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ANALYSIS OF THE INFLUENCE OF AIR TEMPERATURE ON THE COMPACTION OF ASPHALT DURING INSTALLATION

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SUMMARY

In this paper, the influence of air temperature on asphalt compaction during installation was investigated. The reason for this research is that during the construction of roads or the reconstruction of existing ones, the need to completely or partially replace the asphalt layers of the flexible pavement structure most often arises. The lifespan of a flexible pavement construction, i.e. road, always depends on the quality of the subgrade, but also on the quality of the final asphalt works. In order to arrive at the best possible procedure for installing the asphalt mixture, research was carried out on several concrete examples, observing the air temperature through the compaction feature of the installed asphalt, that is, through the required number of roller passes during the installation of the asphalt mixture. During the research, numerous other data that are important for the research were measured, such as the weight of the rollers, the temperature of the asphalt at the construction site, etc. On the basis of the obtained results, sorting and analysis of the same was carried out. Based on the analysis of the obtained results, conclusions were reached.

Keywords: air temperature during asphalt installation, asphalt mixture temperature, asphalt compaction

1. INTRODUCTION

The aim of the research in this paper is to investigate the influence of air temperature on asphalt compaction during installation. In order to reach the desired goal, research was carried out on the construction of flexible pavement structures.

During the production of a flexible pavement construction using the hot process, the most critical procedures during the implementation of asphalt works are the transportation of the hot asphalt mixture from the production plant to the construction site and the installation process itself. In order for flexible pavement construction to be of high quality, it is necessary to pay attention to other procedures (selection of aggregates and composition of asphalt mixture, design of asphalt mixture, production and storage of asphalt mixture). The temperature of the asphalt mixture during the installation of asphalt became particularly important because it directly affected the quality of the performed works, and was limited by the temperature of the asphalt mixture in the asphalt plant, the length of the transport of the asphalt mixture, the quality of the means of transport, the air temperature, etc. [1] [2].

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Most often, during the preparation of the asphalt mix recipe, the influence of the air temperature during the execution of the works was not taken into account. Later, in practice, it was shown that a higher air temperature has a positive effect on the installation of the asphalt mixture, and a lower air temperature in all cases was an aggravating circumstance. It is known that many materials, including asphalt, expand when heated and contract when cooled. As the temperature drops, the compaction of the asphalt material is prevented due to cooling, which causes an increase in tensile stress that can lead to failure (appearance of microcracks) if the maximum tensile strength is reached, which is especially pronounced during the rolling of the asphalt mixture. In simpler terms, the stress in the asphalt sample gradually increases in parallel with the drop in temperature, until the sample breaks. [3]

In order to obtain data on how much temperature affects the workability of the asphalt mixture, air temperature was measured on several road routes, the temperature of the asphalt mixture during installation, the number of roller passes and the compaction of the installed asphalt mixture were measured.

2. AIR TEMPERATURE AND INSTALLATION OF ASPHALT MIXTURE

The installation of the asphalt mixture consists of the following stages:
- substrate preparation,
- transport of asphalt mixture,
- spreading of asphalt mixture,
- rolling of the spread layer [4].

Transport of the asphalt mixture from the asphalt plant to the place of installation is carried out by a cargo vehicle - a dump truck. During manual installation (inaccessible places, curved surfaces), trucks with a smaller load capacity are used for transport for easier access to the location and faster transport. Installation using a paver requires greater transport capacities. It is necessary to enable the continuous operation of the paver, that is, the number and capacity of transport means should be chosen based on the capacity of production and installation. It is necessary to carefully analyze that cycle and establish how many trucks of a certain size are needed to achieve compliance with the capacity of the asphalt plant and equipment for spreading and compacting asphalt. [9]

In the entire process of production, transportation and installation of asphalt mixture, the surrounding air temperature must be taken into account. If the temperature is too low, it may happen that the installation of the asphalt mixture takes much longer, so it is necessary to harmonize the dynamics of production of fresh asphalt mixture, transport and installation, i.e. asphalt rolling. All this will significantly affect the quality of the installed asphalt layer. A drop in the temperature of the fresh asphalt mixture can also cause segregation of aggregates in the asphalt, which results in a partial or complete suspension of the asphalt mixture installation process.

Transport vehicles are open, so it is possible to cool the asphalt mixture due to the effect of wind and low temperatures. It is necessary to protect the mixture from atmospheric influences (rain, wind), but also to reduce the harmful impact on the environment, i.e. to prevent its excessive cooling and the formation of a crust on the surface. That is why vehicles must be equipped with a mechanism for covering the asphalt mixture - a tarpaulin, regardless of the season, distance from the construction site and type of asphalt mixture. [9]

The study of the cooling of the asphalt mixture during transport showed that different truck cargo boxes and covers significantly affect the cooling during transport. Thermal crates insulated with polyurethane and covered with a tarpaulin attached to the crate, so that there is no direct contact between the asphalt mass and the tarpaulin, proved to be the best. It also showed that the hot asphalt mixture cools differently in different parts of the box depending on the speed of the vehicle and other external influences. Before the start of transportation and at the construction site before installation, the temperature of the fresh asphalt mixture is controlled. [9]

Asphalt mixtures arriving at the construction site are first controlled. Its temperature is determined and its adequacy is visually checked. As already mentioned, the temperature is of particular importance for the workability of the asphalt, and its verification is an important and necessary step when receiving

asphalt mixture. The temperature is measured not only in the paver but also in the vehicle, during which precise and proven instruments that quickly register the temperature (secondary thermometer) should be used [9].

Figure 1. Second remote thermometer for measuring asphalt temperature at the place of production and at the place of installation

3. RESEARCH IN SITU

As the subject of research in this work is air temperature, and in connection with the temperature of the asphalt mixture, the authors measured and recorded all the data in the field that could have an impact on the temperature change or the compaction of the embedded layer. Asphalt temperatures at the installation site were measured immediately before installation, as well as air temperature. Measurements were made with remote thermometers shown in Figure 1. During the installation of the asphalt mixture, data was recorded on the number of passes of the rollers when compacting the spread layer of asphalt. After rolling, the asphalt layer samples was taken. The samples taken were also examined in the laboratory. Data on compaction, voids and thickness of the asphalt layer were recorded and analyzed for this research.

Asphalt installation and all measurements were carried out in the area of north-eastern Bosnia and Herzegovina on real examples of asphalt works. Asphalt compaction testing was done in laboratory conditions.

Figure 2. Production temperature and temperature during installation of asphalt at location 1 – Rastošnica; air temperature 6° C

General information about the examination site 1.
Project: Reconstruction of the regional road R456 Priboj - Sapna;
The distance of the asphalt base is 35 km;
Asphalt installation date April 9, 2020.

In total, measurements were carried out at 14 locations in the area of northeastern BiH in the period December 2019 - May 2020.

Table 1. Measurement of asphalt properties

No.	The temperature of the produced asphalt	Asphalt temperature during installation	The difference in temp.	Temp. air	Date	Asphalt compaction	Nominal number of roller passes
1	162,00	136,30	25,7	**6**	09.04.	101,6	62
2	152,00	139,90	12,1	**15**	08.04.	101,9	50
3	146,00	123,80	22,2	**8**	19.12.	101,9	61
4	141,00	112,80	28,2	**5**	18.12.	98,4	64
5	167,00	152,90	14,1	**20**	18.06.	94,64	48
6	170,00	157,80	12,2	**29**	26.08.	96,1	40
7	170,00	155,40	14,6	**20**	27.08.	98,9	35
8	169,00	154,20	14,8	**23**	27.08.	98,6	37
9	170,00	158,40	11,6	**22**	27.08.	99,5	39
10	172,00	160,40	11,6	**29**	28.08.	99,1	43
11	170,00	155,90	14,1	**26**	28.08.	99,4	41
12	172,00	160,10	11,9	**32**	29.08.	98,5	45
13	171,00	160,70	10,3	**31**	29.08.	98,3	50
14	173,00	157,40	15,6	**22**	17.08.	100,20	47

4. REGRESSION ANALYSIS

When we want to investigate two or more variables or variables that are inherently related, we often use regression analysis

The regression technique allows us to quantitatively express the dependence/relationship between such variables and to define that relationship by shape and direction.

In the first step of the regression analysis, it should be determined whether there is any connection between the observed phenomena. Three forms of connection usually appear, namely:

- straight line form (linear connection), the most common form,
- curvilinear shape (non-linear connection),
- spatial form.

If there is a connection between the observed phenomena, the second step of the analysis is carried out, in which the strength of the connection between the observed phenomena is investigated. Simple regression is applied when two phenomena between which there is a connection are observed at the same time, where a certain function, i.e. a line, can be well adapted to the original values of the characteristics. If the function is a straight line, then the functional dependence is called linear regression, and it can also be a higher-order line, exponential function, hyperbolic, logarithmic [6].

A linear relationship describes a relationship between phenomena that is characterized by the fact that each unit increase in the value of one variable corresponds to an approximately equal linear change in the other variable. The quadratic function is based on the condition that the sum of the squares of the vertical deviations of the points in the scatter plot from the required regression direction is minimal. A specific indicator of the representativeness of the regression is the coefficient of determination (R). The more representative the model is, the closer the coefficient of determination is to 1, i.e. the stronger the connection between the observed phenomena.

In accordance with that, the degrees of strength of connection between observed phenomena are defined, depending on the value of the coefficient of determination, i.e. the correlation coefficient (R):

- $0.00 < |R| \leq 0.25$ - there is no connection between the observed phenomena,
- $0.26 < |R| \leq 0.50$ - weak to moderate association between observed phenomena,
- $0.51 < |R| \leq 0.75$ - good correlation between observed phenomena,
- $0.76 < |R| \leq 0.99$ - very good to excellent association between observed phenomena,
- $|R| = 1.00$ - mathematical connection. [6]