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"WARM MIX ASPHALT'' FOR AIRPORT USE

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Rezumat

"Warm Mix Asphalt" (WMA) este o tehnologie dezvoltată pentru obţinerea unei mixturi asfaltice la temperaturi scăzute. Această metodă are beneficii semnificative atât economice cât şi în ceea ce priveşte mediul înconjurător.

După cum bine se ştie tehnologia "warm mix asphalt" presupune folosirea de aditiv în bitum pentru a îi reduce vâscozitatea în scopul de a reduce temperatura de malaxare şi compactare a mixturii asfaltice.

Tehnologia "hot mix asphalt" folosită pentru suprafeţele aeroportuare, în special pentru zona de rulare şi platformă trebuie să satisfacă în plus faţă de condiţiile pentru drumuri şi cerinţele privind rezistenţa la carburanţi şi la agenţi de degivrare conform normelor europene.

Se poate folosi tehnologia "warm mix asphalt" pentru zonele aeroportuare în concordanţă cu normele europene?

Aceasta este întrebarea la care răspunde această lucrare care are ca scop determinarea caracteristicilor mixturii asfaltice pentru aeroporturi BBA16 atunci când se utilizează sau nu aditivi, având în vedere o serie de teste de laborator: încercarea Marshall, încercarea la compresiune ciclică triaxială, încercarea la întindere indirectă pe epruvete cilindrice – modul de rigiditate şi rezistenţa la carburanţi.

Cuvinte cheie: warm mix, mixtură pentru aeroporturi, teste dinamice

Abstract

"Warm Mix Asphalt" (WMA) is a technology developed to obtain an asphalt mixture at lower temperatures. The method has significant benefits for the economic and environmental area.

As known, "warm mix asphalt" uses additives in bitumen having the purpose to reduce the viscosity in order to decrease the mixing and compaction temperatures.

Hot mix asphalt used in the airport area, especially the area of taxiway and the apron must satisfy beside usual requirements for roads, some requirements related to fuel resistance and de-icing agents according to European norms.

Does warm mix asphalt for airport use meet the requirements according to European norms? This is the question from this paper which aims to determine the characteristics of asphalt mixtures for airports BBA16 when using or not using an additive, considering a series of laboratory tests: cyclic triaxial compression test, fatigue test, stiffness modulus test and resistances to fuels test.

Keywords: warm mix, airport mix, dynamic tests

1. INTRODUCTION

"Hot mix asphalt" technology consists in a mixture of three elements: solid element (aggregates and potential mineral additives or fiber), the cell visco - elastic - plastic (bitumen) and gas component (air), at high temperature (Figure 1).

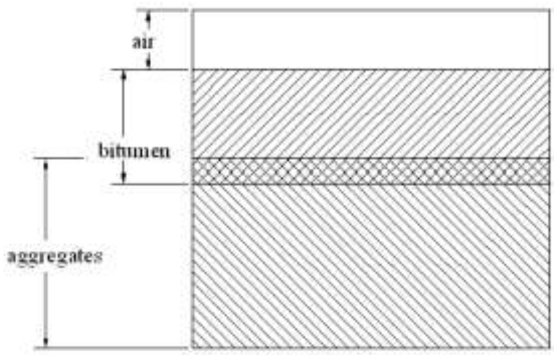

Figure 1. Composition of asphalt mixture

The first road where asphalt mixture was used in the pavement was in Babylon, between 625 and 604 BC. Due to high level temperatures used for this technology, the amount of energy required for manufacturing is high, and so are emissions.

Road construction industry has tried over time several ways to reduce the energy required to manufacture hot mix asphalt in order to combine saving energy with environmental benefits.

The desire to achieve low-temperature asphalt mix is dating from the nineteenth century. The first attempt was made using steam, in 1956, by Professor Ladis Csányi from Iowa State University, USA. Later on, the USA, Australia and Europe used foaming technology, and in the last 20 years, wax was used to change the viscosity of the bitumen and thus reduce the mixing and compaction temperatures of asphalt mixtures (Germany).

"Warm mix asphalt" technology and the use of chemical additives was initiated in the US, under the name EVOTHERM and later on various companies have made changes in this technology using various chemical additives.

"Warm mix asphalt" technology versus "hot mix asphalt" technology allows significant decrease in the mixing and compaction temperature of asphalt mixtures, and thus reducing polluting emissions and odors through bitumen viscosity reduction. These benefits due to "warm mix asphalt" technology lead to better working conditions.

2. OBJECTIVE

The objective of this study is to determine the performance of asphalt mixtures of airports by using "warm mix asphalt" technology, and compare them to those achieved with "hot mix asphalt" technology, considering standards SR EN 12697-35, SR EN 12697-25, SR EN 12697-26, SR EN 12697-43 and SR 605.

Laboratory studies were done in the Roads Laboratory of the Research Centre "Roads and Airports", Faculty of Railways, Roads and Bridges, Technical University of Civil Engineering of Bucharest.

3. MATERIALS AND BBA 16 ASPHALT MIX RECIPE FOR AIRPORTS USE

The designed recipe is for asphalt mix used in the wear layer of airport structures, mixture having maximum grain size of 16 mm.

Modified bitumen used are 45/80-65 and 45/80 Fr (45/80-65 bitumen with additive for low viscosity and fuel resistance) (Table 1).

The used aggregates were 8/16, 4/8 and 0/4 sort, and the filler was a limestone filler (Table 1).

Table 1. Materials

Mix type	Source / type/ and %	Sort			Filler	Fiber	Bitumen
		8/16	4/8	0/4			
BBA 16	Source/ type	Revărsarea			Holcim	-	OMV 45/80 Fr, OMV 45/80-65
	%	29	23	37	11	-	5.3

4. LABORATORY STUDIES AND TEST CONDITIONS

The tests were carried out on Marshall samples made with 50 blows on each side. Tests on asphalt mixture with 45/80 Fr bitumen using "warm mix asphalt" technology were carried out in two stages, considering different temperatures for aggregate and compaction:

- First stage: aggregate temperature = 180 ° C, compaction temperature = 130°C, 140°C, 155°C;
- Second stage: aggregate temperature/compaction temperature = 150°C/130°C; 120°C/140°C, 160°C/155°C.

Tests on asphalt mixture using "hot mix asphalt" technology for both types of bitumen (Fr 45/80 and 45/80-65) were carried out considering the following temperatures:

- for aggregate: 180°C;
- for compaction: 160°C.

Bitumen temperature of 160°C was used for the two working technologies.

Marshall testing was performed according to SR EN 12697-34.

The results for stability and the Marshall flow using "warm mix asphalt" technology are shown in Figures 2 and 3. The height of the sample according to the compaction temperature is shown in Figure 4.

For "warm mix asphalt" technology there were taken into account the values from SR EN 13108-1 for Marshall stability, and there were chosen for further study a compaction temperature of 130°C and an aggregate temperature of 150°C as the closest values to those obtained with the "hot mix asphalt" technology.

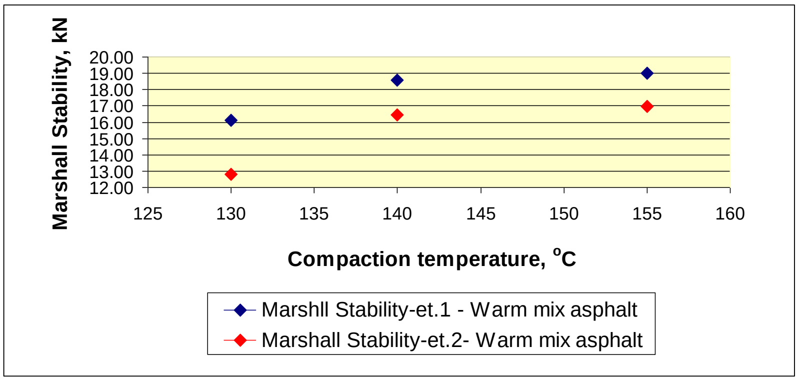

Figure 2. Marshall Stability versus compaction temperature in stage 1 and stage 2

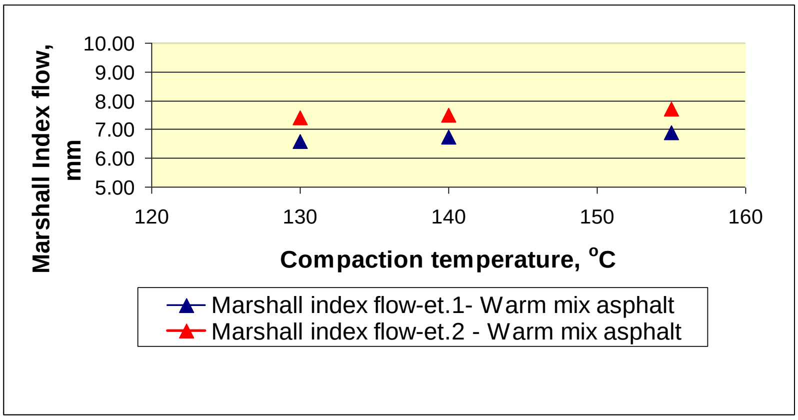

Figure 3. Marshall Index Flow versus compaction temperature in stage 1 and stage 2

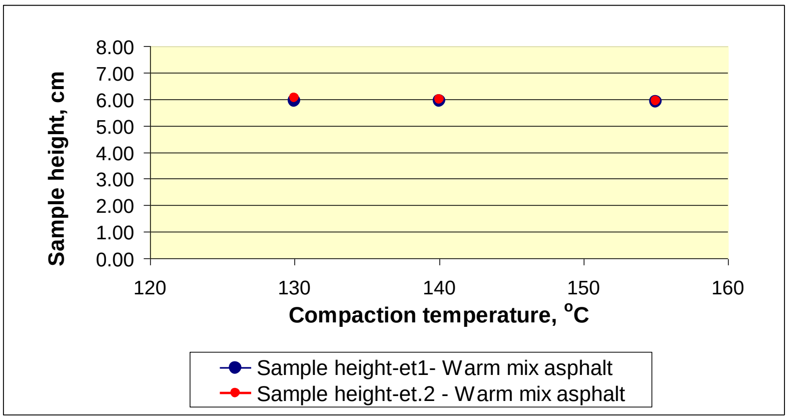

Figure 4. Sample height versus compaction temperature in stage 1 and stage 2

Marshall characteristics and the height of compacted samples versus execution technology and type of used bitumen are shown in Figures 5, 6 and 7.

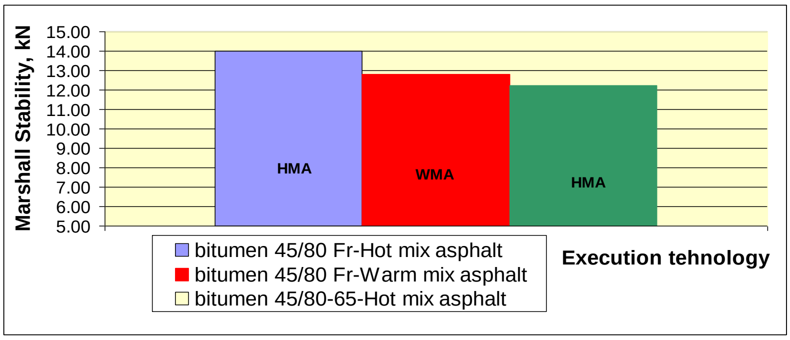

Figure 5. Marshall Stability versus technology and type of bitumen

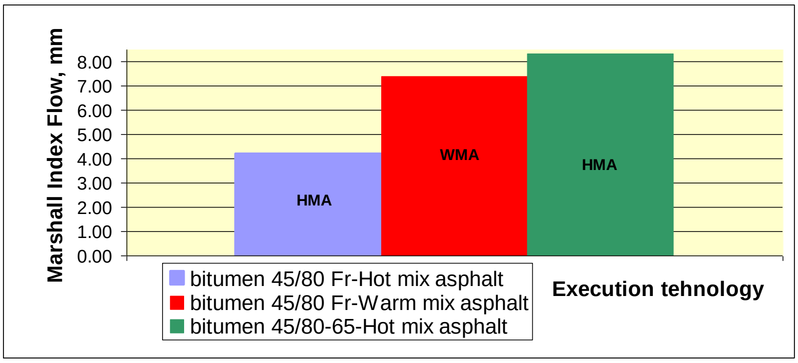

Figure 6. Marshall Index Flow versus technology and type of bitumen

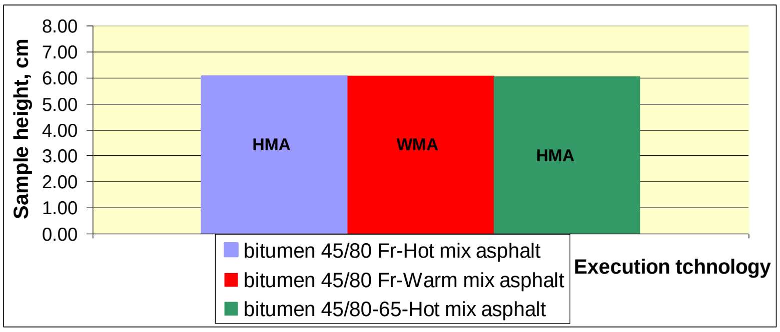

Figure 7. Sample height versus technology and type of bitumen

Indirect tensile on cylindrical specimens test (IT-CY) for stiffness modulus was performed according to SR EN 12697-26, Annex C: 15^{o}C and 20^{o}C, loading time of 124μs (Figure 8);

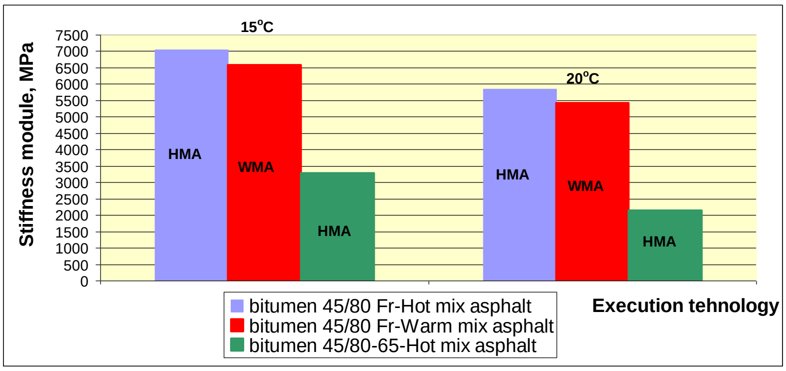

Figure 8. Stiffness module versus technology and type of bitumen

Triaxial cyclic compression test was carried out according to SR EN 12697-25, method B: 50^{o}C, 300kPa, 1 bar, 1s/1s (Figure 9), (Table 4).

Table 7. Method 1 of calculation for creep parameters on Marshall samples

Mix Type / Technology	Parameters and equation in stage II Method 1 ($\varepsilon_n=A_1+B_{1\ n}$)		Creep rate $f_c=B_1$	Creep modulus $E_n=\sigma/\varepsilon_n$, kPa	
	A_1	B_1		initial	10000
BBA 16 45/80 Fr A –Hot mix	5421.8	0.0243	0.0243	798	530
BBA 16 45/80 Fr A – Warm mix	6424.1	0.0405	0.0405	695	440
BBA16 45/80-65 – Hot mix	5190.5	0.0229	0.0229	827	545

Table 8. Method 2 of calculation for creep parameters on Marshall samples

Mix Type	Parameters and equation in stage II Method 2 ($\log\varepsilon_n=\log A+\log Bn$)		Permanent deformation ε_{1000} $\varepsilon_{1000,\ calc}=A1000^B$	Permanent deformation ε_{10000}: $\varepsilon_{10000,\ calc}=A10000^B$
	A	B		
BBA 16 45/80 Fr A – Hot mix	4027	0.037	5200	5662
BBA 16 45/80 Fr A – Warm mix	4539.4	0.0442	6160	6820
BBA16 45/80-65 –Hot mix	4049.5	0.0315	5034	5413

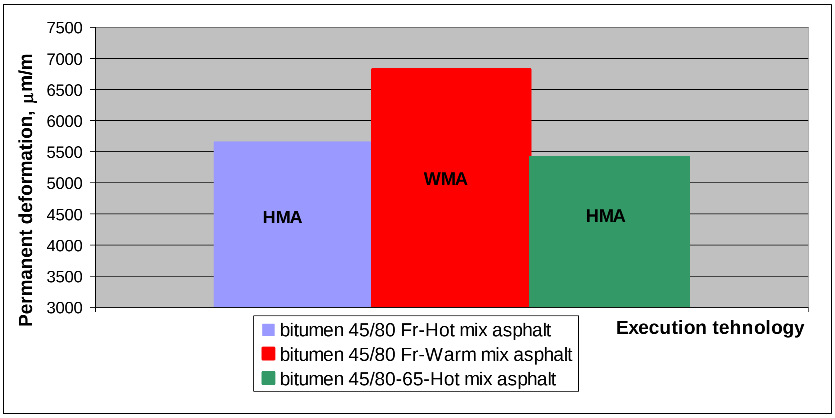

Figure 12. Permanent deformation versus technology and type of bitumen used for 10,000 cycles in accordance with Method 2

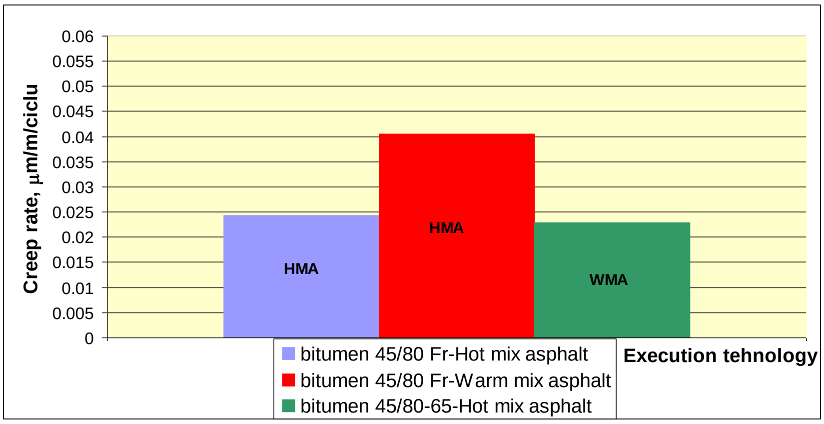

Figure 13. Creep rate versus technology and type of bitumen in accordance with Method 1

Fuel resistance was carried out according to SR EN 12697-43. After drying, the mass loss was calculated (Figure 17 and 18).

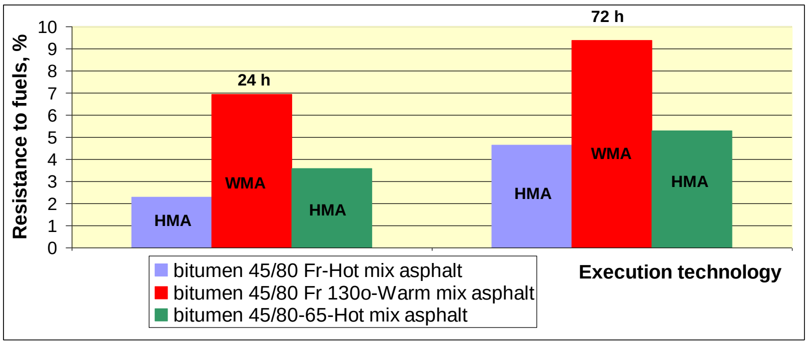

Figure 17. Mass loss versus execution technology and type of bitumen

The final classification was done on the BBA16 airports asphalt mix results in European Standard SR EN 13108-1 versus technology and type of used bitumen (Table 10).

Table 10. Asphalt mixture categorizing in European Standard SR EN 13108-1 depending on technology

Characteristics	Bitumen	Categorizing according to SR EN 13108-1
Marshall Values S, KN F, mm	bitumen 45/80 Fr-Hot mix	$S_{min\ 12.5}$ $S_{max\ 15}$ F_4
	bitumen 45/80 Fr-Warm mix	$S_{min\ 12.5}$ $S_{max\ 15}$ F_8
	bitumen 45/80-65-Hot mix	$S_{min\ 10}$ $S_{max\ 12.5}$ F_8
Stiffness modulus: IT-CY,20^{o}C, 124μs	bitumen 45/80 Fr-Hot mix	$S_{min\ 5500}$ $S_{max\ 9000}$
	bitumen 45/80 Fr-Warm mix	$S_{min\ 4500}$ $S_{max\ NR}$
	bitumen 45/80-65-Hot mix	$S_{min\ 1800}$ $S_{max\ NR}$
Resistance to permanent deformation - triaxial cyclic compression test, 50^{o}C, 300kPa, 1bar, 1s/1s – creep rate	bitumen 45/80 Fr-Hot mix	$f_{cmax0.2}$
	bitumen 45/80 Fr-Warm mix	$f_{cmax0.2}$
	bitumen 45/80-65-Hot mix	$f_{cmax0.2}$
Fuel resistance -24h -72 h	bitumen 45/80 Fr-Hot mix	≤ 5% - good resistance ≤ 5% - good resistance
	bitumen 45/80 Fr-Warm mix	≤ 5% - good resistance ≥ 5% - poor resistance
	bitumen 45/80-65-Hot mix	≥ 5% - poor resistance ≥ 5% - poor resistance

3. CONCLUSIONS

This study concludes the following:

- it is noted that when using "warm mix asphalt" technology both Marshall Stability and Marshall Index flow increase with higher temperature, and the sample height decreases with increasing temperature for 45/80 Fr bitumen;

- Marshall Stability is higher for "hot mix asphalt" technology than for "warm mix asphalt" by approximately 9%. Marshall Stability is higher when using a 45/80 Fr bitumen than using a 45/80-65 bitumen by approximately 14%;
- Marshall Index flow is lower for "hot mix asphalt" technology than for "warm mix asphalt" technology by approximately 76%. Marshall Index flow is lower when using a 45/80 bitumen Fr than using a 45/80-65 bitumen by approximately 99%;
- Samples height is smaller for "hot mix asphalt" technology than for "warm mix asphalt" technology by approximately 1%. Sample height is approximately equal for the two types of bitumen;
- Stiffness module for 15^{o}C temperature is higher for "hot mix asphalt" technology than for "warm mix asphalt" technology by approximately 7%. Stiffness module is higher for "hot mix asphalt" technology using 45/80 bitumen Fr than 45 / 80-65 bitumen by approximately 115%;
- Stiffness for 20^{o}C temperature is higher for "hot mix asphalt" technology than for "warm mix asphalt" technology by approximately 8%. Stiffness is higher for "hot mix asphalt" technology using 45/80 bitumen Fr than 45/80-65 bitumen by approximately 170%;
- Permanent deformation is lower for "hot mix asphalt" technology than for "warm mix asphalt" technology by approximately 20%. Permanent deformation is higher when using modified additive bitumen Fr 45/80 than using a modified bitumen 45/80-65 by approximately 5%;
- Creep rate is lower for "hot mix asphalt" technology than for "warm mix asphalt" technology by approximately 20% (calculated with the first method) and by 67% (calculated with the second method). The creep rate is higher when using 45/80 Fr bitumen than using 45/80-65 bitumen by approximately 6% (calculated using the first method) and by 17% (calculated with the second method);
- Mass loss after 24 hours is by 56% less for "hot mix asphalt" technology than for "warm mix asphalt" technology, and by approximately 200% when using 45/80 Fr bitumen comparing to 45/80-65 bitumen. Mass loss after 72 hours is by 14% less for "hot mix asphalt" technology than for "warm mix asphalt" technology and approximately 100% when using 45/80 Fr bitumen comparing to 45/80-65 bitumen.

The aggregate temperature influences the Marshall results, a higher temperature improving the Marshall characteristics.

Marshall Stability falls into the same set of values for 45/80 Fr bitumen, regardless of technology, and the category is superior when 45/80-65 bitumen is used. The Index flow has the same set of values for 45/80 Fr bitumen- "warm mix asphalt" technology and 45/80-65 bitumen "hot mix asphalt" technology and the category is inferior when using 45/80 Fr bitumen - "hot mix asphalt" technology.

Stiffness falls into the category of similar values as 45/80 Fr bitumen depending of technology and the sets of values for 45/80-65 bitumen is inferior.

Fuel resistance is good when using 45/80 Fr bitumen (regardless of technology), and low when using 45/80-65 bitumen.

Given the findings and conclusions set out above, we can say that using "warm mix asphalt" technology we get about the same sets of values for Marshall characteristics, stiffness modulus, permanent deformation and fuel resistance according to European standard SR EN 13108-1.

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