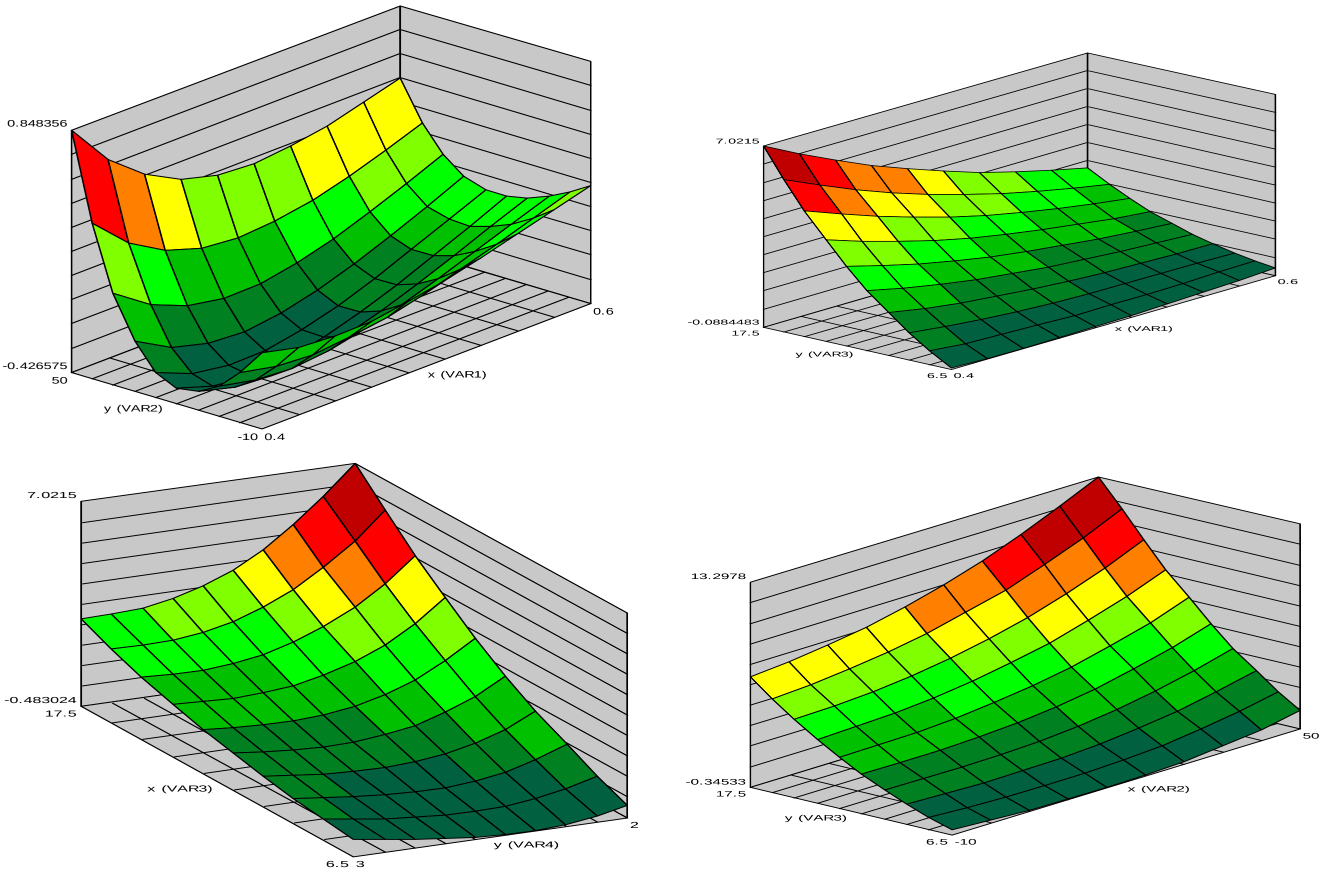


Fig. 6 (end). A general view of the response surfaces for the binder based on SCA — 30ARKPN for Var1, Var2, Var3, Var4

Dependency of preservation of layer SHPO of the number of rubber in the binding is different depending on the type of applied modifier.

For modifiers type SCS-30 ARKPN the best preservation matched compositions with the content of rubber in the 2.5 % by mass.

Summarizing all the above stated it can be said that the proposed method of determining the effectiveness of any additives used to improve the properties of bitumen in the installation of layers of rough pavement surface treatments, provides the most accurate forecast of preservation layer in subsystem “binder — chip”.

References

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