

## New additives for road bitumen

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### Summary

*The paper presents the results of laboratory tests for two additives ADIROL ALCAMID F and ADIROL ALCAMID FS. Three mixtures were made in laboratory, with two types of bitumen of 4 dosages each, in order to assess characteristic physical and mechanical values of mixtures made with bitumen having 0,5 % additives.*

*The analysis of results shows a substantial improvement of the characteristic physical and mechanical values of these mixtures as compared to mixtures made with non-additive bitumen.*

KEYWORDS: bitumen, additives, aggregate.

### 1. INTRODUCTION

The use on a large scale of natural ballast-pit aggregates - which have a content of SiO<sub>2</sub> 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 aditivate 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 over road bitumen, there have been made tests in the ROADS laboratory at the Technical University of Iași, Faculty de Civil Engineering, on two types of bitumen: the first type manufactured by Astra refinery from Ploiești and the second manufactured by Suplacu refinery from Barcău (Bihor-Romania).

Both types of bitumen have been determined the main characteristic values, both in pure state and in mixture with 0.5 % (of weight) with the two previously mentioned additives - everything is presented in the Table 1.



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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 PLOIEȘTI 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

Both pure state (witness) and aditivated types of bitumen have been used as binding material in the composition of three mixtures: an asphalted concrete rich in chippings - BA 8 and an asphalted 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 asphalted 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 as well as the dosages used for each mixture as well as 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.

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 asphalted mixtures with 4 dosages of bitumen for each type of asphalted concrete out of which there have been produced 8 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 as comparing to witness mixtures are presented in the Table 6 for optimal dosages of bitumen.



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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:	Ø 25	-	100,00	-
		Ø 16	-	95,59	-
		Ø 10	100,00	71,13	100,00
		Ø 8	89,16	61,60	93,38
	Sieve:	# 4	60,64	47,57	72,10
		# 2	48,37	39,50	53,63
		# 1	39,54	32,92	42,66
		# 0,63	34,47	29,15	36,38
		# 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		
Crusher sand 0-4 (Turcoaia)	-	15,00	-		
Crusher sand 0-4 (Harghita)	-	-	22,00		
Natural sand (Tecuci)	23,00	18,00	-		
River sand (Timișești)	-	-	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	0,94	Light yellow
Natural sand 0 ... 4 Timișești	1,95	Light yellow



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Table 4. The values of physical and mechanical characteristics of mixtures made with bitumen ASTRA Ploiești.

No. crt.	Mixture type	Bitumen type	Bitumen dosage (%)	$\rho_a$ (kg/m <sup>3</sup> )	A vol. (%)	Marshall trial		
						S (kN)	I (mm)	S/I (kN/mm)
1	I-BA 8 WITNESS (Turcoaia)	ASTRA Ploiești	5,00	2367	1,678	7,6	1,90	4,000
			5,25	2387	0,501	7,9	2,70	2,926
			5,50	2393	0,248	9,7	3,93	2,468
			5,75	2383	0,198	9,3	4,70	1,979
2	I-BA 8 F (Turcoaia)	ASTRA Ploiești	5,00	2374	1,252	10,0	2,60	3,846
			5,25	2379	0,859	8,5	3,70	2,194
			5,50	2396	0,132	10,0	4,33	2,309
			5,75	2390	0,020	8,6	4,93	1,744
3	I-BA 8 FS (Turcoaia)	ASTRA Ploiești	5,00	2368	1,544	8,8	3,55	2,479
			5,25	2381	0,718	10,5	4,20	2,500
			5,50	2394	0,126	10,6	4,40	2,409
			5,75	2392	0,093	8,4	5,48	1,533
4	II-BA16 WITNESS (Turcoaia)	ASTRA Ploiești	4,25	2404	1,093	12,2	3,77	3,236
			4,50	2407	0,701	11,9	4,46	2,668
			4,75	2414	0,461	9,0	4,53	1,987
			5,00	2410	0,266	8,3	5,27	1,575
5	II-BA 16 F (Turcoaia)	ASTRA Ploiești	4,25	2393	1,414	11,2	3,43	3,265
			4,50	2397	0,838	13,4	4,33	3,095
			4,75	2414	0,272	10,0	4,78	2,092
			5,00	2405	0,258	10,2	5,47	1,865
6	II-BA 16 FS (Turcoaia)	ASTRA Ploiești	4,25	2392	1,223	9,2	2,45	3,755
			4,50	2407	0,423	10,0	3,17	3,155
			4,75	2413	0,310	9,6	4,20	2,286
			5,00	2410	0,288	10,2	4,33	2,356
7	III-BA 8 WITNESS (Harghita)	ASTRA Ploiești	5,50	2349	2,993	9,1	2,20	4,136
			5,75	2356	2,583	8,7	2,43	3,580
			6,00	2362	1,768	10,4	3,43	3,032
			6,25	2355	1,420	9,0	3,93	2,290
8	III-BA 8 F (Harghita)	ASTRA Ploiești	5,50	2324	3,918	8,3	3,13	2,652
			5,75	2347	2,936	8,8	3,20	2,750
			6,00	2353	2,267	8,1	3,35	2,418
			6,25	2351	1,723	10,5	4,13	2,542
9	III-BA 8 FS (Harghita)	ASTRA Ploiești	5,50	2311	3,710	7,8	2,95	2,644
			5,75	2343	2,015	9,1	3,80	2,395
			6,00	2366	0,911	10,0	3,95	2,532
			6,25	2363	0,408	9,8	5,47	1,792



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Table 4 (continuation). The values of physical and mechanical characteristics of mixtures made with bitumen ASTRA Ploiești.

No. crt.	Mixture type	Swelling, (%) vol. after ... days			
		7	14	21	28
1	I-BA 8	0,000	0,013	0,020	0,287
	WITNESS	0,000	0,079	0,013	0,191
	(Turcoaia)	0,000	0,112	0,000	0,092
		0,000	0,146	0,066	0,258
2	I-BA 8	0,000	0,000	0,039	0,170
	F	0,026	0,000	0,065	0,269
	(Turcoaia)	0,000	0,000	0,020	0,172
		0,000	0,000	0,033	0,147
3	I-BA 8	0,000	0,364	0,039	0,117
	FS	0,065	0,287	0,055	0,190
	(Turcoaia)	0,039	0,190	0,125	0,164
		0,106	0,178	0,160	0,099
4	II-BA 16	0,107	0,000	0,047	0,000
	WITNESS	0,139	0,000	0,086	0,000
	(Turcoaia)	0,033	0,000	0,127	0,000
		0,109	0,040	0,047	0,000
5	II-BA 16	0,000	0,020	0,119	0,020
	F	0,000	0,000	0,000	0,000
	(Turcoaia)	0,000	0,106	0,000	0,046
		0,000	0,060	0,000	0,060
6	II-BA 16	0,000	0,000	0,000	0,067
	FS	0,000	0,000	0,000	0,119
	(Turcoaia)	0,106	0,099	0,086	0,205
		0,027	0,000	0,073	0,147
7	III-BA 8	0,000	0,766	0,806	1,254
	WITNESS	0,098	0,540	0,628	0,903
	(Harghita)	0,000	0,204	0,145	0,394
		0,040	0,337	0,516	0,621
8	III-BA 8	0,060	0,381	0,689	1,162
	F	0,072	0,287	0,267	0,847
	(Harghita)	0,109	0,424	0,128	0,700
		0,013	0,033	0,000	0,190
9	III-BA 8	0,000	0,489	1,096	1,434
	FS	0,000	0,210	0,413	0,597
	(Harghita)	0,000	0,032	0,221	0,739
		0,000	0,000	0,007	0,039



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Tabelul 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 (%)	$\rho_a$ (kg/m <sup>3</sup> )	A vol. (%)	Marshall trial		
						S (kN)	I (mm)	S/I (kN/mm)
1	I-BA 8 WITNESS Turcoaia	Suplacu de Barcău	5,00	2377	1,116	9,3	3,07	3,029
			5,25	2378	0,769	8,4	3,83	2,193
			5,50	2386	0,248	8,3	4,23	1,962
			5,75	2380	0,239	8,8	4,80	1,833
2	I-BA 8 F Turcoaia	Suplacu de Barcău	5,00	2378	0,921	9,5	2,67	3,558
			5,25	2384	0,667	8,7	3,60	2,417
			5,50	2398	0,205	9,2	3,70	2,486
			5,75	2396	0,027	8,3	4,75	1,747
3	I-BA 8 FS Turcoaia	Suplacu de Barcău	5,00	2389	0,848	10,2	3,17	3,218
			5,25	2391	0,604	8,8	3,40	2,588
			5,50	2405	0,013	8,0	4,07	1,966
			5,75	2397	0,000	7,4	4,33	1,709
4	II-BA 16 WITNESS Turcoaia	Suplacu de Barcău	4,25	2385	1,663	10,8	3,03	3,564
			4,50	2400	0,763	10,3	4,25	2,424
			4,75	2413	0,318	10,7	4,60	2,326
			5,00	2411	0,139	10,2	5,38	1,896
5	II-BA 16 F Turcoaia	Suplacu de Barcău	4,25	2388	1,272	11,4	3,00	3,800
			4,50	2408	0,486	9,2	3,55	2,592
			4,75	2411	0,304	8,4	4,00	2,100
			5,00	2407	0,192	9,5	4,50	2,111
6	II-BA 16 FS Turcoaia	Suplacu de Barcău	4,25	2397	1,058	12,3	2,60	4,731
			4,50	2408	0,766	9,8	2,80	3,500
			4,75	2410	0,424	9,4	3,42	2,749
			5,00	2404	0,265	9,6	4,00	2,400
7	III-BA 8 WITNESS Harghita	Suplacu de Barcău	5,50	2339	3,346	10,5	2,27	4,626
			5,75	2362	2,225	9,7	2,60	3,731
			6,00	2368	0,692	9,8	2,93	3,345
			6,25	2364	0,297	8,1	3,90	2,077
8	III-BA 8 F Harghita	Suplacu de Barcău	5,50	2335	2,654	8,3	1,85	4,486
			5,75	2337	2,033	7,8	2,48	3,145
			6,00	2342	1,698	8,2	3,07	2,671
			6,25	2335	1,458	8,8	3,80	2,316
9	III-BA 8 FS Harghita	Suplacu de Barcău	5,50	2348	2,667	9,7	2,73	3,552
			5,75	2363	2,363	10,6	3,47	3,055
			6,00	2373	0,669	11,9	3,83	3,107
			6,25	2367	0,573	10,0	4,36	2,294



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Tabelul 5 (continuation. The values of physical and mechanical characteristics of mixtures made with bitumen SUPLACU DE BARCĂU – Bihor (continue)

No. crt.	Mixture type	Swelling, (%) vol. after ... days			
		7	14	21	28
1	I-BA 8	0,000	0,069	0,000	0,000
	WITNESS	0,000	0,000	0,000	0,000
	Turcoaia	0,000	0,000	0,000	0,000
		0,000	0,000	0,000	0,000
2	I-BA 8	0,000	0,000	0,000	0,007
	F	0,000	0,000	0,000	0,013
	Turcoaia	0,000	0,000	0,000	0,000
		0,000	0,027	0,000	0,027
3	I-BA 8	0,000	0,013	0,000	0,000
	FS	0,000	0,000	0,000	0,039
	Turcoaia	0,000	0,093	0,086	0,000
		0,000	0,066	0,013	0,000
4	II-BA 16	0,000	0,000	0,000	0,000
	WITNESS	0,000	0,000	0,000	0,000
	Turcoaia	0,000	0,007	0,000	0,000
		0,000	0,000	0,007	0,000
5	II-BA 16	0,000	0,000	0,000	0,000
	F	0,000	0,000	0,000	0,000
	Turcoaia	0,000	0,000	0,000	0,000
		0,000	0,000	0,000	0,000
6	II-BA 16	0,000	0,010	0,100	0,040
	FS	0,000	0,000	0,066	0,000
	Turcoaia	0,000	0,000	0,000	0,000
		0,000	0,000	0,046	0,000
7	III-BA 8	0,000	0,171	0,020	0,237
	WITNESS	0,000	0,118	0,033	0,138
	Harghita	0,000	0,000	0,000	0,000
		0,000	0,039	0,000	0,000
8	III-BA 8	0,000	0,000	0,000	0,000
	F	0,000	0,000	0,000	0,000
	Harghita	0,000	0,000	0,000	0,000
		0,000	0,000	0,000	0,000
9	III-BA 8	0,484	0,729	0,749	1,108
	FS	0,231	0,442	0,336	0,501
	Harghita	0,000	0,007	0,000	0,013
		0,007	0,027	0,007	0,066



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Table 6. Variation of physical and mechanical values of experimental mixtures as comparing to witness mixtures (optimal dosages).

Bitumen type	Mixture type	Optimal dosage (%)	Additive	Apparent density $\rho_a$ (%)	Water absorption vol (%)	Marshall Stability (S) (%)	Running Index (I) (%)
ASTRA PLOIEȘTI	BA 8 (I)	5,50	F	100,13	53,23	103,09	110,18
	BA 8 (III)	6,00	F	99,62	128,22	77,88	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	83,67	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 results obtained after the research there has been found that:

- Using the additives does neither remarkably modify the values of the main characteristics of the bitumen (penetration at + 25<sup>0</sup> C and softening point) and neither the initial type of structure (sol-gel) characteristic to the road bitumen;
- 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;
- For the experimental mixtures made using optimal bitumen proportions there has been remarked that:
  - the water absorption reduces, 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: table 13 (ANEXA I);





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- both the values of the stability and of the Marshall running index are practically constant, the variations being reduced: (- 22 % ... + 21 %) to the Marshall stability and (- 26 % ... + 31 %) to the Marshall running index;
- although determining the swelling values is not compulsory according to the latest standard SR 174-1/2002 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 values obtained are very low (under 0.8 %) signaling a good behavior of the mixtures in time to water corrosion.

Considering the facts we have proved so far, 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 de Turcoaia) to which the road un aditivated 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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