Innovative SMA-MA mixture for bridge asphalt pavement

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ABSTRACT

Paper presents innovative technological solution applied in bridge pavement. New asphalt mixture, called SMA-MA, uses benefits of both mastic asphalt (MA) widely used as a bridge waterproofing layer and stone mastic asphalt (SMA) and provides more durable mixture.

According to the wide research plan, several mixtures were tested for their resistance to permanent deformation, water susceptibility, fatigue and aging resistance. Conducted research proved that such mixture can be successfully used as waterproofing and protective layer as well as traffic carrying layer. In comparison to the typically used asphalt mixtures (SMA, MA or asphalt concrete), SMA-MA presents: mixture resistant to permanent deformation with very low air voids content (about of 0.5%) reachable with typical asphalt mixture compaction temperature of 180°C. The temperature of application SMA-MA mixture is about 30°C less than temperature of mastic asphalt, but the ability of sealing is comparable. SMA-MA mixture is a fast application technology using conventional equipment. In climatic conditions of middle Europe showing high number of freezing-thawing cycles, it is recommended to use such innovative technological solution on bridge decks.

Keywords: Mastic Asphalt, Mixture design, Stone Mastic Asphalt, Stiffness, Waterproofing

1. INTRODUCTION

Bridge pavement is a decisive constituent affecting the durability of bridge structure. It is exposed to various load conditions, subjected to traffic loads and climatic conditions.
Properly designed and constructed bridge pavement should meet the following [1, 2]:

- evenly distribute the load on the bridge,
- suppress the dynamic effects of the traffic loads,
- show good adhesion to the bridge deck,
- take deformation of the deck caused by temperature changes in the range from -30°C to +70°C,
- be equal and rough,
- be resistant to low temperature and fatigue cracking and rutting.

The role of the pavement on a bridge structure, in addition to providing convenient and safe traffic conditions is the deck protection against water and de-icing agents. In Poland and in Europe asphalt pavements are commonly used. The cement concrete paving technology on bridge structures did not find recognition in Europe. Bridge concrete pavements are a common material and technological solution in the US. The risk of water penetration through a standard layers of asphalt mixtures that should not be compacted on bridges by vibration is given as one reason for avoiding bridge asphalt pavements in the United States [3, 4].
The article presents the test results of an innovative asphalt mixture designed for bridge pavements - high stone content mastic asphalt SMA-MA, which features pavement application ease, high tightness, fatigue life, resistance to permanent deformations and resistance to technological ageing. In addition, influence of high temperature (200°C-300°C) on properties of SMA-MA and traditional asphalt mixtures used for bridge pavements was discussed here. Such high temperature in pavement layers can be caused by bridge or vehicles fire. It should be investigated whether asphalt pavements exposed for such conditions can be further use or rather should be replaced.

2. PAVEMENT STRUCTURE ON BRIDGE DECK

The layers of bridge pavement differ from the pavement layers on soil. Material and technological solutions applied in Europe for bridge pavements rely on previously primed deck for waterproofing and pavement application, which consists of the protective and wearing layer. Pavement including waterproofing forms a pavement system on a bridge deck of an adequate durability.
Fig. 1 shows a schematic of pavement structure on subgrade and on a bridge deck.

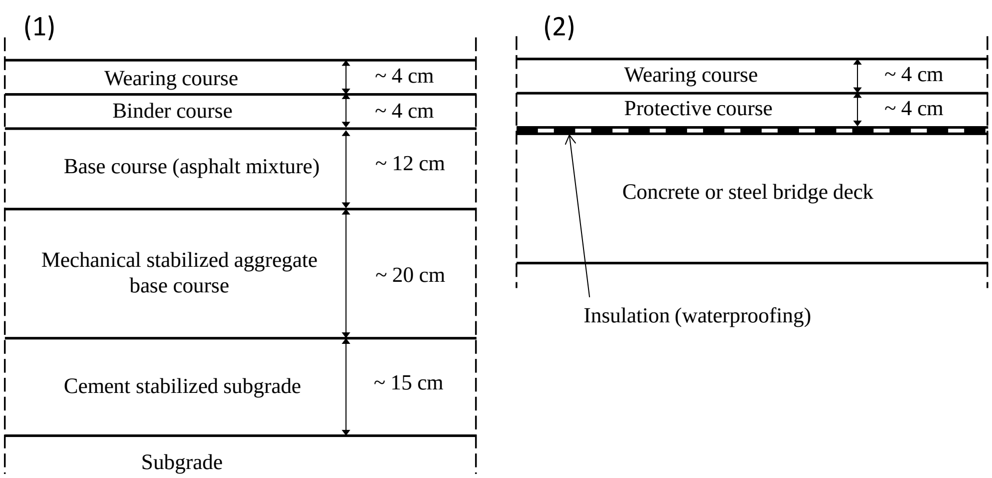

Figure 1: The pavement structure on the subgrade (1) and on the bridge deck (2)

Bridge wearing layer should exhibit sealed and closed structure and have the ability to carry and spread loads on lower layers [5, 6].
Protective layer is designed to protect the waterproofing from damage that might occur during application of the upper pavement layer, as well as to protect the waterproofing during operation conditions.
Bridge waterproofing must meet the following requirements:

- water tightness and resistance to water under pressure,
- good adhesion to the base surface and to the layer applied on top of the waterproofing,
- adequate strength in a wide temperature range from - 30°C to + 70°C,
- flexibility,
- thermal stability,

- high durability and resistance to ageing,
- ease of use,
- possibility of applying pavement layers directly on the insulation.

As the research shows [7] one of the main causes for lower durability of bridge pavements may be the lack of proper bond between the bridge deck and the pavement. Damages of both pavement and waterproofing are also linked to the occurrence of permanent deformations, low temperature cracks and the lack of pavement resistance to water and frost. These damages are particularly visible on orthotropic steel plates. Surface damages may be additionally caused by the asphalt mixture's lack of resistance to ageing.
In order to mitigate the risk of bridge pavement damage, a new innovative asphalt mixture SMA-MA was designed, dedicated to bridge protective layer or bridge waterproofing.

3. MATERIAL AND TECHNOLOGICAL SOLUTIONS OF BRIDGE PAVEMENTS

The Warsaw University of Technology completed a research project „Material and technological solutions for bridge deck waterproofing and pavements" in years 2011-2013. The aim of the project was to analyse the commonly used material and technological solutions of waterproofing and pavements on concrete and steel bridge decks with particular emphasis on the impact of high technological temperatures on materials durability used for waterproofing and pavement layers.
In the course of the project currently used material and technological solutions of waterproofing and waterproofing protective layers were analysed taking into account their composition, layers application requirements, the risk of damage occurrence. The recent technologies incorporating new solutions for waterproofing and pavements increasingly recommend the use of modifying additives, i.e. mainly polymers, the application of which requires scrupulous adherence to technological recommendations. Application requirements consider primarily technological temperature limits which, if exceeded, in the case of using polymers, can cause degradation of waterproofing or protective layer.
The following asphalt mixtures can be used for bridge pavement layers [8]:

– protective layer
  - mastic asphalt (MA) grain size 8 and 11 mm,

– wearing course
  - stone mastic asphalt (SMA) grain size 5, 8 and 11 mm,
  - very thin layer asphalt concrete (BBTM) grain size of 8 and 11 mm,
  - asphalt concrete (AC) grain size of 11 mm.

The following asphalt binders are recommended for mineral asphalt mixtures:

- for protective layer - bitumen 35/50 multigrade bitumen 35/50,
- for wearing layer - bitumen 35/50 and multigrade bitumen 35/50 for mastic asphalt MA, polymer modified binders PMB 45/80-55, PMB 45/80-65 and PMB 65/105-60 for SMA. These binders may be applied to asphalt concrete AC and BBTM.

The following types of waterproofing (insulation) can be used on steel and concrete decks [9]:

- liquid membrane e.g. polyurethane,
- bituminous coating e.g. bitumen-polymer, bitumen-epoxy, bituminous adhesive,
- epoxy resins coating,
- polyurethane resin coating,
- asphalt sheets – torch-on membrane or self-adhesive bitumen-polymer preformed sheets,
- mastic (traditional)
- mastic asphalt MA,
- bitumen coating with protective plates (e.g. the system Servidek / Servipak),
- high stone content mastic asphalt SMA-MA - a new solution.

It should be noted that a large group of waterproofing materials used on bridge structures are bituminous materials with polymer content. The use of high technological temperatures (up to 200°C) during layers application may cause damage to the binder's polymer network and consequently lower the durability of the pavement.
Among these material and technological solutions used for bridges waterproofing, besides bituminoust sheets and plastics, it is possible to use the traditional mastic or mastic asphalt. These sorts of waterproofing are used successfully in many European countries due to their application ease, mechanically. In Poland, mastic waterproofing is used in a limited extent, but in case of several large bridges they meet all requirements in a very good way and exhibit high durability.
Waterproofing of traditional mastic is applied on horizontal surfaces of road bridge decks, steel bridges and concrete bridges. Traditional mastic consists of 30-40% m/m of filler, 40-60% m/m of sand and 14-16% m/m of binder.
Commonly used type of asphalt mixture layer for waterproofing and protecting layer is mastic asphalt of high sealing ability. A disadvantage of both mastic asphalt and traditional mastic is their reduced resistance to permanent deformation, low workability and high production and application temperatures (200-230°C).

New material and technological solution that can be applied to waterproofing layer and pavement layers is high stone content mastic SMA-MA. SMA-MA is an asphalt mixture combining tightness and resistance to ageing of mastic asphalt and resistance to rutting of stone mastic asphalt SMA, at a reduced application temperature of about 180°C.

4. HIGH STONE CONTENT MASTIC SMA-MA AS AN INNOVATIVE SOLUTION FOR BRIDGE PAVEMENT

High stone content mastic asphalt SMA-MA, is a creative combination of mastic asphalt technology SMA, mastic asphalt MA and traditional mastic as waterproofing or protective layer. The use of high stone mastic asphalt eliminates the drawbacks of traditional mastic, regarding mainly low bearing capacity (mechanical properties and stiffness). This technology recommends the use of large amounts of grit based on the model of stone mastic asphalt SMA, in order to increase mechanical resistance to permanent deformation. As a result, high stone content mastic SMA-MA has extended grit backbone, increased content of sand fraction (as in mastic asphalt) and high binder content - about 8.5-9% m/m (as in conventional mastic). Such composition of the mixture results in its high tightness (the content of air voids around 0.5-0.8% m/m) and resistance to permanent deformation. SMA-MA production and application technological temperatures (about 180°C) does not pose any overheating risk to polymer modified asphalt or damage risk of the polymer network. The same standard equipment is used for SMA-MA application, as for SMA or AC.
An example of SMA-MA mixture composition and comparative mixtures: traditional mastic, mastic asphalt MA and stone mastic asphalt SMA are shown in Table 1.

Table 1: Examples of mineral asphalt mixture compositions for waterproofing and bridge pavements

Material	SMA-MA 8	SMA 8	MA 8	Traditional mastic (M)
	% m/m			
Binder	9.0	7.0	8.0	13.0
Mineral filler	12.7	11.2	27.6	35.0
Sand not broken	-	-	11.0	-
Sand broken	12.7	12.1	11.1	52.0
Gabbro grit 2/5	14.6	17.7	18.4	-
Gabbro grit 5/8	51.0	52.0	23.9	-

It should be noted that when designing a high stone content mineral mastic SMA-MA mixture the border points of SMA mixture are used.

5. PROPERTIES SMA-MA MIXTURE

Asphalt mixtures designed for bridge decks may be exposed to the effects of high temperatures related to its manufacturing and installation, applying on its top the next hot layer or which can be caused by bridge or vehicles fire. This can result in accelerated ageing of the mixture and consequently lead to an adverse change in its technical properties. For this reason, in order to evaluate properties of SMA-MA mixture and comparative mixtures, their resistance to ageing was determined. Loose asphalt mixture was subjected to heating (thermal conditioning) in the laboratory at 200°C, 250°C and 300°C at a layer thickness of about 50 mm, for one hour. After heating process appropriate samples were moulded. The depth of indentation of traditional mastic, SMA-MA mixture and mastic asphalt MA was performed at 40°C, according to EN 12697-20. The test of stiffness modulus at 10°C by the method of indirect tensile strength of cylindrical specimen IT-CY, according to EN 12697-23 (all asphalt mixtures), fatigue strength test according to EN 12697-24 (SMA-MA, SMA, AC) and test of water sensitivity by the method of indirect tensile strength ratio ITSR, according to EN 12697-12 (SMA-MA, AC) were also determined.
The research results of the properties of asphalt mixture were determined in form of properties index IS change, calculated on the basis of the following formula:

$$IS_{x\ property} = \frac{Y_{x\ property}\ \ (200; 250; 300°C)}{Y_{x\ property}}$$

where:

$Y_{x\ property}$ (200;250;300°C) - value of the property, for example: depth of indentation, stiffness of the asphalt mixture, etc. after heating (thermal conditioning) at a temperature of respectively 200°C, 250°C, 300°C,

$Y_{x\ property}$ - value of the property, for example: depth of indentation, stiffness of the asphalt mixture, etc. prior to heating.

The immutability criterion of the selected feature is 1.0 (IS = 1.0). Each variation of consistency index in relation to the value of 1.0 indicates a change in tested feature as a result of high temperature.

5.1. Types of asphalt mixtures used for the tests

In order to determine the effect of high temperature on the functional properties of bridge waterproofing layer and pavement the tests of selected heavy traffic asphalt mixtures were carried out. The waterproofing of high stone content mastic asphalt (SMA-MA) and comparatively of mastic asphalt (MA) and traditional mastic (M) were evaluated. Protective and wearing layers were designed of high stone content mastic asphalt (SMA-MA) and comparatively mastic asphalt (MA), stone mastic asphalt (SMA), asphalt concrete (AC).
Basic features of the designed mixes are shown in Table 2.

Table 2: Properties of asphalt mixtures for waterproofing layers and for bridge pavements

Type of mixture	Layer type	Binder content % m/m	Air voids content, V_m, % v/v	Type of asphalt binder
MA 8	waterproofing	8.0	-	PmB 25/55-60 20/30 35/50 35/50 + 2% natural asphalt
Traditional mastic (M)	waterproofing	13.0	-	PmB 45/80-55 35/50 35/50 + 2% natural asphalt
SMA-MA 8	waterproofing / protective	9.0	0.7	PmB 45 80-55 Rubber modified bitumen
SMA 8	protective / wearing	7.0	2.6	PmB 45/80-55
AC 11	protective wearing	5.4	2.1	PmB 45/80-55 PmB 25/55-60

For each of the asphalt mixtures, depending on their type and intended use (waterproofing, protecting, wearing layer), the type of binder was chosen individually. In addition to unmodified hard bitumen used in mastic asphalt and in mastic, polymer modified binders were also selected. The properties of polymer modified binders may be subjected to adverse changes as a result of ageing, especially at temperatures above 200°C. Two new types of binders were used for asphalt mastic and high stone content mastic SMA-MA, e.g. 35/50 modified road bitumen with 2% m/m of natural asphalt Trinidad and a binder with the addition of crumb rubber from used car tires. The addition of natural asphalt Trinidad causes an increase in viscosity and a reduction of output bitumen penetration and bitumen adhesion improvement to the aggregate [6, 10]. It is recommended primarily for the production of mastic asphalt for wearing, protective and waterproofing layers for bridges decks loaded with heavy traffic. Trinidad asphalt additive is particularly beneficial for workability and compactability of asphalt mixtures. Pavement layers made with the use of this additive achieve a significant increase in resistance to permanent deformation [11]. The binder containing no less than 15% m/m of crumb rubber of a particle size of 1.0 mm was manufactured in "wet" technology and its penetration is approximately 50-70 [·0.1 mm]. Rubber modified binders are characterized by high resistance to ageing and good adhesion to aggregate. The asphalt mixtures with these binders feature high resistance to fatigue, low temperature cracking resistance, resistance to deformation at high temperatures, which in the case of bridge decks is especially important.

5.2. Evaluation of the impact of high temperature on the properties of mixtures used for bridge waterproofing

Action of high temperature and its influence on asphalt mixtures used as a bridge insulation is a result of mastic asphalt technology where production temperature can reach 230°C-250°C. Another source of high temperature are bridge accidents (e.g. fire in bridge technical installation) or vehicles fire. An assessment of resistance to high temperatures of the mixtures used for bridge deck waterproofing is shown as a hardness index variation vs. the function of heating temperature variation in depth of indentation test and stiffness modulus for high stone content mastic (SMA-MA), the traditional mastic (M) and mastic asphalt (MA) with different types of binders (Fig. 2, Fig. 3). Depth of indentation test is a measure of permanent deformation of mastics used for bridge pavements.

On the basis of test results shown in Fig. 2, it was found that at high temperatures in the range 200°C - 300°C for traditional mastic with road bitumen 35/50 and the bitumen with natural asphalt additive there is a slight change in the consistency measured by depth of indentation test. In contrast, high stone content mastic SMA-MA with modified binders shows significant changes in consistency, particularly in the case of rubber modified asphalt mixture. Under heating temperature of 200°C this mastic is plasticized (index IS > 1.0), which is most likely a result of further reaction of the bitumen with the rubber particles in the rubber modified binder. At higher temperature (250°C, 300°C), beneficial stabilization of the SMA-MA consistency takes place. SMA-MA mixture with the polymer modified binder in the whole range of tested temperatures retain similar degree of consistency, which is a result of the stabilizing influence of grit backbone of the mineral mix. The destructive effect of temperature on the polymer modified bitumen spatial network is in this case reduced.

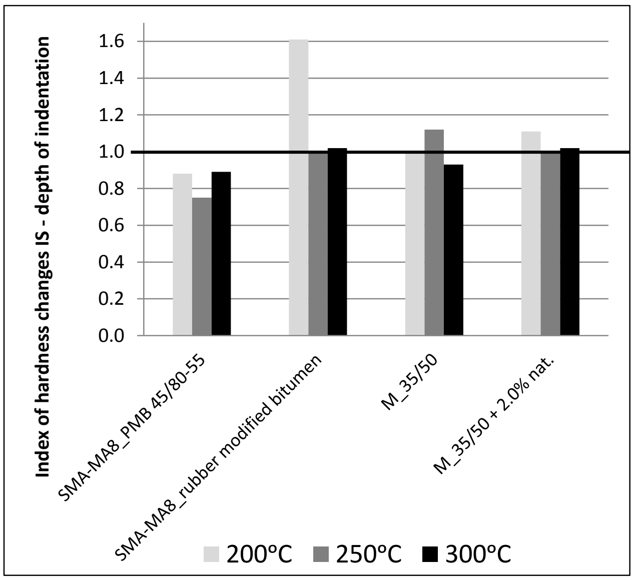

Figure 2: Index changes in hardness – depth of indentation of SMA-MA and traditional mastic (M) vs heating temperature

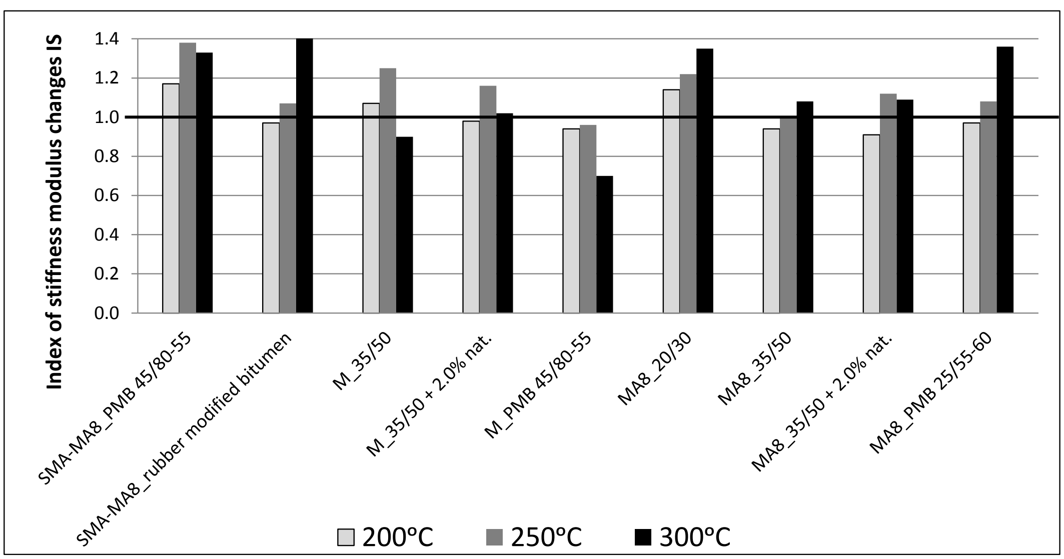

Figure 3: Index changes in stiffness modulus of SMA-MA, traditional mastic (M) and mastic asphalt MA vs heating temperature

Based on the research results of mastic stiffness modulus (Fig. 3), it can be concluded that the traditional mastic comprising bitumen 35/50 and the bitumen 35/50 with natural asphalt additive, with increasing heating temperature of 200°C to 250°C, shows a significant increase of the index change in stiffness modulus IS. In the same heating temperature range, mastic with polymer modified binder shows slight changes of hardening index. The heating temperature of 250°C is for mastics comprising different binders a critical temperature above which a substantial decrease of the stiffness modulus takes place. The stiffness modulus of mastic with 35/50 bitumen at heating temperature of 300°C is lower than the stiffness modulus of bitumen heated at 250°C, which may be caused by the process of structure deterioration of the binder in the mixture. The stiffness modulus variation index of mastic with polymer modified bitumen at heating temperature in the range 250°C - 300°C shows a significant stiffness (IS = 0.7) drop. Such significant mastic plasticization is the result of degradation of the polymer network structure, by exposure to temperatures above 250°C [12].
The test results of the mastic SMA-MA 8 with polymer modified binder indicate higher stiffness rate of SMA-MA mixture than the traditional mastic with other binders. It should be emphasized that the SMA-MA mixture at higher heating temperatures (250°C, 300°C) retains constant stiffness. Traditional mastic with natural asphalt exhibits similar stiffness stability in the entire range of tested high temperatures, but without the initial increase in stiffness modulus at heating temperature of 200°C. Other examined traditional mastics comprising road bitumen and polymer modified binder at temperature above 250°C exhibit a high unfavourable stiffness decrease.
In summary it should be noted that examined traditional mastics and high stone content mastic SMA-MA at high temperatures are retain consistence and stiffness as a function of temperature changes. There is a particularly favourable behaviour of the traditional mastic comprising natural asphalt additive and high stone content mastic SMA-MA comprising rubber modified binder. It should also be noted that mastics with polymer modified binders are not resistant to high temperatures, particularly above 250°C.
At temperatures above 250°C mastic asphalt MA 8, except mixtures comprising natural asphalt, show similar slight hardness values. Mastic asphalt comprising binder modified with natural asphalt exhibits greater consistency stability in heating temperature range of 250°C - 300°C compared to MA mixture comprising road bitumen 20/30.
It can be concluded that the SMA-MA 8 comprising polymer modified bitumen exhibits higher hardness values in respect to hardness at 200°C which may the result of favourable impact of mineral backbone. For mastic asphalt MA 8, the temperature of 250°C to be regarded as borderline temperature. Above this temperature stiffness modulus variation index of high stone content mastic SMA-MA comprising polymer modified bitumen retains stable value and is more favourable than the IS index of mastic asphalt MA.
In summary it can be concluded that the impact of high temperature on the variations of hardness index IS of asphalt mixtures depends primarily on the type of asphalt mixture. The IS index is also influenced by the amount and nature of the binder. There is a positive stabilizing effect of natural asphalt additive on the properties of the mixtures after ageing in contrast to more sensitive to hardness index change polymer modified mixtures.

5.3. Evaluation of high temperature impact on the mixtures properties used for bridge pavements

Study on the impact of high temperature on the asphalt mixtures with different binders, used for protective and wearing layer is shown in Fig. 4, Fig. 5 and Fig. 6.
Fatigue life tests were performed on samples of AC 11 asphalt concrete, stone mastic asphalt SMA 8 and high stone content mastic SMA-MA 8 comprising polymer modified bitumen pre-treated to heating temperature of 250°C. Examinations were carried out involving four point flexural tests at the following conditions:

- test temperature +10°C,
- four point cyclic bending of the beam at constant strain amplitude varying according to a sine function,
- load frequency of 10 Hz.

The test results of the fatigue life are shown in Fig. 4 and Fig. 5. Linear regression equation adequately describing the test results with correlation expressed by R^2 coefficient of determination.

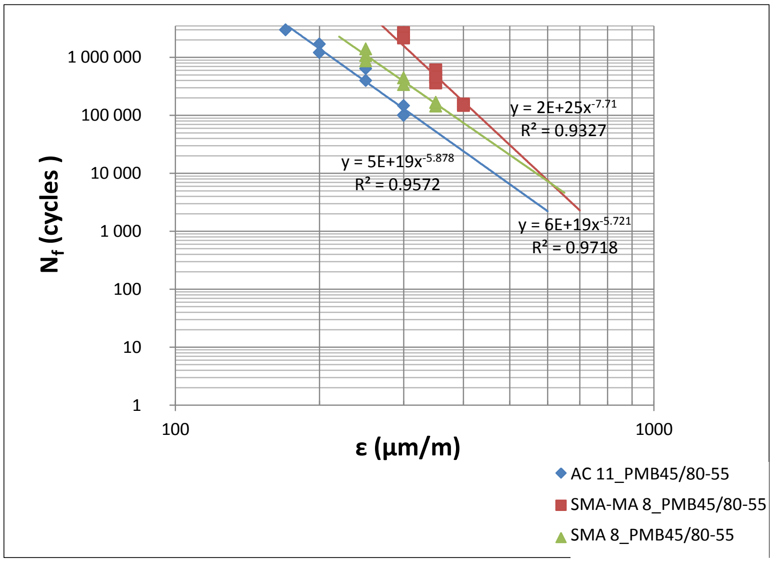

Figure 4: Fatigue life of AC 11, SMA 8 and SMA-MA 8 asphalt mixtures prior to heating process

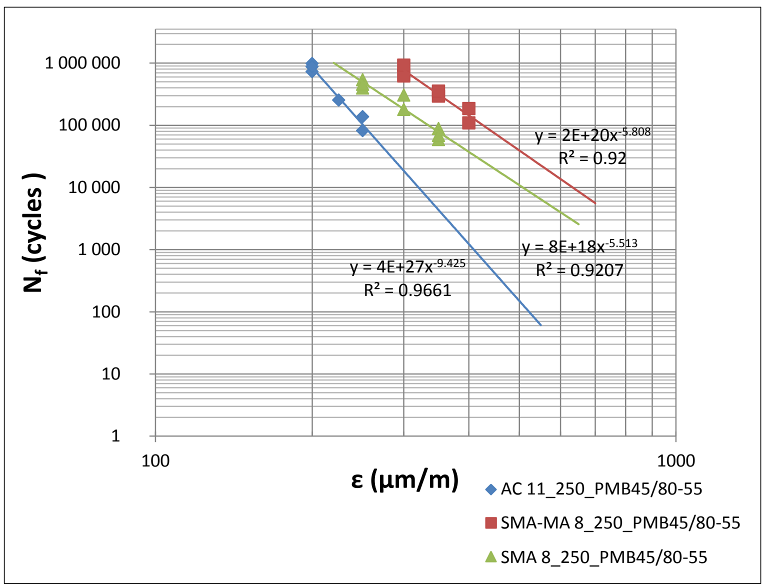

Figure 5: Fatigue life of AC 11, SMA 8 and SMA-MA 8 asphalt mixtures after heating at 250°C

By analysing the test results shown in Fig. 4 and 5 it must be concluded that the fatigue life of the asphalt concrete after the heating process is much lower than before ageing. Much lower decrease in fatigue life occurs in the case of SMA and SMA-MA mixtures.

In summary it can be concluded that high short-term heating temperature causes a slight reduction in the fatigue life of the high stone content mastic SMA-MA and stone mastic asphalt SMA, but in a larger extent the reduction of fatigue life occurs in asphalt concrete AC. It may be explained by the fact that the thickness of the mastic film surrounding the aggregate grains in SMA-MA mixture is the highest and consequently the least susceptible to adverse changes of viscoelastic properties.

The test results of the water sensitivity (ITSR ratio) of the SMA-MA mixture with different binders and comparative mixture - asphalt concrete AC used for protective and wearing layer are shown in Fig. 6.

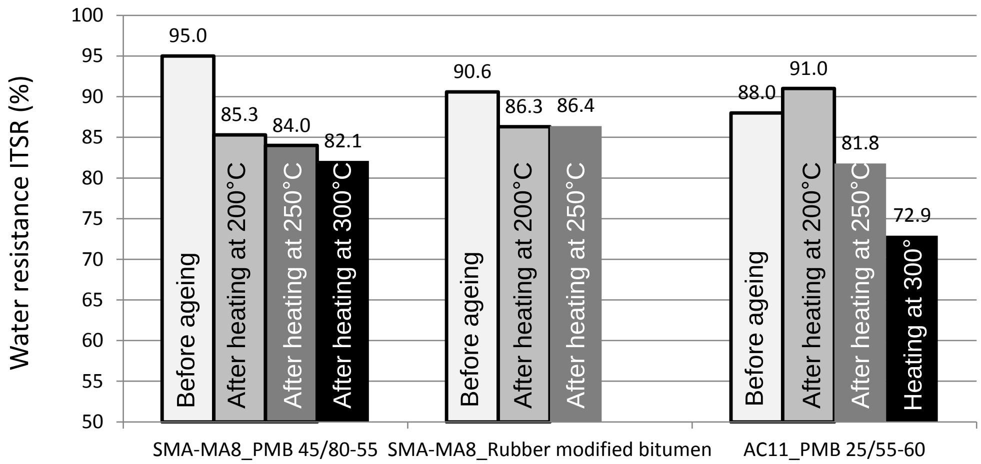

Figure: 6: Water sensitivity (ITSR) of SMA-MA 8 and AC 11 mixtures, before and after heating (ageing)

By analysing the test results shown in Fig. 6 it must be concluded that the SMA-MA mixtures exhibits greater the water sensitivity before ageing and after heating at 250°C compared to asphalt concrete AC.
The resistance to water of the asphalt concrete after the heating at 300°C is much lower than before heating. Much lower decrease in ITSR ratio occurs in the case of SMA-MA mixture with PMB 45/80-55 binder.
It should be emphasized that the SMA-MA mixtures at higher heating temperatures (200°C, 250°C, 300°C) retains constant water sensitivity.

6. SAMPLE MATERIAL AND TECHNOLOGICAL SOLUTIONS OF BRIDGE PAVEMENTS WITH THE USE OF HIGH STONE CONTENT MASTIC SMA-MA

At Warsaw University of Technology new material and technological solutions have been analysed that take into account the use of new materials such as high stone content mastic SMA-MA. Selection of the proposed solutions was based on technical experience in application of traditional asphalt mixtures (SMA, MA, AC) in Polish bridges.
Table 3 lists the proposal of asphalt pavement layout on bridge structures taking into account the layer of a new SMA-MA mixture. Proposed selection examples of the type of protective and wearing layer and thickness of these layers, depending on the traffic category is shown in Table 4. As a following study, proposed structural layers are going to be verified based on the functional tests, e.g. rutting test on multilayer sample.

Table 3: Selection proposals of structural layers of bridge pavements [3]

Wearing course / Protective layer	1. SMA	2. MA	3. AC	4. BBTM
1. SMA	+	+/-	+/-	+
2. MA	+	+	+	+
3. AC	+	-	+	+
4. SMA-MA	++	+	+	++
5. HRA	+	+	+	+

"++" Highly recommended
"+" Recommended
"+/-" Acceptable
"-" Not recommended

Wearing course:
1. SMA
2. mastic asphalt MA
3. asphalt concrete AC
4. very thin layer asphalt concrete BBTM

Protective layer
1. SMA
2. mastic asphalt MA
3. asphalt concrete AC
4. SMA-MA
5. hot rolled asphalt HRA

Table 4: Examples asphalt pavement structures on concrete bridge decks [3]

Light traffic intensity	Medium traffic intensity	Heavy traffic intensity
≤ 0.50 mln axles 100 kN	0.50 – 7.30 mln axles 100 kN	> 7.30 mln axles 100 kN
AC 11: 4 cm – wearing course AC 8: 3 cm – protective layer Membrane: 0,5 cm – insulation Bituminous coating – primer bridge deck 7 cm + 0,5 cm bituminous membrane	AC 11: 5 cm – wearing course **SMA-MA 8: 3 cm** – protective layer Membrane: 0,5 cm – insulation Bituminous coating – primer bridge deck 8 cm + 0,5 cm bituminous membrane	AC 11: 5 cm – wearing course AC 11: 4 cm – protective layer SMA 5: 2 cm – protective layer Membrane: 0,5 cm – insulation Bituminous coating – primer bridge deck 11 cm + 0,5 cm bituminous membrane
SMA 8: 4 cm – wearing course AC 8: 3 cm – protective layer Membrane: 0,5 cm – insulation Bituminous coating – primer bridge deck 7 cm + 0,5 cm bituminous membrane	SMA 11: 4 cm – wearing course **SMA-MA 11: 4 cm** – protective layer Membrane: 0,5 cm – insulation Bituminous coating – primer bridge deck 8 cm + 0,5 cm bituminous membrane	SMA 11: 5 cm – wearing course SMA 11: 4 cm – protective layer **SMA-MA 5: 2 cm** – protective layer Membrane: 0,5 cm – insulation Bituminous coating – primer bridge deck 11 cm + 0,5 cm bituminous membrane

7. CONCLUSIONS

Based on the own research results and analysis of the literature the following conclusions can be made:

1. Materials used for bridge waterproofing and pavements should have a good sealing properties and high strength parameters in a wide range of operating and technological temperatures.
2. There is a possibility of constructing bridge pavements with increased resistance to high technological temperatures by appropriate selection of pavement layout, material selection and application of appropriate technology.
3. A new material and technological solution is high stone content mastic SMA-MA that combines the advantages of resistance to permanent deformation (hardness, stiffness) and fatigue of SMA mixture and mastic asphalt MA benefits in terms of tightness and durability. The resistance of permanent deformation of SMA-MA mixture will be verified in further rutting tests.
4. High temperature used in the production of asphalt mixtures for the protective and wearing layers of bridge pavement may cause a significant reduction in fatigue resistance of traditional asphalt mixtures compared to high stone content mastic SMA-MA. The temperature of 250°C which can be caused by technological processes or by bridge or vehicles fire is for asphalt mixtures a critical temperature above which a substantial decrease of the mechanical properties (stiffness modulus, fatigue life) takes place.

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