UDC 625.70

IMPLEMENTATION OF STONE MASTIC ASPHALT WITH THE NATURAL BITUMEN ADDITIVE

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Анотація. У статті наводиться досвід влаштування шару щебенево-мастикового асфальтобетону на ділянці автомобільної дороги Київ-Ковель-Ягодин км 30+490 – км 33+500.
Об'єкт дослідження – температурні режими приготування суміші щебенево-мастикового асфальтобетону та влаштування шару покриття.
Мета роботи – визначення і обґрунтування доцільності та придатності інноваційної технології, а також усунення технологічних недоліків, що супроводжують будівництво.
Метод дослідження – статистичний та аналітичний аналіз результатів тепловізійної зйомки.
Результати статті можуть бути упроваджені при приготуванні асфальтобетонних сумішей та влаштуванні покриттів.
Прогнозні припущення щодо розвитку об'єкта дослідження – поліпшення технологічного процесу будівництва асфальтобетонних покриттів.
Ключові слова: температура, тепловізор, щебенево-мастиковий асфальтобетон, природний бітум, контроль якості, будівництво.

Аннотация. В статье приводится опыт устройства слоя щебеночно-мастикового асфальтобетона на участке автомобильной дороги Киев-Ковель-Ягодин км 30+490 – км 33+500.

Объект исследования – температурные режимы приготовления смеси щебеночно-мастикового асфальтобетона и устройства слоя покрытия.
Цель работы – определение и обоснование целесообразности и пригодности инновационной технологии, а так же устранения технологических недостатков, что сопровождают строительство.
Метод исследования – статистический и аналитический анализ результатов тепловизионной съемки.
Результаты статьи могут быть внедрены при изготовлении асфальтобетонных смесей и устройстве покрытий.
Прогнозируемые предположения относительно развития объекта исследования – улучшение технологического процесса строительства асфальтобетонных покрытий.
Ключевые слова: температура, щебеночно-мастичный асфальтобетон, природный битум, контроль качества, строительство.

Annotation. The article presents the experience and results of stone mastic asphalt preparation and building on-site km 30+490 - km 33+500 of Kyiv-Kovel-Yagodyn highway.
Object of the study – temperature conditions of stone mastic asphalt preparation pavement construction.
Purpose of the study – definition and foundation of innovative technology suitability, technology flaws elimination that accompany construction.
Method of the study – statistical and analytical analysis of thermal recording results.
The results of the article can be incorporated under the preparation of asphalt mixes and pavement construction.
Forecast assumptions about the object of study – improvement of asphalt concrete pavement construction process.
Key words: temperature, thermal imager, stone mastic asphalt, natural bitumen, quality control, construction.

Introduction

Road construction is complicated engineering process. The complexity is due to a number of factors that influence and accompanying construction. Such as: construction technology, property of materials, weather conditions, working process organization, etc. [1, 2]. Solving this positions or not influences the final road quality

level. The quality of pavement determined in accordance with normalized parameters, such as equality, compaction ratio, roughness of pavement, required modulus of elasticity, etc. These parameters are determined after pavement construction, and their maintenance requires consideration of the above factors and control during the construction. Technological development provides modern technologies for road engineers that open up new possibilities in the field of construction quality control. These technologies also include the thermal method. Thermal imager is a device of non-destructive and operational control, which enables to determine problem areas and make quick decisions to eliminate them, in addition, the device allows you to identify and resolve a number of issues related to technological flaws that are so far beyond the human eye [3].

In the countries of Western Europe and North America the natural bitumen varieties are used as additives to artificial road bitumen sorts, improving their properties.

Adding natural bitumen into a binder enhances pavement resistance to deformation, shoving in high summer temperature conditions, occurrence of low-temperature and fatigue cracks, which significantly extends the road operating lifespan. Natural bitumen has an advantage on other bitumen additives through its stability, usability and cost efficiency.

The field of application of natural bitumen is construction of upper layers of asphalt concrete, producing poured asphalt, wearing and high-strength base courses.

Purpose of the study – definition and foundation of innovative technology suitability, technology flaws elimination that accompany construction.

Research placing of pavement SMA-20 on bitumen BND 60/90 with new modifier Selenizza SLN -120. Works carried out during the period from 26.09.2013 till 10.10.2013.

Location construction: Kyiv region, Kyiv-Kovel-Yagodyn road km 30+49 - 33+500, with exclusive of km 31+520 - 32+355 (LHS, 835 m using Kroton), km 52+223 - 52+770 (RHS of the roundabout, 547 m.), km 52+416 - 52+30 (on the roundabout 564 m.)

Location of preparation: Borodyanka, Kyiv region.

Plant: - asphalt plant “LINTEC”, Germany.

- pneumatic - transporter with a batcher “Kredmash”, Ukraine

Manufacturer of the asphalt concrete mix: JSC “Evrascon”.

1. Road pavement design on site

In accordance with the recommendations developed on the basis of inspection of the existing road pavement condition, composition and intensity of traffic, on 07.06.2012 the Technical Board of the State highway agency of Ukraine accepted the design on asphalt pavement layers, as described below.

1 – Stone mastic asphalt concrete, fine-grained SMA – 20 (fr. 20), dense, grade I. According to DSTU B V 2.7-127-2006 h – 5 cm,

2 - coarse-grained dense asphalt concrete (fr. 25) with bitumen BND 60/90 with PAR additive, according to DSTU B.V.2.7-119-2003 Ь – 8 cm.

3 – coarse-grained porous asphalt concrete (fr. 40) with bitumen BND 60/90 with PAR additive, according to DSTU B.V.2.7-119-2003 Ь – 8 cm.

Base cold asphalt concrete mix of milled asphalt concrete 50% and 50% of sand aggregate mix C7, strengthened with emulsion and cement M400, to achieve grade M40, that is:

- regeneration of the existing pavement, thickness 0.15 m, applying cold recycling technology, with addition of bitumen emulsion, cement and sand-aggregate mix C7.
- 0.15 m; content by mass:
- Bitumen emulsion - 1.5%;
- Cement - 3.5%;
- Aggregate and sand mix C7 - 50%;
- Bitumen emulsion sprayed - 0.6 l/m;
- Optimal aggregate and sand mix C5,

according to DSTU B B.2.7-30-95 - 20 cm;

- Medium grain sand, according to DSTU B B.2.7-32

(granite rock fines 100%) - 25 cm;

Strengthening provided of the following layers: Existing road pavement

- sand – 0.20 m;
- granite aggregates – 0.10 …0.31 m;
- asphalt concrete – 0.17 …0.30 m;
- milling the existing pavement – 0.05 …0.10 m;
- regeneration of the existing pavement, thickness 0.15 m, applying cold recycling technology, with addition of bitumen emulsion, cement and sand-aggregate mix C7 – 0.15m;

Content by mass:

- Bitumen emulsion - 1.5%;
- Cement - 3.5%;
- Aggregate and sand mix C7 - 50%;
- Bitumen emulsion sprayed - 0.6 l/m;

Upper asphalt concrete layers are described above.

According to calculations made, total thickness of the upper asphalt concrete layers of road pavement is 50+80+80=210 mm.

2. Asphalt mix design

Stone-mastic mix SMA-20 with **Selenizza SLN** - 120 additive, prepared on the basis of OJSC "Evrascon" mix design. Consumption of materials for 2500 kg of SMA-20 is shown in the table 1.

Table 1 – Consumption and characteristics of materials, applied for SMA-20 2500 kg batch preparation.

Screen size, mm	283
0 - 5	188
5 - 12.5	1602
Filler	282
Bitumen 60/90 (with PAR)	137.5
Stabilizing additive (Topcel)	7,5
Natural bitumen Selenizza SLN – 120	8,3
PAR Wetfix	0,2

3. Technical specifications for ACM (SMA) preparation and placing of asphalt concrete pavement, using natural bitumen Selenizza SLN – 120

Preparation of ACM (SMA) with natural bitumen Selenizza SLN – 120 is carried out with no alterations to the standard (ordinary) technology, applied by a manufacturer, with the exception of application of the artificial polymeric modifier "Kraton".

Mix design of ACM SMA stays the same, including quantity of bitumen and its grade BND 60/90 (70/100).

Natural bitumen Selenizza SLN – 120 is applied in the quantity of 6% of the base bitumen weight, and replaces the equivalent quantity of the latter.

When the weight of ACM SMA in the asphalt plant mixer - 2 500 kg:

- weight of bitumen –5,5 ± 0,2 % of the weight of the mix 137,5 kg:

- including the weight of natural bitumen Selenizza filled is – 6% of the weight of bitumen - 8,25 ± 0,3 kg (see enclosure).

Laboratory study of ACM SMA (SC 2-3) were carried out by JSC «Evrascon», indicate conformity of its characteristics to the requirements of DSTU B.V.2.7.-89-99 and DSTU 2.7-127:2006.

Natural bitumen Selenizza SLN – 120 is fed to the weighting hopper by the pneumatic transporter, and from there it goes to the preliminary storage hopper – cumulating rock materials. Feeding takes place during the last stage of loading of rock materials, which are of the temperature, as specified in SC 9. The weighting hopper is automatically controlled, and it is synchronized with the controllers loading rock materials.

After the end of the stage of loading the preliminary storage hopper – the accumulator, the rock materials and the natural bitumen Selenizza SLN – 120 are transferred to the mixer.

At the same time filler, fiber and received bitumen are fed to the mixer. In this case the bitumen does not need any provisional preparation. The quantity of bitumen should be adjusted in accordance with the above requirements.

After all the components are loaded, the mixing process takes place, and it lasts 37 seconds.

The temperature of the prepared mix should be 170±5 °C.

After completion of the mixing process the mix gets discharged.

Placing and compaction of the mix are carried out when its temperature is not lower than 150±5 °C, measured directly behind an asphalt paver and compactors on any type, with the weight 8 – 13 t.

Checking of conformity of the process of production of the mix and placing of the pavement, to the parameters, as outlined in the norm, is carried out in the course of a trial section construction [5, 8].

Weather conditions

Air temperature + 5ºC…+16 ºC.

Temperature of the existing asphalt layer +10 ºC…19 ºC.

Adding to SMA Selenizza SLN -120 natural bitumen – powder, black color, maximal diameter 5 mm, in 500 kg packages.

The additive was integrated to the mixer on the asphalt plant with the help of pneumatic dispenser, in automatic regime, in the amount 6% of the bitumen mass. Batch – 2500 kg.

Temperature of asphalt mix coming out of the mixer 170…175 ºC.

Temperature of asphalt mix at the beginning of compaction 150…130 ºC.

Placing of asphalt mix was carried out by two asphalt pavers Vogelr 1900, compaction – by four rollers: two rollers Bomag 141 – 8t, two rollers Bomag 161 – 11 t.

The physical and mechanical the properties of the asphalt concrete mix SMA 20 were received in the laboratory of Evrascon are shown in the table 2.

Table 2 - Physical and mechanical the properties of asphalt concrete mix SMA-20

No.	Readings identity	Units	Test results	Requirements of DSTU BV2.7-127: 2006
1	Water saturation, by volume	%	2,0 – 2,3	1,0 – 3,0
2	Residual porosity	%	2,9 – 3,2	1,5 – 3,5
3	Porosity of filler	%	15,5 – 18,5	15 – 19
	Limit of compressive strength at temperature:			
4	+20 ºC, not less	MPa	3,3 – 3,7	2,0
5	+50 ºC, not less	MPa	1,2 – 1,6	0,6
6	Waterproofing coefficient at continuous water saturation, not less		-	0,75
7	Average density of samples	g/cm^3	2.480 – 2,482	-
8	Compaction coefficient		0,98 – 1,03	0,98

Quality control of the technological process on the Asphalt Plant and on Site was carried out in the process of construction. Examples with results of heat monitoring of temperature behavior in the course of preparation of asphalt concrete mixes and placing of asphalt concrete pavement are shown below.

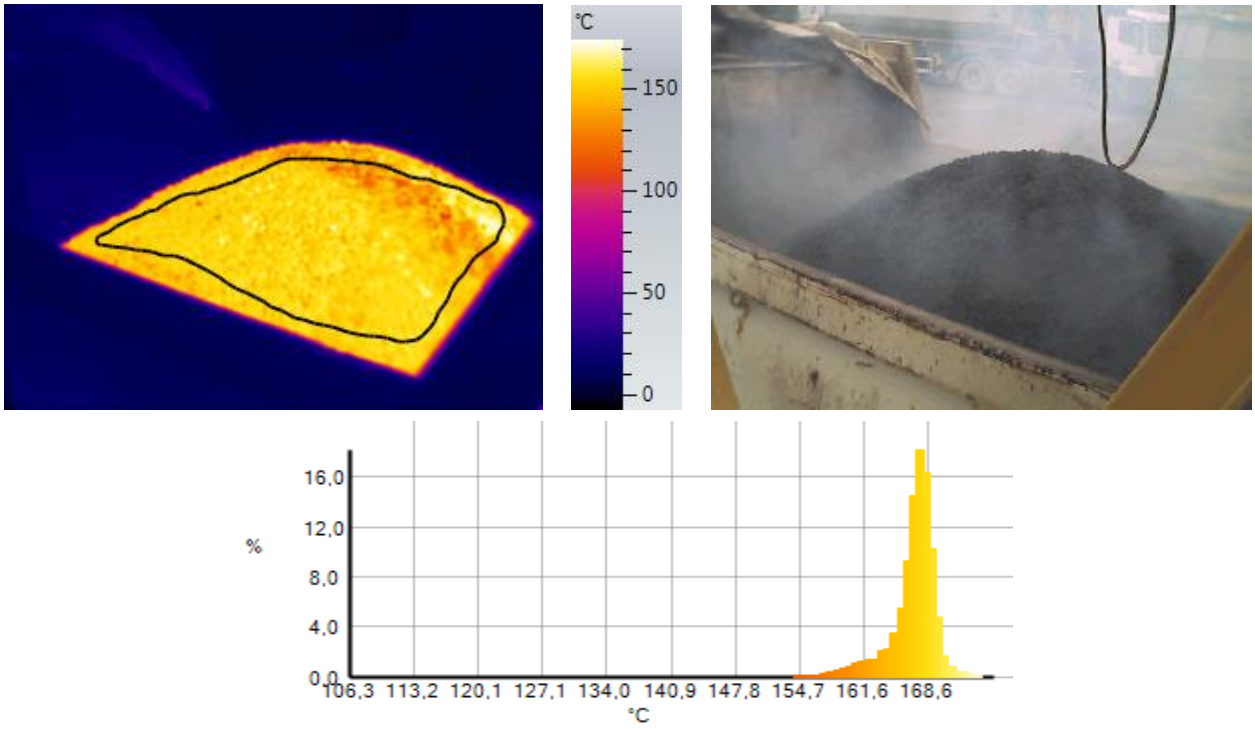
1. Asphalt plant

In order to achieve high quality it is important to follow the specified temperature pattern when producing asphalt mix and placing of asphalt concrete pavement.

According to the results of heat monitoring, on the first day of paving, when failures in proportioning and mixing of natural bitumen took place, the asphalt mix was partially overheated, which lead to evaporation of volatile fractions of the binding agent. This was caused by the breaks in the process of the mix preparation, that occurred due to repairs to the broken pneumodosimeter and a bearing replacement.

This resulted in overheating of the rock materials. Usage of a pyrometer “Nimbus”, which shows punctual surface temperature, also does not allow correct measurement of temperature of a mass.

After correction of disorders, henceforth the temperature pattern on the Asphalt Plant strictly followed the technical specifications 170 ±5 ºC.

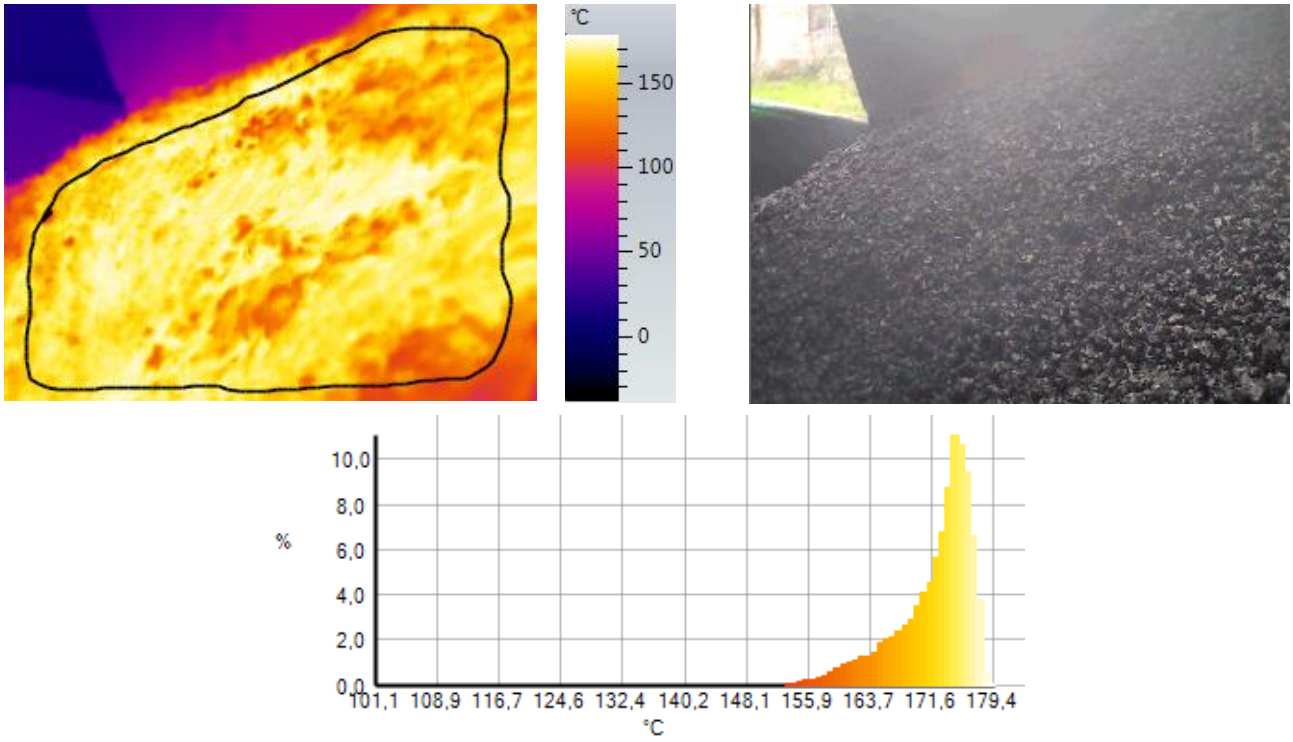


03.10.2013p. 10:46 – T_{min}=153 ºC, T_{av}=167 ºC, T_{max}=170 ºC

Figure 1 – Variation of asphalt mix temperature in a truck body on the territory of the Asphalt Plant

2. Temperature of the mix in a dump truck body after transportation

During construction of the layer the mix delivered had the temperature conforming to the requirements, however plant failures took place.



01.10.2013p. 13:34 – T_{min}=153 °C, T_{av}=173 °C, T_{max}=179 °C

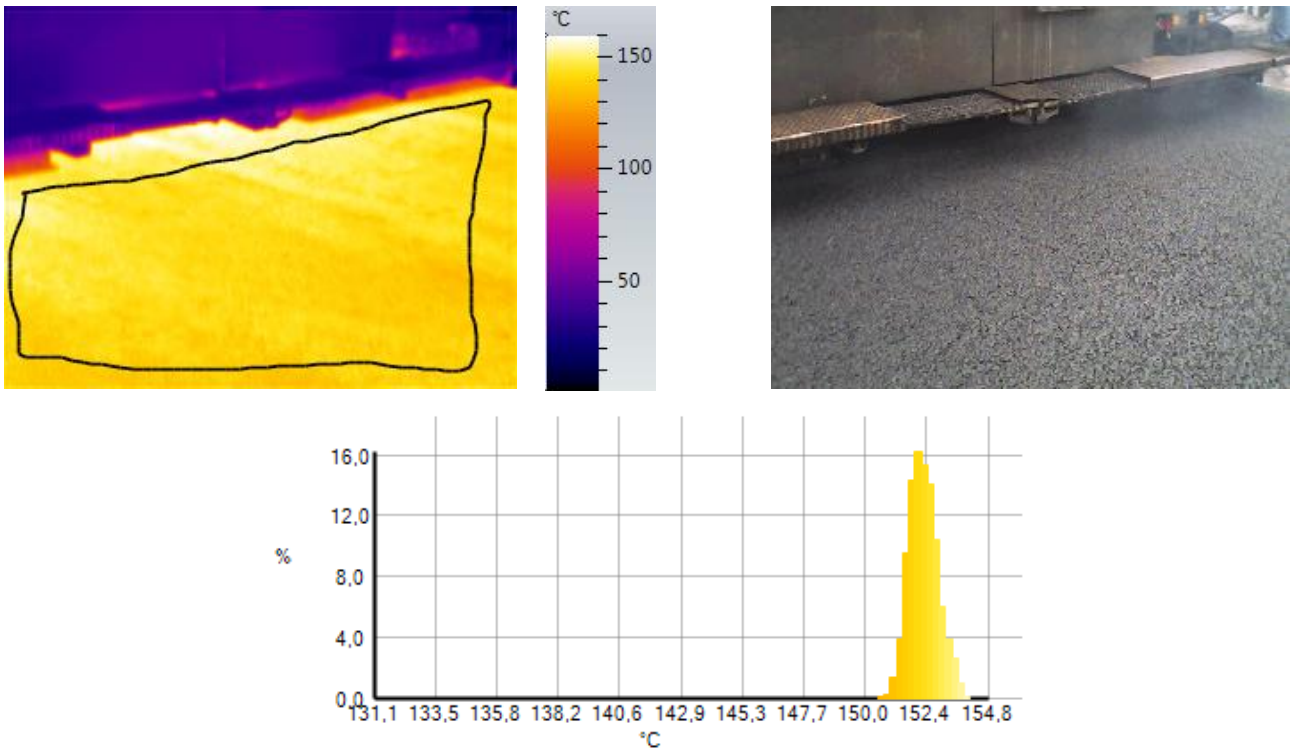
Figure 2 – Variation of the asphalt mix temperature in a dump truck body, in the course of loading the mix into the asphalt paver

3. Temperature of the mix, as it leaves an asphalt paver

In general temperature of the mix leaving the asphalt paver repeats the tendency established at the asphalt plant, however there appear other issues related to unforeseen circumstances on site. At present the temperature of pavement is higher than the temperature specified for the mix leaving the asphalt plant.

Most of paving was carried out by two pavers, which resulted in a number of issues: efficiency of two asphalt pavers is higher than the efficiency of the rollers and the Asphalt Plant, the efficiency of the rollers is compensated by the efficiency of the Asphalt Plant, since there was almost no stored mix on site, and the asphalt paver had to make technological stops.

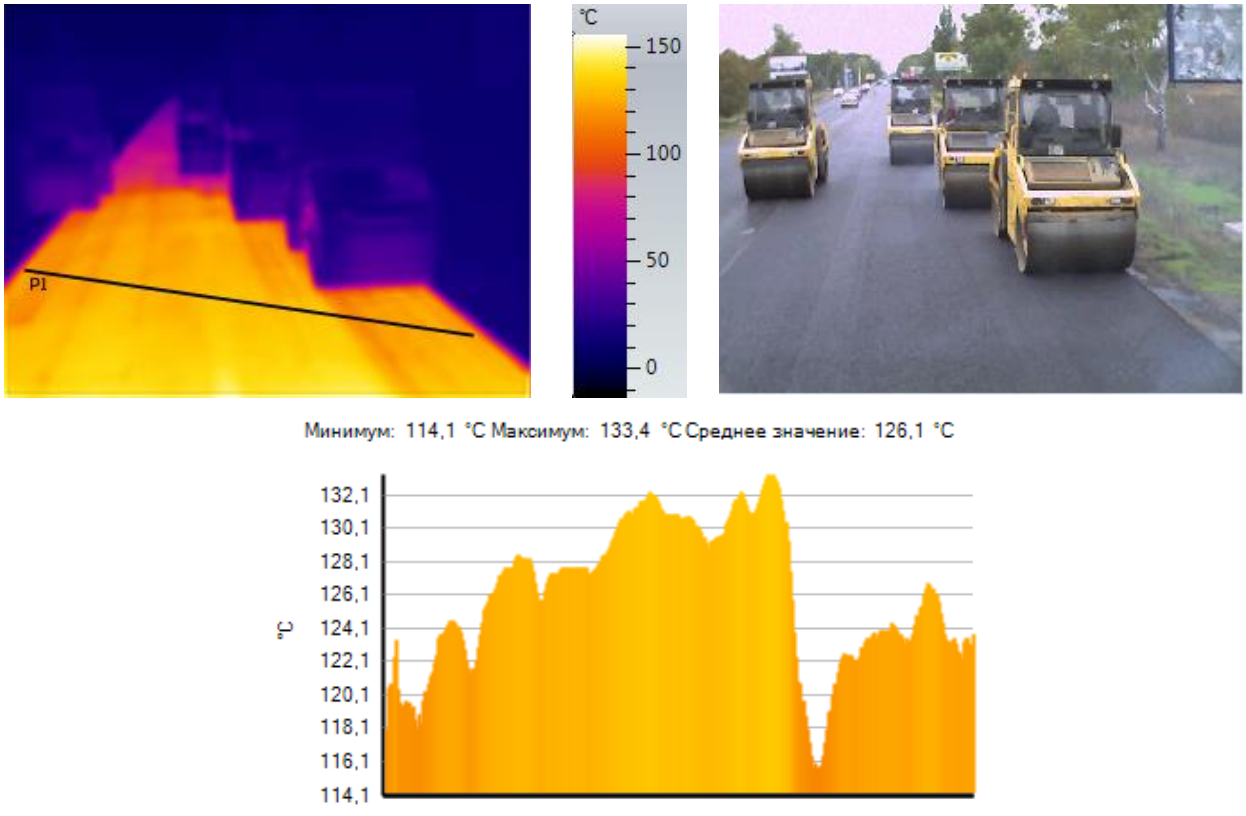
As the result of approximation of the pavement cooling down temperature change readings, we received the following logarithmic relationship (fig. 5).



03.10.2013p. 13:44 – T_{min} =150 ºC, T_{av} =152 ºC, T_{max}=154 ºC

Figure 3 – Variation of asphalt concrete layer temperature behind the asphalt paver

4. Temperature behavior in the course of asphalt mix compaction



06.10.2013p. 14:49 – Temperature range during compaction 120 ºC - 130 ºC, after several roller passages the temperature falls by ≈10 ºC

Figure 4 – Variation of asphalt concrete layer temperature behind the asphalt paver

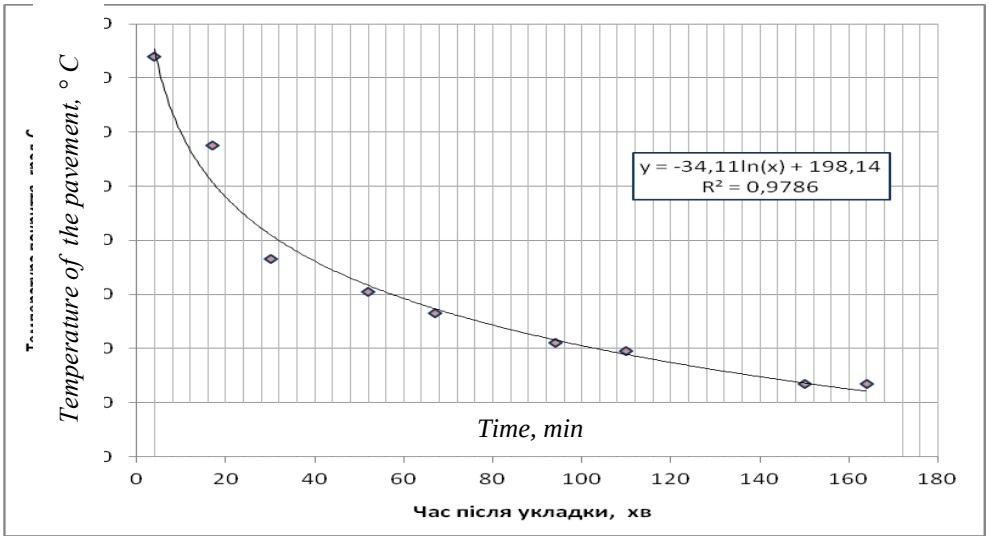


Figure 5 – Results of the approximation of the pavement cooling down temperature change readings

As an example, table 3 shows some results of the static analysis of the SMA 20 pavement placing technological process parameters, 05.10.2013.

Table 3 - Results of the static analysis of the SMA 20 pavement placing technological process

Readings	Mix weight, t	Transportation time, hours	Paving time, hours	Temperature of the mix in the truck body, °C	Thickness of SMA, cm
Min	25	0:17:00	0:06:00	166,0	7,40
Max	45	0:53:00	1:02:00	175,0	5,10
Av	32,7	0:33:36	0:19:15	169,8	6,55
Standard	8,96	0:07:36	0:11:19	2,3	0,503
Variation coefficient	27,41%	15,08%	20,04%	1,3 %	7,68

In the conditions of production of asphalt concrete mix and placing of asphalt concrete pavement, for the purpose of ensuring quality of pavement, it is important to follow the temperature pattern specifications.

According to the results of the heat monitoring on the first day of paving, when failures in weighing and mixing of the natural bitumen additive took place, the asphalt mix was partially overheated, which lead to evaporation of volatile fractions of the binding agent. There were instances, when the temperature of the mix in the

pavement reached up to 200 oC. This was caused by the breaks in mix preparation, due to repairs to the repairs to the broken pneumodosimeter and a bearing replacement.

This resulted in overheating of the rock materials. Usage of a pyrometer "Nimbus", which shows punctual surface temperature, also does not allow correct measurement of temperature of a mass.

After correction of disorders, henceforth the temperature pattern on the Asphalt Plant strictly followed the technical specifications 170 ±5 ºC.

Temperature of the asphalt mix virtually did not reduce during transportation, due to presence of a large quantity of mix in the tip-trucks (25 – 40t) and insulation of the truck bodies with tent cloth. Attention should be paid to transportation of the asphalt mix in a 25 t tip-truck, since due to a smaller body, at the first loading of the mix, temperature shock occurs and a considerable heat loss for heating the truck body, as well as ten cloth insulation failures. In the course of discharging of the asphalt mix, containing natural bitumen Selenizza SLN 120, no material sticks to the sides of the truck body, which is representative of mixes modified with polymeric additives. In this case there is no need to additionally lubricate the truck body sides, with light organic agents (diesel, kerosene) or with soap solution.

Reduction of volatile evaporation is observed in the process of paving, which is a positive feature for the road workers and for the environment. Also reduced are the symptoms of respiratory passages irritation, as well as strong smell. Reduced is the number of complaints, regarding headache.

The asphalt mix temperature in the asphalt paver and at the beginning of compaction was in accordance with the specification. 4 operating rollers ensured the compaction temperature pattern in accordance with the technical specification.

When the air temperature is close to the allowed minimum (+5 - +10ºC), compaction should be more intense. The asphalt mix compaction should start immediately after the asphalt paver and keep operating within 35 m from it. The number of passages along one track should be not less than 6.

The asphalt paver needs to be modified. On the sides of the hopper the asphalt mix cools down more quickly, so it does not get mixed by the augers and consequently it is paved as a spot in the middle of a lane. Temperature of the mix in the spot is 30-40 ºC lower than the remaining mix temperature, which causes undercompaction. In the areas, where the last portions of asphalt mix, from a truck

body, were placed, the pavement looks more porous, which leads to water saturation, and further defects, such as weathering and occurrence of pot holes.

On a lane 6,25 m wide, with SMA 5,0 cm thick, such defects occur every 50 – 55 m, for a 40 t. truck, and 25-30 m for a 25 t/ truck.

Therefore, heat monitoring method has proven itself to be efficient in terms of quality control for production and placing of stone mastic asphalt pavement, with natural bitumen additive.

For compliance with the temperature regime, efficient energy usage and prevention of defects and deterioration, it is necessary to develop a methodology for heat monitoring, and provide the necessary equipment to the quality control authorities and scientific organizations.

Natural bitumen additive improves the technological process of preparation and placing pavements of modified asphalt mixes, and is more environmentally friendly compared to other chemical additives.

5. Result of visual inspection of the road section in the process of operation

In the process of operation, every 3 - 4 months, during years 2014 – 2015, visual inspections were carried out on the trial sections, on which SMA 20 with natural bitumen additive was placed.

Intense traffic of heavy vehicles (mostly 5 axle) is observed on this road (fig. 6 - 7).

The road section is in good operational condition. No defects or deteriorations have been were discovered (fig. 8 - 9).

Figure 6 – General view of the ramp on PK 33+850

Figure 7 – Heavy vehicles traffic on a road section

Figure 8 – Joint with SMA including Kraton (profile)

Figure 9 – Lack of rutting on a straight section

General conclusions

According to the results of the trail we can outline a number of advantages of the natural bitumen Selenizza, compared to other binding agents, used in production of asphalt mixes:

1. Practical manifestation of the physical and mechanical properties of the natural bitumen Selenizza is a considerable (1,5-2,5 times) increase of resistance to rutting formation, failure resistance, deterioration resistance of the road pavement. These are the factors that characterize mainly the workmanship of road construction companies.

2. This becomes possible thanks to the natural composition of bitumen Selenizza, for it contains more than 50% of natural asphaltene. The common ground of Selenizza and the base bitumen ensures their rapid and homogenous mixing and melting, which does not require introduction of any changes to the traditional technologies for production and placing of Asphalt Mix. In fact, compaction of Asphalt Mix on site is carried out faster and with higher quality.

3. Selenizza allows easy correction of the base bitumen drawbacks, developing its parameters to the required ones, in each specific case, or to the parameters stipulated by normative. Check parameters in this case are penetration and softening point temperature. Therefore, for preparation of Asphalt Mix you get bitumen, which

is always of stable quality, despite the quality of base bitumen received from an oil refinery. This circumstance indisputably influences the quality of product.

4. Selenizza also allows to change bitumen grade, for example from BND 90/130 to BND 60/90. Obviously this extends the scope of technical capacity, which helps to optimize business planning for company, particularly in the unstable conditions of Ukrainian market.

5. In accordance with the Technical Certificate No. 234 dd. 14.02.2013 Selenizza is classified as a bitumen modifier for preparation of Asphalt Mix, and is used in the estimated quantity, within 4 - 12 % of bitumen weight.

6. The cost of Selenizza is higher than the cost of the base bitumen, therefore, at first sight, it causes a certain increase in the cost of an Asphalt Mix. However, there is a cumulative saving effect, which lies in increasing the speed of many production processes, and corresponding saving of power, materials, plant and equipment resources. Also, you get an opportunity to increase the quality of your product, in terms of physical and mechanical parameters, and in terms of reliability and durability.

7. Compared to other modifiers, that have chemical origin, of SBS type, Selenizza does not require a long process of mixing with the base bitumen, and is supplied directly into an Asphalt Plant mixer, or it can be mixed with the base bitumen in tanks, with no limitations as to its further storage. This considerably affects the dependence of your technological process on various factors beyond your control, such as weather conditions, equipment failures, etc..

8. Selenizza is considered to be a “green bitumen”, ecologically friendly, so it does not produce polluting exhalations, and even reduces the effect of polycyclic hydrocarbons, which are contained in air-blown bitumen. This is very important for health and safety of workers.

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