

THE USAGE OF BITUMINOUS SANDS IN ROAD PAVEMENT ASPHALT MIXTURES COMPOSITION

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Abstract: In order to obtain significant costs reductions associated with the use of road bitumen in asphalt mixes, this product currently being only obtained through imports, an ample research have been undertaken regarding the use of bituminous sands or oil sands, which present great advantages, especially in areas near deposits located in Bihor County. These raw materials present the advantage of having a percentage of natural bitumen in their mineral composition and thus their usage for asphalt mixtures preparation leads to substantial reductions of bitumen quantities required in the mix. Specific technological recipes have been researched in road laboratory, based on the department norm CD 42-85, concerning the direct use of oil sands, with and without adding hard paving grade bitumen, for warm asphaltic road pavement construction.

Keywords: AGGREGATES, BITUMINOUS SAND, HARD PAVING GRADE BITUMEN, ASPHALT MIXTURES, ROAD PAVEMENT

1. Introduction

Bituminous binders, according with specialized literature, are complex mixtures of animal origin hydrocarbons or are being obtained through a pyrogenic reaction, often accompanied by their combinations with oxygen, nitrogen, sulfur, etc. They are in the form of liquid, viscous or solid, having a dark brownish and black color and being completely soluble in carbon disulfide (Mătăsarul et al., 1966).

In order to fulfill their role as road binders, bituminous materials must have a bond strength or agglomeration. This condition is satisfied only by two categories of compounds, namely natural bitumen and tar. Bituminous binders, which occur in nature, are most often associated with minerals and also are used from ancient times (Les ENROBES bitumineux - Tome 1 + 2, 2005).

The largest oil field is located near Athabasca, Alberta Canada, but there are significant oil reserves located in Venezuela (Lake Bermudes), Cuba, Madagascar, Syria, Albania (SELENE) (Joseph K. Anocha -Boateng, Erol Tutumluer, 2012).

In Romania, the bitumen is found naturally in the form of sand impregnations in two geographical areas, namely: in Bihor County, in the Derna-Tatarus-Budoii basin, near Oradea, Prahova County, Matita and Pacureti. The impregnated substance is a very soft asphalt that must be processed in order to obtain the bitumen. The sands contain on average 10-20% pure bitumen, the separation of bitumen from sand being performed with warm water having weak alkaline properties. An extracting attempt of bituminous material has been performed using kerosene, but the results haven't been favorable (Nicoară et al., 1985). The structure and the composition is very similar to the natural petroleum bitumen; the superiority in behavior is given occasionally by the higher content of anhydrides.

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 constitutes about 80 % by bitumen weight and water is about 15% and 5% (Ronald F. Probststein, Edwin E. Hicks, 2006).

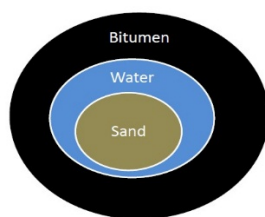


Fig.1 Bituminous sand (Dayna Linley, 2010)

2. The research methodology

In roads laboratory have been conducted four technological recipes complying with the directions of departmental normative CD 42-85 concerning the direct use of bituminous sands with and without adding hard paving grade bitumen for the execution of warm asphalt mixtures for road pavements.

The first recipe conducted in the laboratory is for asphalt base associated with road pavements for light traffic (A.31.nb.), the asphalt mixture, containing bituminous sands and having added hard paving grade bitumen, mostly being used for roads with a technical class III. The other three warm asphalt mix recipes have in their composition bituminous sand without adding additional hard paving grade bitumen, as follows: 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. All these asphalt mixes have in their composition bituminous sands from Derna-Tătăruș, Bihor County and cylindrical samples have been realized in order to study their behavior.

It has been used crushed sand and gravel from Cristesti (Iasi), natural sand from Boureni (Iasi) quarry, filler originated from Bicz (Neamt County), bituminous sand from Derna Tatarus (Bihor County) career and the hard paving grade bitumen have been supplied by OMV Refining & Marketing GmbH (Austria). The preparation of asphalt mixtures in the laboratory is carried out by heating and mixing the mixture components for 10-15 minutes at 170-180°C in the case of bituminous mixtures with additional hard paving grade bitumen and temperatures of 175-190°C for mixes without hard paving grade bitumen (Indicativ 605-2014, 2014).

The bitumen content specific to bituminous sands from Derna-Tatarus in Bihor County is 19.39%.

Table 1 presents of the particle size distribution curves of the used aggregates.

Table 1: Particle size distribution of natural aggregates (gradation)

Aggregate	Percentage of weight passing sieve, [%]										
	31.5	25	20	16	12.5	8	4	2	1	0.125	0.063
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	

Table 2: Hard paving grade bitumen characteristics

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 dosage of natural aggregates and aggregate mixture distribution 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.

The calculation for the addition value of hard paving grade bitumen in the case of asphalt concrete base with crushed gravel, designed for road pavements with light traffic A.31.nb, has been done as recommended by appropriate standard CD 42-85, as follows: natural bitumen content in the mixture is required to be 70% and the hard paving grade bitumen 30%.

For each type of mixture performed in the laboratory have been calculated 5 dosages binder as presented below:

- natural bitumen percentage: binder percentage x 0.7 = a% ;
- hard paving grade bitumen percentage: binder percentage x 0.3 = b% ;
- dosage of bituminous sand: $\frac{a \cdot 100}{19.39} = c\%$;
- dosage of natural sand contained in the 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%).

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

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
Limits particle size area		90...100	85...100	77...94	70...90	63...86	55...80	46...65	39...59	36...56	12...26	-

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

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	98.36	92.26	81.80	72.52	62.41	58.60	50.90	44.67	9.80	4.72
Limits particle size area		90...100	85...100	77...94	70...90	57...81	40...70	33...61	29...56	26...52	9...25	-

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

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
Limits particle size area		90...100	85...100	71...94	60...90	48...81	32...70	25...59	22...54	21...51	9...22	-

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

Aggregate	[%]	Percentage of weight passing sieve, [%]										
		31.5	25	20	16	12.5	8	4	2	1	0.12	0.06
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
Limits particle size area		90...100	85...100	77...100	70...100	58...91	43...80	37...73	34...69	31...66	13...34	-

3. Results and discussions

For all the 4 types of mixtures carried out in the roads laboratory have been determined the following physical-mechanical (only in static regime): apparent (bulk) density; water absorption; swelling over time; stability and creep Marshall.

Table 7: Physical-mechanical properties of the asphalt mixture test samples A.31.nb

Characteristic name	UM	Bitumen percentage [%]					Normative boundaries CD 42-85
		5.00	5.20	5.40	5.60	5.80	
Apparent density	g/cm ³	2.232	2.237	2.246	2.250	2.269	≥ 2.100
Water absorption	% vol	6.766	7.179	6.940	6.358	4.615	≤ 9
Stability at 60° C	kN	5.2	4.4	9.9	7.3	5.9	≥ 3.0
Flowing index	mm	1.7	1.4	2.5	2.6	2.1	1.5...4.5
Swelling at 28 days	%	0.544	0.450	0.625	0.027	0.462	-

Table 8: Physical-mechanical properties of the asphalt mixture test samples B.a.31.nb.f

Characteristic name	UM	Bitumen percentage [%]					Normative boundaries CD 42-85
		4.00	4.20	4.40	4.60	4.80	
Apparent density	g/cm ³	2.239	2.214	2.204	2.212	2.250	≥ 2.000
Water absorption	% vol	10.108	10.035	10.633	10.130	7.820	≤ 15
Stability at 60° C	kN	5.1	3.0	4.5	3.2	2.8	≥ 2.5
Flowing index	mm	1.2	1.5	2.0	1.0	1.8	1.5...4.0
Swelling at 28 days	%	0.325	0.000	0.319	0.273	0.000	-

Table 9: Physical-mechanical properties of the asphalt mixture test samples A.b.31.nb.f

Characteristic name	UM	Bitumen percentage [%]					Normative boundaries CD 42-85
		3.80	4.00	4.20	4.40	4.60	
Apparent density	g/cm ³	2.211	2.227	2.227	2.231	2.227	≥ 2.000
Water absorption	% vol	10.284	9.915	9.050	8.262	8.167	≤ 13

Stability at 60° C	kN	2.8	3.5	3.7	3.5	3.2	≥ 2.0
Flowing index	mm	1.6	1.3	1.7	1.7	1.0	1.0...4.0
Swelling at 28 days	%	0.287	0.144	0.000	0.000	0.000	-

Table 10: Physical-mechanical properties of the asphalt mixture test samples A.31.nb.f

Apparent density Water absorption	UM	Bitumen percentage [%]					Normative boundaries CD 42-85
		4.50	4.70	4.90	5.10	5.30	
Stability at 60° C	g/cm ³	2.206	2.215	2.238	2.250	2.237	≥ 2.000
Flowing index	% vol	9.880	9.767	8.558	7.014	7.760	≤ 14
Swelling at 28 days	kN	4.6	7.0	6.8	5.4	5.0	≥ 2.5
Apparent density	mm	1.5	2.2	2.2	1.6	2.0	1.0...4.0
Water absorption	%	0.000	0.661	0.030	0.000	0.175	-

4. Conclusions

Analyzing the results values obtained from the laboratory research and in particular the behavior in time to water action (swelling), due to a good adhesion to natural aggregates of natural bitumen from bituminous sands, the four types of mixtures with and without adding hard paving grade bitumen: the first warm asphalt mix is an asphalt base concrete with crushed gravel, designed for road pavements with light traffic (A.31.nb), the mixture containing added hard paving grade bitumen and the other three bituminous mixture without hard paving grade bitumen in their composition, namely asphalt concrete (open graded asphalt concrete) with crushed gravel for the binder layer (B.a.31.nb.f), asphalt base for bituminous base course (A.b.31.nb.f) and asphalt base designed for light traffic (A.31.nb.f), it can be affirmed that the physical and mechanical characteristics are within the limits imposed by normative CD 42-85. However, given the conditions and the necessity to complete the results with dynamic tests imposed by normative AND 605/2014, it is required to develop an update of the norm CD 42-85.

5. References

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