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THE IMPACT OF AGING ON WATER AND FROST RESISTANCE OF ASPHALT CONCRETE WITH LOW – TEMPERATURE BITUMEN

Abstract

The application of low – viscosity (low – temperature) bitumen in asphalt concrete results in an improvement of its mechanical properties (Marshall stability and deformation, static creep modulus and indirect tensile strength). The tests conducted with the procedures LTOA (long term aging) and STOA (short term aging) according to SHRP methodology prove that use of low – temperature bitumen results in slowing down the aging process of asphalt concrete. The dynamics of this process is slower than in case of traditional bitumen. The measurements of water and frost resistance (according to AASHTO T283) of asphalt concrete and of its resistance to low – temperature cracking (according to PANK 4303) have showed that the use of low – temperature bitumen results in higher resistance to weathering than that of the road bitumen 35/50 as a binder.

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Keywords: asphalt concrete, low viscosity bitumen, asphalt weather resistance, LTOA, STOA, AASHTO T283, PANK 4303

1. Introduction

Asphalt pavements are subject to various defects. They are the results of the combined impact of traffic and weather factors. This impact causes the constant changes in stress, deformations, temperature and humidity. Bitumen and asphalt concrete are thermoplastic materials. Temperature causes changes in their consistency. High temperature leads to lower viscosity, cohesion and adhesion. When temperature falls the binder and asphalt concrete become stiffer. The materials become breakable and prone to cracking as a result of contraction in low temperatures. The efficiency of mixes produced in „hot" technology depends on many factors. Some of them are: the interaction between durability of the mixes due to the effects of traffic and weather resistance (water and frost). The mixes made from best materials and modern technology will not perform well if they are subject to water and frost. Therefore the water and frost resistance tests are important factors in design of the composition of an asphalt concrete.

Asphalt concrete should also meet other functionality criteria, such as: fatigue crack, thermal crack, hydraulic conductivity and workability during disintegration and compaction processes. To obtain asphalt concrete which is resistant to the formation of ruts the amount of bitumen needs to be reduced. But then the number of created voids is higher and the energy consumption increases. Maintaining this relation reduces, however, the resistance of the mix to cracking and reduces water and frost resistance. The lack of durability to water and frost is caused by two factors: an excessive number of voids and the insufficient amount of the plastic mass. The aging process needs to be considered too. Regardless of the kind of mix it has an impact in the production and operation processes. Limiting the aging process requires the reduction in the void fraction and thicker coating. Therefore the compromise between the mineralogical composition and the amount of bitumen should be found.

One of the ways of solving these problems is the use of low – viscosity bitumen. Other components which lower viscosity in higher temperatures have been added. They are aliphatic hydrocarbons of long chains. Bitumen of this kind has higher softening point and lower viscosity at 25^{o}C [4].

The significant number of fractured grains and limited amount of plastic mortar form the mix which is difficult to compact. The mixes with low compaction temperature have lower internal friction. Thus, there is a reduction in the compaction resistance at temperatures of 20°C. When the aging processes are considered and temperature induced intensification of the first stage is reduced, it's possible to produce mixes of proper water and frost resistance and low susceptibility to changes in the againg process.

2. Tests on low – viscosity bitumen

The Olexobit 30 NV bitumen was used to determine the impact of aging on water and frost resistance of asphalt concrete. The traditional 35/50 bitumen from Petrochemia Płock (Poland) was used as reference. The basic properties of the bitumen undergoing the tests have been presented in Table 1.

Table 1. The basic properties of the bitumen used in the tests

No.	Property	Unit	Olexobit 30 NV	35/50 btumen	Test methodology
1.	Penetration at 25ºC	0.1 mm	33	44	PN-EN 1426:2001
2.	Softening point according to PiK	ºC	65.5	55.0	PN-EN 1427:2001
3.	Elastic recovery	%	60	10	PN-EN ISO 13398:2005
4.	Ductility at 15°C	cm	79	–	PN-85/C04132
5.	Breaking point	ºC	-15.0	-14.0	PN-EN 12693:2004
6.	Change of mass after evaporation in a thin film	% (decrease)	0.38	0.51	PN-EN 126071:2004
7.	Increase in softening point after evaporation in a thin film	ºC	6	4	PN-EN 12607-1:2004 PN-EN 1427:2001
8.	Change of penetration after evaporation in a thin film	0.1 mm	6	9	PN-EN 12607-1:2004
9.	Elastic recovery after evaporation in a thin film	%	55	–	PN-EN ISO 13398:2005

The analysis of the above test results proves that the parameters of the low – viscosity bitumen are better than those of the 35/50 bitumen. The penetration value of Olexobit 30 NV is 50% lower and its softening point 10°C higher than the 35/50 bitumen. A significant elastic recovery is an additional advantage of the low – viscosity bitumen, while the value of the elastic recovery in case of the traditional bitumen is very low.

It needs to be emphasised that during the tests on Olexobit 30 NV almost no emissions of volatile bitumen components were detected, while such emissions were observed during the measurements conducted on the 35/50 bitumen [Iwański, Mazurek 2008].

3. Design of the asphalt concrete composition

In order to determine water and frost resistance of asphalt concrete the tests were performed on asphalt concrete whose grading was 0/12.8 mm, which is used to produce the wearing coarse of the road surface loaded with KR5 type traffic. Such asphalt concrete is used in Poland for national and transit roads. An assessment of the impact of the kind of mineral aggregate on the properties of the asphalt concrete produced with the mentioned bitumen was also an important element of the tests. Asphalt concrete with the main diabase aggregate (BA-D), quarzite aggregate (BA-K) and gabbro aggregate (BA-G) was designed. A dolomite mix 0/4 and granite fractured sand was used to increase the fine fraction content. The composition of the mineral mixes of the tested asphalt concrete has been presented in Table 2.

Table 2. The composition of the asphalt concrete mineral mixes

No.	BA-G		BA-K		BA-D	
	Components	MMA	Components	MMA	Components	MMA
1.	Limestone powder	6.0	Limestone powder	6.0	Limestone powder	6.0
2.	Granite fractured Sand	19.0	Granite fractured sand	19.0	Granite fractured sand	24.0
3.	Dolomite mix 0/4	26.0	Dolomite mix 0/4	24.0	Dolomite mix 0/4	23.0
4.	Gabbro 2/5	11.0	Quarzite 2/6.3	18.0	Diabase 2/6.3	23.0
5.	Gabbro 5/8	13.0	Quarzite 6.3/10	33.0	Diabase 6.3/10	24.0
6.	Gabbro 8/11	26.0	–	–	–	–
	Total	100%	Total	100%	Total	100%

To ensure the required adhesion between bitumen and aggregate grains of the mineral mix an adhesive agent Teramin 14 was used. Its amount was of 0.2% in relation to bitumen for the tested asphalt concrete with gabbro and diabase chippings. The amount of the adhesive agent for asphalt concrete with quarzite chippings was higher. It equalled to 0.4%. The determination of the required amount of bitumen, was based on the strength measurements (according to Marshall method). Asphalt concrete produced with the traditional bitumen was compacted at 145°C. The asphalt concrete with the low – viscosity bitumen at 125°C [Iwański, Mazurek 2008].

The mineral mixes of asphalt concrete with gabbro, quarzite and diabase aggregate were designed in such a way that the void fraction contents for different kinds of bitumen, but the same kind of chippings, were similar.

It enables to properly assess and compare the test results of the analysed asphalt concrete. A statistical analysis of the void fraction content of samples with the traditional bitumen and low – viscosity bitumen was done. The hypothesis of the identity of mean values of the void fraction content was verified. The results of the analysis are presented in Table 3.

Table 3. Test results of identity of void fraction content's mean values

	BA-K[Z,O]	BA-D[Z,O]	BA-G[Z,O]
Total variance	0.040508333	0.046136667	0.063373333
Observations	6	6	6
Df	10	10	10
t Stat	2.165778992	-1.854664488	1.90355
Test t	2.228138842	2.228138842	2.228138842

The t-values are within the acceptable range. They do not contradict the hypothesis stating, that the void fraction contents are equal.

To have similar values of the void fraction content in the samples of asphalt concrete and low – viscosity bitumen, it was necessary to decrease the amount of bitumen. In the samples with the traditional bitumen of 0.2% at most for mixes with quarzite aggregate (from 5.5% to 5.3%) and diabase aggregate (from 5.4% to 5.2%). The content of bitumen in mixes with gabbro aggregate remained at the level of 5.2%.

4. Methodology and analysis of the results

The measurements were taken only for samples whose void fraction content ranged between V – 2s; V + 2s), where: V – is a mean void fraction content value in asphalt concrete, s – standard deviation. On this basis the identity of mean void fraction content values of the samples were assessed.

Based on strength tests in different temperature ranges it was determined that the samples with the low – viscosity bitumen would undergo short – term aging at 125°C. While asphalt concrete with the traditional bitumen would undergo long – temperature aging (LTOA) according to the SHRP method at 145°C. Asphalt concrete, in which the traditional 35/50 bitumen was used, was denoted with a letter Z e.g. BA-Z (similarly, concrete produced with the Olexobit 30 NV bitumen was designated with a letter O e.g. BA-O).

The tests were carried out to determine the basic physical and chemical parameters of the investigated kinds of asphalt concrete. These measurements were conducted for non – aged samples (NS) produced with the 35/50 bitumen and Olexobit 30 NV bitumen to find out the basic physical and mechanical parameters. The test results are presented in Figure 1 and 2.

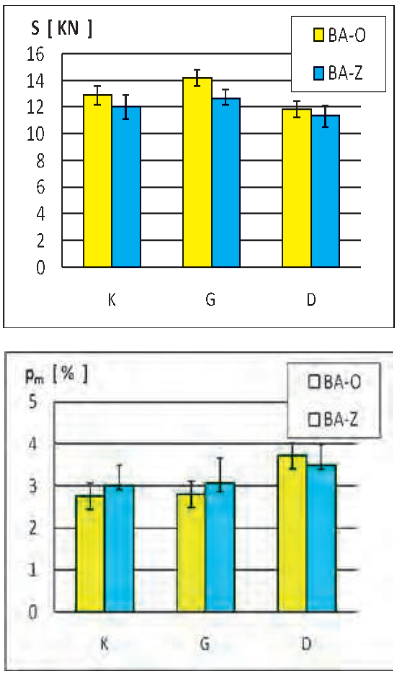

Fig. 1. Marshall stability and void fraction content in asphalt concrete for different kinds of binder

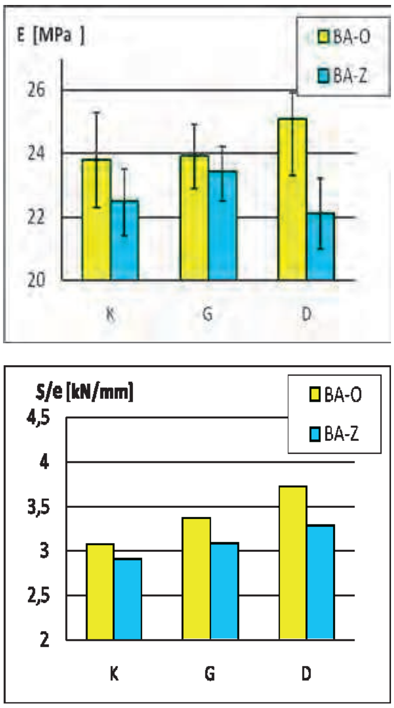

Fig. 2. Static creep modulus and Marshall stiffness of asphalt concrete for different kinds of binder

The test results of non – aged samples of Marshall stability and static creep modulus prove that the mechanical properties of asphalt concrete with low – viscosity bitumen as binder are more advantageous than that of traditional bitumen. Such asphalt concrete is more resistant to permanent deformations. The use of the low – viscosity bitumen resulted in significant increase in stability of asphalt concrete. A considerable difference between static modulus and Marshall stiffness of asphalt concrete with diabase chippings is the increased void fraction content.

In the graphs presenting changes of the physical and mechanical parameters under the aging process, asphalt concrete with the traditional 35/50 bitumen was denoted with the letter Z e.g. BA-DZ (asphalt concrete with diabase aggregate and the 35/50 bitumen) and with the letter O e.g. BA-DO when the Olexobit 30 NV bitumen was used.

The analysis of the results of stability changes of diabase, quarzite and gabbro asphalt concrete after the aging process and changes of its parameters are presented in Figure 3.

During the short and long term aging an increase in stability of asphalt concrete is observed (regardless of the kind of bitumen and aggregate). However, the increase in stability of asphalt concrete produced from the low – viscosity bitumen during the aging process (STOA/NS, LTOA/NS and LTOA/STOA) occurs more slowly than in case of the traditional bitumen. The increase in stability of asphalt concrete with the low – viscosity bitumen (regardless of the aging stage) is between ca. 10 – 15% of the stability increase as compared to asphalt concrete produced from the traditional bitumen. Consequently, during the aging process asphalt concrete with the low – viscosity bitumen becomes less stiff than in the case of the application of the traditional bitumen. Such asphalt concrete is more durable and resistant to the effects of weathering and traffic. The parameters of changes of the static creep modulus after aging WKM are presented in Figure 4.

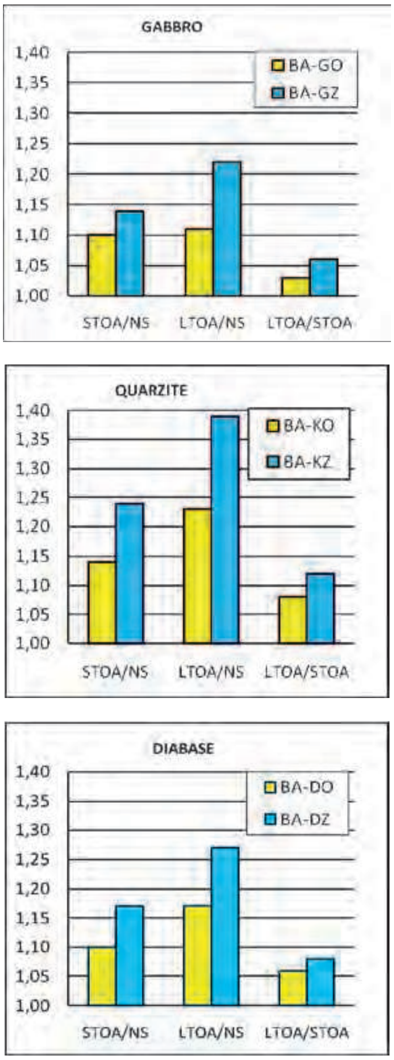

Fig. 3. The impact of aging on the stability change of asphalt concrete

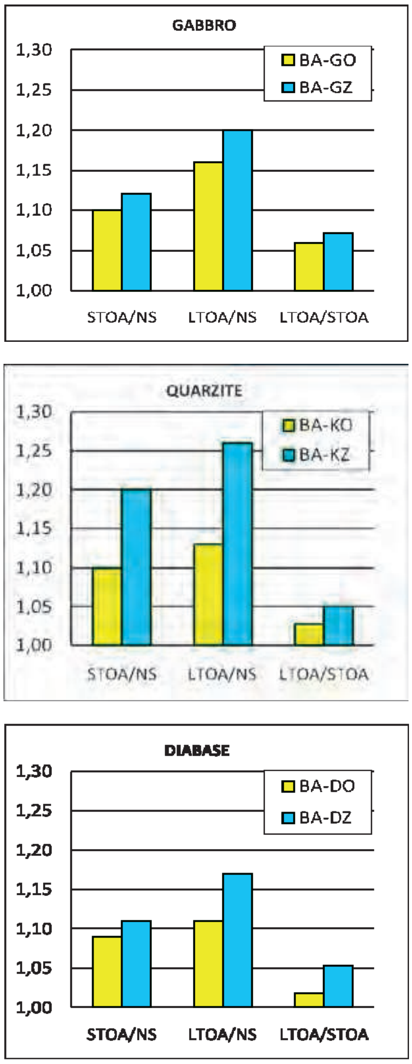

Fig. 4. The impact of aging on changes of the static creep modulus of asphalt concrete

The tests of static creep were done to verify the test results from Marshall method. The static creep modulus is determined at the temperature of 40°C under loading of 0,1 MPa for 2, 3, 5, 10, 15, 20, 30, 40, 50, 60 min with the 0.0001 mm/mm reading resolution of the deformation. From the results the following parameters are determined:

– deformation ε from the formulae:

$$\varepsilon_{max} = \Delta h / h \text{ [mm/mm]} \qquad (1)$$

where: Δh = the difference between the initial height and the height after the loading period, and *h* = the initial height:

– the static creep modulus from the formulae (measurement error up to 0.1 MPa)

$$M_s = \delta_s / \varepsilon_{max} \qquad (2)$$

where: δ_s = compressive stress, which equalls 0.1 MPa; and ε_{max} = deformation after 1 *h* of loading.

Changes of static creep of asphalt concrete after aging (with regard to the kind of bitumen and aggregate) are similar to the results of Marshall stability after aging. However, the dynamics of the changes of the static creep of asphalt concrete with the low – viscosity bitumen is lower than in the case when the stability change of asphalt concrete after aging was tested. During the STOA and LTOA aging the static creep of asphalt concrete with the Olexobit 30 NV bitumen was at most 10% lower (when the quarzite aggregate was used) than the static creep of asphalt concrete with the 35/50 bitumen.

The intensity of changes of the static creep of asphalt concrete with both the low – viscosity and traditional bitumen during the STOA and LTOA aging (STOA/LTOA) is similar. It implies that the rate of change of static creep modulus of asphalt concrete does not depend on the kind of bitumen.

From the analyses of test results after aging we may state that the aggregate used in its production has a significant impact on its mechanical properties. Quarzite aggregate is least suited, especially when the traditional 35/50 bitumen is applied. In this case the stability and static creep change is highest as compared to diabase and garbo aggregate.

To assess resistance to water and frost the tests were performed to determine:

- indirect tensile strength before and after curing cycles, simulating weathering on roads according to the American procedures – the AASHTO T283 method. Its detailed description can be found in [2].

Indirect tensile strength after curing, simulating the impact of temperatures below 0°C, according to the PANK 4302 standard is described in [2] and [5].

An assessment of aging on water and frost resistance was also made. The tests were focused only on the the short – term aging due to its significant influence on mechanical properties. The results are presented in Table 4.

Table 4. The impact of aging on water and frost resistance of asphalt concrete

No.	Property of asphalt concrete	The kind of aging	The kind of asphalt concrete					
			BA-D		BA-G		BA-K	
			Z	O	Z	O	Z	O
1.	Indirect tensile strength at -2°C according to PANK 4302 [MPa]	NS	4.0	3.9	3.7	3.2	4.1	3.9
		STOA	4.5	4.3	4.0	3.5	4.5	4.2
		LTOA	4.6	4.5	4.2	3.7	4.7	4.4
2.	Indirect tensile strength ratio at 20°C according to AASHTO T283 [%]							
2a.	After curing in water and frost W_{WM}	NS	76.1	79.9	78.0	81.9	77.4	79.2
		STOA	74.1	76.2	74.9	78.6	73.8	76.1
		LTOA	70.5	75.4	71.5	76.4	67.9	75.2

There is a significant impact of the aging on water resistance and combined water and frost resistance as well as resistance to low – temperature cracking. The aging has the worst effect in case of asphalt concrete with quarzite aggregate. In this case the binder was the 35/50 bitumen with the adhesive agent. Indirect tensile strength after aging (according to PANK 4302) at 2°C was 4.7 MPa (i.e. close to the critical value of 4.8 MPa). Aging, especially short – term aging, did not cause excessive stiffening in the case of asphalt concrete with the low – viscosity bitumen. Consequently, if the road surface is made from asphalt concrete with quarzite aggregate it can experience low – temperature cracking during winter. However, this is much more likely to happen for asphalt concrete with the traditional bitumen. The aging process has also an unfavourable impact on water and frost resistance according to AASHTO T283 methododology. The indirect tensile strength ratios after aging of asphalt concrete produced from quarzite, diabase and gabbro aggregate with the 35/50 bitumen were below 75%. That is the limiting value of proper water and frost resistance. In the case of asphalt concrete produced from quarzite aggregate and the 35/50 bitumen, it lost its resistance in low temperatures as a result of aging (the ratio was below the critical value of 70%). The indirect tensile strength ratios after aging process according to AASHTO and indirect tensile strength according to PANK are presented in Figure 5.

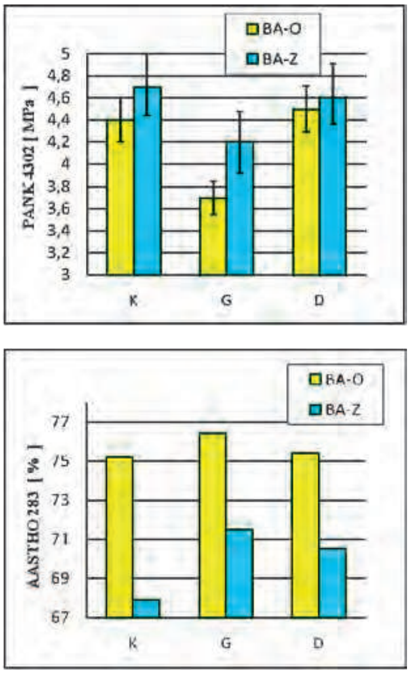

Fig. 5. Indirect tensile strength after long – term aging at 2°C and the ratios of indirect tensile strength of cured samples of asphalt concrete after long – term aging

Asphalt concrete with the low – viscosity asphalt remains elastic despite the destructive impact of aging on water and frost resistance. It may be also much more durable. In spite of aging it is still resistant to the effects of temperatures below 0°C.

The values of the indirect tensile strength ratios of asphalt concrete with low – viscosity asphalt and diabase and quarzite aggregate are similar. It can be explained by a significant void fraction content in asphalt concrete with diabase aggregate.

Based on the tests of the impact of aging on water and frost resistance of asphalt concrete with the low – viscosity bitumen, it can be concluded that this kind of bitumen limits the effects of aging due to the reduced stiffening of the mastix. Thus its significantly improving water and frost resistance of asphalt concrete.

5. Conclusions

From the analysis of the test results the following conclusions can be drawn:

1. Low-viscosity bitumen is suitable for production of asphalt concrete.
2. Low – viscosity bitumen has higher softening point and lower penetration than the traditional bitumen.
3. Asphalt concrete with the low – viscosity bitumen is characterised by better mechanical properties such as: stability, static creep and indirect tensile strength, and less considerable changes after aging.
4. The use of the low – viscosity bitumen slowed down and reduced the consequences of aging of asphalt concrete.
5. This has a significant impact on maintaining its physical and mechanical properties at the required level during the operation period.
6. Low – viscosity bitumen maintains the water and frost resistance and resistance to low temperature cracking of asphalt concrete.
7. The use of Olexobit 30 NW bitumen enables to lower the required compaction temperature of asphalt concrete of about 15-20°C.
8. Its physical and mechanical properites are at the required level; the resistance to weathering is also ensured.

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Wpływ starzenia na wodo- i mrozoodporność betonu asfaltowego z asfaltem niskotemperaturowym

1. Wprowadzenie

Jednym ze sposobów rozwiązania problemów optymalizacyjnych w zakresie technologicznym i ekologicznym produkcji betonu asfaltowego, jak również innych rodzajów mieszanek mineralno-asfaltowych wytwarzanych „na gorąco" jest zastosowanie podczas ich produkcji asfaltów niskowiskozowych. Skład ramowy tych asfaltów został wzbogacony o składniki (parafiny twardokrystaliczne) obniżające lepkość w wyższych temperaturach, którymi są węglowodory alifatyczne o długich łańcuchach. Ponadto tego rodzaju asfalty charakteryzują się znacznie wyższą temperaturą mięknienia oraz obniżoną lepkością w temperaturze 25ºC w porównaniu z tradycyjnymi asfaltami ponaftowymi [Nowości Zagranicznej Techniki Drogowej 2007].

Z uwagi na zastosowanie dużej ilości ziarn łamanych oraz normowych ograniczeń ilości plastycznej zaprawy uzyskuje się mieszanki mineralno-asfaltowe coraz trudniejsze w zagęszczaniu. Mieszanki o niskiej temperaturze zagęszczania znacznie obniżają tarcie wewnątrz mieszanki zmniejszając opór zagęszczania w temperaturach o około 20°C niższych niż w sytuacji, gdy jako lepiszcze zastosowano asfalty zwykłe. Dodatkowo uwzględniając etapy starzenia wg programu SHRP oraz redukując temperaturową intensyfikację etapu pierwszego można uzyskać mieszanki o stosunkowo dobrych wynikach odporności na działanie wody i mrozu przy niskiej wrażliwości na zmiany w procesie starzenia.

2. Badania asfaltu niskowiskozowego

W badaniach wpływu starzenia na wodo- i mrozoodporność betonu asfaltowego zastosowano asfalt Olexobit 30 NV (NV – niskowiskozowy) czyli o niskiej lepkości nazywany również asfaltem niskowiskozowym oraz w celach kontrolnych asfalt zwykły 35/50 pochodzący z petrochemii w Płocku (Polska).

Analiza wyników badań pozwala stwierdzić, że asfalt niskotemperaturowy charakteryzuje się korzystniejszymi parametrami w porównaniu z asfaltem 35/50. Posiada on mniejszą o połowę penetrację przy jednocześnie większej o 10ºC temperaturze mięknienia w porównaniu z asfaltem 35/50. Dodatkową jego zaletą jest duży nawrót sprężysty, przy prawie braku tej właściwości asfaltu tradycyjnego.

Należy również zaznaczyć, że podczas wykonywanych badań asfaltu Olexobit 30NW nie odczuwano prawie wcale emisji lotnych związków asfaltu, natomiast podczas prac z asfaltem 35/50 emisja lotnych związków asfaltu była bardzo duża [Iwański, Mazurek 2008].

3. Projekt betonu asfaltowego

W celu oceny odporności betonu asfaltowego na działanie wody i mrozu w aspekcie zastosowanego asfaltu badania wykonano na betonie asfaltowym o uziarnieniu 0/11 mm przeznaczonym na warstwę ścieralną nawierzchni obciążonej ruchem. Istotnym elementem badań była również ocena wpływu rodzaju mineralogicznego kruszywa na właściwości betonu asfaltowego ze stosowanymi w badaniach asfaltami. Zaprojektowano beton asfaltowy z kruszywem głównym diabazowym (BA-D), kwarcytowym (BA-K) oraz z kruszywem gabro (BA-G). Jako kruszywo doziarniające zastosowano mieszankę dolomitową 0/4 oraz piasek łamany granitowy.

W celu zapewnienia wymaganej adhezji pomiędzy asfaltem a ziarnami kruszywa mieszanki mineralnej zastosowano dodatek środka adhezyjnego Teramin 14 w stosunku do asfaltu w ilości 0,2% dla badanych betonów asfaltowych z grysem gabro oraz diabazowym. Natomiast dla betonów asfaltowych z grysem kwarcytowym ilość środka adhezyjnego ustalono na poziomie 0,4%. Wymaganą ilość asfaltu w zaprojektowanych betonach asfaltowych określono na podstawie badań wytrzymałościowych Marshalla. Należy dodać, iż beton asfaltowy z asfaltem zwykłym zagęszczano w temperaturze 145°C, natomiast beton asfaltowy z asfaltem niskowiskozowym w temperaturze 125°C [Iwański, Mazurek 2008].

Mieszanki mineralne betonu asfaltowego z kruszywem gabro, kwarcytowym, diabazowym zaprojektowano tak, aby zawartości wolnych przestrzeni w badanych betonach asfaltowych z różnymi rodzajami asfaltów i tym samym rodzajem grysu były zbliżone do siebie. Umożliwi to dokonanie prawidłowej oceny i porównywanie wyników badań wykonanych betonów asfaltowych. W tym celu poddano krótkiej analizie statystycznej wyniki zawartości wolnych przestrzeni próbek z asfaltem zwykłym i niskowiskozowym. Sprawdzono hipotezę o równości średnich zawartości wolnych przestrzeni.

Stwierdzono, że wartość statystyki mieści się w obszarze dopuszczalnym, zatem uzyskane wartości nie przeczą hipotezie, że zawartości wolnych przestrzeni są istotnie równe.

Aby doprowadzić zawartość wolnych przestrzeni w próbkach betonu asfaltowego z asfaltem niskowiskozowym wymagane było obniżenie ilości asfaltu w stosunku do próbek z asfaltem zwykłym o maksymalnie 0,2% dla mieszanek z grysem kwarcytowym (z poziomu 5,5% do 5,3%) i diabazowym (z poziomu 5,4% do 5,2%). Natomiast w mieszankach z grysem gabro pozostawiono wartość asfaltu na poziomie 5,2%.

4. Metodyka oraz analiza rezultatów badań

Beton asfaltowy z asfaltem niskowiskozowym charakteryzuje się tym, że proces starzenia, szczególnie krótkoterminowego STOA, nie wywołuje nadmiernego jego usztywnienia tak jak w przypadku gdy jako lepiszcze zastosowano zwykły asfalt drogowy. Również bardzo niekorzystnie proces starzenia wpływa na odporność betonu asfaltowego na oddziaływanie wody i mrozu ocenianą zgodnie z AASHTO T283. Wskaźnik wytrzymałości na pośrednie rozciąganie po procesie starzenia betonów asfaltowych wykonanych z kruszyw kwarcytowych, diabazowych i gabro, mającymi w składzie asfalt 35/50 osiągnęły wartości mniejsze niż 75% która odpowiada dobrej odporności na działanie wody i mrozu. W przypadku betonu asfaltowego z kruszywem kwarcytowym i asfaltem drogowym 35/50 należy zauważyć, iż utracił w wyniku starzenia odporność na oddziaływanie niskich temperatur z uwagi na wartość wskaźnika poniżej krytycznego poziomu 70%. Natomiast w przypadku betonów asfaltowych w skład których wchodził asfalt niskowiskozowy pomimo destrukcyjnego wpływu starzenia na wodo- i mrozoodporność nadal zachowują one rezerwę elastyczności i będą znacznie trwalsze. Pomimo procesu starzenia są one w dalszym ciągu odporne na oddziaływanie ujemnych temperatur. Należy zwrócić uwagę iż wartości wskaźnika wytrzymałości na rozciąganie pośrednie w betonach asfaltowych z asfaltem niskowiskozowym z kruszywem diabazu i kwarcytu są zbliżone. Na fakt ten może mieć wpływ stosunkowo duża zawartość wolnych przestrzeni w betonie asfaltowym z kruszywem diabazowym.

Podsumowując wykonane badania wpływu procesu starzenia betonu asfaltowego na oddziaływanie wody oraz mrozu z asfaltem niskowiskozowym można stwierdzić, że tego rodzaju asfalt ogranicza skutki starzenia, poprzez zmniejszenie usztywnienia mastyksu, poprawiając przy tym znacznie wodo- i mrozoodporność betonu asfaltowego.

5. Wnioski

Dokonując analizy wyników wykonanych badań można stwierdzić, że zastosowanie asfaltu niskotemperaturowego w betonie asfaltowym wpływa korzystnie na zmiany jego parametrów mechanicznych w porównaniu ze stosowaniem asfaltu zwykłego. Asfalt niskotemperaturowy powoduje zwolnienie tempem starzenia temperaturowego (LTOA i STOA) betonu asfaltowego. Dynamika procesu starzenia jest znacznie mniejsza z tym rodzajem asfaltu, niż gdy stosowano asfalt zwykły 35/50. Beton asfaltowy z asfaltem niskotemperaturowym charakteryzuje się również większą odpornością na oddziaływanie wody i mrozu zarówno przed, jak i po okresie starzenia, niż w przypadku, gdy jako lepiszcze zastosowano asfalt drogowy 35/50.