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STUDY ON THE EFFECT OF BUTONAL NX4190 POLYMER LATEX ON THE PROPERTIES OF BITUMEN BINDER AND ASPHALT CONCRETE

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Abstract. This article deals with the results of the study on the effect of technological parameters of the Butonal NX4190 cationic polymer latex modification on the physical and mechanical properties of road bitumen and various types of hot dense asphalt concrete and crushed-mastic asphalt concrete. The modification technological parameters were the content of the modifier and the modification time. The modification temperature was constant. The optimal amount of polymer latex for modification was determined according to the criteria for improving the physical and mechanical properties of bitumen and asphalt concrete.

Keywords: polymer-modified bitumen, cationic latex, hot dense asphalt concrete, crushed-mastic asphalt concrete.

1. Introduction

The growth of road traffic intensity in Western Europe and the USA in the early 1960s resulted in the search for improving existing materials for the production of asphalt concrete.[1] One of the effective ways to improve the quality of asphalt concrete is its modification with various polymer materials. However, over many years of experience of polymers application in road construction, it has been noted that despite the general trend of increasing strength indicators of modified asphalt concrete, in many cases (especially in Ukraine) the results differ depending on the manufacturer.[2-5]

Taking into account that the road traffic intensity and load in Ukraine are growing the same as in the whole world, the requirements for the quality of asphalt concrete and its components are also growing. Road bitumen as one of the main components of asphalt concrete is produced at Ukrainian plants but its quality is insufficient. This, leads to the appearance of cracks, potholes, ruts, *etc.*, on the pavement surface.[6-8] An alternative solution for improving the rheological behavior of bitumen is its modification with corresponding polymers, in particular in the form of latexes. These polymers have additional flexibility at low temperatures and extra load-bearing resistance. However, taking into account that domestic road bitumen differs from that used in the USA and Western European countries, the question arose of studying the influence of such modifiers on the properties of road bitumen used in Ukraine. Butonal NX4190 cationic latex was chosen as a polymer modifier, due to its popularity for improving the properties of bituminous binders and asphalt concretes abroad. An important factor that affects road bitumen is the resistance to technological aging processes, which must be within acceptable limits.[9] In addition, there is a negative experience of non-compliance with all parameters of technology due to the lack of machines and mechanisms, as well as the lack of training of personnel on the ground. This calls for additional research.

Therefore, the issue of bitumen and asphalt concrete mixtures modification is also relevant to this day and requires thorough research into the technology of their production, laying and compaction.[10-12]

2. Experimental

2.1. Determination of Parameters of Bitumen Modification with Polymer Latexes and Bitumen Properties

To fulfill the task, in the conditions of the research laboratory "Educational Research and Production Center of Transport Construction of the National Transport Univer-

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sity" at the Department of Bridges, Tunnels and Hydrotechnical Structures, Butonal NX4190 modified bitumen in the amount of 2, 4, and 6 wt. % was produced with the help of a laboratory paddle mixer (Fig. 1), which allows us to meet the requirements for the preparation of polymer modified bitumen (PMB). The modification temperature was 448 K, modification time was 3, 6, and 9 h. This method was used in the development of the standard of the organization of Ukraine to produce bitumen modified with polymers and adhesives, using a laboratory paddle mixer.[13]

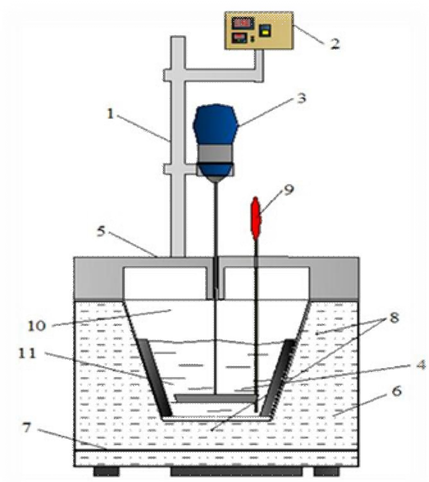

Fig. 1. Laboratory paddle mixer (side view): 1 – tripod; 2 – control unit; 3 – electric motor; 4 – paddle mixer; 5 – oil thermostat; 6 – oil tank; 7 – electric heater; 8 – thermocouple in an oil thermostat; 9 – thermocouple for modified bitumen; 10 – metal container; 11 – bituminous binder

Different amounts of polymer and modification time are necessary not only to set the optimal modification parameters, but also to determine the optimal amount of polymer latex and modification time, in order to obtain the maximum effect.

After the modification, PMB is subjected to laboratory tests according to DSTU 9116:202114 for the following parameters: penetration, softening temperature, elasticity and the same parameters after segregation during storage.

2.2. Raw Materials

Physico-mechanical indices of the initial bitumen of BND 70/100 grade are represented in Table 1.

By its chemical nature Butonal NX4190 is a high solid, cold-polymerized, cationic styrene-butadiene dispersion; physical form may be liquid or dispersion. Main features of the Butonal NX4190 are represented in Table 2.[15]

The preparation of different versions of hot asphalt concrete mixtures and crushed stone-mastic mixtures and concrete met Ukrainian standards.[16-18]

Granite crushed stone and limestone mineral powder were used for the production of asphalt concrete. The granulometric composition of the mineral part of asphalt concrete mixtures was selected according to the average curve in accordance with the requirements for each individual version of asphalt concrete.

Table 1. Physico-mechanical properties of road bitumen BND 70/100

Parameters	Unit	Value
Penetration at 298 K	dmm	97
Softening point	K	322
Ductility at 298 K	cm	355.6
Properties change after heating: residual penetration	%	95
Softening point change	K	275
Fraass breaking point	K	251
Flash temperature	K	513
Adhesion	%	90

Table 2. Main features of the Buttonal NX 4190

Solid content, %	EN ISO 3251	64
pH value	EN ISO 976	5.4
Viscosity, dynamic (at 296 K, 100 1/s), mPa·s	EN ISO 3219	250 - 2000
Density, g/cm^3		0.97
Tg, K	DSC	326

3. Results and Discussion

3.1. Determining the Optimal Amount of Polymer

When preparing polymer-modified bitumen, to achieve its best properties an optimal amount of polymer was initially determined.

The results of determining the penetration, softening point, and elasticity of bitumen modified with different amounts of polymer and produced at different times (3, 6, and 9 h) at a temperature of 448 K are shown in Figs. 2-7.

A significant change in the bitumen penetration (Fig. 2) occurs in the first three hours of its modification. After three hours its penetration value (298 K) decreased by 14 % (modified with 2 % polymer), 24 % (4 % polymer), and 29 % (6 % polymer); after 6 hours of modification the penetration value decreased by 18 % (2 % polymer), 32 % (4 % polymer), and 39 % (6 % polymer); after 9 h penetration decreased by 24 % (2 % polymer), by 34 % (4 % polymer), and by 42 % (6 % polymer). It is obvious that the rate of penetration decrease after 3 h of modification is higher compared with 6 h (*cf.* penetration decreased by 14, 24, and 29 % after 3 h and by 4, 11, and 13 % after 6 h for the samples modified with 2, 4, and 6 % polymer, respectively). The similar tendency is observed when comparing the penetration rate after 6 and 9 h of modification.

Thus, the modification time of 3 h was found to be the optimal one to establish a PBM constant viscosity, on the basis of which the grade of the obtained PMB can be established.

Analyzing the PMB tests according to the softening point (Fig. 3), which were carried out at different amounts of polymer and different times of its modification, we can conclude that a significant increase in this value occurs after the first three hours of binder modification with a polymer, namely: the softening point increased by 12 % (modification with 2 % polymer), 20 % (with 4 % polymer), and 42 % (with 6 % polymer). Subsequently, after six and nine hours of bitumen modification, the increase in the softening point decreases rapidly, and compared to the results after the first three hours of modification, it is as follows: with 2 % polymer the softening point increased by 3 %, with 4 % polymer – by 4 %, and with 6 % – by 3 %.

As for the results of determining the elasticity of bitumen modified with different amounts of Butonal NX4190 polymer at different modification times, it is obvious (Fig. 4) that a significant change in these values also occurs in the first three hours of modification: with 2 % polymer the elasticity increased by 51 %, with 4 % polymer – by 67 %, and with 6 % – by 83 %.

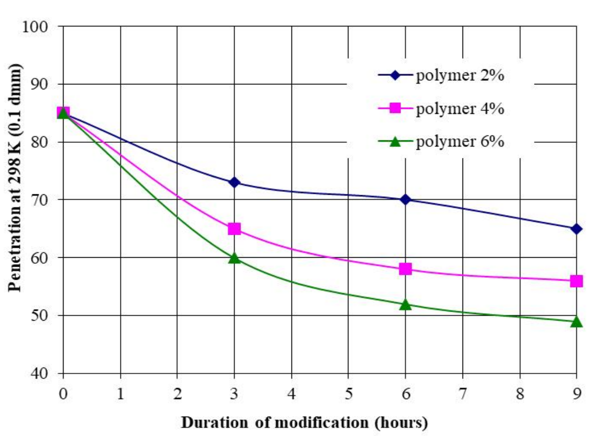

Fig. 2. PMB penetration at 298 K *vs.* modification time at different amounts of polymer

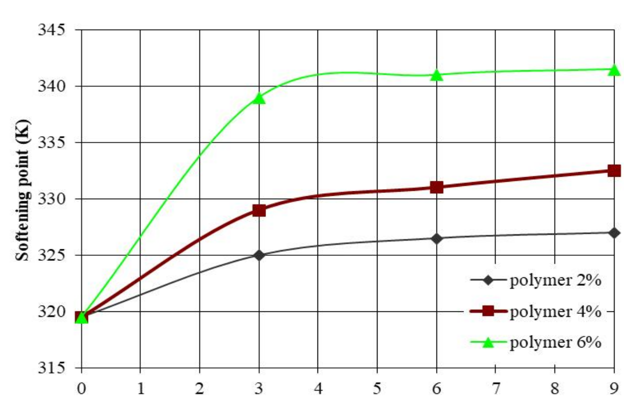

Fig. 3. PMB softening point *vs.* modification time at different amounts of polymer

The change in the penetration value (Fig. 5) depending on the polymer amount and the modification time after PMB segregation during storage was also investigated. Taking into account that after three hours of PMB preparation, the penetration (for the polymer amount of 2 %) before segregation during storage (Fig. 2) was 73 dmm, we compare it with the value after segregation during storage for 24 h. Thus, the upper part of the sample (Fig. 5) with 2 % polymer after three hours of PMB preparation showed penetration of 78 dmm, and the lower part - 62 dmm. According to the standard requirementss,[14] for BMPA 50/70-60 and BMPP 50/70-65, after segregation during storage the difference in penetration should be no more than 30 (298 K, 0.1 mm). Comparing penetration values of the upper and lower parts (78 and 62 dmm, respectively) we conclude that the investigated indicator meets the standard requirements,[14] since the difference between mentioned values (Fig. 5) is 16 dmm. The segregation of PMB in this case is insignificant – the upper part of the sample had a lower viscosity than the lower part due to the fact that the amount of polymer that was segregated transfered to the upper part of the tube during the test. The difference between the penetration value before segregation during storage is +7 % for the upper part of the sample and –15 % for the lower one.

Next, we compare the penetration of PMB with 4 % polymer after segregation after three hours of modification, which was 65 units before segregation during storage (Fig. 2). The upper part of the sample (Fig. 5) with 4 % polymer after three hours of PMB preparation showed a value of 70 dmm, and the lower part - 56 dmm, which in turn allows us to conclude that this indicator meets the requirements,[14] since the difference between the values is 14. The segregation of PMB in this case is insignificant – the upper part of the sample, similar to the previous one, also has a lower viscosity compared with the lower part due to the fact that the segregated polymer transfers to the upper part of the tube during conducting a test. The difference between the penetration value before segregation during storage is +8 % for the upper part of the sample and –14 % for the lower part.

For PMB with 6 % polymer we observed the similar regularities. The difference between the penetration value before segregation during storage is +8 % for the upper part of the sample and –30 % for the lower one.

The analysis of the PMB test results after segregation during storage was carried out only for the first three hours of PMB preparation because this time was determined to be the optimal one.

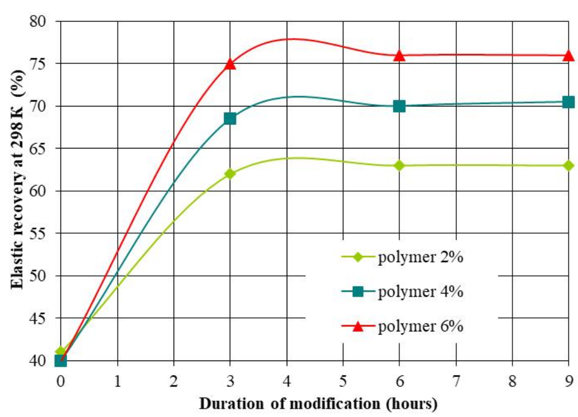

Fig. 4. PMB elasticity at 298 K *vs.* modification time at different amounts of polymer

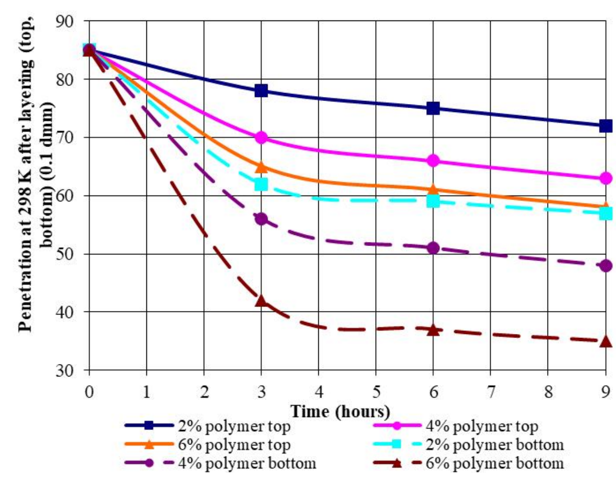

Fig. 5. PMB penetration (P25) after segregation *vs.* modification time at different amounts of polymer

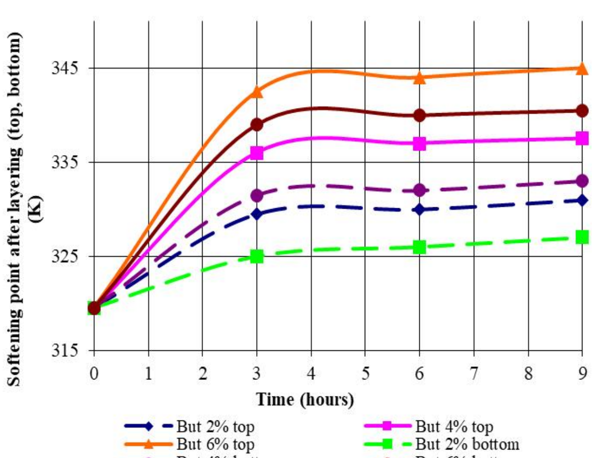

Fig. 6. PMB softening point (R&B) after segregation *vs.* modification time at different amounts of polymer

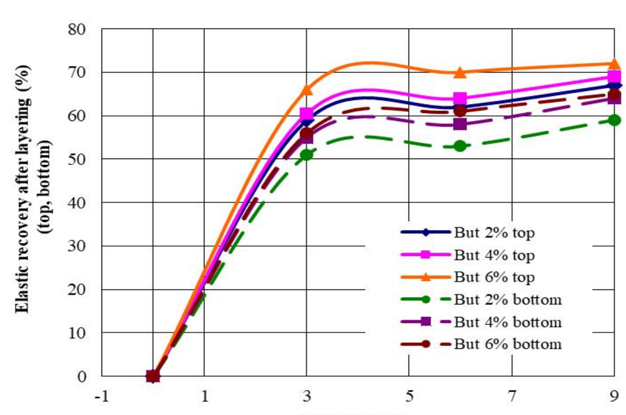

Fig. 7. PMB elasticity after segregation *vs.* modification time at different amounts of polymer

Let's analyze the obtained results regarding the softening point of PMB after segregation during storage (Fig. 6). The analysis is carried out based on the results obtained after the first three hours of PMB preparation, according to which, the difference in softening points should be no more than 8 K.

Before segregation the softening point of PMB with 2 % Butonal NX4190 polymer latex was 325 K (Fig. 2). After segregation during storage, the upper part of the PMB had a softening point of 329.5 K, and the lower part had 325 K. The difference is 4.5 K, which in turn indicates that the segregation occurred insignificantly, and this indicator meets the standard requirements.[14]

Using the same methodology, we estimate the difference in softening points of the upper and lower parts of the tube after segregation of PMB with 4 % and 6 % polymer. These indicators are as follows: PMB samples with 4 % polymer – 4.5 K, PMB samples with 6 % polymer – 3.5 K.

In order to objectively evaluate the results obtained, a test for elasticity after segregation during storage was conducted, although this indicator is not included in the list of requirements. One can see (Fig. 7) that all obtained results for elasticity after segregation during storage are higher than 50 %.

The analysis of the obtained results showed that the optimal amount of Butonal NX4190 latex is 2–4 %, and the optimal preparation time is 3–4 hours (Figs. 2–7). Under these parameters, we obtained PMB with a significant improvement in its properties in relation to unmodified bitumen.

3.2. Determination of Standard Physical and Mechanical Properties of Asphalt Concrete Modified with Polymer Latex

To establish the preparation time of the asphalt concrete mixture in order to ensure its homogeneity, studies on the physical and mechanical properties of asphalt concrete were previously carried out. The preparation time of the mixture varied from 30 s to 5 min, the preheating temperature of the starting materials met the requirements.[14]

Comparative results of the physical and mechanical properties of the tested asphalt concrete of different granulometry are shown in Figs. 8-37.

The results of determining the compressive strength (Figs. 8, 14, 20) at the temperatures of 273 K, 293 K, and 323 K made it possible to establish the optimal amount of bitumen: 7.5 % for type H, 6.0 % for B-10, 6.0 % for B-20, 6.5 % for SMA-10, and for 6.0 % for SMA-20.

The optimal amounts of PMB with 2 %, 4 %, and 6 % of Butonal NX4190 cationic polymer latex for various types of asphalt concrete were determined at 273 K, 293 K, and 323 K according to the compressive strength (Figs. 9-13, 15-19, 21-25): 6.2 % for B-10, 6.3 % for B-20, 8.0 % for H, 6.8 % for SMA-10, and 6.2 % for SMA-20.

When introducing this polymer latex in the amount of 3 % and 6 % directly in the mixture during its preparation, we have the following optimal amount of BND 70/100 bitumen for the asphalt concretes: 6.1 % for B-10, 6.2 % for B-20, 7 for SMA-10, and 6.1 % for SMA-20. The results of determining the physical and mechanical properties depending on the polymer amount showed that they increase even with a small amount of polymer latex.

When determining the compressive strength at 293 K for asphalt concrete of B-10 type (Fig. 9), we have the following results: at PMB with 2 %, 4 %, and 6 % polymer the R293 increases by 5, 14, and 20 %, respectively. When polymer latex is introduced directly into the mixture during its preparation in the amount of 3 % and 6 %, the R293 increases by 10 % and 13 %, respectively.

For asphalt concrete of B-20 type (Fig. 10), similar regularities are observed: at PMB with 2 %, 4 %, and 6 % polymer the R293 value increases by 9 %, 11 %, and 16 %, respectively. When polymer latex is introduced directly into the mixture (3 % and 6 %), the R298 value increases by 8 % and 13 %, respectively.

Asphalt concrete of type H (Fig. 11) shows an increase in R293 by 19 %, 33 %, and 39 %, respectively, at PMB with 2 %, 4 %, and 6 % of latex. The introduction of the polymer directly into the mixture during its preparation (3 % and 6 %) made it possible to increase the R293 index by 18 % and 38 %, respectively.

The results of the SMA-10 (Fig. 12) and SMA-20 (Fig. 13) tests show the following results: at PMB with 2 %, 4 %, and 6 % of the polymer the R293 index for SMA-10 increases by 13 %, 18 %, and 26 %, respectively, and by 16 %, 21 %, and 30 %, for SMA-20. The introduction of 3 % and 6 % polymer directly into the mixture made it possible to increase the compressive strength at 293 K by 15 % and 18 %, respectively, for SMA-10 and by 13 % and 25 % for SMA-20.

Asphalt concrete samples were also tested for compressive strength at a temperature of 323 K. In comparison with traditional asphalt concrete of type B-10 and B-20 (Figs. 15 and 16), the increase in the R323 index by 15 %, 40 %, and 45 % for B-10 and by 28 %, 34 %, and 40 % for B-20 occurs due to the use of PMB with 2 %, 4 %, and 6 % of polymer latex, respectively. When polymer latex (3 % and 6 %) is introduced directly into the asphalt concrete mixture during its preparation, the compressive strength at a temperature of 323 K for B-10 increases by 23 % and 33 %, respectively, and for B-20 – by 28 % and 35 %.

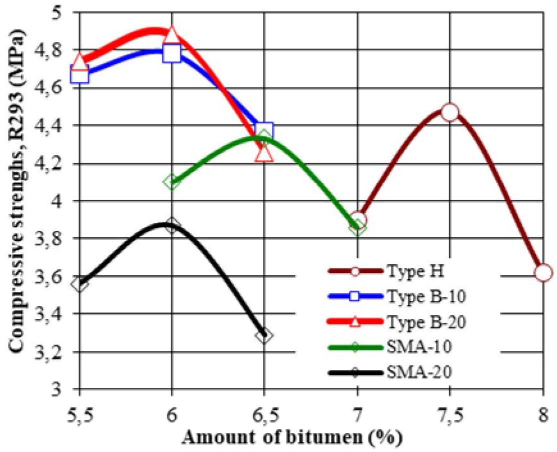

Fig. 8. Compressive strength R293 *vs.* amount of bitumen for asphalt concrete of different granulometry

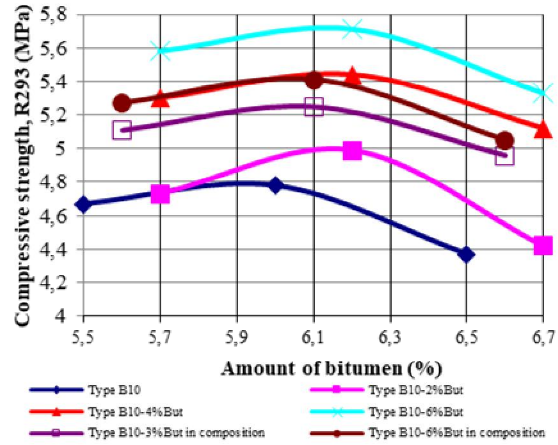

Fig. 9. Compressive strength R293 *vs.* amount of bitumen and polymer latex, type B-10

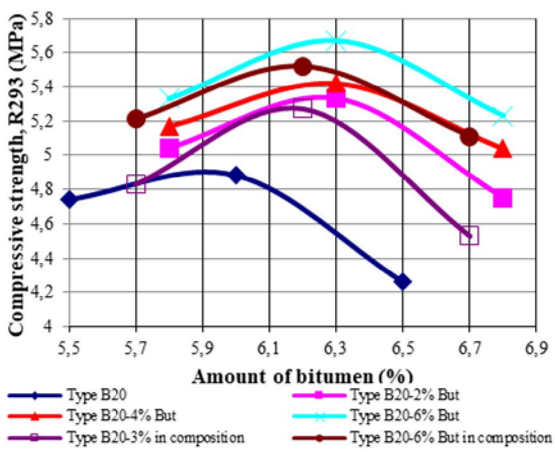

Fig. 10. Compressive strength R293 *vs.* amount of bitumen and polymer latex, type B-20

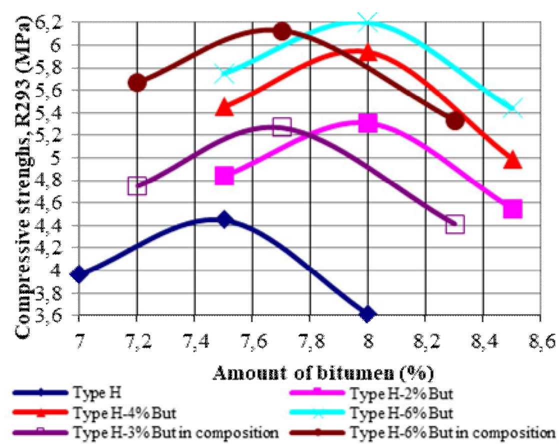

Fig. 11. Compressive strength R293 *vs.* amount of bitumen and polymer latex, type H

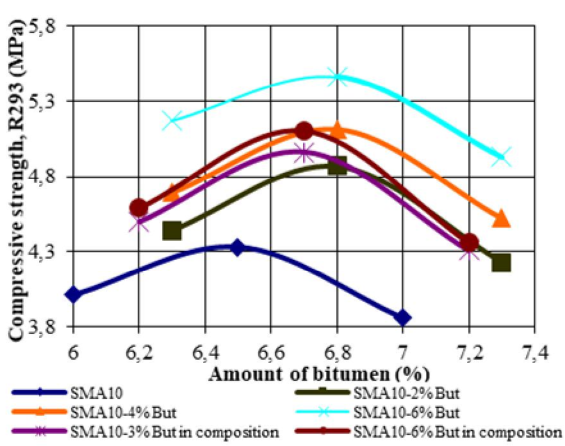

Fig. 12. Compressive strength R293 *vs.* amount of bitumen and polymer latex, type SMA-10

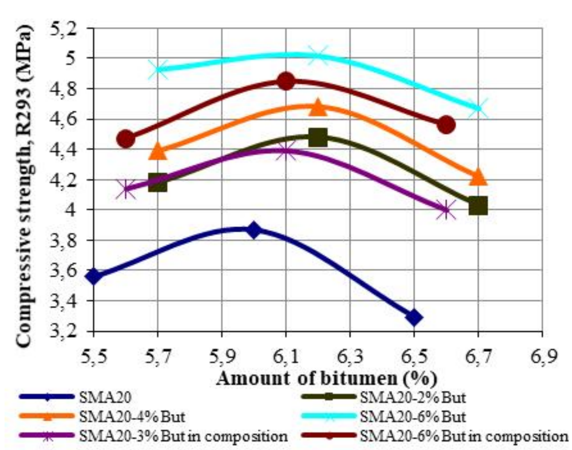

Fig. 13. Compressive strength R293 *vs.* amount of bitumen and polymer latex, type SMA-20

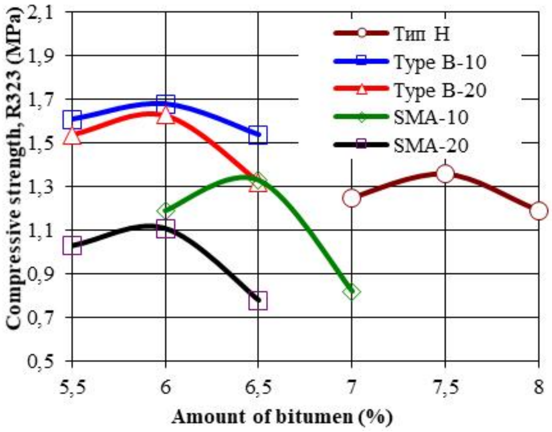

Fig. 14. Compressive strength R323 *vs.* amount of bitumen for asphalt concrete of different granulometry

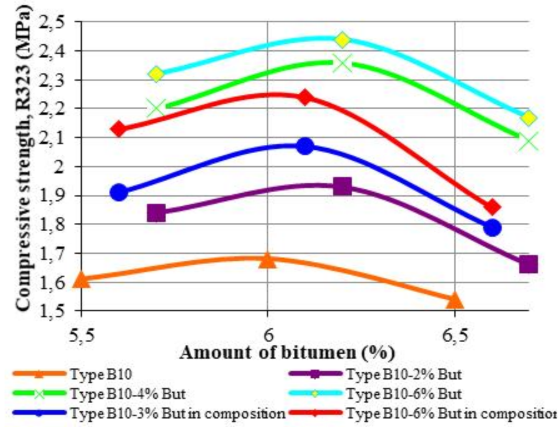

Fig. 15. Compressive strength R323 *vs.* amount of bitumen and polymer latex, type B-10

Asphalt concrete of type H (Fig. 17) shows an increase in R323 by 55 %, 101 %, and 115 %, respectively, at PMB with 2 %, 4 %, and 6 % of polymer. The direct introduction of latex increases the R323 index by 52 % and 90 % at 3 % and 6 % of polymer, respectively.

The results of SMA-10 (Fig. 18) and SMA-20 (Fig. 19) tests show the following results: the R323 index for SMA-10 increases by 10 %, 35 %, and 41 %, respectively, at 2 %, 4 %, and 6 % polymer in PMB. With the same amount of polymer latex, for SMA-20 this index increases by 24 %, 51 %, and 67 %. The introduction of the polymer in the amount of 3 % and 6 % directly into the mixture made it possible to increase the compressive strength at a temperature of 323 K for SMA-10 by 39 % and 58 %, respectively, and for SMA-20 – by 15 % and 61 %.

The compressive strength at a temperature of 273 K was determined for asphalt concrete of B-10, B-20, and H types (Figs. 21-23, respectively), and compressive fracture strength at the same temperature – for SMA-10 (Fig. 24) and SMA-20 (Fig. 25).

The results (Figs. 21, 22) of B-10 and B-20 asphalt concretes tests when using PMB with 2 %, 4 %, and 6 % polymer latex show a slight increase in R273 by 0.5 %, 2.0 %, and 6.5 %, respectively, for B-10 type and by 0.4 %, 2.0 %, and 3.2 % for B-20 compared with traditional B-10 and B-20 asphalt concretes. When polymer latex was introduced in the amount of 3 % and 6 % directly into the asphalt concrete mixture during its preparation, the compressive strength limit at a temperature of 273 K The direct introduction of 3 % and 6 % of polymer latex increases R273 by 0.4 % and 1.0 %, respectively, for B-10 and by 0.3 % and 1.5 % for B-20. Asphalt concrete of type H (Fig. 23) also shows a slight increase in this indicator by 3.3 %, 8.1 %, and 11.8 %, respectively at 2 %, 4 %, and 6 % polymer in PMB. The introduction of latex directly into the mixture during its preparation made it possible to increase the R273 index by 3.0 % at 3 % polymer and by 7.3 % – at 6 % polymer.

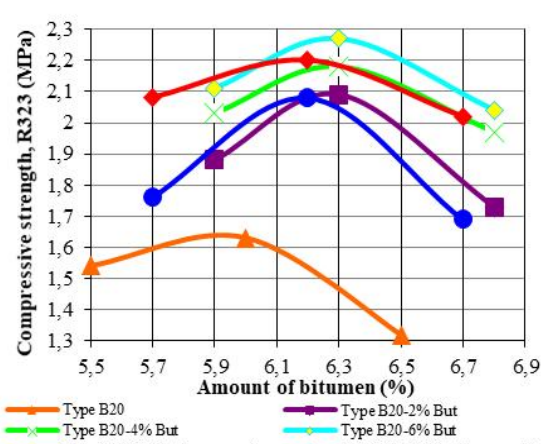

Fig. 16. Compressive strength R323 *vs.* amount of bitumen and polymer latex, type B-20

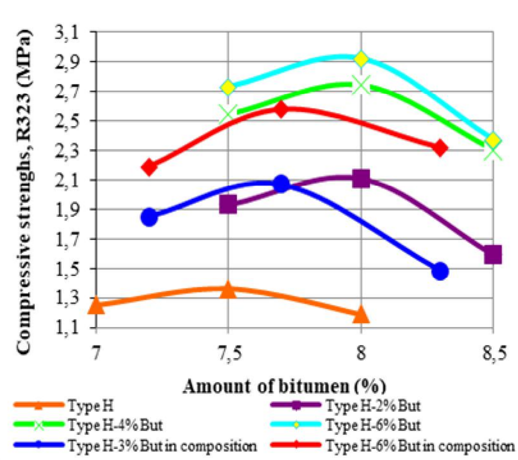

Fig. 17. Compressive strength R323 *vs.* amount of bitumen and polymer latex, type H

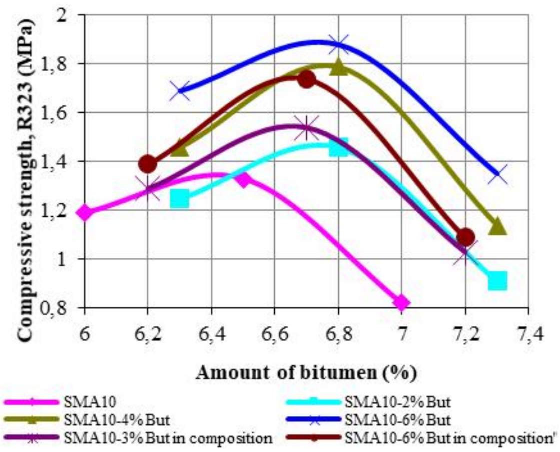

Fig. 18. Compressive strength R323 *vs*. amount of bitumen and polymer latex, type SMA-10

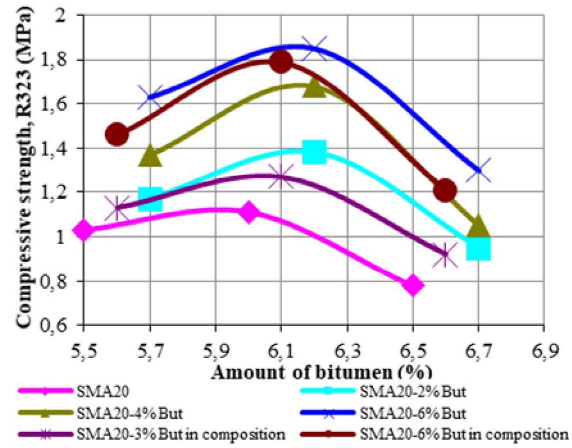

Fig. 19. Compressive strength R323 *vs*. amount of bitumen and polymer latex, type SMA-20

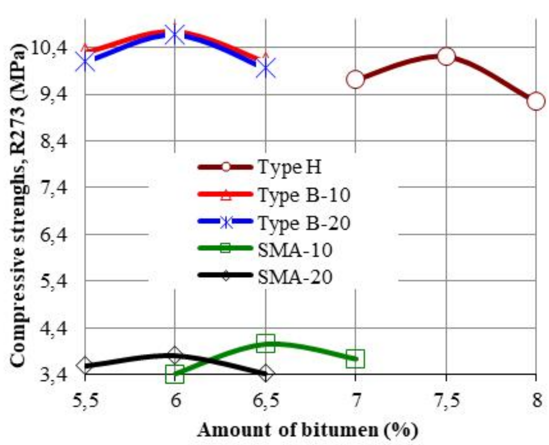

Fig. 20. Compressive strength (SMA-10 and SMA-20 – fracture) R323 *vs*. amount of bitumen for asphalt concrete of different granulometry

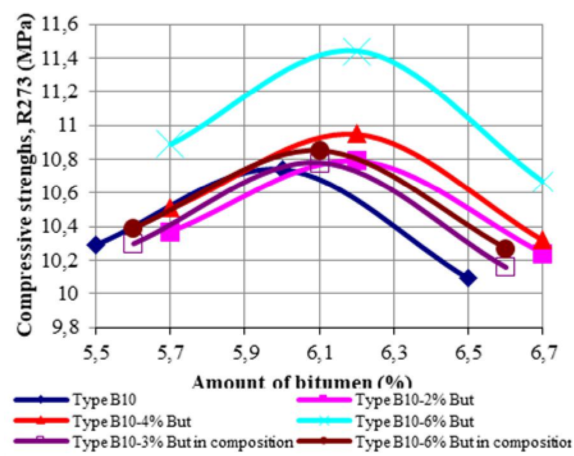

Fig. 21. Compressive strength R273 *vs*. amount of bitumen and polymer latex, type B-10

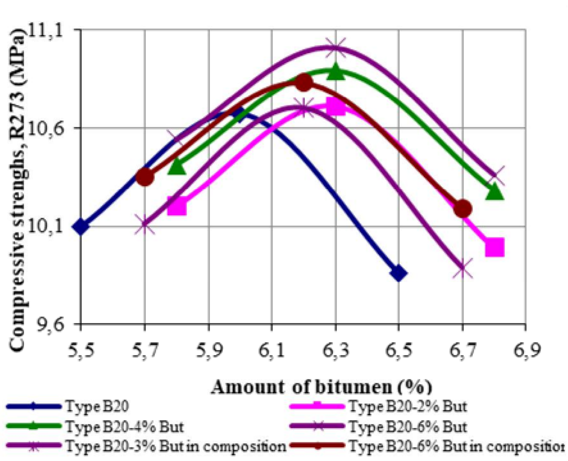

Fig. 22. Compressive strength R273 *vs*. amount of bitumen and polymer latex, type B-10

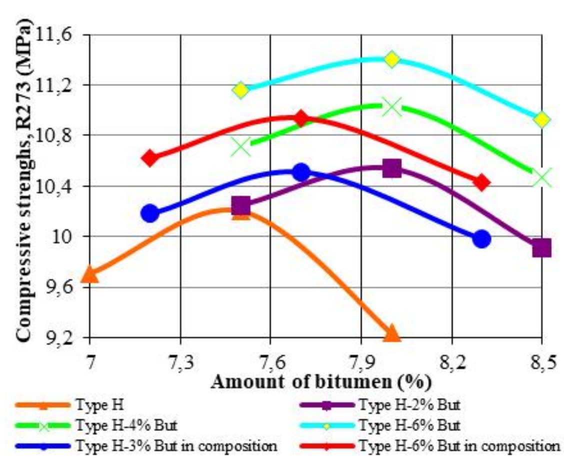

Fig. 23. Compressive strength R273 *vs*. amount of bitumen and polymer latex, type H

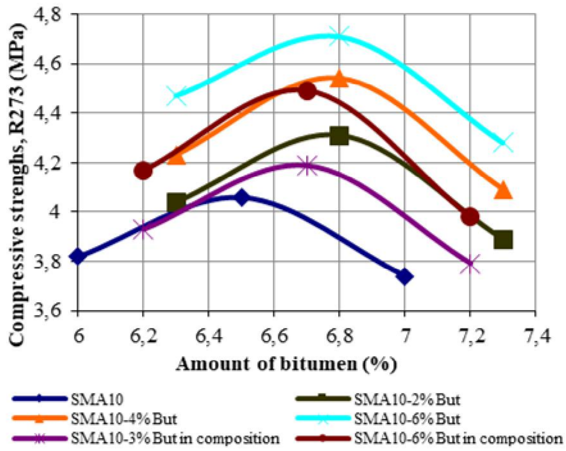

Fig. 24. Compressive strength R273 *vs.* amount of bitumen and polymer latex, type SMA-10

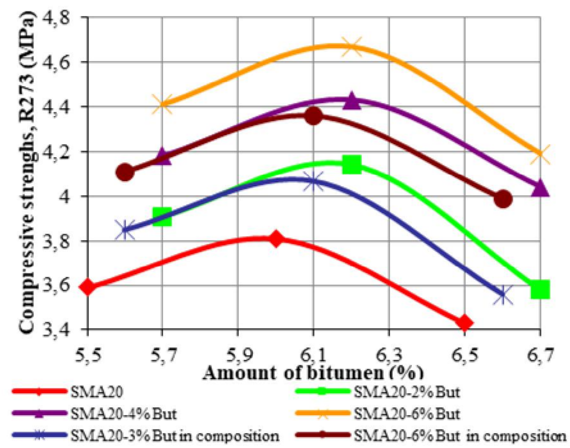

Fig. 25. Compressive strength R273 *vs.* amount of bitumen and polymer latex, type SMA-20

The results of SMA-10 (Fig. 24) and SMA-20 (Fig. 25) tests for fracture at a temperature of 273 K show an increase in R273 for SMA-10 by 6.2 %, 11.8 %, and 16, 0 %, respectively, at 2 %, 4 %, and 6 % polymer in PMB. With the same amount of polymer latex, this indicator for SMA-20 increases by 8.7 %, 16.3 %, and 22.6 %. The introduction of the polymer in the amount of 3 % and 6 % directly into the mixture increases the compressive fracture strength at a temperature of 273 K for SMA-10 by 3.2 % and 10.6 %, respectively, and for SMA-20 – by 6.8 % and 14.4 %.

Along with the above indices, the change in the water saturation index was also studied.

According to Fig. 26, with the determined optimal amount of bitumen (Figs. 8, 14, and 20) for asphalt concrete of different granulometry, the water saturation (*W*, %) has the following values: for B-10 and B-20 the water saturation is 2.84 % and 2.76 %, respectively, for type H – 1.29 %, and for SMA-10 and SMA-20 – 3.80 % and 3.51 %, respectively.

Let us analyze how the water saturation values are changed when using Butonal NX4190 cationic polymer latex (Figs. 27-31).

Thus, for asphalt concrete of B-10 and B-20 types (Fig. 27-28), with the optimal amount of PMB with 2 %, 4 %, and 6 % polymer, the following values of water saturation were obtained: for type B-10 W = 2.40 %, 2.25 %, and 1.90 %, and for B-20 W = 2.36 %, 2.10 %, and 1.69 %. In this case, the water saturation index (in comparison with that of the same types of asphalt concrete but with ordinary bitumen of BND 70/100 grade) decreases for B-10 by 16 %, 21 %, and 33 %, respectively, at 2 %, 4 %, and 6 % of polymer latex in PMB, and for B-20 – by 15 %, 24 %, and 38 %, respectively. When the polymer in the amount of 3 % and 6 % was directly introduced into the mixture during its preparation, the water saturation index for type B-10 decreased by 9 % and 18 %, and for B-20 by 13 % and 24 %, respectively.

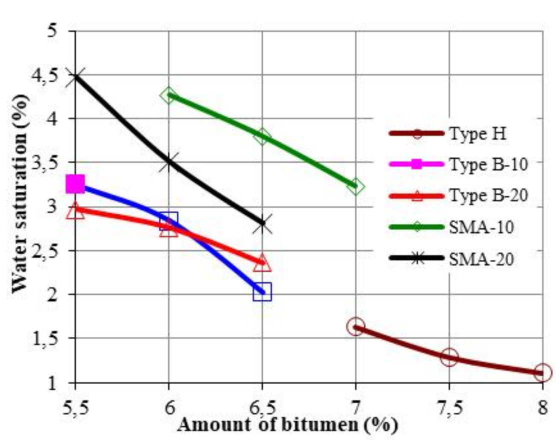

Fig. 26. Water saturation *vs.* amount of bitumen for asphalt concrete of different granulometry

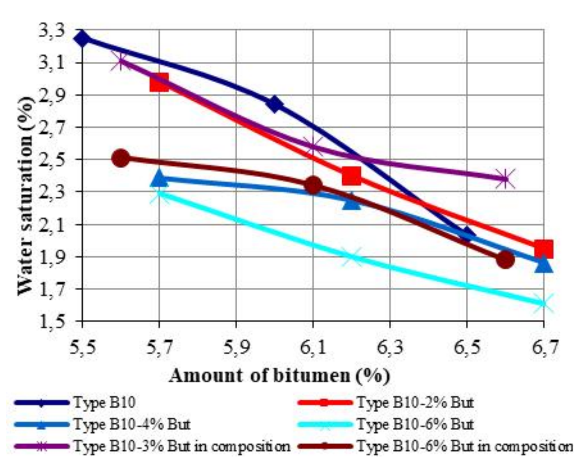

Fig. 27. Water saturation *vs.* amount of bitumen and polymer latex, type B-10

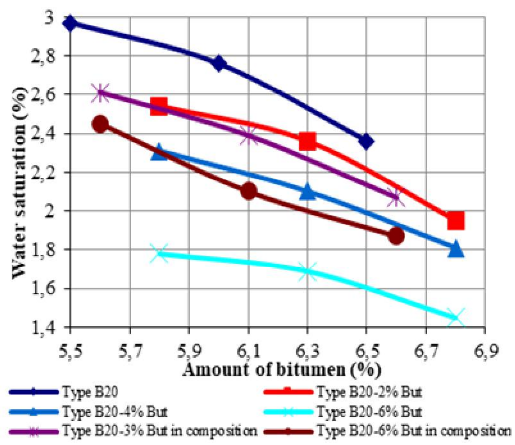

Fig. 28. Water saturation *vs.* amount of bitumen and polymer latex, type B-20

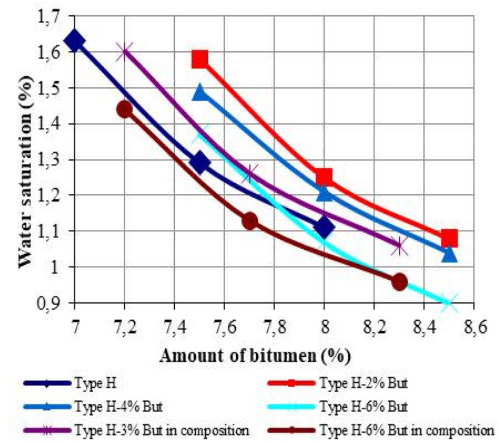

Fig. 29. Water saturation *vs.* amount of bitumen and polymer latex, type H

When using PMB with Butonal NX4190 polymer latex (2 %, 4 %, and 6 %), the water saturation index for asphalt concrete type H (Fig. 29) decreases by 3 %, 6 %, and 17 %, respectively. In the case of polymer introduction in the amount of 3 % and 6 % directly into the mixture during its preparation, the *W* index decreases by 3 % and 13 %, respectively.

One can see from Figs. 30 and 31 that the *W* index decreases by 17 %, 30 %, and 42 % for SMA-10 and by 13 %, 41 %, and 43 %, for SMA-20 with PMB+polymer latex as compared with the same types of asphalt concrete but with ordinary bitumen BND 70/100. When the polymer (3 % and 6 %) was directly introduced into the mixture, the *W* index for SMA-10 decreases by 13 % and 25 %, and for SMA-20 by 9 % and 43 %, respectively.

According to Fig. 32, with the determined optimal amount of bitumen (Figs. 8, 14, and 20) for asphalt concrete of different granulometry, the water resistance coefficient after 30 days has the following values: for B-10 and B-20 it is equal to 0.96 and 0.975, respectively, for type H – 0.97, and for SMA-10 and SMA-20 – 0.96 and 0.98. When using the Butonal NX4190 cationic polymer latex, the water resistance coefficient improved (Figs. 33-37), the same as other indices characterizing the physical and mechanical properties of asphalt concrete.

Thus, for asphalt concretes of B-10 and B-20 types (Figs. 33 and 34), at the optimal amount of PMB with 2 %, 4 %, and 6 % of polymer, the following values of the water resistance coefficient were obtained: for type B-10 they are equal to 0.97, 0.98, and 0.99, and for B-20 – 0.975, 0.99, and 0.99, respectively. In this case, in comparison with the same types of asphalt concrete with ordinary bitumen of the BND 70/100 grade, an increase in the water resistance coefficient to its maximum possible value is observed. A similar increase in the water resistance coefficient occurs when the polymer is introduced in the amount of 3 % and 6 % directly into the mixture during its preparation (0.97 and 0.98 for B-10, and 0.98 and 0.98 for B-20).

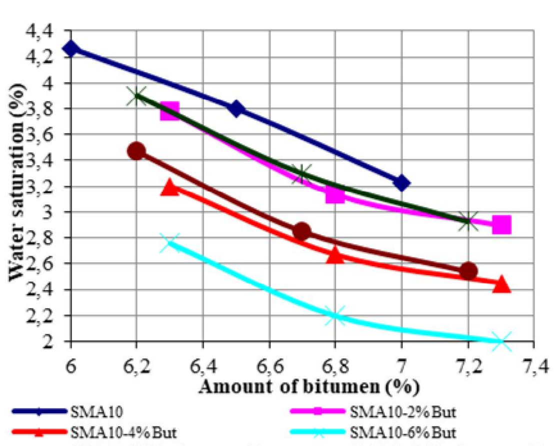

Fig. 30. Water saturation *vs.* amount of bitumen and polymer latex, type SMA-10

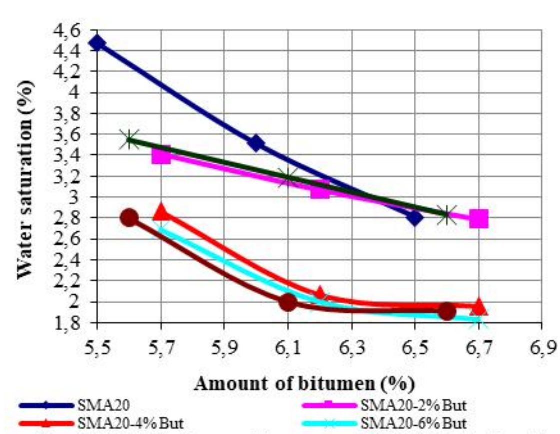

Fig. 31. Water saturation *vs.* amount of bitumen and polymer latex, type SMA-20

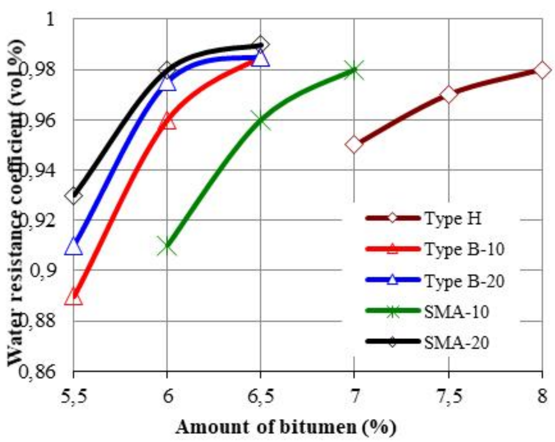

Fig. 32. Water resistance coefficient *vs.* amount of bitumen for asphalt concrete of different granulometry

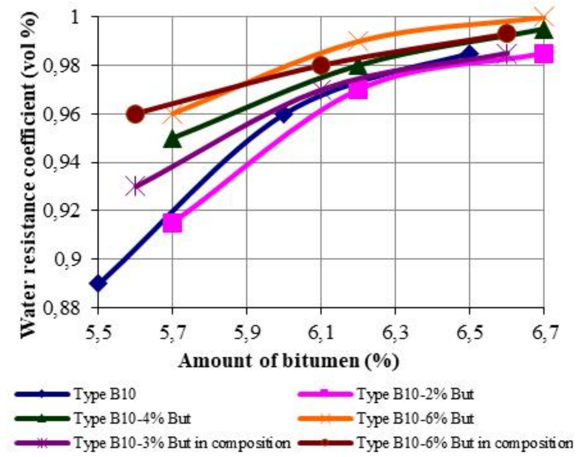

Fig. 33. Water resistance coefficient *vs.* amount of bitumen and polymer latex, type B-10

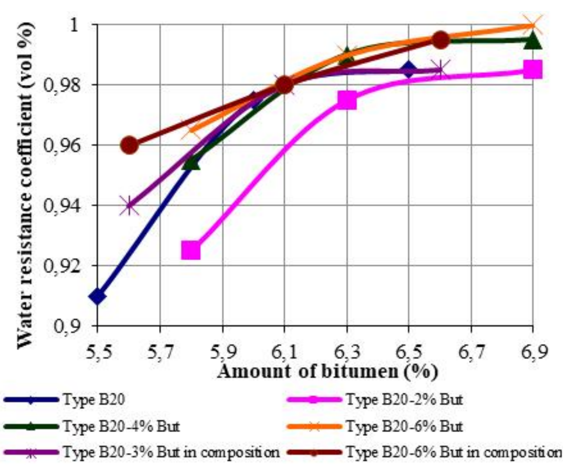

Fig. 34. Water saturation *vs.* amount of bitumen and polymer latex, type B-20

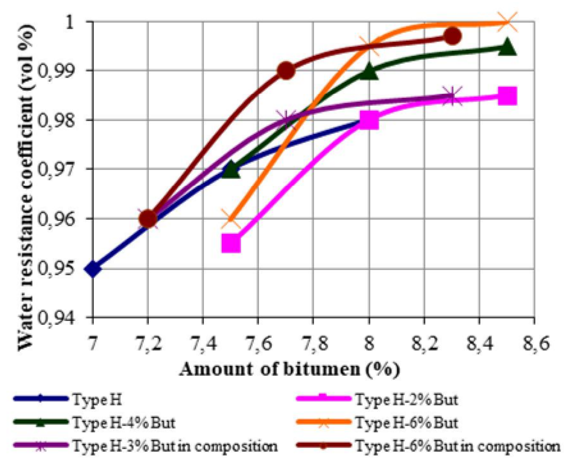

Fig. 35. Water saturation *vs.* amount of bitumen and polymer latex, type H

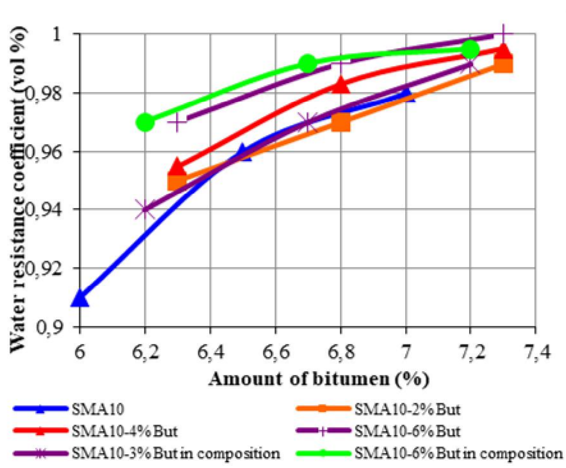

Fig. 36. Water saturation *vs.* amount of bitumen and polymer latex, type SMA-10

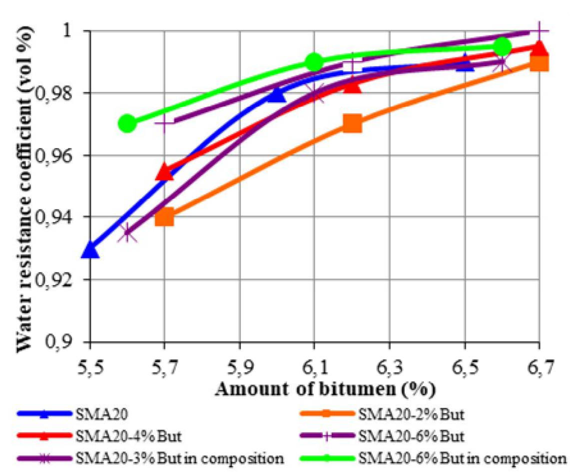

Fig. 37. Water saturation *vs.* amount of bitumen and polymer latex, type SMA-20

For asphalt concrete of H type (Fig. 35) the coefficient is equal to 0.98, 0.99, and 0.995, respectively. In the case of polymer direct introduction this index is 0.98 and 0.99 at polymer amount of 3 % and 6 %, respectively.

For the samples SMA-10 and SMA-20 (Figs. 36 and 37), at 2 %, 4 %, and 6 % of polymer latex in PMB, the following coefficients of water resistance were obtained: for SMA-10 it is equal to 0.97, 0.983, and 0.99, and for SMA-20 – 0.97, 0.983, and 0.99, respectively. When the polymer was introduced in the amount of 3 % and 6 % directly into the mixture during its preparation, this indicator is 0.97 and 0.99 for SMA-10, and 0.98 and 0.99 for SMA-20, respectively.

4. Conclusions

The results of determining the physical and mechanical properties depending on the polymer amount and the PMB preparation time show that they are significantly improved even with a small amount of polymer. The optimal amount of Butonal NX4190 latex is 2–4 wt. % relative to bitumen, and the optimal time for PMB preparation is 3–4 hours.

When using polymer latex in the asphalt concretes under study, a significant increase in strength indices is observed. The compressive strength at the temperatures of 273 K, 293 K, and 323 K significantly increases with the introduction of Butonal NX4190 polymer latex in PMB in the amount of 2–4 % for all tested asphalt concretes. For example, at the temperatures of 293 K and 323 K, the compressive strength increases from 19 % to 101 % for H type, from 14 % to 40 % for B-10 type, from 11 % to 34 % for B-20 type, from 10 % to 35 % for SMA-10 type, and from 16 % to 51 % for SMA-20 type.

Also, the use of latex in bitumen and asphalt concrete makes it possible to improve its so-called weather resistance indices, especially the water resistance coefficient. In some cases, this index achieves the maximum possible value, which is close to 1.0. This indicates that the use of this polymer latex increases the resistance of asphalt concrete to the action of atmospheric factors and their possible consequences.

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ДОСЛІДЖЕННЯ ВПЛИВУ ПОЛІМЕРНОГО ЛАТЕКСУ БУТОНАЛ NX4190 НА ВЛАСТИВОСТІ БІТУМНОГО В'ЯЖУЧОГО Й АСФАЛЬТОБЕТОНУ

Анотація. *У статті наведено результати дослідження впливу технологічних параметрів модифікації катіонного полімерного латексу Бутонал NX4190 на фізико-механічні властивості дорожніх бітумів і різних типів гарячих щільних асфальтобетонів і щебенево-мастикових асфальтобетонів. Технологічними параметрами модифікації були вміст модифікатора та час модифікації. Температура модифікування була постійною. Оптимальну кількість полімерлатексу для модифікування визначали за критеріями покращення фізико-механічних властивостей бітумів та асфальтобетонів.*

Ключові слова: *полімермодифікований бітум, катіонний латекс, гарячий щільний асфальтобетон, щебенево-мастиковий асфальтобетон.*