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METHOD OF PREPARATION AND TEST RESULTS OF BITUMEN MODIFIED WITH POLYMERS USING LABORATORY BLADE MIXER

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Abstract. An important step in the preparation of modified bitumen is selection of the composition and verification of various polymers’ effectiveness. Therefore, paddle mixers are widespread in both industrial and laboratory conditions for efficient mixing of bitumen with polymers. The developed method allows to determine the completion time of modification process at various process parameters (temperature, mixing speed and content of the modifier) to complete stabilization of the properties and the homogenization of bitumen. The results of studies showed that optimal time for bitumen modification at wich take place both stabilization of the properties and homogenization, ie astringent take the necessary level of uniformitywith latex Butonal NS198, is about 3 hours.

Keywords: cracking resistance, rutting resistance, shear resistance, water resistance, polymer-modified bitumen, laboratory blade mixer, homogenization.

Introduction

Roads of Ukraine are characterized by high traffic volumes and intensity, and significant dynamic load on pavement of bridges and airfields require increased requirements to asphalt concrete, and, correspondingly, to bitumen. The most common and effective way to increase quality of asphalt is use of bitumens modified with polymers which significantly improve the properties of asphalt, namely cracking resistance, rutting resistance, shear resistance and water resistance, etc. (Zolotarev 2009; King, Radovskii 2004; Hochman 2004).

An important step in the preparation of modified bitumen is selection of the composition and verification of various polymers’ effectiveness. These issues require availability of appropriate laboratory mixers for making polymer-modified bitumens. Modern practice of laboratory tests of modified bitumen shows lack of standardized procedures in the laboratory mixing and related laboratory equipment, which does not allow to get polymer-modified bitumens in compliance with sole preparation technology, whereby it is possible to get no reliable laboratory test results (Hochman 2004; Onishchenko 2008; Kirichek *et al.* 2008).

The most simple and quite effective technical means of mixing low-viscosity liquids and liquids with solids that are in a state of near suspension are blade mixers. Therefore, blade mixers are widely used, in both industrial and laboratory conditions for efficient polymer bitumen modification.

Analysis of recent research

Objective to develop methodology for preparation of polymer modified bitumen with use of laboratory blade mixer with the purpose of selection of its composition and establishment of requirements to the process of mixing.

The authors developed method of preparation of modified bitumen using laboratory blade mixer (Fig. 1). Method to determine the time of completion of modification process at different process parameters (temperature, mixing speed and amount of modifier) to complete homogenization and stabilization properties of bitumen.

The technique is to set a time during modified bituminous binder, wherein the stabilization properties will, and homogenization, i.e. binder acquires desired level of uniformity. At the beginning of bitumen modification process polymer is fed and time of modification completion is set. Estimation of bitumen stabilizing properties and homogenization when feeding polymer is carried out by the following criteria:

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– rate of penetration change (with additional 1 hour of bitumen modification) ≤ 2 × 0, 1 mm / hour (modified bitumen acquired penetration stabilization);

– rate of elasticity change (with additional 1 hour of bitumen modification) ≤ 2 % / h (modified bitumen acquired elasticity stabilization);

– variation coefficient in terms of penetration and elasticity (with additional 1 hour of bitumen modification) ≤ 2 % (modified bitumen acquired penetration and elasticity uniformity).

Table 1. Technical peculiarities of laboratory blade mixer

Peculiarities (conditions)	Technical data
Metal zinc container, dm3 (DSTU 3277)	7
Number of agitator blades	4
Angle of the blades, degrees	90
Helix angle of the blades, degrees.	22
Dimensions of blades, mm	L = 100, H = 20
The minimum distance between blades, at least, mm- Between the wall – Between the tank bottom	15 50
Frequency of rotation of blade shaft, rot / min.	10…30
Electric motor with speed control, power, kW	2
Oil electric tensor with electric temperature range, ° C (GOST 13268)	from 0 to 250
Thermocouples GOST R 8.585 with temperature range, ° C	from 0 to 300
Heating of the oil thermostat to a temperature T, º C	220
Heat-resistant oil (GOST 18852) permissible temperature	250

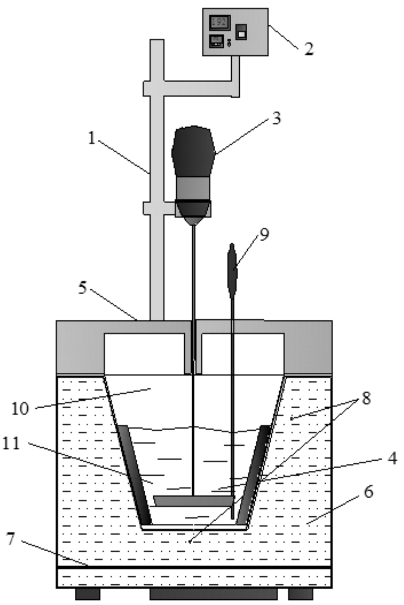


Fig. 1. Laboratory blade mixer (side-view)
1 – tripod, 2 – control unit, 3 – electric motor, 4 – blade agitator, 5 – oil thermostat 6 – oil tank 7 – electric tensor, 8 – thermocouple in the oil thermostat, 9 – thermocouple for modified bitumen, 10 – Metal container according to DSTU 3277, 11 – bitumen binder

Sampling schedule of modifying bitumen polymer is set taking into account stabilization properties of the binder and its homogenization. If the nature of such rates is not known for certain polymer-modified bitumen, it is recommended to carry out a trial modification, to establish nature and pace of modifications to select the appropriate sampling schedule.

Modification completion time is assumed to be the time at which all the processes of bitumen stabilization and homogenization have taken place. In order to define this time laboratory tests for definition of penetration and elasticity, their coefficients of variation at different sampling times are held. Based on the results changes of these indicators in each period between the time the mixing of sampling are assessed. Completion of the modification time is defined on the basis of the achievement of stability and uniformity properties of polymer-modified bitumen, in accordance with the scheme shown in (Fig. 2–5).

Fig. 2. presents a case where penetration stabilization properties of bitumen are achieved faster than uniformity. In this case, the time to achieve maximum coefficient of variation for penetration $K_в^П(t)$ corresponds to time $t_{одн}^{Кв}$. It is larger than the time which corresponds to the completion of penetration stabilization. Therefore, the process of completing of bitumen modification with polymers will be when the stabilization time for penetration $t_{ст}^{П25}$ will be equal to or exeed mixing time $t_{одн}^{Кв}$.

Fig. 3. presents a case where homogeneity of asphalt binder is reached faster than stabilizing of penetration properties. In this case, the time to achieve maximum coefficient of variation for penetration $Кв^П(t)$ corresponds to time тоднКв. It is smaller than the time which corresponds to the completion of penetration stabilization. Therefore, the process of completing of bitumen modification with polymers will be when mixing time is equal to or greater than penetration stabilization time $t_{ст}^{П25}$.

A similar scheme is used to determine process of completing of bitumen modification with polymers according to elasticity (Fig. 4–5).

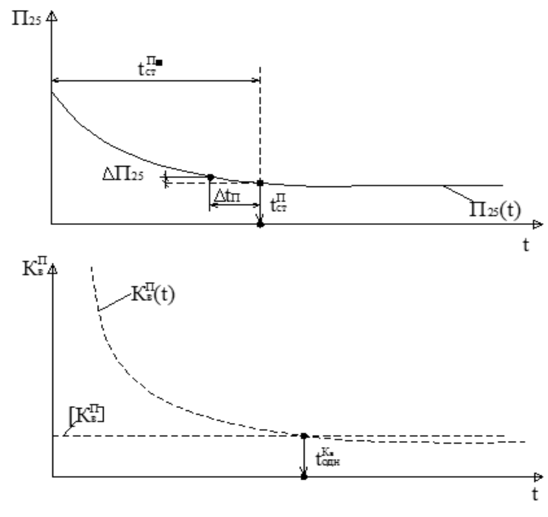


Fig. 2. Defining $t_{зм}$ – time for mixing bitumen with polymer, using laboratory blade mixer on the basis of changes in penetration $П_{25}(t)$ and coefficient of penetration variation $K_в^П(t)$ depending on mixing time $t_{зм}$ when $t_{одн}^{Кв} \geq t_{ст}^{П25}$

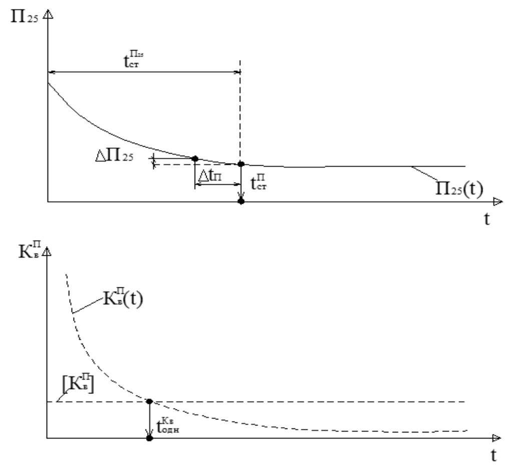
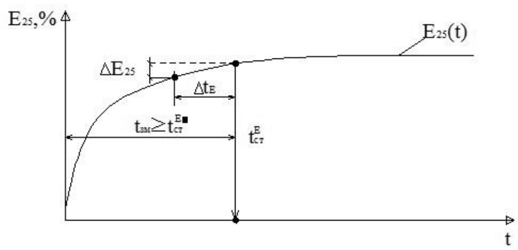


Fig. 3. time for mixing bitumen with polymer, using laboratory blade mixer on the basis of changes in penetration $П_{25}(t)$ and coefficient of penetration variation $К_в^П(t)$ depending on mixing time $t_{зм}$ when $t_{одн}^{Кв} \leq t_{ст}^{П25}$

The developed method of modified bitumen preparation using laboratory blade mixer allows to determine accurately time and accurate information concerning completion of stabilization properties and homogenization of the modified asphalt binder. After each sampling test results are input into record book and test results are processed (Zolotarev 2009; Hochman 2004; Kirichek *et al.* 2008; Onishchenko 2008; DSTU... 2007).



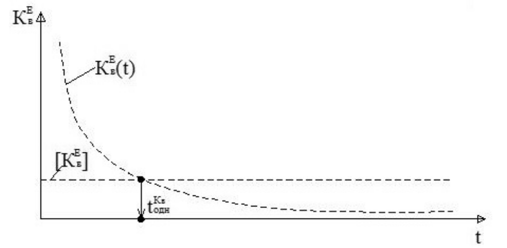


Fig. 4. Defining time for mixing bitumen with polymer, using laboratory blade mixer on the basis of changes in elasticity $E_{25}(t)$ and coefficient of elasticity variation $К_в^E(t)$ depending on mixing time $t_{зм}$ when $t_{одн}^{Кв} \leq t_{ст}^{E25}$

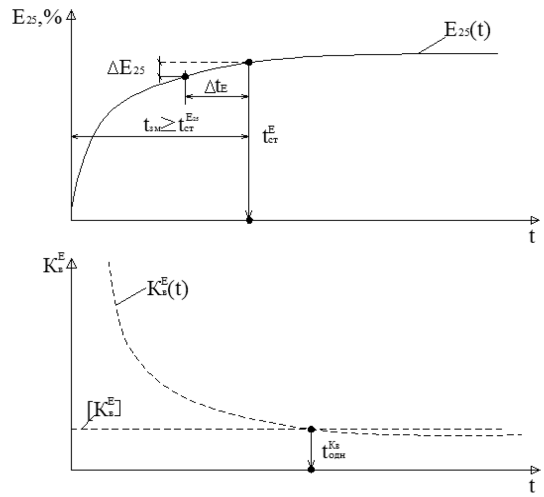


Fig. 5. Defining time for mixing bitumen with polymer, using laboratory blade mixer on the basis of changes in elasticity $E_{25}(t)$ and coefficient of elasticity variation $К_в^E(t)$ depending on mixing time $t_{зм}$ when $t_{одн}^{Кв} \geq t_{ст}^{E25}$

The authors conducted tests on Mozyrskogo bitumen BND 90/130, using different amounts of cationic polymer latex Butonal NS198. The test results are shown in Table 2.

Table 2. Physico-mechanical properties of bituminous binder according to amount of polymer and modification time

Initial bitumen type, type and amount of polymer,%	Mixing time, T, hour	Penetration $П_{25}$, mm^{-1}	R&B T_p, °C	Elasticity E_{25}, %	Ductility D_{25}, cm	Variation coefficient $К_в^П$, %	Variation coefficient $К_в^E$, %
BND 90/130	–	97.0	47.0	–	>85	–	–
BND 90/130+2% Butonal NS198	1	80.0	52.0	62.0	>80	5.73	3.34
	2	73.0	53.0	67.0	77	3.34	3.09
	3	73.0	54.0	69.0	75	2.74	2.22
	4	72.0	55.0	69.0	72	1.39	1.45
	5	71.0	55.0	69.0	71	1.41	0.84
	6	70.0	55.0	69.0	71	0.82	0.72
BND 90/130+4% Butonal NS198	1	77.0	56.0	66.0	74	6.29	3.79
	2	67.0	57.0	70.6	61	4.45	3.56
	3	64.0	57.0	71.0	59	3.13	2.82
	4	62.0	60.0	71.7	59	2.48	2.13
	5	60.0	61.0	72.0	56	1.67	1.39
	6	59.0	61.0	72.3	56	1.30	0.80
BND 90/130+6% Butonal NS198	1	75.0	63.0	67.0	60	6.67	4.48
	2	69.0	65.0	71.0	47	2.51	4.23
	3	61.0	67.0	72.3	44	4.10	3.48
	4	57.0	67.5	72.6	43	3.51	2.86
	5	54.0	68.0	72.4	43	2.34	1.67
	6	53.0	68.0	72.5	43	1.89	1.38

Conclusions

1. Relative deviation of penetration bitumen at modification time (1–6 hr.) with feeding 2 % Butonal NS198 varies from 1 to 6 %, with 4 % Butonal NS198 varies from 2 to 12 % and with 6 % Butonal NS198 from 1 to 13 %, respectively.

2. Similarly determined relative deviation of bitumen elasticity at modification time (1–6 hr.) with feeding 2 % Butonal NS198 varies from 0.5 to 8.0 %, with 4 % Butonal NS198 from 0.5 to 7, 0 %, and with 6 % Butonal NS198 varies between 0.5 and 6.0 % respectively.

3. Test results are shown in Table 1 indicate that the obtained bituminous binders from initial material using series of different amounts of latex Butonal NS198 have different penetration parameters, but very similar parameters of softening temperature and elasticity. Significant difference of penetration, primarily associated with the rapid process of oxidation and aging of raw materials, as well as modification time and the amount of polymer.

4. The results showed that the optimal bitumen modification at which stabilization of properties and homogenization will be take place, i.e. binder acquires required level of uniformity with latex Butonal NS198, is about 3 hours. For other polymer modification time is set for the above described procedure.

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