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TIME BEHAVIOR TO WATER ACTION OF ASPHALT MIXTURES MADE WITH BITUMINOUS SAND

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Abstract: *Given that nowadays in our country bitumen is only imported, for an efficient use of this material, bituminous sands can be incorporated in the mix in order to produce asphalt mixtures. These types of sands represent a particularly advantageous solution, mainly at local level, due to the percentage of natural bitumen in their mineral phase, through their use resulting significant hard paving grade bitumen savings. The purpose of this paper is to emphasize the behaviour in time of asphalt mixtures made with bituminous sand according to the CD 42-85 standard for the direct use of bituminous sands with and without adding hard paving grade bitumen for the execution of hot mix bituminous road pavements.*

Key words: *bituminous sand, hard paving grade bitumen, asphalt mixture, road pavement.*

1. Introduction

In nature, natural bitumen is not found in its pure state, but rather is impregnated in limestone rocks or sand. In Romania, deposits of natural bitumen are found in Bihor County, basin-Derna-Tatarus-Budoi and in Prahova County, at Matita and Pacureti, present in the form of impregnations in the sand. These sands contain on average 10-20% pure bitumen and are successfully used in local road works with or without adding hard paving grade bitumen [5]. In situ, the bituminous sand deposits are mainly composed of quartz sand, which have a thin film of water and fine particles and the bitumen fills the pore spaces between grains of sand. Quartz sand, silt and clay, meaning the inorganic materials of the oil sand composition, normally constitute about 80 % by bitumen weight and water is about 15% and 5% [4,6]

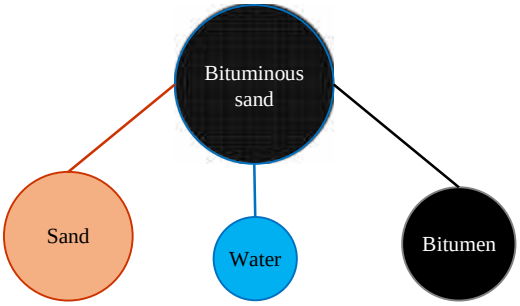

Fig. 1 *Bituminous sand composition [3]*

2. Material and Methods

In the roads laboratory four asphalt technological recipes have been designed taken into consideration the departmental normative CD 42-85 [1] for the direct use

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of bituminous sands with and without adding hard paving grade bitumen for the execution of hot mix bituminous road pavements, namely: asphalt base for light traffic road pavements (A.31.nb.), the asphalt mixture, containing bituminous sands and having added hard paving grade bitumen, mainly being used for roads with a technical class III, and the other three recipes being conducted with bituminous sand without adding hard bitumen: asphalt concrete (open graded asphalt concrete) with crushed gravel for the binder layer (B.a.31.nb.f), asphalt base concrete for bituminous base course (A.b.31.nb.f.) and asphalt base concrete (A.31.nb.f.) designed for light traffic, which are used for roads with a technical class of IV-V, from which cylindrical samples have been made [1].

All four asphalt mixtures recipes are prepared with bituminous sand from Derna-Tatarus-Budoi (Bihor County), crushed sand and gravel from Cristesti (Iasi County), filler from Bicaz (Neamt County) and the hard paving grade bitumen was supplied from OMV Refining & Marketing GmbH shape (Austria). The preparation of four asphalt mixtures in the road laboratory has been conducted by heating and mixing the mixture components for 10-15 minutes at 170-180°C for the bituminous mix realized with sand and hard paving grade bitumen, asphalt base for light traffic road pavements (A.31.nb.) and at 175-190°C for the other three bituminous mixtures carried out with bituminous sand, without hard bitumen: asphalt concrete with crushed gravel for the binder layer (B.a.31.nb.f), asphalt base concrete for bituminous base course (A.b.31.nb.f.) and asphalt base concrete (A.31.nb.f.) [2]. The bitumen content from bituminous sand Derna-Tatarus in Bihor County is 19.39%. Table 1 presents the particle size distribution curves of the aggregates and hard paving grade bitumen are shown in Table 2.

The dosage of natural aggregates and aggregate mixture curve for each type of mixture is represented in the tables below as follows: Table 3 for A.31.nb, Table 4 for B.a.31.nb.f, Table 5 for A.b.31.nb.f and Table 6 for A.31.nb.f. Addition computation of hard bitumen for asphalt base with crushed gravel for light traffic road pavements A.31.nb has been performed as CD 42-85 [1] norm recommends, as follows: natural bitumen content of the mixture is required to be 70% and 30% hard paving grade bitumen.

For each type of mixture made in the road laboratory five dosages binder have been calculated, as follows:

- natural bitumen percentage: percentage of binder x 0.7 = a%;
- hard paving grade bitumen percentage: percentage of binder x 0.3 = b%;
- dosage of bituminous sand: $a \times 100/19.39 = c\%$
- dosage of natural sand from bituminous sand: c – a = d %.

For the asphalt base concrete with crushed gravel, designed for road pavements with light traffic (A.31.nb) have been used bitumen percent of: 5.00%, 5.20%, 5.40%, 5.60%, 5.80% (the recommended values ranging between 5.00% and 6.00%); for asphalt concrete with crushed gravel for the binder layer (B.a.31.nb.f) have been used bitumen percent of: 4.00%, 4.20%, 4.40%, 4.60%, 4.80% (the recommended values ranging between 4.00% and 5.00%); for the asphalt base concrete for bituminous base course (A.b.31.nb.f) the used percentages were: 3.80%, 4.00%, 4.20%, 4.40%, 4.60% (the recommended range being between 3.80% and 4.60%); for asphalt base designed for light traffic (A.31.nb.f), the bitumen percent is: 4.50%, 4.70%, 4.90%, 5.10%, 5.30% (the recommended values ranging between 4.50% and 6.00%).

Particle size distribution of natural aggregates (gradation) Table 1

Aggregate	Percentage of weight passing sieve, [%]										
Sieve size, mm	31.5	25	20	16	12.5	8	4	2	1	0.125	0.063
Crushed gravel 16 – 31.5	100.00	93.49	70.40	30.72	6.52	0.56	0.18	-	-	-	-
Crushed gravel 8 – 16	-	-	100.00	99.47	80.53	26.12	4.13	1.56	0.89	0.38	0.20
Crushed gravel 4 – 8	-	-	-	100.00	99.89	99.23	38.77	9.96	3.69	0.97	0.56
Crushed gravel 0 – 4	-	-	-	-	-	100.00	99.76	83.86	63.68	3.12	0.92
Natural sand 0 – 4	-	-	-	-	-	100.00	99.27	79.26	62.73	11.15	3.70
Bituminous sand	-	-	-	-	-	-	100.00	99.69	98..69	15.47	5.75
Filler	-	-	-	-	-	-	-	-	100.00	88.67	72.02

Hard paving grade bitumen characteristics Table 2

No.	Characteristics	U.M	Values obtained	Reference values EN 13304 – 2009	Test method
1	Penetration at 25°C	1/10 mm	10	5 – 15	SR EN 1426 – 07
2	Softening point	°C	91.5	85 – 95	SR EN 1427 – 07
3	Solubility in organic solvents	%	99.62	Min.99	SR EN 12592 – 03
4	Loss of bitumen mass by heating at 163 °C	%	0.24	Max. 0.5	SR EN 12607/1 – 07
5	Marcusson flash point	°C	267	Min. 250	EN ISO 2592

The natural aggregates dosage for asphalt base concrete with crushed gravel, designed for road pavements with light traffic A.31.nb Table 3

Aggregate	[%]	Percentage of weight passing sieve, [%]										
		31.5	25	20	16	12.5	8	4	2	1	0.125	0.063
Crushed gravel 16 – 31.5	25.37	25.37	23.72	17.86	7.79	1.65	0.14	0.05	-	-	-	-
Crushed gravel 8 – 16	10.57	10.57	10.57	10.57	10.51	8.51	2.76	0.44	0.16	0.09	0.04	0.02
Natural sand 0 – 4	39.92	39.92	39.92	39.92	39.92	39.92	39.92	39.63	31.64	25.04	4.45	1.48
Bituminous sand	17.80	17.80	17.80	17.80	17.80	17.80	17.80	17.80	17.74	17.57	2.75	1.02
Filler	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	5.62	4.57
Total		100.00	98.35	92.49	82.36	74.22	66.96	64.26	55.88	49.04	12.86	7.09
Granulometric limits		90…100	85…100	77…94	70…90	63...86	55...80	46...65	39...59	36...56	12...26	-

The natural aggregates dosage for asphalt concrete (open graded asphalt concrete) with crushed gravel for the binder layer B.a.31.nb.f Table 4

Aggregate	[%]	Percentage of weight passing sieve, [%]										
		31.5	25	20	16	12.5	8	4	2	1	0.125	0.063
Crushed gravel 16 –31.5	26.15	26.15	24.45	18.41	8.03	1.70	0.15	0.05	-	-	-	-
Crushed gravel 8 – 16	15.69	15.69	15.69	15.69	15.61	12.64	4.10	0.65	0.24	0.14	0.06	0.03
Natural sand 0 – 4	35.89	35.89	35.89	35.89	35.89	35.89	35.89	35.63	28.45	22.51	4.00	1.33
Bituminous sand	19.13	19.13	19.13	19.13	19.13	19.13	19.13	19.13	19.07	18.88	2.96	1.10
Filler	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	2.78	2.26
Total		100.00	98.30	92.26	81.80	72.50	62.41	58.60	50.90	44.67	9.80	4.72
Granulometric limits		90…100	85…100	77…94	70…90	57…81	40…70	33…61	29…56	26…52	9…25	-

The natural aggregates dosage for the asphalt base for bituminous base layer A.b.31.nb.f Table 5

Aggregate	[%]	Percentage of weight passing sieve, [%]										
		31.5	25	20	16	12.5	8	4	2	1	0.125	0.063
Crushed gravel 16 – 31.5	31.31	31.31	29.27	22.04	9.62	2.04	0.18	0.06	-	-	-	-
Crushed gravel 8 – 16	15.66	15.66	15.66	15.66	15.58	12.61	4.09	0.65	0.24	0.14	0.06	0.03
Natural sand 0 – 4	31.67	31.67	31.67	31.67	31.67	31.67	31.67	31.44	25.10	19.87	3.53	1.17
Bituminous sand	18.23	18.23	18.23	18.23	18.23	18.23	18.23	18.23	18.17	17.99	2.82	1.05
Filler	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	2.78	2.25
Total		100.00	97.96	90.73	78.23	67.68	57.30	53.51	46.64	41.13	9.19	4.50
Granulometric limits		90…100	85…100	71…94	60…90	48…81	32…70	25…59	22…54	21…51	9…22	-

The natural aggregates dosage for asphalt base concrete designed for light traffic A.31.nb.f Table 6

Aggregate	[%]	Percentage of weight passing sieve, [%]										
		31.5	25	20	16	12.5	8	4	2	1	0.125	0.063
Crushed gravel 16 – 31.5	21.03	21.03	19.66	14.81	6.46	1.37	0.12	0.04	-	-	-	-
Crushed gravel 8 – 16	15.77	15.77	15.77	15.77	15.69	12.70	4.12	0.65	0.25	0.14	0.06	0.03
Natural sand 0 – 4	34.42	34.42	34.42	34.42	34.42	34.42	34.42	34.17	27.28	21.59	3.84	1.27
Bituminous sand	21.42	21.42	21.42	21.42	21.42	21.42	21.42	21.42	21.35	21.14	3.31	1.23
Filler	7.36	7.36	7.36	7.36	7.36	7.36	7.36	7.36	7.36	7.36	6.53	5.30
Total		100.00	98.63	93.78	85.35	77.27	67.44	63.64	56.24	50.23	13.74	7.83
Granulometric limits		90…100	85…100	77…100	70…100	58…91	43…80	37…73	34…69	31…66	13…34	-

3. Results and Discussion

For the four types of asphalt mixtures realised in the road laboratory the optimal percentage of binder has been determined, namely:

- *5.40 %* for asphalt base concrete with crushed gravel, designed for road pavements with light traffic A.31.nb;
- *4.40 %* for asphalt concrete with crushed gravel for the binder layer B.a.31.nb.f;
- *4.20 %* for the asphalt base concrete for bituminous base course A.b.31.nb.f;
- *4.90 %* for asphalt base designed for light traffic A.31.nb.f.

For these optimal percentages of binder the behavior in time has been monitored for 90 days, obtaining swelling values for each type of asphalt mixture to 7, 14, 21, 28, 45, 77, 90 days, represented as a graph namely, Graph 1 for asphalt base concrete with crushed gravel, designed for road pavements with light traffic (A.31.nb), Graph 2 for for asphalt concrete with crushed gravel for the binder layer, Graph 3 for the asphalt base concrete for bituminous base course A.b.31.nb.f and Graph 4 for for asphalt base designed for light traffic A.31.nb.f.

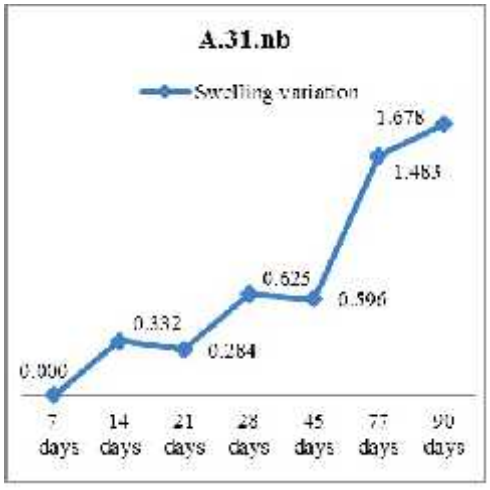

Fig. 1. *Swelling values in time for asphalt base concrete with crushed gravel, designed for road pavements with light traffic A.31.nb*

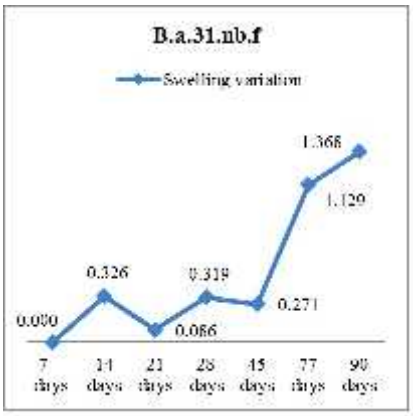

Fig. 2. *Swelling values in time for asphalt concrete with crushed gravel for the binder layer B.a.31.nb.f*

Fig. 3. *Swelling values in time for the asphalt base concrete for bituminous base course A.b.31.nb.f*

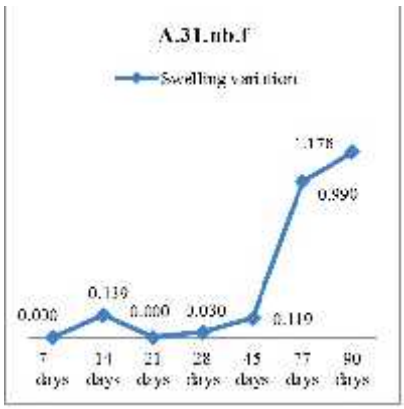

Fig. 4. *Swelling values in time for asphalt base designed for light traffic A.31.nb.f*

The low values obtained for behaviour in time to water action over 90 days for each type of mixtures realized in the road laboratory, namely: asphalt base concrete with crushed gravel, designed for road pavements with light traffic (A.31.nb), asphalt concrete with crushed gravel for the binder layer (B.a.31.nb.f), asphalt base concrete for bituminous base course (A.b.31.nb.f) and asphalt base designed for light traffic (A.31.nb.f) highlight a good adhesion to natural aggregates of natural bitumen contained in the bituminous sand.

4. **Conclusions**

The use of bituminous sand from Derna-Tatarus-Budoi to produce asphalt mixtures is an efficient solution both in terms of economic and quality for locally road works. The four technological asphalt recipes performed in the road laboratory considering the departmental normative CD 42-85 [1] for the direct use of bituminous sands with and without adding hard paving grade bitumen for the execution of hot mix bituminous road pavements shows a good behaviour to water action due to the natural bitumen adhesion contained in bituminous sands to natural aggregates that compose the mix asphalt.

References

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