ROAD BITUMEN MODIFIED WITH NATURAL ASPHALT TRYNIDAD EPURé AND GILSONITE ADDITION

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ABSTRACT

The objects of the research and analysis presented in the paper are composites prepared of 35/50 and 50/70 penetration grade bitumen, with the addition of Trinidad Epuré and Gilsonite natural asphalt. The aim of research is to evaluate the changes of rheological properties of composites as a result of those two modifiers addition. The research area includes tests of temperature susceptibility characterized by the penetration index PI value, the adhesion to the basalt and granite aggregates, the maximum tensile force determined by force-ductility method, resistance to low temperature cracking characterized by stiffness modulus and m-value determined by using Bending Beam Rheometer BBR.

Keywords: Adhesion, Ageing, Natural asphalt, Rheology, Temperature susceptibility

1. INTRODUCTION

Trinidad Natural Asphalt is mined from Trinidad Pitch Lake, which is located nearby city La Brea on Trinidad Island, on the Caribbean Sea. This raw material separated from the surface of the lake is a natural mixture of: bitumen - 39.3%, minerals - 27.2%, water and volatile substances - 29.0 to 30.2% and bound water - 3.3%. It is purified through evaporation of free water and volatile materials and separation of mineral or organic pollutants in the form of stones and wood. The final product of this technology is pure asphalt called the Trinidad Epuré. It contains: natural bitumen - 53.0 to 55.0%, minerals - 36.0 to 37.0%, organic matter insoluble in CS_2 - 9.0 to 10.0%. Powder in the Trinidad Epuré is composed of particles <0.09 mm in an amount about 82% and grains 0,09-0,25 mm in an amount about 18% [1].
Many years of experience have shown benefits of addition the natural asphalt to the hot mix asphalt on their workability and compactibility. Professor Radenberg's publications shows that the addition the Trinidad Epuré to asphalt improves its resistance to rutting [2]. This additive to the hot mix asphalt is allowed to use lower temperature compaction. It is very beneficial from the point of view of surface technology and environmental friendliness. In Germany the Trinidad Epuré is used successfully as an additive for hot thin layers in many parts of the repair pavement. The purpose of use is to create favorable conditions for compacting hot thin layers, which is rapidly cooled by the rollers and the weather condition.
Gilsonite was discovered in 1860 in north-eastern part of Utah (USA) in the Uintah basin. The production of this unique material began in 1885, when Samuel H. Gilson characterizing ore called it his name. Gilsonite is a glossy, black, solid hydrocarbon resin similar in appearance to coal or hard asphalt. A special feature of Gilsonite, which significantly differ it from Trinidad Epuré is a very high content of pure bitumen in amount about 98%. This raw material is a natural mixture of: coal - 84.9% (aliphatic carbon - 68.3%, 31.7% of aromatic carbon), hydrogen -10.0%, nitrogen - 3.3%, sulfur - 0.3%, oxygen - 1.4% and other ingredients in amounts - 0.1%. This ore is crushed and delivered to customers in the form of granules of grain size 0/2 mm or powder [3, 4].
Gilsonite is used in road construction as a performance-enhancing agent of hot mix asphalts. This additive may partially replace using SBS polymers, what could reduce the cost of production of modified bitumen. Gilsonite modified hot mix asphalts have higher stability, reduced deformation, reduced temperature susceptibility and increased resistance to water. Gilsonite is used in the form of solvent and emulsion as a surface sealant resistant to adverse weather conditions [5].
We do not have detailed knowledge of effects of changes the functional and rheological properties of composites as a result of those two modifiers addition. In this research work authors attempt to get to know the impact of using this additives.

2. PURPOSE AND SCOPE OF THE RESEARCH

Aim of this study is to get to know the impact of addition of natural asphalt Trinidad Epuré and Gilsonite, respectively marked with symbols TE and GIL in this paper, to change the following properties of bitumen 35/50 and 50/70:
- Temperature susceptibility characterized by the penetration index PI value, determined before and after aging according to the method RTFOT,
- Adhesion to basalt and granite aggregate,
- The maximum tensile force, determined by force-ductility method, at 10°C,
- Stiffness modulus and m-value which characterize the resistance to low temperature cracking, determined by using Bending Beam Rheometer BBR at -8°C, -16°C, -24°C and -32°C before and after aging according to the RTFOT method.

3. METHODS AND RESULTS OF RESEARCH

3.1. Materials

Two penetration grade bitumens 35/50 and 50/70 named base bitumens and natural asphalt Trinidad Epuré and Gilsonite were used in the research programme.
Preparation of composites with the addition of TE was consisted of preheat containers filled with bitumen grade 35/50 to temperature of 175°C and bitumen grade 50/70 to temperature of 165°C. Next step was adding the natural asphalt TE in appropriate proportions. In order to dissolve the bitumen contained in the asphalt TE composites was heated at these temperatures. For homogenization the composites with the base bitumen and nature asphalt the laboratory mixer was used.
Preparation of composites with the addition of GIL was consisted of preheat containers filled with bitumen grade 35/50 and 50/70 to temperature 190°C. Next step was adding the natural asphalt GIL in appropriate proportions. In order to dissolve the bitumen contained in the asphalt GIL composites was heated at this temperature. For homogenization the composites with the base bitumen and nature asphalt a laboratory glass stick was used.
Obtained composites were marked by specifying the grade of base bitumen, type of additive (TE or GIL) and its content in the composite.
Example description of composites:
- 35/50 penetration grade bitumen with addition of 15% of Trinidad Epuré - marked as 35/50 + 15% TE,

- 50/70 penetration grade bitumen with addition of 7% of Gilsonite - marked as 50/70 + 7% GIL.

3.2. Temperature susceptibility

To evaluate the temperature susceptibility of tested specimens, the following properties were determined:
- Penetration at 25°C - according to EN 1426,
- Softening Point according to the method of "Ring and Ball" - according to EN 1427.

Penetration Index (PI) values (Figures 1 and 2) were calculated using the formula (1) based on the results of determination of penetration at 25°C and softening point [6]:

$$PI = \frac{1952 - 500 \cdot \log(Pen25) - 20 \cdot T_{R\&B}}{50 \cdot \log(Pen25) - T_{R\&B} - 120} \quad (1)$$

where:
$Pen25$ - Penetration at 25°C, 10^{-1} mm
$T_{R\&B}$ - Softening Point, °C

The detailed results of determination of penetration at 25°C and softening point for Trinidad Epuré are presented by the authors in an article [7].

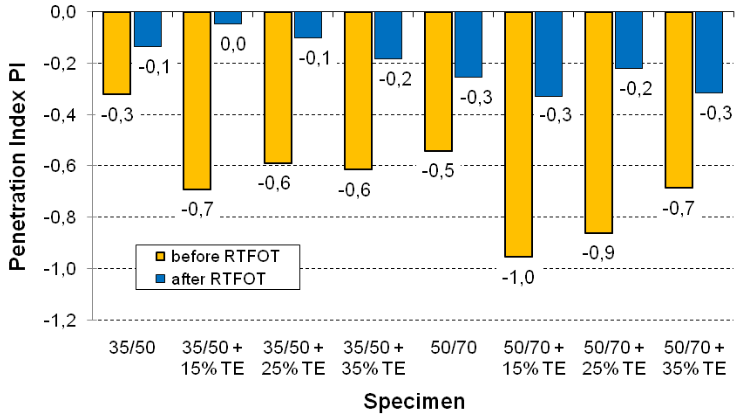

Figure 1 : Penetration index PI values before and after RTFOT - specimens containing TE addition

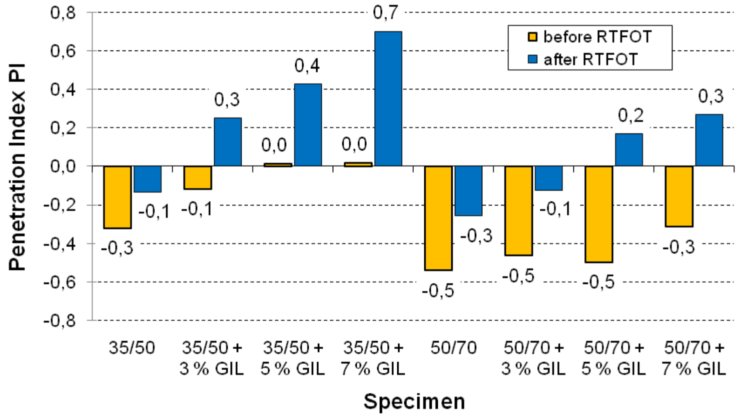

Figure 2 : Penetration index PI values before and after RTFOT - specimens containing GIL addition

3.3. Adhesion to the surface of aggregates

Good adhesion of bitumen to the surface of mineral aggregates is a very important factor for the durability of asphalt pavements [8].
Bitumen adhesion to aggregates was assessed on the basis of results of cooking test carried out in accordance with PN-B-06714-22. The aggregates with different acidity: basalt and granite, were used in the research programme.
In order to achieve a better accuracy of measurement compared to the standard method, the evaluation using "computer test" was carried out. This method has been described by the authors in the paper [7]. Results of adhesion test are shown in Figures 3 and 4.

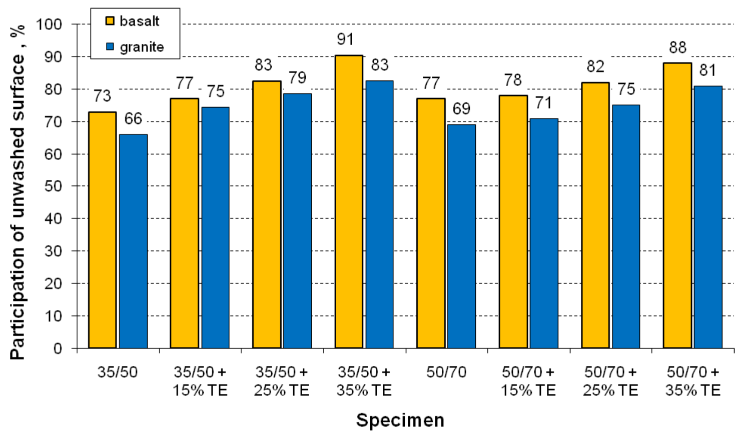

Figure 3 : Participation of surface covered with bitumen (unwashed) on basalt and granite aggregates (computer evaluation) - specimens containing TE addition

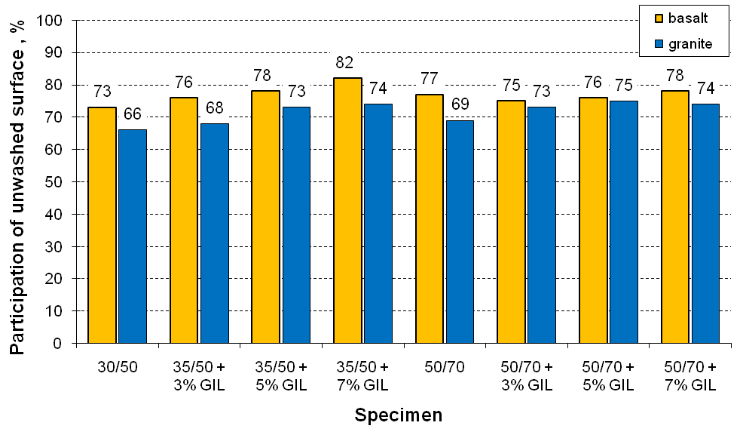

Figure 4 : Participation of surface covered with bitumen (unwashed) on basalt and granite aggregates (computer evaluation) - specimens containing GIL addition

3.4. Force-ductility method

The investigation was conducted using ductilometer at 10°C in accordance with EN 13589. Determined values of maximum tensile force are presented in Figures 5 and 6.

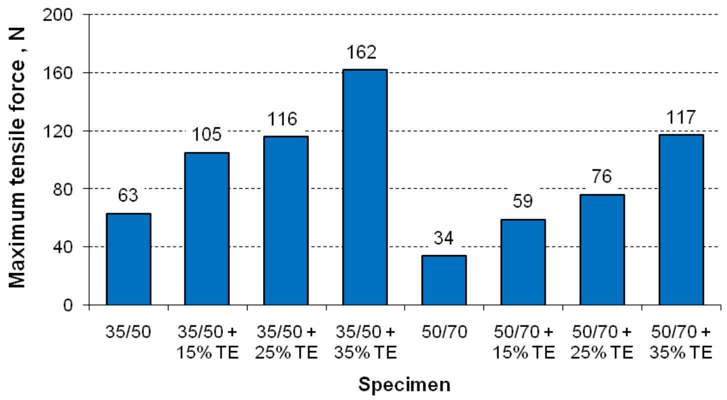

Figure 5 : Maximum tensile force values - specimens containing TE addition

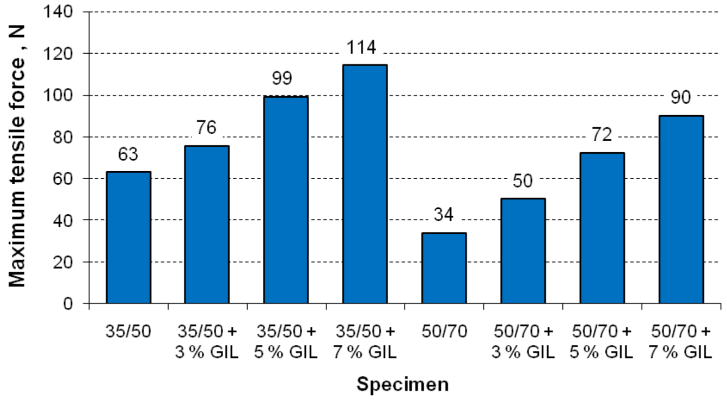

Figure 6 : Maximum tensile force values - specimens containing GIL addition

3.5. Bending Beam Rheometer (BBR) test

The research was conducted in Bending Beam Rheometer BBR at -8°C, -16°C, -24°C and -32°C before and after RTFOT according to EN 14771. Stiffness modulus values $S_m(t)$ expressed in Pascals were calculated by the following formula:

$$S_m(t) = \frac{Pl^3}{4bh^3\delta(t)} \quad (2)$$

where:

P – specimen load; *P* = (980±50) mN

l – distance between supports; *l* = 102 mm

b – specimen width; *b* = 12,7 mm

h – specimen height; *h* = 6,3 mm

$\delta(t)$ – specimen deflection at the time *t*

The m-values were calculated in accordance with the rules described in EN 14771, as the ratio of the logarithm of stiffness $S_m(t)$ to the logarithm of time of the load *t*, according to the formula:

$$m(t) = \frac{d \log S_m(t)}{d \log(t)} \quad (3)$$

Figures 7 and 8 show examples of stiffnes moduli and m-values determined at -16°C specimens containing TE addition.

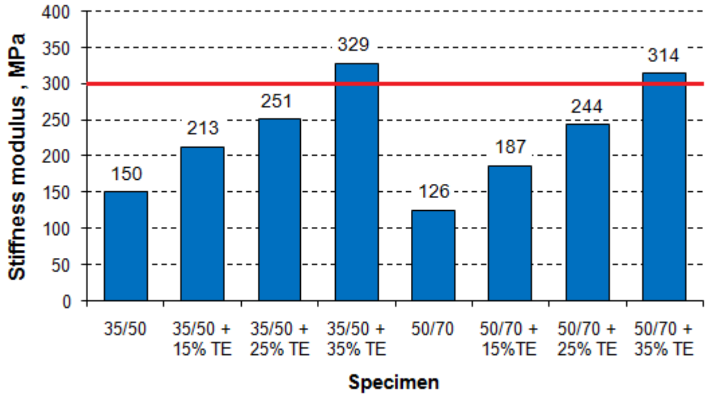

Figure 7 : Stiffness modulus values determined at -16°C - specimens containing TE addition

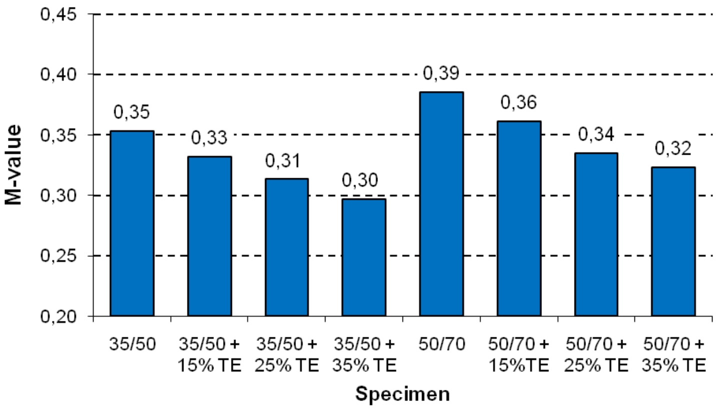

Figure 8 : M-value values determined at -16°C - specimens containing TE addition

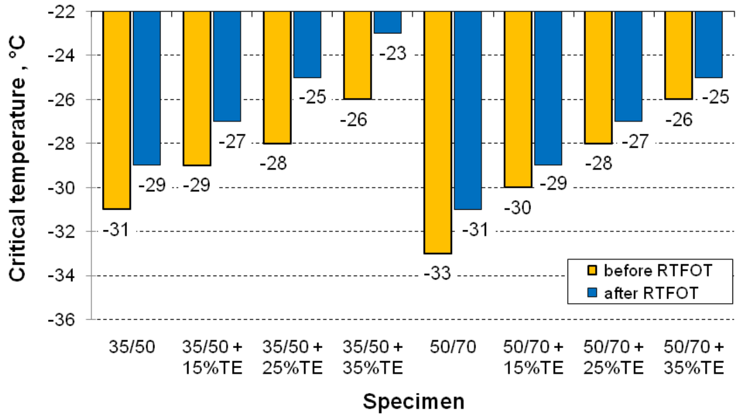

Figure 9 : Critical temperature values - specimens containing TE addition

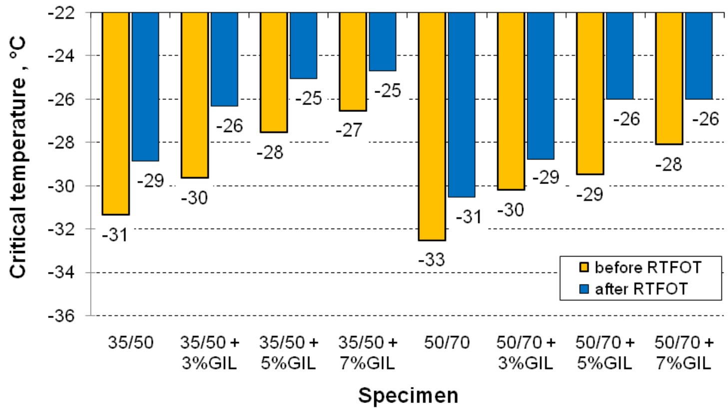

Figure 10 : Critical temperature values - specimens containing GIL addition

4. DISCUSSION

Trinidad Epuré and Gilsonite additives have a varied impact on the temperature susceptibility of the composites. At Figure 1 it can be seen that the addition of TE causes a decrease in penetration index PI. Differences of values of penetration index for composites with harder bitumen 35/50 are not significant, while for the softer bitumen 50/70 they are larger. As a result of the RTFOT aging process penetration index is increased. It can be seen that the values of PI of base bitumen and composites after RTFOT do not differ significantly. GIL additive increases penetration index value (Figure 2). Larger increase of PI values has been observed in the case of composites with harder bitumen 35/50. Together with increasing the GIL additive content the value of PI increases. As a result of the RTFOT aging process the values of penetration index PI are increased. It can be seen greater increase for the composites containing 35/50 bitumen.

The results of research show that the addition of Trinidad Epuré for road bitumen 35/50 and 50/70, improves the adhesion to the surface of mineral aggregates. In Figure 3 it can be seen that it is a larger part of unwash surface with asphalt when harder bitumen was used. The study shows that the addition of Gilsonite does not significantly improve the adhesion to the surface of mineral aggregates (Figure 4).

Additives of Trinidad Epuré and Gilsonite for road bitumen 35/50 and 50/70 affect the increase of the maximum tensile force of the tested composites. Figure 5 presents composites with addition of TE. It can be seen that this additive affects greater increases for the composites with harder bitumen 35/50. GIL additive (Figure 6) affects increase of the maximum tensile force of the composites with softer bitumen 50/70.
Analysis of the results obtained in the Bending Beam Rheometer (BBR) at -8°C, -16°C, -24°C and -32°C before and after RTFOT aging process showed that Trinidad Epuré and Gilsonite additives affect increase of the stiffness modulus. Performed in Figure 7 line meaning the value 300 MPa of stiffness modulus indicates excessive stiffness of the composites with the addition of 35% TE at -16°C. It may be a reason of a high sensitivity to low temperature cracking. In Figure 8 it can be seen that the conventional measures of rigidity (m-value) presents for the TE before the RTFOT aging process at temperature -16 °C complies the requirements and there are less than 0.3 according to the recomendation [10]. Analysis of the results of critical temperature for base bitumens and composites (Figures 9 and 10) showed that for both TE and GIL additives the critical temperature increases lower when a softer bitumen 50/70 was used. As a result of the RTFOT aging process the critical temperature was increased. It can be seen lower increase in the critical temperature when the GIL additive was used.

5. CONCLUSIONS

Based on performed research of the road bitumen penetration grade 35/50 and 50/70 and the obtained composites with the addition of natural asphalt TE and GIL, and the discussion we can formulate the following conclusions:
- additives of natural asphalt TE and GIL have a varied impact on the temperature susceptibility of the obtained composites. After the RTFOT aging process the impact can be assessed positively (increase of the PI value). It can also be stated that using GIL additive is more beneficial
- additive of TE to road bitumens 35/50 and 50/70 improves the adhesion to the surface of mineral aggregates. Addition of GIL additive does not improve significantly the adhesion of bitumen to the surface of aggregates. It can also be stated greater part of unwashed surface when harder bitumen 35/50 is used
- additive of TE affects hardening in the case of bitumen 35/50 and GIL additive – in the case of bitumen 50/70
- additive of TE and GIL to road bitumen 35/50 and 50/70 increased critical temperature. It was observed a greater increase of the critical temperature for a bitumen - 50/70. It can also be stated lower rise of the critical temperature using the GIL additive.

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