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ADDITIVES FOR ROADS

BY

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Abstract. The results of laboratory tests for two additives: ADIROL ALCAMID F and ADIROL ALCAMID FS are presented. Three mixtures were made in laboratory, with two types of bitumen of four dosages each, in order to assess characteristic physical and mechanical values of mixtures made with bitumen having 0.5% additives. The analysis of obtained results shows a substantial improvement of the characteristic physical and mechanical values of these mixtures as compared to mixtures made with non-additive bitumen.

Key Words: Bitumen; Additives; Aggregate.

1. Introduction

The use on a large scale of natural ballast-pit aggregates, which have a content of SiO_2 exceeding 65%, in the composition of asphalt mixtures, requires the fact that we should consider special measures on insuring the bitumen's adhesiveness to these acid aggregates. One of these measures is to additivate bitumen with different tensioactive substances.

2. Additives Tested in the Laboratory

In order to study the influence of the following additives: ADIROL ALCAMID F and ADIROL ALCAMID FS on road bitumen, there have been made tests in the ROADS Laboratory at the Technical University of Jassy, Faculty of Civil Engineering, on two types of bitumen: the first type manufactured by Astra refinery from Ploieşti and the second manufactured by Suplacu refinery from Barcău (Bihor-Romania). The main characteristic values of both types of bitumen have been determined both in pure state and in mixture with 0.5% (of weight) with the two previously mentioned additives (Table 1).

Both pure state (witness) and those with adided types of bitumen have been used as binding material in the composition of three mixtures: an asphalting concrete rich in chippings – BA 8 and an asphalting concrete rich in chippings – BA 16, both with chippings of 4...8, 8...16 and crusher sand of 0...4 from Turcoaia (Tulcea) quarry: granite, and an asphalting concrete rich in chippings –

BA 8 with chippings of 4. . . 8 and crusher sand of 0. . . 4 from Homorod (Harghita) quarry: andesite.

The granulometric curves of natural aggregates and the dosages used for each mixture and the granulometric curves of mixtures of aggregates are presented in the Table 2, and the values of the impurities from the natural sands are presented in the Table 3.

Table 1
Characteristics of Both Types of Bitumen

Type of bitumen	Characteristics			
	Penetration at 25°C, 1/10 mm	Softening point (I.B.)	Penetration index (P. I.)	*a*, susceptibility to heat
Astra Ploieşti Refinery				
Witness bitumen	84	51.8	−0.615	0.037
Bitumen +0.5% additive F	91	49.6	+0.278	0.038
Bitumen +0.5% additive FS	76	51.2	−0.166	0.039
Suplacu de Barcău Refinery				
Witness bitumen	103	47.2	−0.017	0.040
Bitumen +0.5% additive F	101	48.1	+0.185	0.039
Bitumen +0.5% additive FS	86	49.0	−0.059	0.040

The granulometric curves of natural aggregates are framed in the SR 174-1/2002 (mixtures I and II) and the SR 174 -1/2002 (mixture III).

In the laboratory there have been made asphalting mixtures with four dosages of bitumen for each type of asphalting concrete out of which there have been produced eight Marshall-type cylinder samples for each (D = 10.16 cm and H = 6.35 cm) for which there have been determined the values of the physical and mechanical characteristics presented in the Tables 4 and 5.

The variations of the values of physical and mechanical characteristics of experimental mixtures, compared to witness ones, are presented in the Table 6 for optimal dosages of bitumen.

Table 2
The composition of Mixtures of Natural Aggregates and Granulometric Curves for Mixtures I, II and III

			Mixtures		
			I – BA 8	II – BA 16	III – BA 8
Passed, [%], through	Screen	ϕ25	–	100.00	–
		ϕ16	–	95.59	–
		ϕ10	100	71.13	100.00
		ϕ8	89.16	61.60	93.38
	Sieve	# 4	60.64	47.57	72.10
		# 0.63	34.47	29.15	36.38
		# 1	39.54	32.92	42.66
		# 0.2	17.92	16.42	17.79
		# 0.1	11.97	10.82	10.12
		# 0.071	9.34	9.13	7.90
Chippings 4...8 (Turcoaia)			45.00	20.00	–
Chippings 8...16 (Turcoaia)			20.00	35.00	–
Chippings 4...8 (Harghita)			–	–	45.00
Chippings 4...8 (Harghita)			–	–	45.00
Crusher sand 0...4 (Turcoaia)			–	15.00	–
Crusher sand 0...4 (Harghita)			–	–	22.00
Natural sand (Tecuci)			23.00	18.00	–
River sand (Timişeşti)			–	–	25.00
Filler (Bicaz)			12.00	12.00	8.00

Table 3
Values of the Content of Impurities in the River Sands, Used for Mixture Composition

Natural aggregate	Characteristics	
	Part that can be levigated, [%]	Content of humus (the colour of the solution of 3% NaOH)
Natural sand 0...4 Tecuci	70.94	Light yellow
Natural sand 0...4 Timişeşti	1.95	Light yellow

Table 4
The Values of Physical and Mechanical Characteristics of Mixtures Made with Bitumen ASTRA, Ploieşti.

No. crt.	Mixture type	Bitumen type	Bitumen dosage, [%]	ρ_a kg/m^3	A_{vol}, [%]	Marshall trial		
						S kN	*I* mm	*S/I* kN/mm
1	I-BA 8 WITNESS (Turcoaia)	ASTRA Ploieşti	5.00	2,367	1.678	7.6	1.9	4.000
			5.25	2,387	0.501	7.9	2.7	2.926
			5.50	2,393	0.248	9.7	3.93	2.468
			5.75	2,383	0.198	9.3	4.7	1.979
2	I-BA 8 F (Turcoaia)	ASTRA Ploieşti	5.00	2,374	1.252	10	2.6	3.846
			5.25	2,379	0.859	8.5	3.7	2.194
			5.50	2,396	0.132	10	4.33	2.309
			5.75	2,390	0.020	8.6	4.93	1.744
3	I-BA 8 FS (Turcoaia)	ASTRA Ploieşti	5.00	2,368	1.544	8.8	3.55	2.479
			5.25	2,381	0.718	10.5	4.2	2.500
			5.50	2,394	0.126	10.6	4.4	2.409
			5.75	2,392	0.093	8.4	5.48	1.533
4	II-BA 16 WITNESS (Turcoaia)	ASTRA Ploieşti	4.25	2,404	1.093	12.2	3.77	3.236
			4.50	2,407	0.701	11.9	4.46	2.668
			4.75	2,414	0.461	9.0	4.53	1.987
			5.00	2,410	0.266	8.3	5.27	1.575
5	II-BA 16 F (Turcoaia)	ASTRA Ploieşti	4.25	2,393	1.414	11.2	3.43	3.265
			4.50	2,397	0.838	13.4	4.33	3.095
			4.75	2,414	0.272	10.0	4.78	2.092
			5.00	2,405	0.258	10.2	5.47	1.865
6	II-BA 16 FS (Turcoaia)	ASTRA Ploieşti	4.25	2,392	1.223	9.2	2.45	3.755
			4.50	2,407	0.423	10.0	3.17	3.155
			4.75	2,413	0.310	9.6	4.2	2.286
			5.00	2,410	0.288	10.2	4.33	2.356
7	III-BA 8 WITNESS (Harghita)	ASTRA Ploieşti	5.50	2,349	2.993	9.1	2.20	4.136
			5.75	2,356	2.583	8.7	2.43	3.580
			6.00	2,362	1.768	10.4	3.43	3.032
			6.25	2,355	1.420	9.0	3.93	2.290
8	III-BA 8 F (Harghita)	ASTRA Ploieşti	5.50	2,324	3.918	8.3	3.13	2.652
			5.75	2,347	2.936	8.8	3.20	2.750
			6.00	2,353	2.267	8.1	3.35	2.418
			6.25	2,351	1.723	10.5	4.13	2.542
9	III-BA 8 FS (Harghita)	ASTRA Ploieşti	5.50	2,311	3.710	7.8	2.95	2.644
			5.75	2,343	2.015	9.1	3.80	2.395
			6.00	2,366	0.911	10.0	3.95	2.532
			6.25	2,363	0.408	9.8	5.47	1.792

Table 4
Continuation

No. crt.	Mixture type	Swelling, [% vol.], after			
		7 days	14 days	21 days	28 days
1	I-BA 8 WITNESS (Turcoaia)	0.000	0.013	0.020	0.287
		0.000	0.079	0.013	0.191
		0.000	0.112	0.000	0.092
		0.000	0.146	0.066	0.258
2	I-BA 8 F (Turcoaia)	0.000	0.000	0.039	0.170
		0.026	0.000	0.065	0.269
		0.000	0.000	0.020	0.172
		0.000	0.000	0.033	0.147
3	I-BA 8 FS (Turcoaia)	0.000	0.364	0.039	0.117
		0.065	0.287	0.055	0.190
		0.039	0.190	0.125	0.164
		0.106	0.178	0.160	0.099
4	II-BA 16 WITNESS (Turcoaia)	0.107	0.000	0.047	0.000
		0.139	0.000	0.086	0.000
		0.033	0.000	0.127	0.000
		0.109	0.040	0.047	0.000
5	II-BA 16 F (Turcoaia)	0.000	0.020	0.119	0.020
		0.000	0.000	0.000	0.000
		0.000	0.106	0.000	0.046
		0.000	0.060	0.000	0.060
6	II-BA 16 FS (Turcoaia)	0.000	0.000	0.000	0.067
		0.000	0.000	0.000	0.119
		0.106	0.099	0.086	0.205
		0.027	0.000	0.073	0.147
7	III-BA 8 WITNESS (Harghita)	0.000	0.766	0.806	1.254
		0.098	0.540	0.628	0.903
		0.000	0.204	0.145	0.394
		0.040	0.337	0.516	0.621
8	III-BA 8 F (Harghita)	0.060	0.381	0.689	1.162
		0.072	0.287	0.267	0.847
		0.109	0.424	0.128	0.700
		0.013	0.033	0.000	0.190
9	III-BA 8 FS (Harghita)	0.000	0.489	1.096	1.434
		0.000	0.210	0.413	0.597
		0.000	0.032	0.221	0.739
		0.000	0.000	0.007	0.039

Table 5
The Values of Physical and Mechanical Characteristics of Mixtures Made with Bitumen SUPLACU DE BARCĂU, Bihor

No. crt.	Mixture type	Bitumen type	Bitumen dosage, [%]	ρ_a kg/m^3	A_{vol}, [%]	Marshall trial		
						S kN	*I* mm	*S/I* kN/mm
1	I-BA 8 WITNESS (Turcoaia)	Suplacu de Barcău	5.00	2,377	1.116	9.3	3.07	3.029
			5.25	2,378	0.769	8.4	3.83	2.193
			5.50	2,386	0.248	8.3	4.23	1.962
			5.75	2,380	0.239	8.8	4.80	1.833
2	I-BA 8 F (Turcoaia)	Suplacu de Barcău	5.00	2,378	0.921	9.5	2.67	3.558
			5.25	2,384	0.667	8.7	3.60	2.417
			5.50	2,398	0.205	9.2	3.70	2.486
			5.75	2,396	0.027	8.3	4.75	1.747
3	I-BA 8 FS (Turcoaia)	Suplacu de Barcău	5.00	2,389	0.848	10.2	3.17	3.218
			5.25	2,391	0.604	8.8	3.40	2.588
			5.50	2,405	0.013	8.0	4.07	1.966
			5.75	2,397	0.000	7.4	4.33	1.709
4	II-BA 16 WITNESS (Turcoaia)	Suplacu de Barcău	4.25	2,385	1.663	10.8	3.03	3.564
			4.50	2,400	0.763	10.3	4.25	2.424
			4.75	2,413	0.318	10.7	4.60	2.326
			5.00	2,411	0.139	10.2	5.38	1.896
5	II-BA 16 F (Turcoaia)	Suplacu de Barcău	4.25	2,388	1.272	11.4	3.00	3.800
			4.50	2,408	0.486	9.2	3.55	2.592
			4.75	2,411	0.304	8.4	4.00	2.100
			5.00	2,407	0.192	9.5	4.50	2.111
6	II-BA 16 FS (Turcoaia)	Suplacu de Barcău	4.25	2,397	1.058	12.3	2.60	4.731
			4.50	2,408	0.766	9.8	2.80	3.500
			4.75	2,410	0.424	9.4	3.42	2.749
			5.00	2,404	0.265	9.6	4.00	2.400
7	III-BA 8 WITNESS (Harghita)	Suplacu de Barcău	5.50	2,339	3.346	10.5	2.27	4.626
			5.75	2,362	2.225	9.7	2.60	3.731
			6.00	2,368	0.692	9.8	2.93	3.345
			6.25	2,364	0.297	8.1	3.90	2.077
8	III-BA 8 F (Harghita)	Suplacu de Barcău	5.50	2,335	2.654	8.3	1.85	4.486
			5.75	2,337	2.033	7.8	2.48	3.145
			6.00	2,342	1.698	8.2	3.07	2.671
			6.25	2,335	1.458	8.8	3.80	2.316
9	III-BA 8 FS (Harghita)	Suplacu de Barcău	5.50	2,348	2.667	9.7	2.73	3.552
			5.75	2,363	2.363	10.6	3.47	3.055
			6.00	2,373	0.669	11.9	3.83	3.107
			6.25	2,367	0.573	10.0	4.36	2.294

Table 5
Continuation

No. crt.	Mixture type	Swelling, [% vol.], after			
		7 days	14 days	21 days	28 days
1	I-BA 8 WITNESS (Turcoaia)	0.000	0.069	0.000	0.000
		0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000
2	I-BA 8 F (Turcoaia)	0.000	0.000	0.000	0.007
		0.000	0.000	0.000	0.013
		0.000	0.000	0.000	0.000
		0.000	0.027	0.000	0.027
3	I-BA 8 FS (Turcoaia)	0.000	0.013	0.000	0.000
		0.000	0.000	0.000	0.039
		0.000	0.093	0.086	0.000
		0.000	0.066	0.013	0.000
4	II-BA 16 WITNESS (Turcoaia)	0.107	0.000	0.047	0.000
		0.139	0.000	0.086	0.000
		0.033	0.000	0.127	0.000
		0.109	0.040	0.047	0.000
5	II-BA 16 F (Turcoaia)	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000
6	II-BA 16 FS (Turcoaia)	0.000	0.010	0.100	0.040
		0.000	0.000	0.066	0.000
		0.000	0.000	0.000	0.000
		0.000	0.000	0.046	0.000
7	III-BA 8 WITNESS (Harghita)	0.000	0.171	0.020	0.237
		0.000	0.118	0.033	0.138
		0.000	0.000	0.000	0.000
		0.000	0.039	0.000	0.000
8	III-BA 8 F (Harghita)	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000
9	III-BA 8 FS (Harghita)	0.484	0.729	0.749	1.108
		0.231	0.442	0.336	0.501
		0.000	0.007	0.000	0.013
		0.007	0.027	0.007	0.066

Table 6
Variation of Physical and Mechanical Values of Experimental Mixtures Compared to Witness Mixtures (Optimal Dosages)

Bitumen type	Mixture type	Optimal dosage %	Additive	Apparent density, ρ_a %	Water absorbtion, A_{vol} %	Marshall Stability, S %	Running Index, I %
ASTRA PLOIEŞTI	BA 8 (I)	5.50	F	100.13	53.23	103.09	110.18
	BA 8 (III)	6.00	F	99.62	128.22	77.80	97.67
	BA 16 (II)	4.75	F	100.00	59.06	111.11	105.52
	BA 8 (I)	5.50	FS	100.04	50.81	109.28	111.96
	BA 8 (III)	6.00	FS	100.17	51.53	96.15	115.16
	BA 16 (II)	4.75	FS	99.96	67.25	106.67	92.72
SUPLACU DE BARCĂU	BA 8 (I)	5.50	F	100.50	82.66	110.84	87.47
	BA 8 (III)	6.00	F	98.90	245.38	83.70	104.78
	BA 16 (II)	4.75	F	99.92	95.60	78.50	86.96
	BA 8 (I)	5.50	FS	100.80	50.24	96.39	96.22

3. Conclusions

From the analysis of the obtained results there has been found that

1. Using the additives does neither remarkably modify the values of the main characteristics of the bitumen (penetration at $+250°C$ and softening point) and neither the initial type of structure (sol-gel) characteristic to the road bitumen;

2. All the physical and mechanical characteristics of the experimental mixtures suffer net improvements with the exception of the apparent density whose value remains practically unchanged;

3. For the experimental mixtures made using optimal bitumen proportions there has been remarked that

a) the water absorption is reduced, with three exceptions, with 38% on the average comparing to the witness mixtures; even in the case of the three exceptions the values of the water absorption are much below the maximum admitted limit, –5%, of SR 174-1/2002;

b) both the values of the stability and of the Marshall running index are practically constant, the variations being reduced: $(-22\% \dots + 21\%)$ for the Marshall stability and $(-26\% \dots + 31\%)$ for the Marshall running index;

c) although determining the swelling values is not compulsory according to the latest standard SR l74-1/2002 there have been determined the swelling values at: 7, 14, 21 and 28 days. As it can be observed in the tables 4 and 5, the obtained values are very low (under 0.8%) signaling a good behavior of the mixtures in time to water corrosion.

Considering the obtained results, we can state that using the additives ADIROL ALCAMID (variants F and FS) the characteristics of the road bitumen are not practically modified, but significantly diminish the values of water

absorption to the mixtures made with natural acid aggregate (granite of Turcoaia) to which the road un additivated bitumen have a reduced adhesiveness.

That creates the premises of a good behavior in time of asphalt mixtures and, implicitly, of an improved resistance to freezing and de-freezing, which insures the improvement of the road pavement viability realized with these mixtures in the wearing layer.

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ADITIVI PENTRU DRUMURI

(Rezumat)

Se prezintă rezultatele testelor de laborator ale aditivilor ADIROL ALCAMID F şi ADIROL ALCAMID FS. Pentru prepararea mixturilor s-au folosit două tipuri de bitum în patru dozaje diferite cu 0,5% aditivi. Caracteristicile fizice şi mecanice obţinute în urma analizelor de laborator au fost comparate cu cele ale mixturilor neaditivate.