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## **THE INFLUENCE OF TECHNOLOGICAL FACTORS ON BRIDGE DECK WATERPROOFING WHEN LAYING HOT ASPHALT CONCRETE PROTECTIVE AND WEARING COURSES**

### **Summary**

The paper covers the influence of technological factors on bridge deck waterproofing when laying hot asphalt concrete protective and wearing courses. The influence of crushed stone content in mineral part of hot asphalt mixes, value of compaction loading and asphalt mix temperature on the watertightness parameter of roll polymer modified bituminous waterproofing material has been determined. The technique of samples preparation for the determination of watertightness, simulating influence of technological factors on waterproofing material under hot asphalt concrete protective or wearing course has been developed. The parameter of watertightness is recommended for use as a selection criterion of waterproofing materials for bridge and overbridge decks waterproofing protection.

## 1. Introduction

The majority of highway bridge decks waterproofing technologies include application of polymer modified bituminous membranes or mastics. Laying of concrete protective layer prior to the asphalt concrete wearing courses is generally provided for waterproofing protection. Disadvantages of this design are the increase of superstructure dead load and operation period prolongation. The technology of bridge deck waterproofing, using specified waterproofing materials, omitting the stage of concrete protective layer placing has been spreading throughout Ukraine. According to the specified technology hot (or mastic) asphalt mix is laid directly on the waterproofing layer [1]. However, the influence of such technological factors as high temperature (140-160 °C) (in case of mastic asphalt mix laying it can run to 250 °C) and compaction load (30-40MPa) on the layer of waterproofing material occurs when laying and compacting hot asphalt mix.

As a measure of high service temperatures influence on waterproofing materials designed for roofing the parameter of their heat resistance is traditionally employed. For this purpose manufacturers of waterproofing materials more often use method involving determination of ultimate temperature causing no visual damage (no blisters on the surface and coating displacement) to the sample vertically hung for a certain period [2]. As a rule, the magnitude of high service temperatures gained by waterproofing material in pavement on bridge and overbridge decks does not exceed 70 to 80 °C. Practically all roll waterproofing materials recommended for waterproofing protection of bridge decks are characterized by much higher magnitude of heat resistance index. However, the temperature of waterproofing material can be twice as high values when putting hot asphalt concrete protective layer over waterproofing material. High temperature of asphalt mix results in softening of waterproofing material coating, which is absorbed by asphalt concrete layer due to compaction loading, making waterproofing material thinner. Thereby, the reduction in waterproofing material thickness makes it more susceptible to damage by crushed stone grains, comprising asphalt concrete mix, under its compaction.

The lack of any other external factors, except temperature, which could influence the state of waterproofing material, proves the imperfection of the method [1]. Besides, the influence of high temperature, provided that the sample is vertically located, is not typical for waterproofing materials designed for highway bridge decks waterproofing. The specified method can serve for the evaluation of heat resistance of roofing materials only.

Development of method of heat resistance determination of waterproofing materials, designed for highway bridge decks waterproofing, which could take into consideration simultaneous influence of high technological temperatures, occurring when laying hot asphalt mixes directly on the layer of waterproofing material, and value of compaction load is of considerable importance.

## 2. Materials and procedures

Reinforced roll waterproofing material POLYFLEX HP 25 5 mm thick was taken for the research. Waterproofing material POLYFLEX HP 25 is produced on the basis of polymer modified bituminous composition, modified with atactic polypropylene (APP) and filled with fine mineral filler. The material is reinforced with non-woven spunbond polyester fabric, located in upper zone of the material. Properties of the waterproofing material are detailed in Table 1.

In order to evaluate the influence of high temperature of hot asphalt mix, when placing protective layer, values of compaction load and asphalt mix type on roll polymer modified

bituminous material the authors have developed special technique. According to the technique the impact measure of the factors is index of waterproofing material watertightness.

To estimate watertightness sample of waterproofing material 70 mm in diameter is laid on steel cylinder insert located in special mould. The sample is covered with mineral aggregates of asphalt mix preheated to temperature of asphalt mix laying and loaded by another steel insert. Compaction load is then applied to mineral material via steel insert.

Table 1 – Properties of polymer modified bituminous waterproofing material POLYFLEX HP 25 according to the manufacturer’s data (Polyglass s.p.a.)

Technical features	Nominal values	Technical features	Nominal values
Length	10 m	Tearing resistance:	
Width	1 m	- longitudinal	170 N
Thickness	5 mm	- transversal	180 N
		Cold flexibility	-10 °C
Weight	4,8 kg/mq	Dimensional stability:	
		- longitudinal	-0,4 %
		- transversal	0,3 %
Tensile strength:		Heat resistance	120 °C
- longitudinal (max. charge)	1000 N/50 mm		
- transversal (max. charge)	800 N/50 mm		
Elongation at break:		Water tightness	≥60 kPa
- longitudinal	50 %		
- transversal	50 %		

Compaction of mineral aggregates was performed at loading of 20, 30 and 40 MPa during 3 minutes. Schematic of sample preparation is shown in Fig. 1.

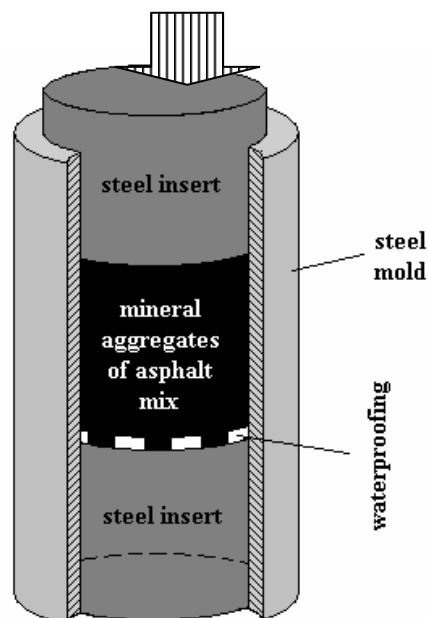


Fig. 1 – Schematic of sample preparation

Laying and compaction of mineral aggregates of type “A”, “Б”, “В” and “Т” asphalt mixes as well as stone mastic asphalt preheated to 120, 140 and 160 °C was carried out for the

estimation of watertightness of waterproofing material. The specified asphalt mix types differ in crushed stone grains content.

### 3. Results

Results of heat resistance determination of roll waterproofing material POLYFLEX HP 25 by means of technique [1] indicate (Fig.2) that being conditioned at 160 °C coating on the underside of waterproofing material softens and completely flows from vertically positioned sample. At the specified temperature coating on the upper surface of the material was covered with blisters. Data obtained confirmed the fact that specified technique does not model real performance conditions of waterproofing material under service conditions on bridges and cannot be applied for evaluation of technological heat resistance of waterproofing materials when laying hot asphalt pavement directly on them.



Fig. 2 – View of waterproofing material sample after 30 minutes of its conditioning in oven at 160 °C (1 – upper side, 2 – underside)

In Fig. 3 is shown general view of waterproofing material surface prepared according to the technique proposed by authors for determination of watertightness. Fig. 3 demonstrates damage of the surface in form of punctures. Evaluation of damage level of roll waterproofing material by crushed stone grains, constituting a part of mineral aggregates of asphalt mixes, was performed by determination of its watertightness index under hydrostatic pressure (0.001 MPa). For this purpose graduated glass cylinder was placed on the surface of the sample obtained from the side of waterproofing material. Glass cylinder was filled with water at  $(20\pm 5)$  °C at the amount necessary to create hydrostatic pressure of 0.001 MPa (Fig. 4). Parameter of waterproofing material watertightness was estimated by change of water level in cylinder within 24 hours. The sample was considered watertight if water level in cylinder after 24 hours did not change.

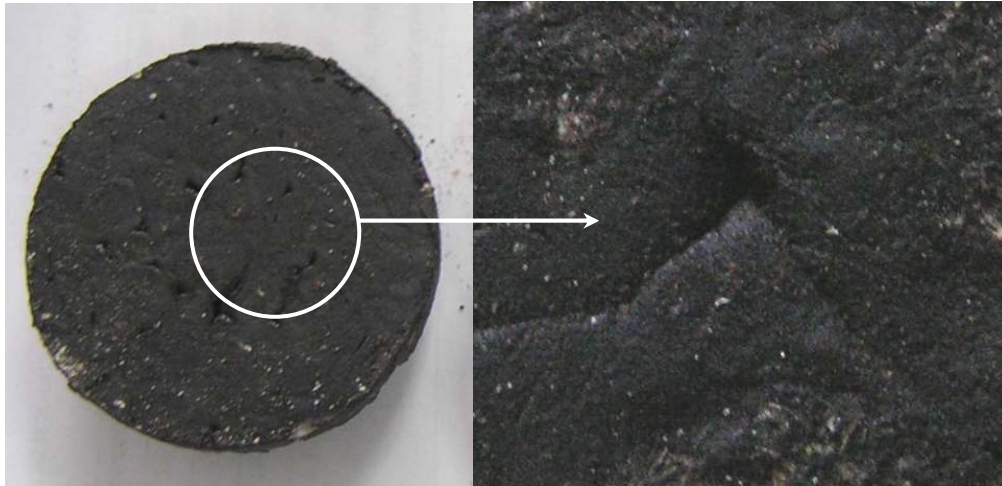


Fig. 3 – View of underside of waterproofing material samples after application and compaction of SMA mineral aggregates at 140 °C

Research results of influence of compaction load, temperature of mineral aggregates of asphalt mixes of different grading types on watertightness of roll waterproofing material under consideration are shown in Table 2.

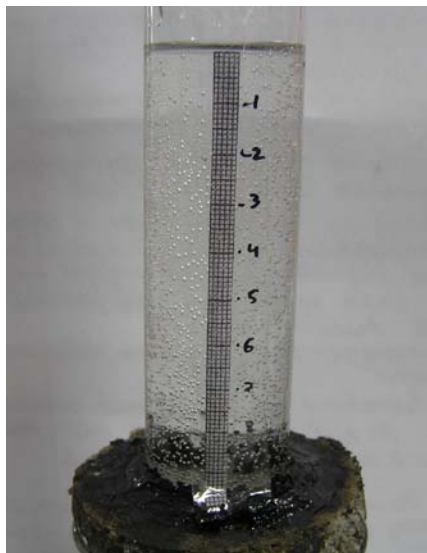


Fig. 4 – Determination of waterproofing material watertightness under hydrostatic pressure of 0.001 MPa

Table 2 – Watertightness of roll polymer modified bituminous waterproofing material after 24 hours of hydrostatic pressure of 0.001 MPa

Type of asphalt mix	Compaction load, MPa		
	20	30	40
<b>Compaction temperature 120 °C</b>			
SMA	+	-	-
“A”	+	+	+
“B”	+	+	+
“B”	+	+	+
“T”	+	+	+

Compaction temperature 140 °C			
SMA	-	-	-
“A”	+	-	-
“B”	+	+	+
“B”	+	+	+
“T”	+	+	+
Compaction temperature 160 °C			
SMA	-	-	-
“A”	-	-	-
“B”	+	+	+
“B”	+	+	+
“T”	+	+	+

Note: grey colour shows samples that have not passed the test, white – those samples that have passed the test

Data presented in Table 2 indicate that enhancement of compaction load from 20 to 40 MPa and mix temperature from 120 to 160 °C results in failure of waterproofing material by watertightness parameter in case of application of mixes other than type “B”, “B” and “T”. When laying stone mastic asphalt mix on waterproofing material the damage of waterproofing material at all specified temperatures and practically all values of compaction load is observed. When using fine-aggregate type A mixes damage of the waterproofing material at 140 and 160 °C and loss of watertightness has been detected. Reduction of the specified mix temperature to 120 °C provides preservation of waterproofing material watertightness.

Research results illustrated in Fig. 5 show that after only 2 hours of water action waterproofing material loses its watertightness. The amount of water leaking through waterproofing material increases with compaction loading increase.

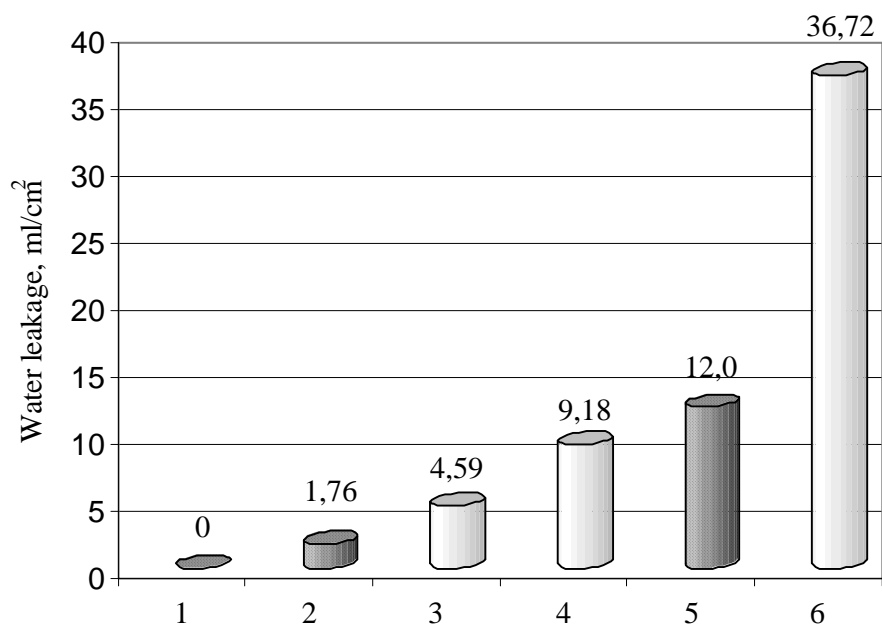


Fig. 5 – Dependence of water leakage parameter through waterproofing material after 120 minutes of 0.001 MPa water pressure after laying of mineral aggregates of type “A” asphalt mix (dark columns) and SMA (light columns) at 140 °C from the magnitude of compaction load (1 – 20 MPa, 2 – 30 MPa, 3 – 20 MPa, 4 – 30 MPa, 5 – 40 MPa, 6 – 40 MPa)

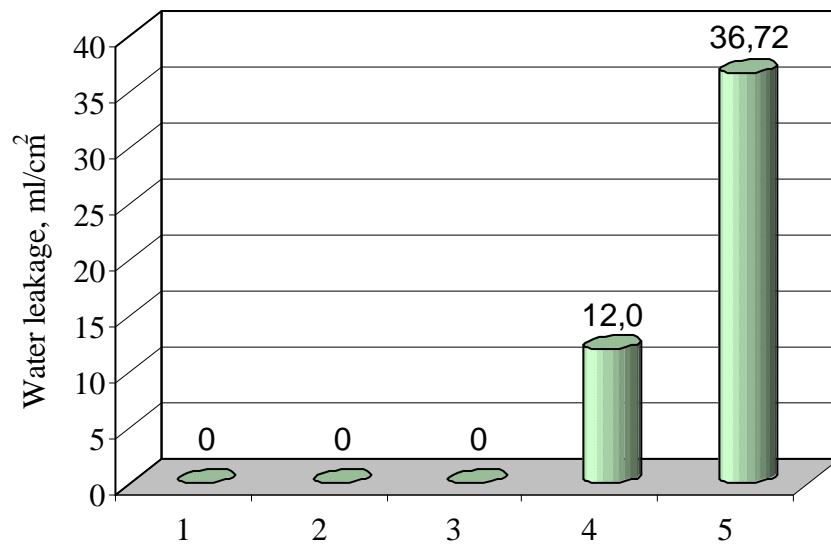


Fig. 6 – Dependence of water leakage parameter through waterproofing material after 120 minutes of 0.001 MPa water pressure after laying of mineral aggregates of asphalt mix at 40 MPa compaction load and 140 °C from crushed stone grains content in asphalt mix (1 – 5 %, 2 – 27 %, 3 – 36 %, 4 – 47 %, 5 – 70 %)

Increase of crushed stone content in mineral part of asphalt mix results in increase of waterproofing material permeability (Fig. 6). Using type “A” asphalt mix as an example (Fig. 7) it is shown that water volume leaking through waterproofing material increases with time. As this takes place, water volume that leaked through waterproofing material increases with the increase of mix temperature and compaction loading.

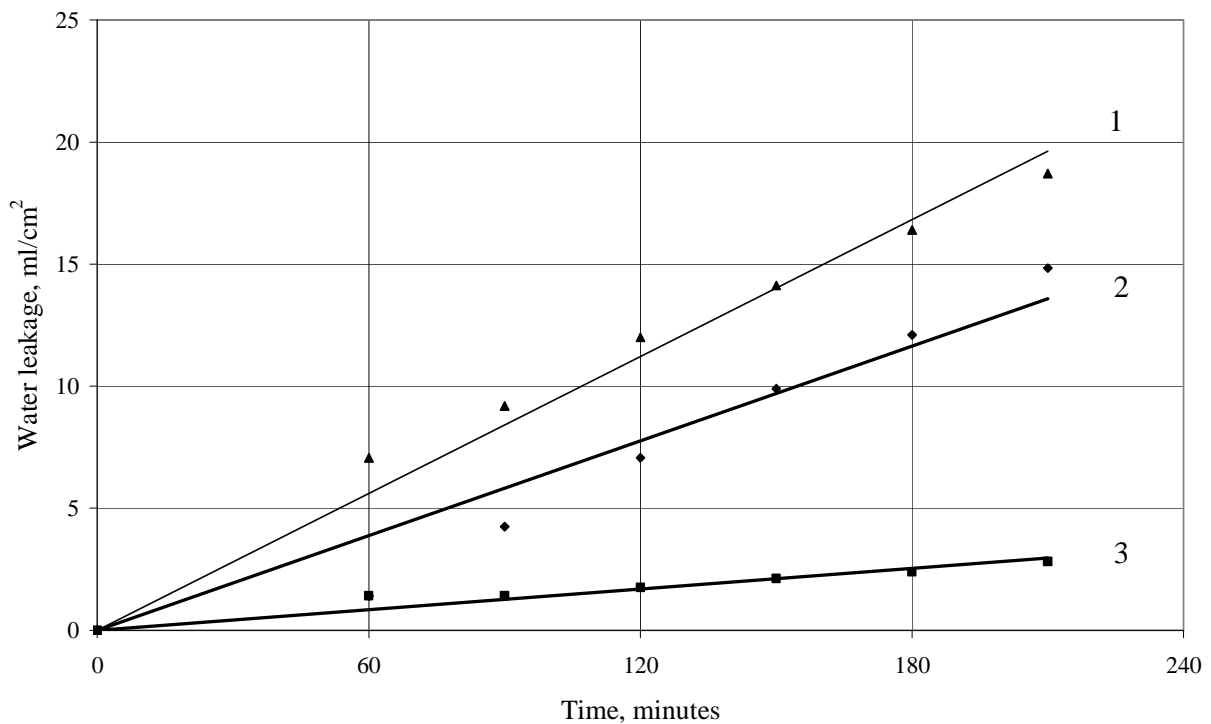


Fig. 7 – Dependence of water leakage parameter under 0.001 MPa water pressure through roll waterproofing material from temperature and magnitude of compaction load (type “A” mix): 1 – 140 °C and 40 MPa; 2 – 160 °C and 20 MPa; 3 – 140 °C and 30 MPa

#### **4. Conclusions**

The influence of crushed stone content in mineral part of hot asphalt mixes, value of compaction loading and asphalt mix temperature on the watertightness parameter of roll polymer modified bituminous waterproofing material POLYFLEX HP 25 has been determined. Asphalt mixes with crushed stone content up to 40 % (by weight) do not damage the waterproofing material when compacting mix at 40 MPa loading at technological laying temperatures. The increase of crushed stone content in mix, asphalt mix temperature and compaction load value contributes to the increase in water permeability of roll reinforced polymer modified bituminous waterproofing material. It is due to the integrity loss of both reinforcement and waterproofing material coating. As a result of aggregate high temperature and influence of compaction load coating loses its heat resistance, passes through reinforcing layer and is absorbed by the layer of hot aggregate. It makes waterproofing material thinner and more susceptible to hydrostatic pressure.

The technique of samples preparation for the determination of watertightness, more closely simulates influence of technological factors on waterproofing material under hot asphalt concrete protective or wearing course. The parameter can be used as a criterion for selection of waterproofing material for bridge and overbridge decks waterproofing protection.

#### **References**

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