Results Of Mathematical Modeling Of Organizational And Technological Solutions Of Effective Use Of Available Resource Of Modern Roofs

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Summary
Relative to the outer surface of the mastic coating, the reliability of the available waterproofing resource is determined by the ability to stabilize the structural characteristics in difficult climatic conditions. Organic components of mastic as a result of solar radiation, elevated temperatures and their alternating change, atmospheric oxidants, especially in industrial areas, have a tendency to self-polymerization and loss of low molecular weight components. This is the gradual loss of deformability and the transition to brittleness with its tendency to crack as the reasons for the gradual transition from normal to emergency operating condition.The presented mechanism of functioning of the coating surface indicates the expediency of increasing its components, able to stabilize the structure and prevent changes in deformability.Durability, hydrophobicity, water displacement, water absorption are accepted as estimating indicators. The main dependences of the influence of the lost additional components of mastic on the operational properties of the formed coating characterize the ability to provide successful resistance to environmental influences and longer stability. As a result, mastic acquires additional service life.

Key words:
mathematical model, mathematical modeling, waterproofing resource, operational reliability, modification of mastics, durability, water displacement, water absorption.

1. Introduction

Introduction into practice of roofing technologies of bituminous-rubber and bituminous-polymeric mastics creates conditions of long-term operation of coverings thanks to existence of a waterproofing resource of the corresponding size [1]. At the same time there is a task of search of more effective use of an available resource on the basis of revealing of laws of functioning of surface zones of a covering in difficult climatic conditions.
The ability of the waterproofing resource of the surface zones of the formed mastic coating is determined by the stability of its structure. Organic components of the coating as a result of solar radiation, high temperatures and their changes, atmospheric oxidants and periodic humidification have a tendency to self-polymerization. These processes eventually manifest themselves in the gradual loss of deformability and the transition to fragility with its tendency to crack. From this moment, these processes are accelerated and the wedging effect of water itself (the so-called Rebinder effect) and its phase transitions takes effect.

The given mechanism of functioning of surface zones indicates prospects of increase of available resources by enrichment of mastics with the components capable to stabilize structure and by that to prevent premature changes of deformability of the formed covering.

2. Theoretical Consideration

Prospects for the effective use of waterproofing and other resources need to identify patterns of relationships between possible additives to mastic and their impact on changes in the structure and properties of the formed coatings, primarily by slowing down destructive processes. The most characteristic estimating parameters of dependences can be durability, hydrophobicity, water absorption, water displacement of the formed coverings.
A previous series of studies has revealed the successful possibility of additional modification of known mastics with additives of diesel oil of white spirit or kerosene and silica dust, including as waste ferroalloy production. The results provided the ability to search for patterns of relationships "composition-properties" to establish measures for the rational use of available resources of known mastics.

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The methods of determining durability are based on the known recommendations of accelerated tests [2] with some changes in the duration and temperature of heating: soaking increased to 1 hour, ultraviolet radiation -1 hour, freezing at -18ºC (± 2ºC) - 5 hours, heating at temperature + 90ºC (± 2ºC) - 12 hours. and exposure under normal conditions - 5 hours. in round-the-clock calculation.

The criteria for assessing durability were the timing of the appearance of clear signs of cracking. According to the provisions of the basic methodology, one day of cyclic action of influencing factors corresponds to one year of climatic action due to a particularly strict test regime.

The hydrophobicity of the surface is characterized by a diameter of the fixed volume of water in 1 ml, in accordance with the established methods [3].

Water absorption indices are determined by changes in the mass of the samples after exposure to water for a certain period according to the standards of the provisions [4]. Water displacement was evaluated, it is recommended [3] to evaluate the value of the spread of droplets of the investigated materials on the wetted surfaces of roofing sheets.

Multifactorial dependence and the need to identify the optimal content of components and corresponding mastics in general on the properties of the formed surface of the coating necessitated the construction of a regressive mathematical model of the experiment (Table 1). Durability, hydrophobicity, water absorption were accepted as estimation parameters.

Table 1: Experiment planning matrix

№	The value of the factor								Values of optimization parameters		
	In coded values				In natural terms						
	X1	X2	X3	X4	White spirit	Mastic	Diesel oil	Siliceous dust	Odds. water absorption W% (Y_1)	Hydrophobicity , Ømm (Y_2)	Durability years (Y_3)
1	-1	+1	+1	+1	2,0	90	4,0	6,0	0,095	0,2	12
2	+1	+1	+1	+1	6,0	90	4,0	6,0	0,092	0,2	12
3	+1	+1	+1	-1	6,0	90	4,0	0,0	0,093	0,2	12
4	+1	+1	-1	-1	6,0	90	0	0,0	1,695	3,6	7
5	+1	-1	-1	-1	6,0	70	0	0,0	1,451	3,5	7
6	-1	-1	-1	-1	2,0	70	0	0,0	1,497	4,0	7
7	+1	+1	+1	0	6,0	90	4,0	3,0	0,091	0,2	12
8	+1	+1	0	0	6,0	90	2,0	3,0	0,0396	0,4	11
9	+1	0	0	0	6,0	80	2,0	3,0	0,397	0,4	10
10	0	0	0	0	4,0	80	3,0	2,0	0,402	0,3	11
11	+1	+1	-1	0	6,0	90	0,0	3,0	1,201	3,2	8
12	+1	-1	0	0	6,0	70	2,0	3,0	0,395	0,4	7
13	-1	0	0	0	2,0	80	2,0	3,0	0,389	0,4	10
14	-1	-1	0	0	2,0	70	2,0	3,0	0,392	0,5	10
15	-1	-1	-1	0	2,0	70	0,0	3,0	1,324	3,9	9
16	+1	-1	+1	-1	6,0	70	4,0	0,0	0,98	0,6	12

The basic regularities of influence of separate additional components of mastics on operational properties of the formed surface of coverings characterize ability to provide successful counteraction to climatic influence and longer stability are revealed. As a result, mastics acquire an additional resource.

As expected, the general patterns of changes in physical and mechanical properties are common, which allows not only to provide an assessment of the results, but also with a certain degree of probability to predict further changes in operational reliability by stabilizing the coating structure.

3. Experimental Consideration

3.1 Simulation Experiment

After the mathematical transformations using the correlation-regression apparatus, the dependences included in the final model for determining the influence of the values of the components on the technological characteristics of the coatings are obtained:

$$Y1 = 0{,}61962+0{,}161X1-0{,}1607X2-0{,}3422X3-0{,}325X4+0{,}206X1X2-0{,}021X1X3-0{,}16X1X4+0{,}045X2X3+0{,}137X2X4+0{,}221X3X4$$

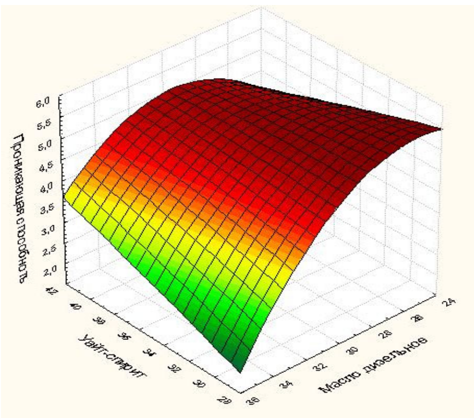
$$Y2 = 1{,}29412+0{,}2176X1-0{,}2882X2-0{,}9882X3-0{,}676X4+0{,}676X1X2-0{,}082X1X3-0{,}229X1X4+0{,}282X2X3+0{,}276X2X4+0{,}629X3X4$$

$$Y3=9{,}2353+2{,}9412X1+1{,}2941X2+1{,}29412X3-1{,}235X4+2{,}941X1X2+1{,}765X1X3-1{,}824X1X4+2{,}588X2X3+1{,}824X2X4+1{,}235X3X4$$

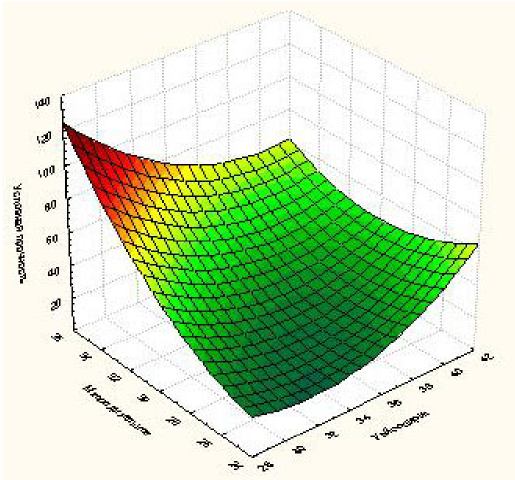
To build a 4-factor model, one of the factors must be taken in turn at a certain level of the variation interval. To do this, we obtained the optimal points and values of functions at these points:

$$Y1 \rightarrow min;\ opt[(4;\ 80;\ 3;\ 2)] = 0{,}095\%$$
$$Y2 \rightarrow min;\ opt[(4;\ 80;\ 3;\ 2)] = 2{,}8\ mm$$
$$Y3 \rightarrow min;\ opt[(4;\ 80;\ 3;\ 2)] = 93{,}33\ MPa.$$

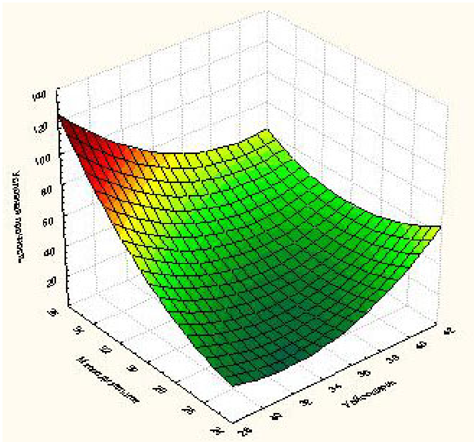
As can be seen from the results of research, there are certain patterns according to which diesel oil gives a certain hydrophobicity and wettability of the surface. It is important that all components of mastic are stored for a long time as a part of coverings and give them the increased properties. Based on the graphical patterns of Figure 1, the optimal content of additives is wt. particles for diesel oil - 3, white spirit (kerosene) - 4, superfine filler - 2, mastic 80 m.h.



a)



b)



c)

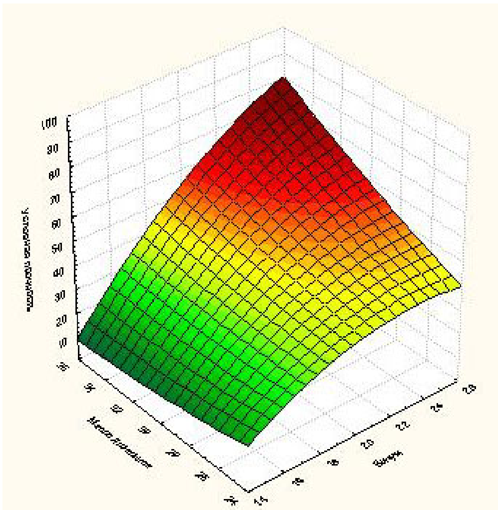


Figure 1: Dependence of the performance of the coating on the content of components in the repair composition

These additives play a role in enhancing the water-repellent capacity, as, firstly, eliminate the need to provide additional dehydration of the surface of screeds or worn bitumen-roofing carpet, and secondly, give the coating sufficient adhesion in the contact areas.

Table 2: Dependence of water displacement parameters on the technology of coating formation

№ type of coatings	Type of coatings	The amount of water released from the cotton wool (%)	Rating
1	A mixture of 3 wt. particles of white spirit up to 1 wt. particles of diesel oil	13	worse than the norm
2	A mixture of 3 wt. particles of white spirit up to 1 wt. the proportion of diesel oil and 0.6 wt. bitumen particles	24	norm
3	A mixture of 3 wt. particles of white spirit up to 1 wt. the proportion of diesel oil and 0.6 wt. bitumen content, 0.05 wt. rubber particles	43	above normal
4	A mixture of 3 wt. particles of white spirit up to 1 wt. the proportion of diesel oil and 0.6 wt. bitumen content, 0.05 wt. rubber particles	68	above normal
5	A mixture of 3 wt. particles of white spirit up to 1 wt. the proportion of diesel oil and 0.6 wt. bitumen content, 0.05 wt. rubber particles, mastic type "Tehron"	73	above normal

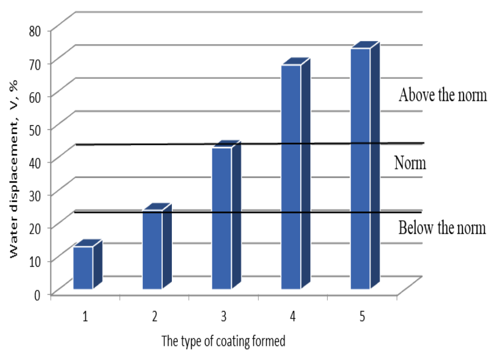


Figure 2: Water displacement indicators depending on the technology of restoration of worn coating

As can be seen from the above data, the best water-displacing effect occurs in the following sequence: mastic type "Tehron", a mixture of diesel oil and white spirit, mastic "Tehron" with additives of diesel oil and white spirit.

4. Conclusions

1. Certain patterns of the effect of enrichment of bituminous-rubber mastic with additives of diesel oil, white spirit and superfine filler indicate an increase in waterproofing resource by 1.6… 1.7 times due to long-term preservation of deformability and prevention of fragility, which results in three.

2. According to research results, the formation of a mastic coating with an additional waterproofing resource eliminates the risk of premature appearance and further accelerated development of defects under the influence of the wedging action of the water itself and its phase transitions. As a result, the inclusion of diesel oil in the composition of mastics, including as waste, as well as eliminating the need for prior complete dehydration of the surface and reducing the thickness of the formed coating provides opportunities to reduce the cost of all types of resources.

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