Asphalt mixture performance and testing

Design of the asphalt mixture using Friction After Polishing parameter

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Abstract

The paper presents results of the research project which aims to design and test wearing courses containing mixtures of aggregates with different resistance to polishing and improve quality and lifespan of skid resistance properties of pavements built in areas where aggregate resistant against polishing is not available. Within the research project, five different SMA mixtures were produced, each containing a different ratio of aggregate from various sources (basalt and greywacke). The test specimens made of these asphalt mixtures were tested according to EN 12697-49: the laboratory equipment simulates the traffic load and thus allows the prediction of the development of the friction coefficient with time. Based on the results of the laboratory measurements, asphalt mixtures were selected for the production of three test sections in the area of the asphalt plant and one test section on the trafficked road. The paper compares the results of FAP (Friction After Polishing) measured in the laboratory and longitudinal friction coefficient measured on site by the dynamic measuring device. The article also summarizes the possibility of using the aggregate less resistant to polishing, even from recycled material, while keeping required skid resistance, might improve road safety and effectivity of the production of asphalt mixtures for wearing courses.

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1. INTRODUCTION

Quality of skid resistance properties of pavement surfaces is influenced by particularly its microtexture and macrotexture. The effect of macrotexture is apparent with increasing vehicle speed, because it improves tire contact with the pavement surface when wet. Microtexture is significant at all speeds and its quality is mostly determined by the value of polishing resistance of the aggregate (Polished Stone Value, PSV) used in the asphalt mixture in wearing course [1]. In order to comply with the required temporal quality requirements of skid resistance properties of pavement surface and the associated higher traffic safety, it is necessary to use aggregate resistant to polishing with a minimum value of PSV equal to 50, or even higher for roads with higher traffic intensity. Such aggregate, however, is not available in some parts of the Czech Republic (fig. 1). A possible solution is using aggregates from local sources, which have unsuitable value of PSV with the addition of a small amount of imported aggregate with a higher value of PSV.

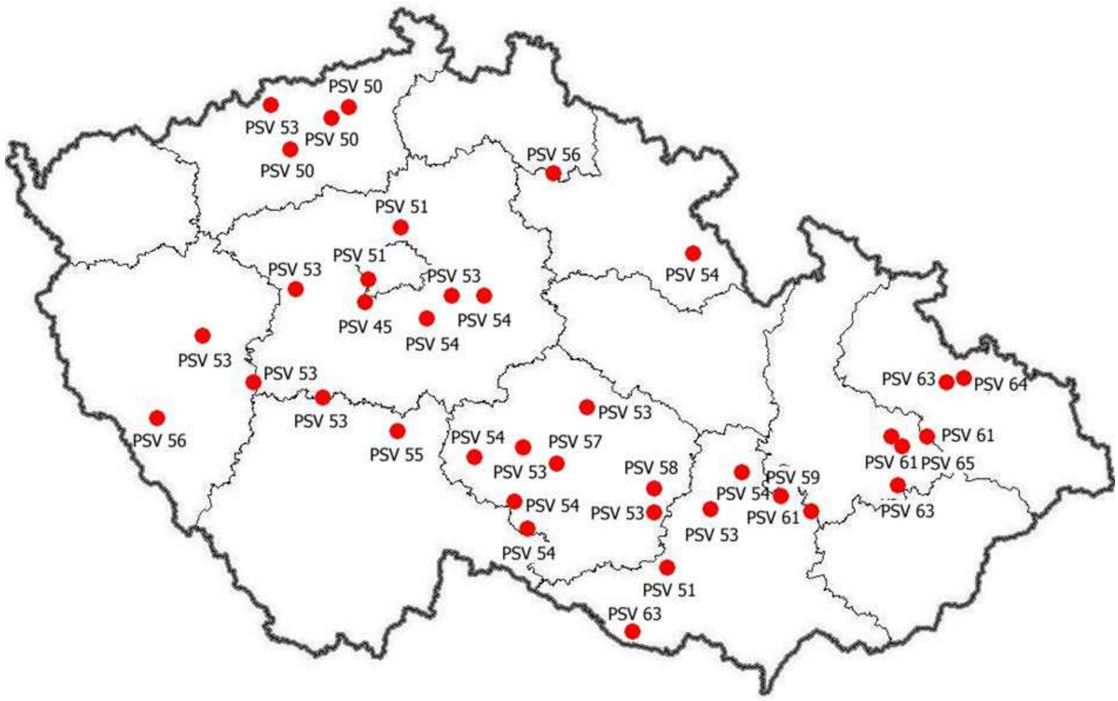

Figure 1: Map showing quarries and PSV values of the produced aggregate based on "Passportization of natural stone quarries in the Czech Republic" [2]

Within the research project TH02030194 [3], asphalt mixtures of AC 11 (asphalt concrete for wearing courses with the aggregate up to 11 mm) and SMA11 (Stone Mastic Asphalt with the aggregate up to 11 mm) type were designed from aggregates greywacke (PSV = 62) and basalt (PSV = 51). Test specimens from these asphalt mixtures were tested by the test method for determination of friction after polishing, in accordance with the EN 12697-49 standard.

2. DETERMINATION OF COEFFICIENT OF FRICITON AFTER POLISHING

During this laboratory test, the process of polishing involves three truncated rubber cones rolling over the tested specimen and in the meantime a mixture of quartz powder and water being added. This process alternates with a process of measuring the coefficient of friction after polishing μ_{FAP}. The measurements are being taken using three rubber pads, which brake on the surface of the specimen from a speed of 100 km/h in the track of the pads, until full stop. Water is being supplied during the measurement to the surface of the specimen and torque is being measured, which is then used to calculate the coefficient of friction after polishing. These two processes alternate until the desired number of passes is reached by the cones, which represents a simulation of traffic load. Result of the test is a graph of friction coefficient after polishing μ_{FAP} in relationship to the number of cone passes. If such measurement is performed on more test specimens made from the same asphalt mixture, the resulting value is the Friction after Polishing (FAP) of this asphalt mixture, which is calculated as an average of the μ_{FAP} values measured for the individual specimens [4].

Figure 2: Device for determination of friction after polishing (left), polishing head (top right), measuring head (bottom right)

3. DESIGNED ASPHALT MIXTURES

Two asphalt mixtures were designed – AC 11 and SMA 11. The design was based on the assumption that skid resistance properties of pavement surface are predominantly affected by aggregate fraction 8/11. Therefore, the aggregate of greywacke type was used only for the 8/11 fraction, for the other fractions basalt was used. The exact aggregate ratios and test specimen labels are given in Tab. 1 and 2.

Table 1. Asphalt mixtures of the type AC 11

Mixture label	Aggregate weight ratio, basalt fr. 8/11 (PSV = 51)	Aggregate weight ratio, greywacke fr. 8/11 (PSV = 62)
127652	100 %	0 %
127654	50 %	50 %
127653	0 %	100 %

Table 2. Asphalt mixtures of the type SMA 11

Mixture label	Aggregate weight ratio, basalt fr. 8/11 (PSV = 51)	Aggregate weight ratio, greywacke fr. 8/11 (PSV = 62)
127655	100 %	0 %
130073	80 %	20 %
129752	66 %	34 %
127657	50 %	50 %
127656	0 %	100 %

Lamellar compactor was used to produce slabs from the asphalt mixtures in a laboratory from which samples of a 225 mm diameter were cut out. These test specimens then underwent the test of accelerated polishing in accordance with the EN 12697-49.

4. RESULTS OF LABORATORY FRICITON PREDICITON

A total of 390 000 cone passes were performed on the test specimens. Measurements of friction coefficient after polishing were performed before the initial polishing cycle and then always after 30 000 cone passes, last two measurements after 60 000 cone passes.

Testing of the first sample from the AC 11 asphalt mixture type showed that it is not possible to remove the bitumen layer from the aggregate surface, which would be removed in the first months due to traffic load by polishing in a laboratory. The binder layer of the slabs produced in a laboratory is also thicker than on real pavement, especially in case of the asphalt mixture SMA 11, because this asphalt mixture type has a significantly higher coefficient of saturation and thus thicker binder film, which covers the aggregate grains on the surface of the test specimen – this is possible by the addition of binder carrier (most commonly cellulose fibers). The EN 12697-49 standard specifies that surplus bitumen must be removed by blasting the specimen surface with corundum. Such corundum blasting, however, caused damage to the course aggregate in the asphalt mixture, especially in case of greywacke (Fig. 3), which affected the measured values of friction coefficient after polishing. Surface of the other specimens was cleaned using benzine dissolving agent. This turned out to be a more suitable method because it does not damage the aggregate of the asphalt mixture in any way (Fig. 4). Even though the initial course of the friction coefficient after polishing values is not determined by the measurements, i.e. the phase when the bitumen is removed from the pavement surface by traffic load, the research project focused primarily on long-term lasting of skid resistance properties of pavement surface.

The process of the bitumen removal was same for all test specimens. The whole surface was poured by exact amount of benzine evenly. After two minutes the benzine with dissolved bitumen was gently wiped by paper towel. This procedure was repeated two times on each specimen so only the bitumen was removed, and the aggregate was not damaged.

Figure 3: Surface detail of the test sample after corundum blasting – aggregate damage (left)

Figure 4: Test sample from asphalt mixture of SMA 11 type: before cleaning (left), after benzine cleaning (middle), after polishing by 390 000 cone passes (right)

Graph in Fig. 5 shows course of the relationship between friction coefficient after polishing and number of cone passes for specimens made from asphalt mixture of AC 11 type. The curves clearly show that there is not a very significant difference between the individual specimens with various greywacke and basalt aggregate content. Also visual inspection of the specimen surface clearly indicated that they contain a very small amount of aggregate fraction 8/11, which could positively affect values of friction coefficient after polishing. This type of asphalt mixture was therefore not further developed and tested and next part of the project focused on asphalt mixture of SMA 11 type, which contains approximately 50 % of 8/11 aggregate fraction. Also, the number of measured specimens for the AC 11 asphalt mixture type was not sufficient to determine the overall FAP value, as it was done in the other graphs for the other asphalt mixtures.

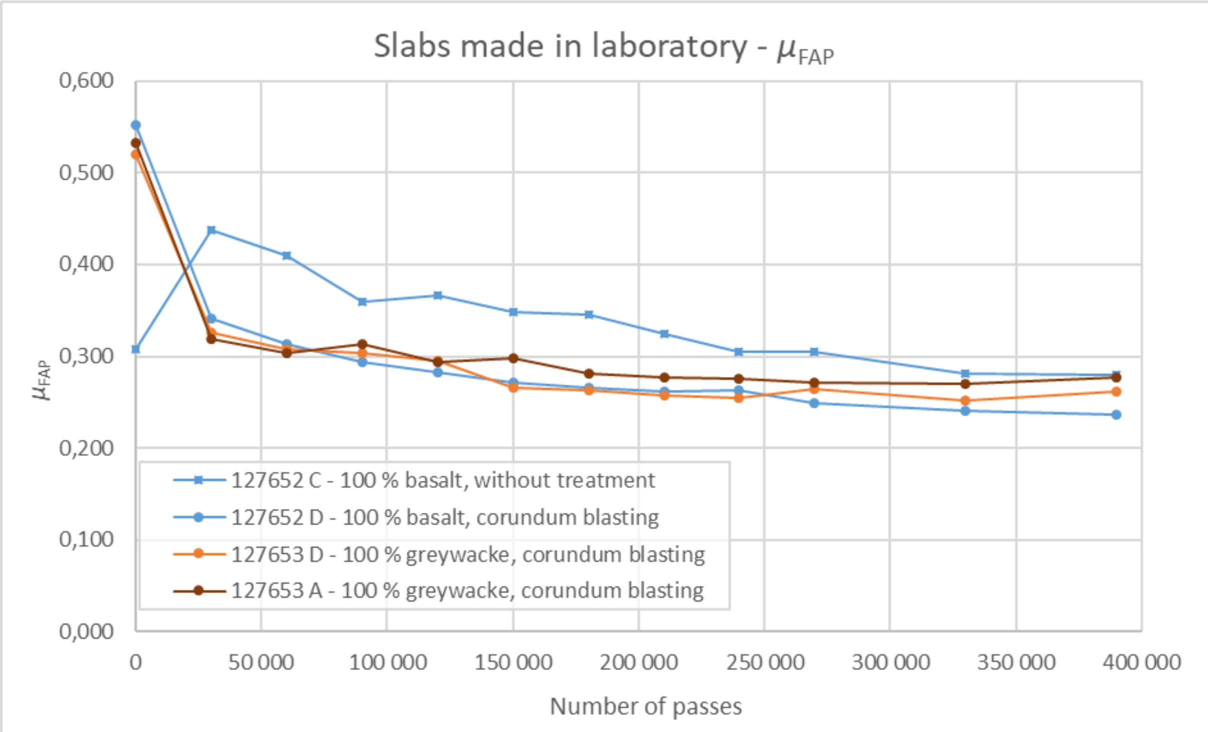

Figure 5: Course of friction coefficient after polishing μ_{FAP} and its relationship with cone passes for asphalt mixture of AC 11 type

Graph in Fig. 6 shows course of the relationship between FAP values and number of cone passes for the asphalt mixture type SMA 11. A difference can be seen between the asphalt mixture containing exclusively basalt aggregate and the other asphalt mixtures. In contrast, various content of greywacke aggregate does not make much difference in the determined FAP value even after 390 000 cone passes. The results show that even a minimum amount of greywacke aggregate (20 % of 8/11 fraction) is enough to maintain higher level of friction coefficient in long-term compared to a situation where only basalt is used.

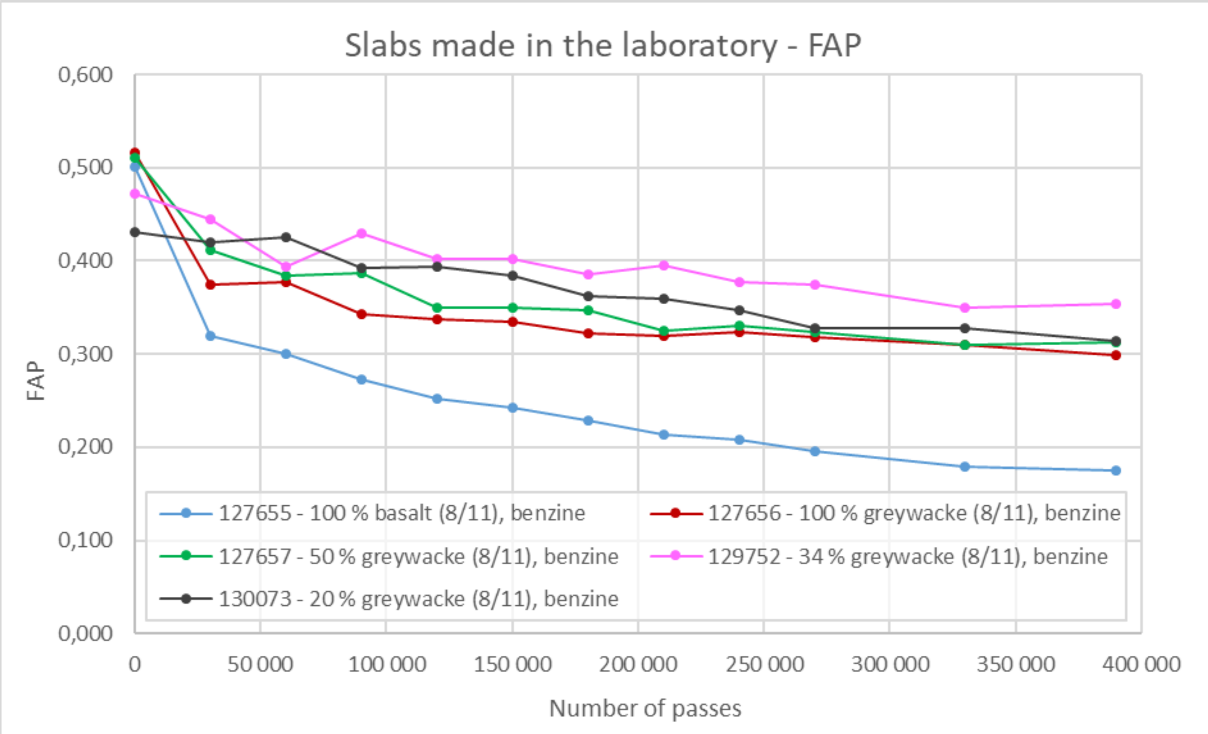

Figure 6: Relationship between course of friction after polishing FAP and number of cone passes for asphalt mixture of type SMA 11, samples made from slabs manufactured in a laboratory

Next step of the research project was supposed to be construction of a test section from a selected asphalt mixture on a road in operation. Given the fact the surface of the slabs manufactured in a laboratory did not correspond to a real pavement surface from SMA 11 type asphalt mixture and its texture could affect the measured FAP values, it was decided to realize the test section from selected asphalt mixtures on the premises of the asphalt mixing plant (Table 3 and Figure 7). Asphalt mixtures containing 34 % and 50 % of greywacke aggregate were selected and for comparison also asphalt mixture containing only basalt. Asphalt mixtures used on the test section were manufactured in an asphalt mixing plant and laid and compacted by routinely used procedures – using a finisher and compacting roller.

Table 3. Test samples on the premises of asphalt mixing plant – asphalt mixture SMA 11

Label of text sample	Lab mixture label	Aggregate weight ratio, basalt fr. 8/11 (PSV = 51)	Aggregate weight ratio, greywacke fr. 8/11 (PSV = 62)
1	127655	100 %	0 %
2	129752	66 %	34 %
3	127657	50 %	50 %

Figure 7: Laying test samples on the premises of the asphalt mixing plant

Samples were taken from the test sections, which then also underwent the test for determination of friction coefficient after polishing. Given the fact that the thickness of the asphalt film was smaller than in case of the samples made in the laboratory from the slabs, it was not necessary to remove the binder by blasting or dissolving agents. Just the number of cone passes was increased to 630 000 because in the initial cycles of the polishing process the value of friction coefficient goes slightly up as the binder layer is being removed from the aggregate grain surface. The resulting FAP value for the individual test sections and its relationship with the number of cone passes is depicted using a graph in Fig. 8. The graph shows that even though the difference between asphalt mixtures containing greywacke aggregate and asphalt mixture containing only basalt aggregate is smaller than in case of samples from panels manufactured in a laboratory, the difference is still apparent (0.086 after 630 000 cone passes). The initial increase of the violet curve (test section No. 2) is caused by the removal of bitumen from the surface of cores – the bitumen was removed just by polishing and not by benzine because the layer was thinner than on the slabs made in the laboratory. For the green curve (test section No. 3) the increase is not significant because one of the tested cores has higher initial values than other cores. That might be caused by the surface texture or by the dirt present on the surface. But the initial values of the friction coefficient are not important for the research that is aiming to skid resistance lifespan.

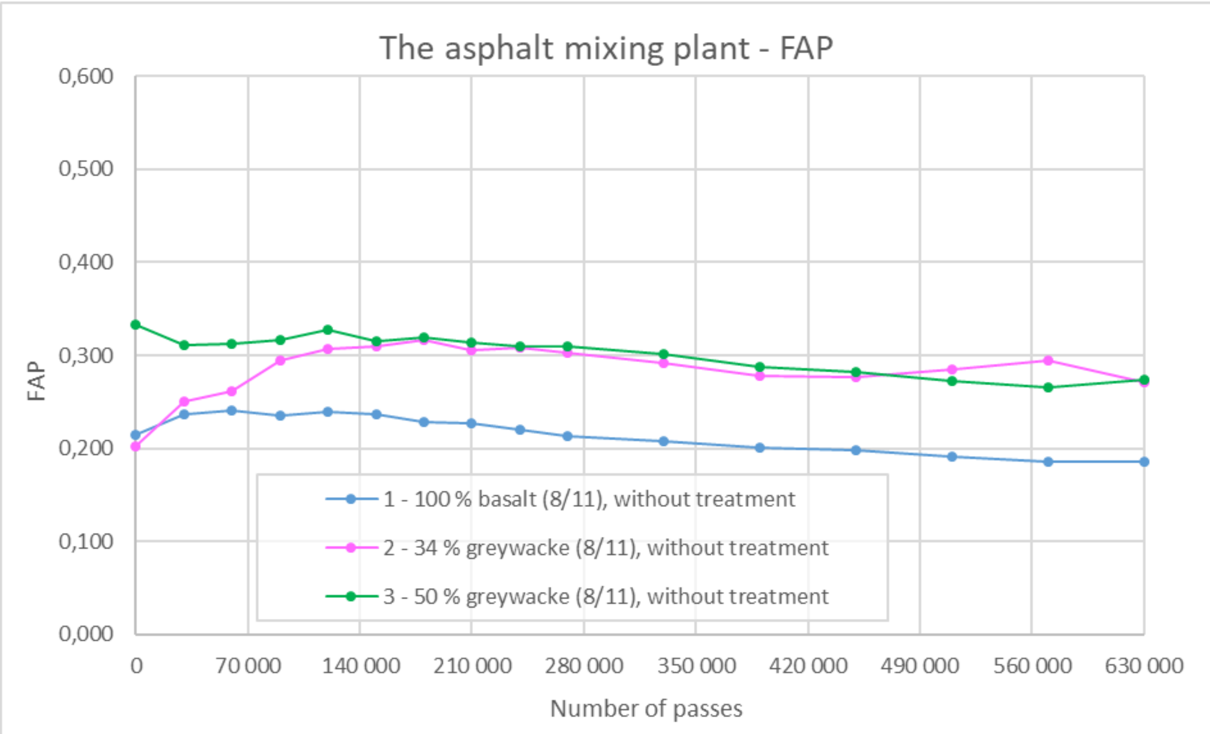

Figure 8: Relationship between course of friction after polishing FAP and number of cone passes for asphalt mixture of type SMA 11, test samples from test section on the premises of the asphalt mixing plant

Fig. 9 graph shows a comparison between progress of FAP values depending on the number of cone passes for samples made from panels manufactures in a laboratory and samples from the test sections. The curves representing the values measured for samples from a laboratory do not have the initial value of cone passes equal to zero, because the bitumen was removed by a dissolving agent and the aggregate was already worn out at the beginning of polishing. In contrast in case of the samples from test sections the bitumen was being removed during the initial cycles of polishing and the aggregate was therefore worn out gradually. The initial value was therefore set to 180 000 cone passes, when the value of friction coefficient after polishing was maximum for the samples from test sections (it can be assumed that at this moment the bitumen was removed from the surface).

The graph also shows that FAP values from samples created from slabs manufactured in a laboratory are higher for the same asphalt mixtures compared to samples taken from the test sections. A possible explanation for this could be different surface texture of the samples (Fig. 10), as well as higher initial FAP value for samples from panels manufactured in a laboratory, where the binder was removed all at once using a dissolving agent and therefore there was no gradual removal of binder and simultaneous wearing out of the aggregate, as was the case for samples from the test section. Nevertheless, the results still proved the assumption that even a small amount of aggregate with a higher value of PSV (in this case greywacke) is enough to ensure long-term suitable skid resistance properties of pavement surface and it was therefore decided to pursue with a test section from asphalt mixture of SMA 11 type with 34 % greywacke aggregate on a section of a road with sufficient traffic load.

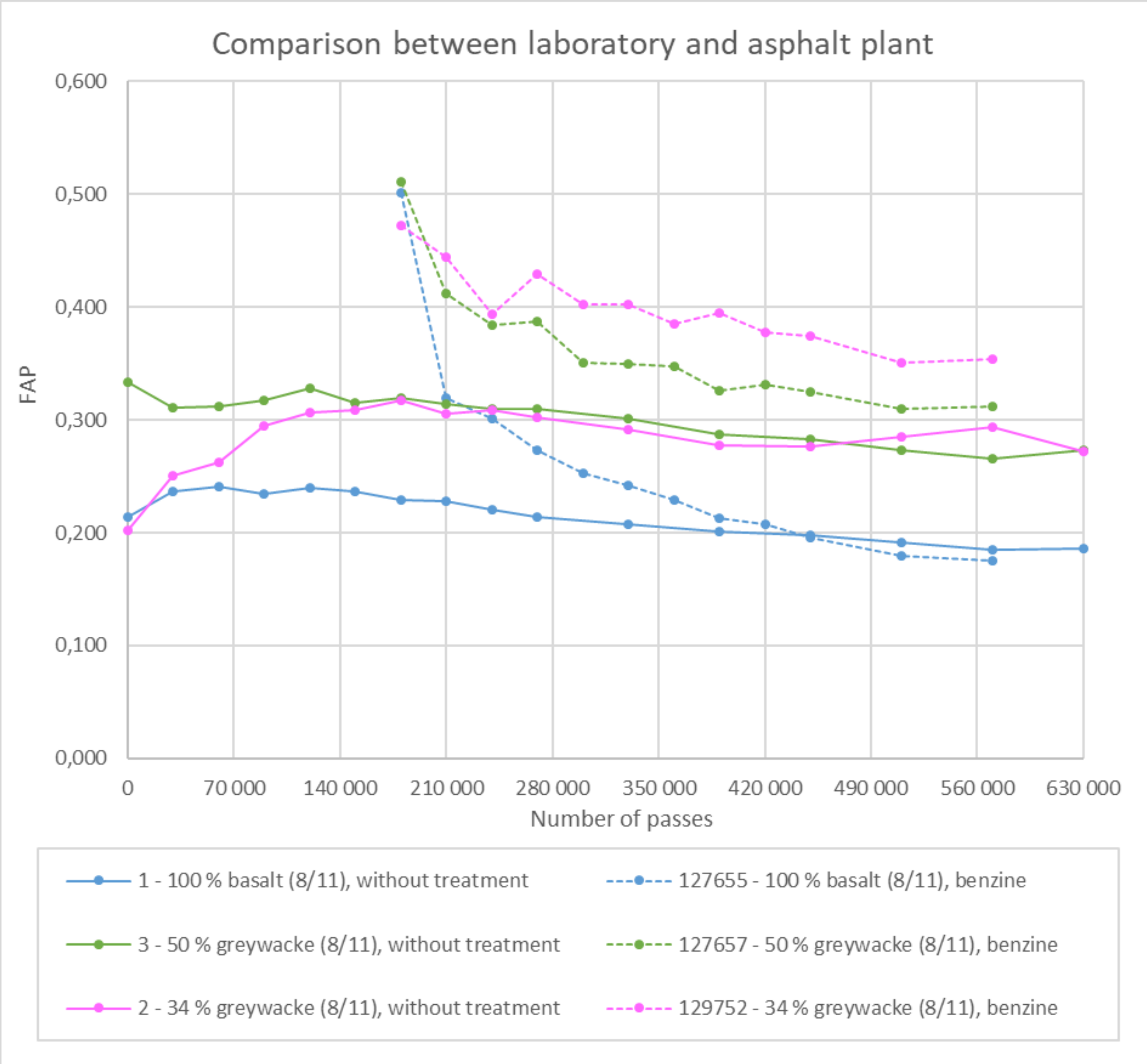

Figure 9: Comparison of course of friction after polishing FAP in relationship with number of cone passes for asphalt mixture of type SMA 11, test samples from test stretch at asphalt mixing plant (solid line) and test samples manufactured in a laboratory (dashed line)

Figure 10: Comparison of surface of test stretch realized on the premises of asphalt mixing plant (left), surface of sample from panels manufactured in a laboratory – before polishing (middle) and after 390 000 cone passes (right)

5. CONCLUSION

This paper described the current state of the TH02030194 project, which focuses on usage of aggregate mixtures with a low and high value of PSV in asphalt mixtures for wearing courses. The performed research included design of several asphalt mixtures of AC 11 and SMA 11 type with various content of basalt and greywacke aggregate fraction 8/11, out of which slabs were manufactured in a laboratory. Samples were taken from these slabs and friction coefficient after polishing was measured and subsequently the value of FAP for the individual asphalt mixtures determined. Based on the measurement results it was decided to construct a test section on the premises of an asphalt mixing plant. The FAP values, determined for samples from this test section, showed similar progress as the samples from the lab-manufactured slabs. The asphalt mixture of SMA 11 type containing 34 % of greywacke aggregate (fraction 8/11) was therefore selected to be used on a real section of a road. This test section was paved in October 2019 (Figure 11). Samples were also taken from this section for subsequent laboratory analysis and measurements of friction coefficient after polishing and longitudinal friction coefficient measurement was performed using a dynamic measuring device.

Figure 11: Paving of the test section

Development of the AC 11 asphalt mixture was currently halted and it will probably be necessary to change the basalt aggregate with greywacke aggregate even in cases of fractions other than 8/11.

Main aim of this project is focused on the possibility of using an aggregate with a low PSV by partial replacement with aggregate with a high PSV. In this respect we think that the chosen procedure to assess the given aim is appropriate. In the future it will be necessary to think about the effect of bitumen film and its lifespan on the initial surface roughness, because FAP, unlike PSV, assesses the mixture as a whole, not as just one of its components, i.e. the aggregate.

ACKNOWLEDGEMENT

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List the references with the respective numbers in square brackets and in the order in which they appear in the text, at the end of the manuscript. References must information as shown in the following example:

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