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ADDITIVE PERCENT INFLUENCE ON "WARM MIX" BEHAVIOR

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Abstract

The benefits of WMA technologies include reduced fuel usage and emissions in support of sustainable development, improved field compaction, which can facilitate longer haul distances and cool weather pavement, and better working conditions. Since this is a relatively new technology, it is necessary to determine the behavior and the performances of this type of asphalt mixture depending on additive percent.
These technologies tend to reduce the viscosity of the asphalt and provide for the complete coating of aggregates at lower temperatures. WMA is produced at temperatures 20 to 30°C lower than typical hot-mix asphalt (HMA).
The paper presents the results obtained in the Road Laboratory of Technical University of Civil Engineering Bucharest on an asphalt mixture with fibers (MASF16) prepared according to the "warm mix" technology with chemical additive. Different percent of additive are used in laboratory to draw up the "master curves" of asphalt mixture obtained by 4PB-PR stiffness modulus results.

Keywords: WMA, chemical additive, 4PB-PR, master curve

1. INTRODUCTION

Development of this technology appear in Europe, in 1997, at the same moment with the Kyoto agreement negotiations, which purpose was to reduce pollutant emissions by industrialized countries by 5,2% between 2008 – 2012, comparatively with those from 1990. Since then on the construction market appears a lot of products and technology processes which promise to implement the directives from Kyoto Agreement, products and technologies that are currently the subject of several laboratory studies internationally.

Aphalt mixture production has evolved over the 130 years from appearence from manual mixing and paving to fully automated production stations and advanced equipment for paving of asphalt mixtures. Over the years, it is widely recognized that temperature plays an important role in aggregate mixinx with bitumen, aggregate mixture stability both during preparation and transport, workability, compaction and finally asphalt mixture performance in situ. During paving operations, asphalt mixture temperature must be high enough to ensure good workability but still below a certain value which can cause problems on the binder drainage from aggregate and bitumen premature aging. If the asphalt mix temperature at the beginning and the end of compaction is lower, the cooling rate of the layer is much lower than that of the asphalt mixture made with the hot mix technology, this leads to increased time compaction. This translates into an opportunity to extend the laying season of asphalt mixtures and the potential to increase the transport distance.

Also, it is possible by reducing temperatures mixing and placing, using additives which lower bitumen viscosity, to improve the compaction characteristics of asphalt mixture layer, by assuring a better density. This will lead to a permeability reduction of asphalt mixture layers, to a better aging behavior with favorable effects on fatigue resistance and moisture degradation of structure layers.

2. OBJECTIVE

The aim of paper is to present a comparative study from laboratory tests point of view between two asphalt mixtures technologies: „warm mix" and „hot mix" and to highlight that using of additive to reduce viscosity and increase lucrability at preparing and compaction, the physical – mechanical characteristics are not affected. Warm mix technology present advantages especially in case of modiffied bitumens, which, as it knows, ask for higher mixing and compaction temperatures coparative with normal bitumens.

This paper present results obtained in in Roads Laboratory of Faculty of Railways, Roads and Bridges (Technical University of Civil Engineering of Bucharest) on asphalt mixture with fibers prepared with Rediset additive on „warm mix" technology compared with „hot mix" technology, pointing out the effect of working technology on asphalt mixture characteristics.

3. MATERIALS AND COMPOSITION

The study was conducted on a asphalt mixture with fibers, MASF16, for wering course. In order to obtain an optimum blend of aggregates, filler and bitumen, proper materials, according norms, were selected. The materials used for the asphalt mixture (aggregates, fiber and bitumen), as well as the composition, are presented in Table 1.

This study was carried out on two types of asphalt mixtures for wearing course designed according to Romanian Norms: an asphalt mixture – noted by “HMA” and an asphalt mixture produced with Rediset organic additive (WMA type) – noted by “WMA”.

Working temperatures used for component mixing and compaction are presented in Table 2.

The organic additive used is a wax (brown flakes) added in bitumen, dissolving easy when bitumen is hot, without any special mixing equipment.

Table 1. Asphalt mixture composition

Materials	**Percentage**			
	MASF16-HMA	MASF16-WMA-1	MASF16-WMA-2	MASF16-WMA-3
Crushed rock 8-16	45 %	45 %	45 %	45 %
Crushed rock 4-8	25 %	25 %	25 %	25 %
Crushed rock 0-4	13 %	13 %	13 %	13 %
Filler	11 %	11 %	11 %	11 %
Bitumen 25/55-65	5.7 %	5.7 %	5.7 %	5.7 %
Fiber Topcel	0.3%	0.3%	0.3%	0.3%
Additive Rediset	-	1% (at bitumen)	2% (at bitumen)	3% (at bitumen)

Table 2. Temperatures used at preparing and compacting of asphalt mixtures

Technology	Aggregates	Bitumen	Mixing	Compaction
	Temperature ^{o}C			
hot mix	180	170-175	180	170 - 175
warm mix	150	170-175	160	150

4. EXPERIMENTAL PROGRAM

Experimental study aimed that through laboratory results to highlight asphalt mixture performance when WMA technology is used and the influence of additive quantity. To evaluate mechanical performance of asphalt mixtures, the cylinder specimens (100.6 mm diameter and 63.5 mm high) were produced with 50 blows compacting energy per side by Marshall Compactor, and the slabs were prepared on wheel-roller machine. The size of the slab samples was 300 mm in length, 300 mm in width and 50 mm in thickness.

4.1. Tests used

To highlight the performance of "warm mix" mixture type MASF16-WMA comparatively with MASF16-HMA, were conducted tests in condition according with european norm SR EN 13108-20:

- On bitumen:

- penetration test, according SR EN 1426;
- ring and ball point test, according SR EN 1427;

- On asphalt mixture:

- Marshall test according SR EN 12697-34;
- Four point bending test on prismatic samples 4PB-PR according SR EN 12697-26 Annex B.

4.2. Results

In the first part of the study were conducted tests on modified bitumen 25/55-65 as well as the bitumen with addition of chemical additives to lower viscosity bitumen, whose results for penetration, ring and ball and penetration index are presented in Table 3.

Continuing of the study tests were made on classic asphaltic mixture MASF 16 for the two technologies - "warm mix" and "hot mix". The results of the bulk density, Marshall stability and flow are shown in Table 4.

Table 3. Bitumen characteristics

Characteristic	**Bitumen type**			
	25/55-65	25/55-65 with additives		
		1%	2%	3%
Penetration, at 25°C, 1/10 mm	46	41	40	39
R&B point, °C	76	78.5	80.5	83
Penetration index	3.4	3.5	3.7	4.0

Table 4. Physical – mechanical characteristics

Characteristic	Asphalt mixture type			
	MASF16-HMA	MASF 16-WMA-1	MASF 16-WMA-2	MASF 16-WMA-3
Density, kg/m^3	2400	2327	2320	2315
Marshall Stability S, kN	9.8	10.2	10.6	10.7
Marshall Flow I, mm	4.3	4.4	4.5	6,5
Marshall Index S/I, kN/mm	2.29	2.32	2.36	1.65

In order to conduct master curves for asphalt mixture prepared with both technologies, prismatic samples were tested at different temperatures and frequencies. Thus, in Figures 1, 2, 3 and 4 are the master curves of stiffness and phase angle at, taking into account different percentages of the additive in case of "warm mix" technology. Figura 5 compare master curves for asphalt mixture stiffness at 15^{o}C for MASF16-HMA, MASF16-WMA-1, MASF16-WMA-2 si MASF16-WMA-3 mixtures.

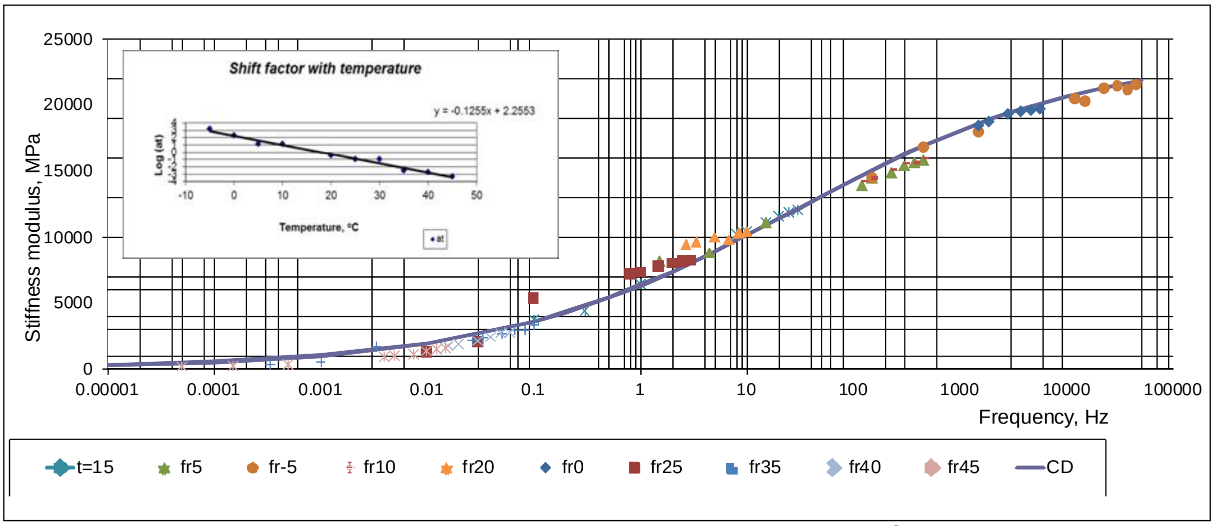

Figure 1. Master curve for MASF16-HMA, T= 15^{o}C (4PB-PR)

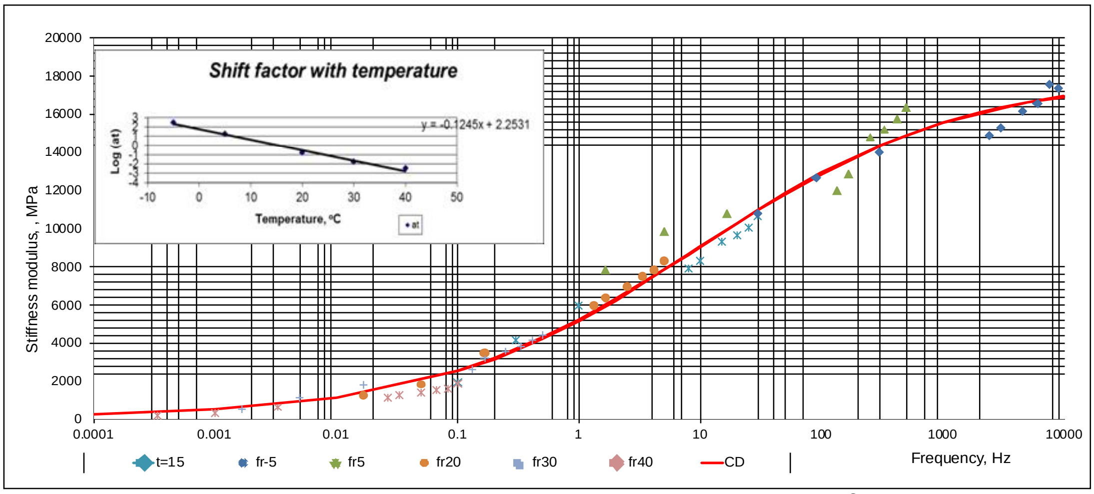

Figure 2. Master curve for MASF16-WMA-1, T= 15^{o}C (4PB-PR)

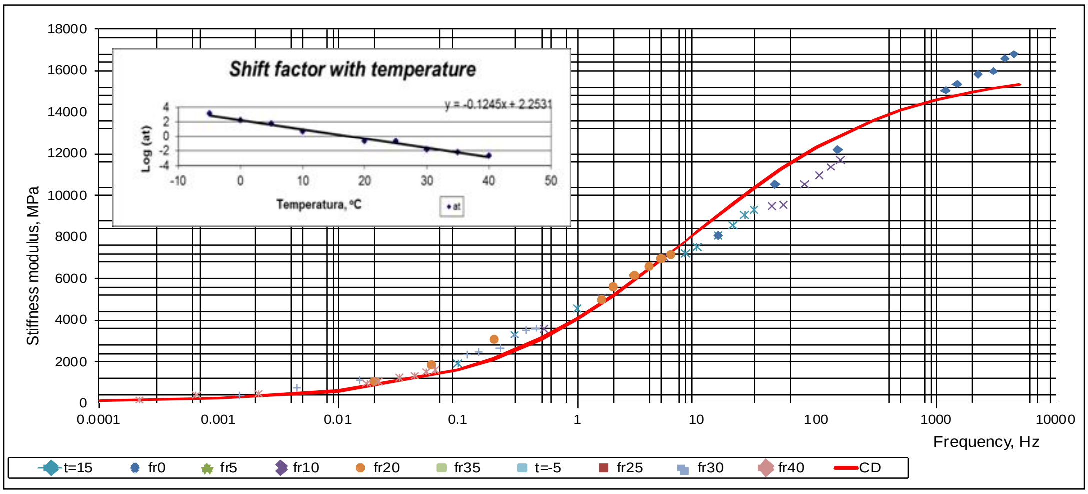

Figure 3. Master curve for MASF16-WMA-2, T= 15^{o}C (4PB-PR)

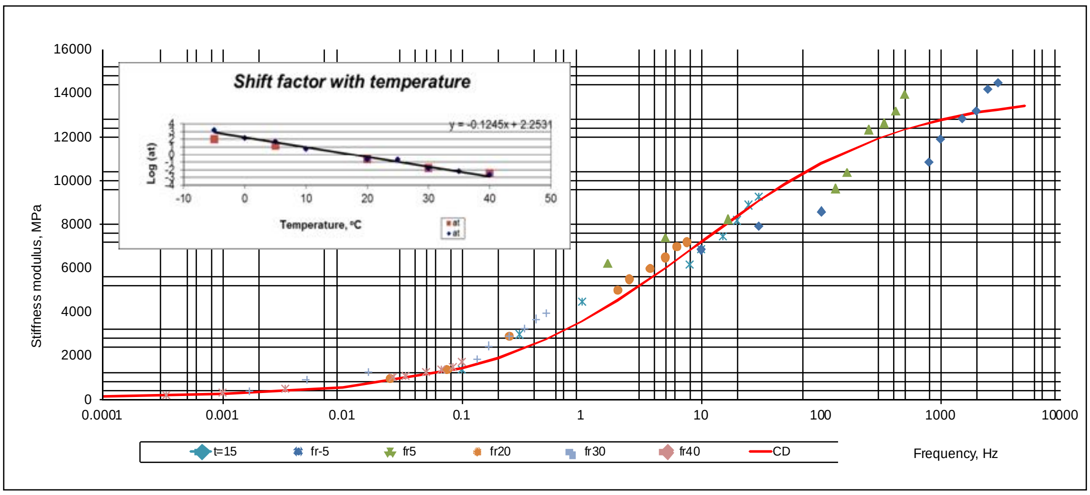

Figure 4. Master curve for MASF16-WMA-3, T= 15^{o}C (4PB-PR)

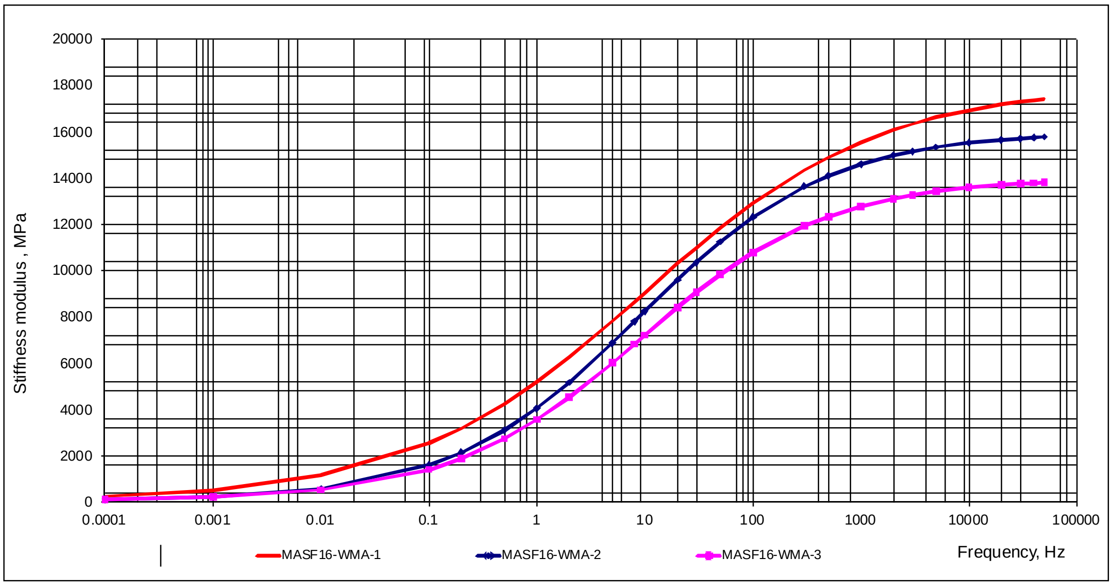

Figure 5. Compared master curve for MASF16-HMA, MASF16-WMA-1, MASF16-WMA-2 şi MASF16-WMA-3, T= 15^{o}C (4PB-PR)

5. CONCLUSIONS

The conclusions drawn from this study are:

- Using the “warm mix” technology, the working temperatures can be reduced by keeping the initial physic – mechanical characteristics of the asphalt mixtures obtained through warm technology “hot mix”; this can bring significant benefits to the environment.
- Adding the chemical additive in asphalt mixture lead to changes of the bitumen characteristics. Thus, there is a slight decrease in the penetration value of 11% to 15% by increasing the proportion of additive and the increase of the softening point by 3% - 8% by increasing the proportion of additive which may lead to a better behavior at permanent deformations of asphalt mixture. In addition, the penetration index is changed from +3.4 (bitumen without additives) to 4 (high percentage of bitumen additivated with additive), which means that the structure of the bitumen is maintained at gel type (elastic behavior - low temperature susceptibility).
- Adding additive in case of "warm mix" technology versus "hot mix" lead to reduced apparent density and increased flow index and Marshall stability.
- Asphalt mixture stiffness is higher at low temperatures and high frequencies while at high temperatures and low frequency values are low. Differences between stiffness modulus value of working technologies become significant in case of low frequencies: increasing the percentage of additive the stiffness

modulus decreases by 52% - 75% compared with the technology "warm mix". If case of high-frequency stiffness modulus decreases by 20% - 37% based on the percentage of added additive versus technology "warm mix".

- Master curves constructed show different rheological behavior of asphalt mixtures made with "warm mix" technology compared to the "hot mix" technology. Therefore, when design a road structures it is necessary to take account of these changes occurred and the temperature susceptibility of asphalt mixtures on climate change in recent years in our country (very hot summers overlapping very cold winters).
- Although the laboratory results appear to indicate some small changes in the performance of the mixtures, they do not consider aging effects and the performance functions are based on conventional mixture data, and therefore need to be validated by field data before any conclusions can be drawn.

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