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Physical-Mechanical Properties of a Composition Based on Rubber Dust

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Abstract

The various properties of bitumen in a wide range make it possible to use them in various industrial fields. However, some characteristics (adhesion, low softening point, elasticity, etc.) of bitumen impair its performance.

This work is devoted to solving these shortcomings. To this end, we have modified oil road bitumen with polymer waste. As a result, a polymer-bitumen binder composition (HSP) was obtained, which provides operational requirements for asphalt concrete coatings.

It is stated that, as a result of the studies, HSP (Howling Scouring Polymer) was obtained, which in its physic mechanical indices surpasses unmodified auxiliary oil bitumen.

Key words: bitumen, modification. Oil refining, polymer waste, rubber waste, polyethylene waste, polymer-bitumen composition, physical and mechanical properties, vulcanization. Key words: bitumen, modification. Oil refining, polymer waste, rubber waste, polyethylene waste, polymer-bitumen composition, physical and mechanical properties, vulcanization.

Studies of tyro wastes in the production of asphalt concrete

Different properties of bitumen in a wide range enable their use in various industrial forests However, some characteristics (adhesion low softening temperature elasticity, etc.) of bitumen deteriorate its operating properties. This work is devoted to the solution of these shortcomings. To this end, we have modified the oil road bitumen with polymer waste. The result is a polymer-bitumen binder (PBB), which devalues the operational requirements for asphalt concrete coatings. Shown that the studies obtained a WSP which according to its physical and mechanical properties are superior to non-modified oil bitumen.

CHARACTERISTICS AND PURPOSE OF THE PRESENT WORK.

Oil road bitumen change their physicochemical parameters in a large range (temperature, cold resistance, ductility, elasticity, adhesion-cohesion, resistance to aggressive media, high dielectric strength, etc.) and, compared with a low cost, make it possible to use them in various fields.

Oil bitumen can be used in agriculture, construction and many other industries [1-8].

Bitumen used in the performance of gluing waterproofing is the remainder of the distillation of petroleum products. It is a solidlooking, black shiny mass that, when exposed to prolonged loads, retains plasticity even at low temperatures.

Over time, during storage and in operating conditions under the action of sunlight and oxygen, the composition and properties of bitumen change: they increase the relative content of solid and brittle components and, accordingly, the number of oily and resinous fractions decreases, and therefore brittleness and hardness increase (process aging). Therefore, the process of bitumen modification is very relevant.

It is possible to improve the properties of bitumen by combining them with polymer additives.

The analysis of the data obtained by us showed that, according to a set of parameters, the greatest potential for improving the properties of bitumen binders has a crumb of general purpose rubbers, including tire.

Currently, in the construction of roads for the manufacture of asphalt concrete pavements, bitumen-polymer compositions are used as a binder, and for this purpose the expensive polymer DST -30 thermoplastic elastomer is used.

Typically, road oil bitumen have a plasticity interval, usually no higher than 60-65 C, which is clearly not enough for the device of external coating layers in the climatic conditions of most regions. In addition, viscous road bitumen has practically no elastic properties, on which the stability of composite materials, such as asphalt concrete, to destruction under the influence of cyclic loading depends. Therefore, bituminous binders fundamentally require modification and improvement of physical and mechanical properties, since by their very nature they cannot provide the necessary durability of asphalt concrete pavements of roads in the conditions of increasing traffic loads.

According to a set of parameters, the greatest potential for improving the properties of bitumen binders has a crumb of general purpose rubbers, including tire.

The key link in which the individual parts of the complex problem can be joined and the tasks set must be solved should be the technology of combining rubber waste with oil bitumen, taking into account all the complexity and chemistry of the processes both in the cementitious and in the final products - asphalt concrete pavements when they are constructed and operation.

Based on the above principles, we have developed a technology for producing rubber-bitumen compositions by modification of bitumen with rubber waste in the form of fine crumbs and investigated the properties of the resulting compositions.

The various properties of bitumen in a wide range make it possible to use them in various industries. However, some characteristics (adhesion, low softening point, elasticity, etc.) of bitumen impair its performance. [1, C.131-134].

Recently, bitumen modified with rubbers or other polymers have been widely used in the production of bituminous asphalt mixtures.

The greatest distribution in the production of building materials was obtained by rubber containing components(UCC) , previously processed into rubber crumb (RC).

The rubber crumb obtained as a result of processing worn tire covers has numerous and promising areas for further practical use, which, when

It is known that for over a hundred years, numerous efforts have been made to combine rubber with bitumen and asphalts in order to utilize it and give rubber-like properties to binders. [2, C.8].

The process of mixing bitumen with rubber powder is accompanied by a change in the basic properties of bitumen: there is an increase in heat resistance, a decrease in the temperature of brittleness, an increase in deformability.

As can be seen from tables 1 and 2, the optimal amount of additive in bitumen is 4-5%. In this case, the decrease in the needle penetration depth does not exceed 19% for bitumen of the road oil bitumen(ROB) 60/90 grade, and 28% for bitumen of the road oil bitumen(ROB) 90/130 grade. In this case, the extensibility decreases from 98 to 170.1 mm and from 100 to 260 mm, respectively. However, underestimated values of extensibility can be considered quite acceptable.

The duration of a single exposure to dynamic load during the passage of the vehicle is about 0.1-1.5 mm, and the deformation rate corresponds to values of about 600-1000 cm / min. Relative temperature deformations in asphalt concrete pavement also do not exceed 0.001.The analysis of our data showed that the complex has the greatest potential for improving the properties of bitumen binders, has a crumb of general purpose rubbers, including tire. In this case, the problem with raw materials is completely eliminated, since the production of rubbers and polymers is mainly monopolized, while the production of rubber crumb does not have these restrictions, the existing equipment for the production of rubber crumb can easily be deployed if there is a noticeable demand for it.Rubber, being an elastomeric material with a unique set of properties, is a particularly large-tonnage product of chemical technology, one of the end products of the oil and gas processing chain, which is widely used in various industries. The scale of production of rubber products is extremely large and the scale of rubber waste generated is also large. No reduction in rubber production is expected in the near future. [3] An inexhaustible source of high-quality elastomeric raw materials for improving the properties of binders. [4-5].

Obviously, the key link that allows the individual parts of the complex program to be joined and the tasks set should be solved should be the technology for combining rubber wastes with oil bitumen, taking into account the complexity and chemistry of the processes, both in the cementitious and in the final products - asphalt pavements with their device and operation

Moreover, the problem must be solved on the basis of their necessary and sufficient parameters of road surfaces, and not from empirical ideas about the usefulness of rubber in bitumen. [6-7]

Table 1

The main properties of the source and extracted bitumen

Name of components	№ samples				
	1	2	3	4	5
	The content of the mass parts				
Bitumen	100	100	100	100	100
RC	2	4	6	8	10
Sulfur	-	-	-	1	2

As a result of the application of this technology, cementitious materials should be designed and obtained, which should significantly and, most importantly, permanently improve the asphalt surfaces of roads. And the main attention should be paid to improving the properties of domestic low-quality oxidized bitumen.

Only in this case is it possible economically and technically effective solution to the problem of rubber waste.

The service life of asphalt concrete coatings prepared using asphalt binders modified with the new technology is 3 times longer than the service life of coatings using unmodified bitumen under the same operating conditions.

Coatings can reduce the noise and vibration level by 2 times, reduce the possibility of ice crust formation, increase adhesion, shorten the braking distance and, in addition, can have a thickness of 1.5-2 times less.

To modify the oil grade bitumen(ROB 25/40, ТБ 70/30 and Ваки 85/25 used rubber waste. The rubber dust formulation and composition are shown in Table 2 and 3, and the physical and mechanical properties of the bitumen used are shown in Table 4.

Subsequently, on the basis of the obtained mineral powders and active bitumen (B75), an asphalt concrete mixture was prepared with the composition: (mass part -46); mineral powder -26; bitumen -10; high molecular weight petroleum acid -2.

Table 2

The composition of the composition based on rubber crumb (RC).

Composition components	The content of components, mass. H. By examples								
	1	2	3	4	5	6	7	8	9
Rubber crumb	-	5	10	15	20	25	30	35	40
Bitumen	200	200	200	200	200	200	200	200	200
Filler	200	200	200	200	200	200	200	200	200
High molecular weight petroleum acid	150	-	-	-	25	40	50	60	80
HWPA (High-molecular Weight Petroleum Acid)	-	-	-	-	10	10	10	20	20
The mixing temperature of the components in the mixer, ° C	100	70	90	100	160-180	70	90	70	100
Mixing time, min	15	10	12	15	65-120	10	12	10	15

In a number of experiments, the active tire rubber powder was first mixed with the mineral components of asphalt concrete using standard mixing equipment, then the mixture was poured with hot bitumen and additionally mixed for only 50-100 seconds.

Despite such a short mixing time, an effective formation of strong bonds between the particles of rubber powder, bitumen molecules and mineral components of the mixture occurs. As a result, the temperature coefficient of the strength of asphalt concrete is significantly reduced, the softening temperature of the road surface does not increase.

Table 3

The composition of bitumen-polymer compositions

№	Indicators	Samples				
		1	2	3	4	5
1.	Penetration of a needle at 25 ° C	38	72	100	71	96
2.	Softening point, ° C	49	68	82	56	75
3.	Fragility temperature, ° C	-10	-10	-26	-8	-20
4.	Tensile at 25 ° C	40	60	70	55	60
5.	Density, g / cm 3	2,34	2,36	2,38	2,2	2,4
6.	Temperature changes at T = 65 ° C for 5 hours	7	6	6	6	6
7.	Tensile strength at 20 ° C	2,4	3,0	3,5	3,1	3,4
	at 50 ° C	0,9	1,0	1,2	1,1	1,3

For example, the introduction of 2 wt.% Active rubber powder into grade A asphalt with good properties leads to a doubling of its softening temperature, while the frost resistance and elasticity of asphalt concrete increase. As shown by laboratory studies, this technology of introducing active rubber powder is not accompanied by the destruction of macromolecules, which provides quite satisfactory elastic properties of the road surface. Fine soot from rubber, in large quantities falling into bitumen, became an additional source of crystallization centers, sharply lowering the stability of binders, their resistance to aging and degradation of properties. Rubber, being an elastomeric material with a unique set of properties, is a particularly large-tonnage product of chemical technology, one of the end products of the oil and gas processing chain, which is widely used in various industries. The scale of production of rubber products is extremely large and the scale of rubber waste generated is also large. Reduced rubber production in the near future is not expected. For the same reasons, the methods of introducing highly dispersed rubber powders with a highly developed and modified surface into bitumen did not justify themselves. With the introduction of such highly active additives, the usual methods of handling bitumen binders significantly changed, for example, their shelf life at technological temperatures was sharply reduced. Rubber, compared with rubbers, is much more resistant to the oxidative effects of oxygen. It is highly resistant to water and salt solutions. In addition, an important feature of rubber crumb, especially tire crumb, is the presence of special chemicals - antioxidants, antioxidants and others. Their presence can increase the resistance of the binder to oxidative degradation under operating conditions. Since the rubber in tires, even worn out, has an excellent level of chemical quality, it can be confidently stated that this type of waste, when properly processed and properly used, becomes a particularly valuable secondary raw material. A complementary combination of the beneficial properties of two different components is the idea of new cementitious materials for asphalt concrete. In our work, the main attention was paid to improving the properties of domestic low-quality oxidized bitumen. Only in this case is a technically and economically feasible solution to the problem of rubber waste disposal possible. The introduction of the active powder leads to a sharp decrease in these properties (table 4. and 5).

Table 4

Physical-mechanical properties of a composition based on rubber dust

Names of indicators	Samples			
	1	2	3	4
Ultimate compressive strength, MPa, At a temperature of 20 ° C 50 ° C	 2,2 0,9	 - -	 - -	 - -
The coefficient of water resistance,%	0,90	-	0,95	0,89
The coefficient of water resistance during prolonged water saturation,% by volume	0,86	0,90	0,94	0,90
Swelling,% by volume	0.6	0,9	0,5	1,0
Residual porosity,% by volume	2,1	2,4	2,0	2,3

The obtained granulated bitumen-rubber composition was tested according to standard methods specified in chapter II. The data are presented in tables 6, 7 and 8

Table 5

Indicators of physical and mechanical properties of asphalt mixtures

Names of indicators	Samples			
	1	2	3	4
Ultimate compressive strength, MPa, At a temperature of 20 ° C 50 ° C	 2,2 0,9	 - -	 - -	 - -
The coefficient of water resistance,%	0,90	-	0,95	0,89
The coefficient of water resistance during prolonged water saturation,% by volume	0,86	0,90	0,94	0,90
Swelling,% by volume	0.6	0,9	0,5	1,0
Residual porosity,% by volume	2,1	2,4	2,0	2,3

Table 6

Properties of bitumen-polymer compositions

Indicators	Indicator Values for Examples								
	1	2	3	4	5 prototype	6	7	8	9
Tensile strength, MPa	4,5	10,0	6,0	6,5	Breaks without load	7,0	8,0	5,0	9,5
Elongation at break,%	650	850	1100	780	-	900	900	700	830
Shore A hardness, Con, unit, усл. Ед	63	50	35	58	20	45	43	40	45
Polymer fluidity T=190 °C, P=49 H, q/10 min	18	20	40	35	100	30	35	30	25

The use of rubber crumb obtained by the processing of used car tires and other waste rubber products as part of bitumen is a promising area for their modification. The annual volume of such waste is millions of tons. They contain a large number of antioxidants, antioxidants, providing high resistance of the material to heat and thermal oxidative degradation.

The introduction of crumb rubber in bitumen allows to obtain a binder, which provides a significant improvement in the deformability and crack resistance of asphalt concrete.

Table 7

Physical -mechanical properties of crushed stone-mastic asphalt concrete with the introduction of Thermoplastic Polyethylene on stone materials

№	The name of indicators	Norms on GOST 31015-2002	0 %	0,1 %	0,2 %	0,3 %	0,5 %
			Thermoplastic Polyethylene				
1	Density (bulk density), g / cm3	-	2,39	2,40	2,40	2,41	2,41
2	Residual porosity,%	2,0–4,0	3,761	3,358	3,358	2,956	2,956
3	Water saturation,% by volume	1,5–4,0	2,82	2,33	2,23	2,16	2,01
4.	Tensile strength in compression, MPa at temperature: 200 ° C 500 ° C	- 2,5-0,70	3,29 0,75	3,52 0,87	3,67 1,00	3,99 1,11	4,12 1,12
5.	Water resistance coefficient	-	0,86	0,92	0,94	0,95	0,97
6.	The coefficient of water resistance during prolonged water saturation (15 days.)	0,75	0,79	0,86	0,88	0,91	0,92
7.	Fracture resistance - tensile strength at split at a temperature of 0 ° C, MPa	3,0 – 6,5	3,48	3,82	3,99	4,21	4,16
8.	Coefficient of internal friction tg	0,94	0,89	0,90	0,92	0,92	0,91
9.	Shear grip at 500 ° C, MPa	0,20	0,18	0,33	0,57	0,60	0,65
10.	The binder runoff index,%	0,20	0,24	0,19	0,18	0,15	0,13

However, as noted by the authors of many works [8, C.923], [9, C.1-4]. despite the obvious advantages over other modifiers, the use of tire rubber in road construction until recently has been restrained mainly by the technological difficulties of combining rubber with bitumen. Thermoplastic Polyethylene has the form of granules of dark color, irregular spherical shape with a bulk density of 0.3-0.4 g / cm3. The results of the studies showed that when Thermoplastic Polyethylene is kept in heated bitumen at temperatures of 140–160 ° C and constant intensive mixing in a laboratory mixer, the bulk of the additive (up to 80%) is melted and evenly distributed in bitumen after 15 minutes. Under these conditions, mainly the polymer component of the granules melts, forming a polymer-bitumen binder with high molecular weight bitumen compounds.

Table 8

Physical-mechanical properties of crushed stone-mastic asphalt concrete with the introduction of Thermoplastic Polyethylene on stone materials

The name of indicators	Norms on GOST 31015-2002	0 %	0,1 %	0,2 %	0,3 %	0,5 %
		Thermoplastic Polyethylene				
Density (bulk density), g / cm3	-	2,38	2,39	2,395	2,406	2,410
Residual porosity,%	2,0-4,0	3,64	3,57	3,13	2,46	1,83

Water saturation,% by volume	1,5-4,0	3,07	2,68	2,52	2,33	2,05
Ultimate compressive strength, MPa at temperature: 200 ° C 500 ° C	- 2,5 - 0,70	3,51 0,72	4,08 0,78	4,26 0,85	4,59 0,89	4,72 0,92
Coefficient of variation R50	0,18	0,07	0,08	0,09	0,03	0,15
Water resistance coefficient	-	0,85	0,88	0,90	0,92	0,94
The coefficient of water resistance during prolonged water saturation (15 days.)	0,75	0,83	0,84	0,87	0,89	0,91
Fracture resistance - tensile strength at split at a temperature of 0 ° C, MPa	3,0 – 6,5	3,95	4,36	4,58	4,75	4,66
Coefficient of internal friction tg	0,94	0,91	0,92	0,92	0,93	0,93
Shear grip at 500 ° C, MPa	0,20	0,20	0,32	0,55	0,59	0,63
The binder runoff index,%	0,20	0,20	0,19	0,15	0,13	0,11

The unbelted rubber particles of rubber crumb, present in the additive, partially subjected to swelling and destruction already in the process of preparing the granules, being in suspension in the resulting HSP, form a new reinforced mesh structure with it.

Larger, non-molten rubber-rubber fragments of Thermoplastic Polyethylene granules subsequently, when combining HSP with mineral materials, dispersive reinforce the system, contributing to the formation of a stable high-strength asphalt concrete.

As can be seen from the tab. 4–8, the optimal amount of Thermoplastic Polyethylene additive in bitumen is 4–5%. In this case, a decrease in the penetration depth of the needle (penetration) at 25 ° C does not exceed 19% for bitumen of the road oil bitumen (ROB) grade 60/90, and 28% for bitumen of the ROB grade 90/130, while the elongation decreases accordingly from 98 to 17 · 0. 1 mm and from 100 to 26 · 0.1 mm.

However, underestimated values of elongation can be considered quite acceptable. In a number of works [1, C142.], [10, C.923] it was shown that high values of this indicator indicate only the homogeneity of the binder, but can cause a decrease in the shear stability of the coating. In the regulatory documents of many countries, probably for this reason, the index of extensibility is not regulated.

The standard method for determining elongation does not reflect the actual operating conditions of bitumen in the road structure. The duration of a single impact of dynamic load during the passage of the vehicle is about 0.1-0.01 s.

When rubber contacting components is added to bitumen, as can be seen from Figure 1, the binder softening temperature rises significantly, the ductility interval and elongation at ° C increase, and a slight decrease in the brittleness temperature is also observed.

The studies also made it possible to establish that the introduction of Thermoplastic Polyethylene additives in bitumen binders increases their adhesion to stone materials.

However, this increase is insignificant, from 2 (initial bitumen) to 3 points with the addition of Thermoplastic Polyethylene (on a five-point scale). To improve this indicator, it is desirable to use ASC (Active Substance Coefficients) additives. The combination of Thermoplastic Polyethylene with ASC in a modified binder, as shown by our studies, provides high shear resistance, crack resistance, and water resistance of asphalt concrete.

The study of the durability of roofing materials based on polymer-bitumen compositions

In this study, we provide a calculation-experimental method for predicting the durability of roofing made on the basis of bitumen and polymer-bitumen compositions. The calculations are based on the principle of summing stresses, when under the influence of various reasons, the test material loses a certain share of durability (Bailey criterion). The results allow us to conclude that the preferred use of polymer-bitumen materials in the installation of roofing in the Krasnodar Territory.

The most common materials for roofing and waterproofing work are oil bitumen and roofing material. However, coatings made using bitumen have a relatively low durability (6-10 years) due to fragility at low winter temperatures. Therefore, such coatings need frequent repair, and after 10 years of operation, their cost almost doubles.

More modern waterproofing materials based on polymer-bitumen compositions, which made it possible to expand the temperature range of operability by increasing heat and frost resistance and, thus, provide higher reliability and durability of structures. In addition, the addition of polymers, changing the properties of bitumen, allows mechanizing the work on the device of roofs, for example, surfacing, rather than sticking roofing materials, which greatly facilitates and simplifies the work. It is known that the most important factors in the aging of bitumen in roofing are:

- thermal oxidation under the influence of ultraviolet radiation in a thin surface layer of 0.1-0.15 mm, as a result of which it intensively ages, cracks and rinses off with water, a coating 2 mm thick is completely destroyed within 6 years, and bitumen filled with mineral powder collapses in 12-15 years;

- thermal stress and cracking of the surface layer under the influence of forces arising in the coating due to the difference in the coefficients of linear thermal expansion of bitumen and concrete base (screed) with temperature.

With the known structural and rheological characteristics of materials as a result of seasonal changes in temperature, the prediction of durability is reduced to the determination of temperature stresses. - In the event that they do not exceed the limit of the long-term strength of the coating material at the design temperature, the condition of continuity of the coating is not violated.

Preparation and testing of samples and coating fragments was carried out in accordance with GOST 2678-97. Materials roll roofing and waterproofing. Test methods. The values of the temperature ranges for the study are determined by interpolation to the SH 2.01.01-82 Construction climatology and geophysics. So, for the city of Krasnodar, the number of days in a year with an average temperature of + 20 ° C is 95, + 10 ° C - 102, 0 ° C - 109, -10 ° C - 64, -20 ° C - 21, and with thunderstorms - 10 days.

The temperature stresses in the coatings were determined by the formula used for viscos-elastic bodies:

$$\sigma_t = (\alpha_n - \alpha_0)\cdot\Delta t\,\frac{E_y \cdot E_3}{E_3 + E_y(1-e^{t/\theta})} \le \sigma_0$$

where α_n - coefficient of linear thermal expansion for coatings, $\alpha_{n.áèò.} = 2{,}19\cdot10^{-4};$ 1/ degree;; $\alpha_{n.ïîëèáèò.} = 4{,}3\cdot10^{-4}$, 1/degree; α_0 -coefficient of linear thermal expansion for concrete screed, $\alpha_0 = 0,1 \cdot 10^{-4}$; 1/ degree; ; Δt - temperature difference; $E_y = \frac{\sigma_t}{\varepsilon_3}$ elastic modulus; Пa; $E_3 = \frac{\sigma_t}{\varepsilon_3}$ modulus of elasticity, Pa; $\theta = \frac{Z_0}{E_3}$ - relaxation time, c; $Z_0 = \frac{\sigma}{d\varepsilon / dt}$ highest structural viscosity, η

The values of structural and rheological constants were established as a result of testing coating samples and constructing rheological curves (Table 9).

Table 9

Structural and rheological constants

t^0, C	Coating 1 (bitumen)				Coating 2 (polymer bitumen)			
	E_y, Po	E_3, Po	θ, c	α_k, 1/degrees	E_y, Po	E_3, Po	θ, c	α_k, 1/degrees
+20°C	2,5-10^6	2,18-10^6	4,6-10^2	4,3-10^2	5,76-10^6	5,02-10^6	1,4-10^2	2,95-10^4
+10°C	6,3-10^6	5,45-10^6	11,1-10^2	-	7,9-10^6	6,84-10^6	3,39-10^2	-
0°C	1,55-10^7	1,15-10^7	27,2-10^2	-	1,41-10^7	1,05-10^7	8,3-10^2	-
-10°C	3,9-10^7	2,94-10^7	1,51-10^3	-	2,59-10^7	1,95-10^7	1,55-10^3	-
-20°C	9,9-10^7	2,07-10^7	5,7-10^4	-	3,08-10^8	6,45-10^7	1,74-10^3	-
Thunderstorm during rain	6,3-10^6	6,3-10^6	11,1-10^2	-	7,9-10^6	6,84-10^6	3,39-10^2	-

Calculations of temperature stresses arising in coatings at different temperatures are given in table 10

Table 10

Temperature stresses in coatings

Stress σ_t	σ_t in the temperature range, Pa					
Type Covered	+20°C	+10°C	0°C	-10°C	-20°C	Thunderstorm
Oil Polymer bitumen 70/30)	4,86	12,24	27,7	70,24	90,7	62,5
Polymer bitumen “The cream”	5,57	7,62	12,5	2,14	43,36	38,17

The calculation of the strength of the reinforcing material (Ruberoid-cardboard, “crunches” -glass mesh) was carried out according to the formula:

$$R_\alpha = K \delta_n b_n \sigma_t$$

where К – safety factor К = 2,5; δ_n - the thickness of the coating mass (accepted for roofing material РКМ 350-2,5 mm, for "cream" -3 mm); b_n - the estimated bandwidth of the material (taken = 50 mm according to GOST 2678-97. Materials roll roofing); σ_t - temperature stresses:

- for Ruberoid $\sigma_{t.\max} = 90{,}7$ Pa;

- for "rename" $\sigma_{t.\max} = 43{,}36$ Pa;

$$R_{\alpha_1}^{\max} = 2{,}5 \cdot 0{,}4 \cdot 5{,}0 \cdot 90{,}7 = 90{,}7 \text{ Pa.}$$

$$R_{\alpha_2}^{\max} = 2{,}5 \cdot 0{,}4 \cdot 5{,}0 \cdot 43{,}36 = 216{,}8 \text{ Pa.}$$

Полученные результаты сравниваем с прочностью на разрыв армирующего материала:
- for Ruberoid RKP-350 - 350 H/5sm;
- for "rename ST 3,5 (B) - 750 H/5sm.

When calculating the durability of roofing coatings, we used the experimental data presented in [1], which examined the patterns of changes in the durability of polymer bitumen compositions as a function of temperature (temperature range +20 ... -20 ° C) and current stresses (Table 11).

Table 11

Durability of materials at a certain temperature

True of cocking	σ_t в in the temperature range, Po					
	+20°C	+10°C	0°C	-10°C	-20°C	Thunderstorm during rain
Polymer bitumen (Ruberoid)	52	44	62	20	11	0,4
Polymer bitumen «crinum»	240	280	890	250	76	0,79

The calculation is based on assumptions under which temperature and stresses change continuously, and the fracture process is irreversible according to the Bailey criterion (principle of stress summation). Under the influence of different stresses, the material each time loses a certain share of durability, and when the sum reaches unity, it breaks.

After determining the values of the durability of the coatings at various temperatures, depending on the current stresses, the total durability of the materials was determined by the formula:

$$\tau_{(\sigma.t)} = \frac{100}{\frac{P_1}{\tau_1} + \frac{P_2}{\tau_2} + \ldots + \frac{P_n}{\tau_n} + \frac{g}{\tau_g}}$$

where $P_1, P_2 \ldots P_n$ is the percentage of days in a year with a temperature of $T_1, T_2 \ldots T_n$;; $\tau_1, \tau_2 \ldots \tau_n$ -durability of the material, respectively, at temperatures $T_1, T_2 \ldots T_n$.

Thus, the calculation and experimental method for predicting the durability of the coating is reduced to experimental studies of the properties of the coating material under various test conditions and further calculating the durability of these coatings.

This paper presents the results of computational and experimental studies of the durability of coatings made of different materials:

- 1 layer of roofing material PCM (Polymer Composition Material) -350 for molten glass bitumen;

- surfaced roll material "crunches" of ST 3,5 (B) grade in two layers of roofing material PCM -350 on bitumen mastic.

Since the most common cause of the destruction of roofing materials is the formation of cracks due to the difference in temperature deformations of the coating and the base or coating layer and the base, therefore, for comparative studies of the resulting temperature stresses, the following were taken:

- waterproofing coating of bitumen Oil Bitumen -IV (Oil Bitumen 70/30) - for roofing material PCM -350;

- waterproofing coating of a polymer-bitumen composition (Oil Bitumen 70/30 + 10% copolymer of ethylene with propylene) - for "rename".

Comparison of the standard properties of roll materials with a polymer-bitumen coating mass and roofing material was reduced to determining changes in structural-rheological and physic-mechanical properties, including weather resistance and water resistance, and as a result, the service life and reliability of these materials were determined.

The predicted durability of the coating materials calculated by this formula for the conditions of Baku amounted to:

- for bitumen Oil Bitumen 4 (roofing material) - 10.1 years;

- for polymer bitumen " crinum "- 24.7 years.

The results allow us to conclude that the preferred use of polymer bitumen materials for the installation of roofing in cities

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