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ANALYSIS OF THE INFLUENCE OF FRESH ASPHALT MIXTURE TEMPERATURE ON ASPHALT COMPARISON DURING INSTALLATION

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SUMMARY

When building new roads in BiH, reconstruction or rehabilitation of existing roads, construction or replacement of asphalt layers is a mandatory part of construction works. The lifespan of the entire pavement structure depends on the quality of the final asphalt layers of the pavement structure. One of the most significant characteristics of the asphalt mixture during installation is the temperature of the asphalt mixture.

Legislation, ie technical conditions, define the minimum temperature of the asphalt mixture as well as the limit air temperature during the installation of asphalt, but special emphasis is given to the optimal temperature of the asphalt mixture. The optimal temperature of the asphalt mixture in this paper was analyzed through the compaction property of the asphalt mixture. Thus, working on several specific examples, observes the optimal temperature of the asphalt mixture so as to obtain the best possible compaction of the installed asphalt. During the research, a number of other data that are important for the research were measured, such as the number of roller crossings, the weight of the rollers, the air temperature, etc.

Keywords: *asphalt mixture temperature, installation, asphalt compaction*

INTRODUCTION

Historically, the process of building asphalt pavement structures has been based on tradition, skill, and a number of different implicit methods based on experience, which have been applied in construction practice. A long time passed until a scientific approach was built in the construction of roads in general and flexible pavement structures in particular. Also, in the first place, asphalt was observed as a building material, and only later was the method of construction of asphalt pavement structures studied in more detail [1,2].

The temperature of the asphalt mixture during the installation of asphalt became especially important because it directly affected the quality of work performed, and was limited by the temperature of the asphalt mixture in the asphalt base, the length of transport of the asphalt mixture, vehicle quality, air temperature, etc.

In nature, many materials, including asphalt, expand when heated and shrink when cooled. If shrinkage due to cooling is prevented, then in the asphalt material with a decrease in temperature there is an increase in tensile stress, which can lead to breakage (appearance of microcracks in the bonding matrix) if maximum tensile strength is reached, which is especially pronounced during asphalt rolling. Simply put, the stress in the asphalt sample gradually increases in parallel with the temperature drop, until the sample breaks [3].

The research in this paper is based on measuring, on several road routes, the temperature of the asphalt mixture during installation, measuring the number of roller passages and measuring the compaction of the installed asphalt mixture.

COMPOSITION AND INSTALLATION OF ASPHALT MIXTURE

The optimal composition of the asphalt mixture is vital for the durability and stability of the asphalt pavement. In addition to the use of quality binder and quality aggregate, a very important thing for obtaining quality and durable asphalt is to find the optimal share of components in the mixture. For asphalt mixtures, organic hydrocarbon substances that have good adhesion to stone are used as a binder of the mineral aggregate. As "load-bearing", asphalt mass constructions are plastic and hydrophobic, ie they repel water and are therefore resistant to the effects of weathering and various aggressive chemicals [4].

When making a flexible pavement structure by hot process, the most critical procedures during the realization of asphalt works are the transport of hot asphalt mixture from the production plant to the construction site and the installation process itself. For this reason, all other procedures (selection of aggregates and composition of the asphalt mixture, design of the asphalt mixture, production and storage of the asphalt mixture) are directed towards them.

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 [5,6].

The asphalt layer is installed on a properly dimensioned and constructed load-bearing base or on a previously prepared existing base. All layers of the pavement structure under the asphalt layer must be sufficiently compacted. Equally important is the good compaction of each layer of embankment, bedrock, reinforced bedrock and lower and upper layers of the pavement structure (insufficiently compacted layer will subsequently compact under traffic load which will result in subsidence and cracks).

Substrates must have a correct drainage system, they must be flat and with the required drop. Depending on the type of substrate (granular unbound material mechanically stabilized, cement or bitumen stabilization, rigid pavements, old asphalt pavements or previous new asphalt layer), through which the asphalt layer is installed, the concrete preparation of the substrate is defined [7].

Asphalt layers are made on the principle of minimal cavities, ie, the stone skeleton consists of stone chips, sand and stone flour, so that as few cavities as possible remain in the mixture [2].

FIELD RESEARCH

As the subject of this paper is the temperature of the asphalt mixture, the author measured and recorded in the field all the data that could have an impact on the temperature change or compaction of the installed layer. Measurements of asphalt temperatures at the installation site were performed immediately before installation, and air temperature. Measurements were performed with remote

thermometers shown in Figure 1. At the same time, data on the passage of rollers during compaction of the spread layer of asphalt were kept. After that, kerning of the asphalt layer was performed, as well as testing of samples, and for this work, data on compaction, cavities and thickness of the asphalt layer were considered.

By comparative analysis of the asphalt installation temperature, the number of roller passes, and the results of asphalt compaction, it is possible to obtain data on the optimal conditions for asphalt compaction. Figure 1.



Figure 1. Remote thermometer for measuring asphalt temperature during installation

Installation of asphalt and all measurements were performed in the area of northeastern BiH on real examples of asphalt works. Testing of asphalt compaction was done in laboratory conditions. Table 1.

Table 1: Measurement of asphalt properties

Sample number	Asphalt temperature during installation	Type of asphalt	Asphalt compaction	Layer thickness	Nominal number of roller crossings
1	136,30	BNS22	101,6	78	62
2	139,90	BNS22	101,9	80	50
3	123,80	BNS22	101,9	71	61
4	112,80	BNS22	98,4	85	64
5	152,90	BNS22	94,64	72	48
6	157,80	AB16	96,1	54	40
7	155,40	AB16	98,9	55	35
8	154,20	AB16	98,6	50	37
9	158,40	AB16	99,5	53	39
10	160,40	AB16	99,1	56	43
11	155,90	AB16	99,4	62	41
12	160,10	AB16	98,5	48	45
13	160,70	AB16	98,3	66	50
14	157,40	BNS22	100,20	69	47

REGRESSION ANALYSIS

The results of field and laboratory tests were processed using regression analysis. Regression analysis is a set of statistical methods that reveal whether there are connections between the observed phenomena and what they are in shape and direction.

The sample is most often examined. In regression analysis, the dependence of two or more variables is examined.

In the first step of the regression analysis, it should be determined whether there is a connection between the observed phenomena at all. There are usually three forms of connection:

- Rectilinear shape (linear connection)
- Curvilinear shape (nonlinear connection)
- Spatial shape

If there is a connection between the observed phenomena, we move on to the second step of the analysis, which investigates the strength of the connection between the observed phenomena. Simple regression is applied when two phenomena between which there is a connection are observed at the same time, whereby a certain function, ie line, can be well adapted to the original values of the feature. 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 [8].

In the case of a linear relationship, the relationship between phenomena is described, which is characterized by the fact that each unit increase in the value of one variable corresponds to approximately equal linear change of 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 scattering diagram from the required regression direction is minimal. A specific indicator of the representativeness of the regression is the coefficient of determination (R^2). The model is more representative the closer the coefficient of determination is to number 1, ie the stronger the connection between the observed phenomena.

Accordingly, the degrees of strength of the connection of the observed phenomena are defined, depending on the value of the coefficient of determination (R^2):

- $0.00 < |R^2| \leq 0.25$ - there is no connection between the observed phenomena,
- $0.26 < |R^2| \leq 0.50$ - weak to moderate connection between the observed phenomena,
- $0.51 < |R^2| \leq 0.75$ - good correlation between the observed phenomena,
- $0.76 < |R^2| \leq 0.99$ - very good to excellent connection between the observed phenomena,
- $|R^2| = 1.00$ - mathematical connection [8].

ANALYSIS OF TEST RESULTS

As we can see from Table 1, we have samples for two types of asphalt, so in the analysis we will divide the asphalts by types and observe them that way. We will first look at BNS22 asphalt samples. In accordance with the input data, we obtained the following diagram describing the influence of asphalt temperature on compaction. Figure 2.

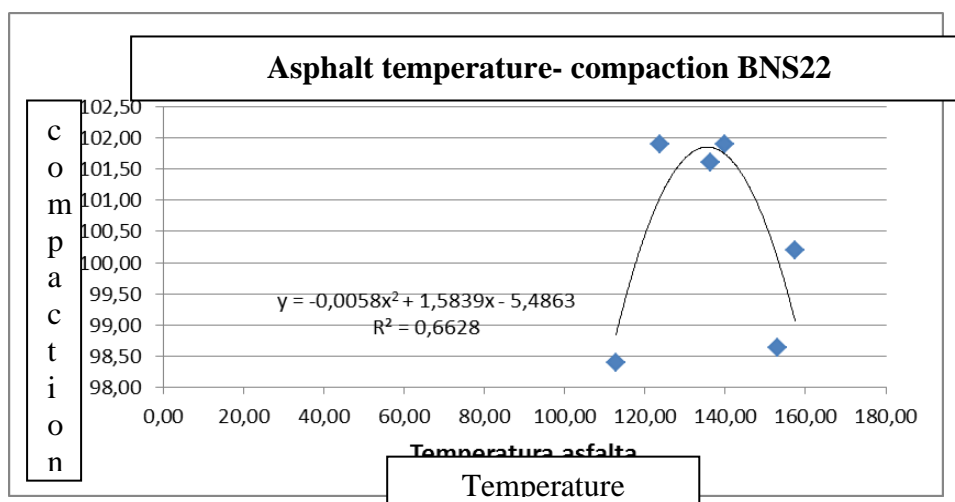


Figure 2. Dependence diagram "Asphalt temperature - compaction - BNS22"

For asphalt AB16 the diagram describing the influence of asphalt temperature on compaction looks like in the picture below. Figure 3.

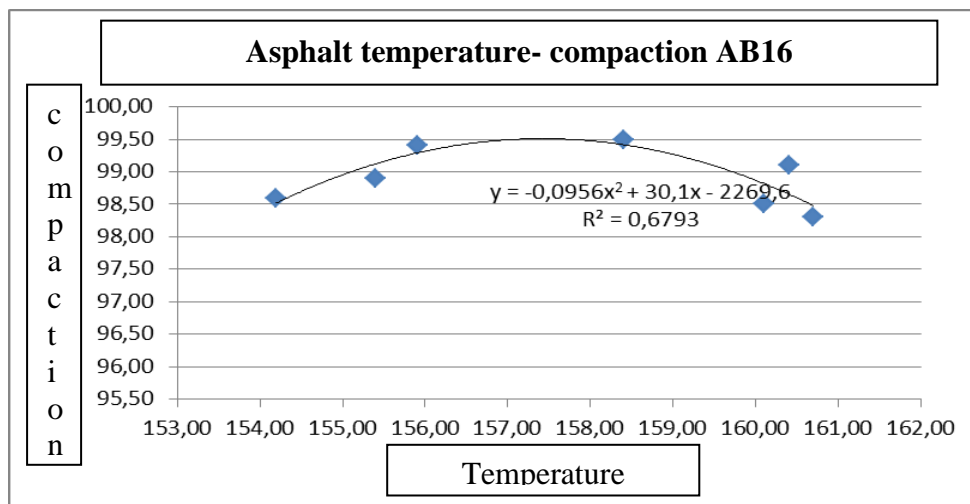


Figure 3. Dependence diagram "Asphalt temperature - compaction - AB16"

By analyzing the curves in the diagrams in Figures 2 and 3, it can be seen that the coefficient of determination - R^2 has a value of 0.66 and 0.67, which represents a good correlation between the observed phenomena. The author opted for the second-order curve because it realistically describes the observed phenomenon. Other curves were considered through the analysis, but due to poorer results, they are not presented here.

Further, if the data for all measurements are shown in a common diagram, then it looks like in Figure 4.

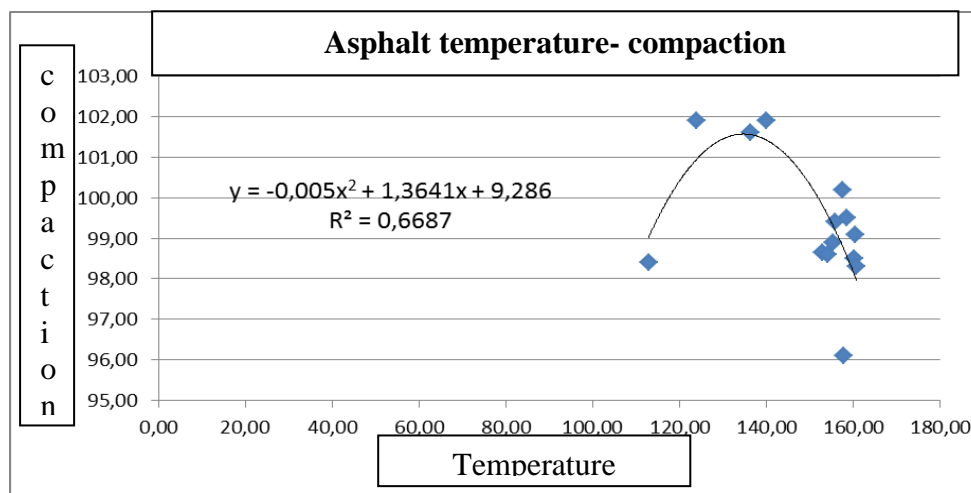


Figure 4. Dependence diagram "Asphalt temperature - compaction"

CONCLUSIONS

By analyzing the curves in the diagrams in Figures 2 and 3, it can be seen that the highest compaction is achieved when the asphalt temperature is between 140 and 157 °C. At any temperature outside this range (higher or lower), less compaction results are obtained regardless of the number of roller passes. And the common diagram for both types of asphalt in Figure 4 shows approximately the same area of optimal asphalt temperature from the aspect of compaction of the installed layer.

The optimal temperature of asphalt for installation from the aspect of compaction is from 140-157° C. Consider samples no. 7, 8 and 9. They were installed at a temperature that is optimal in the interval from the aspect of compaction and cavities, (155.40; 154.20; 158.40), they had the lowest nominal

number of roller crossings (35, 37, 39). , and a satisfactory result was achieved from the aspect of compaction and cavities in the asphalt layer. From the above, it can be seen how by adjusting the production temperature, we can influence the quality of the installed asphalt.

The influence of the outside temperature is also important in order to prevent excessive cooling of the asphalt during transport. However, the upper limit of the asphalt production temperature is usually limited to 175° C, so it is necessary to adjust the outdoor temperature in order to achieve a satisfactory quality of the installed asphalt. It can be concluded that by increasing the outside temperature, and by harmonizing the outside temperature and the temperature of the asphalt, we can create optimal conditions for compacting the asphalt (as few roller passes as possible, as short a rolling time as possible to cool the asphalt).

Also, too high outside temperatures adversely affect the optimal compaction, because it takes more time for the asphalt to cool, and rolling is done until the asphalt reaches the appropriate (low) temperature. As we have limited values of the upper and lower temperature of asphalt production, we can create optimal conditions by adjusting the outdoor temperature for the given circumstances (production temperature, temperature loss in transport).

In order to ensure satisfactory quality of the installed asphalt, we must also take into account the outside air temperature. Therefore, if we respect the maximum temperature of asphalt production (175 ° C), the greater the distance of the installation site from the asphalt base, we must have a higher air temperature to achieve the appropriate compaction and quality of the installed asphalt.

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