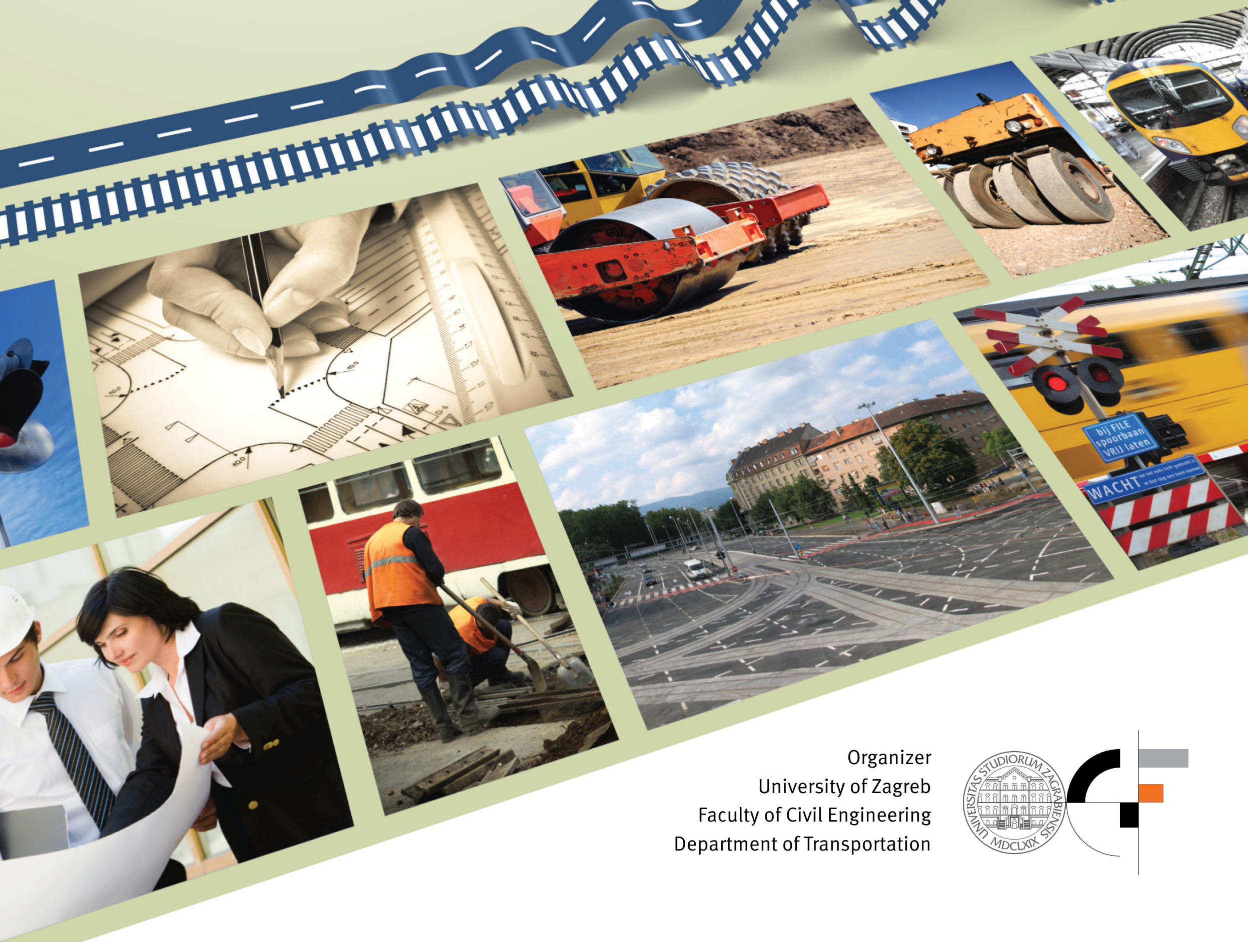
CETRA[2012]

2nd International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



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PERMANENT DEFORMATIONS OF ASPHALT MIXTURES FROM PAVEMENT WEARING COURSES

Adrian Burlacu, Carmen Răcănel
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Abstract

Asphalt mixture is a highly flexible material in road structures. Depending on the layer used: the base layer or wearing course, it must respond to loads coming from the traffic and climate. Asphalt mixture on the wearing course must take tangential forces produced by vehicle's wheels and to transmit vertical loads to the bottom layers, to support loads from climate factors, to provide sufficient rigidity so as to contribute to road structure resistance increase, to be waterproof and with enough roughness, to drain runoff. Because of traffic increment and climate changes, degradations like permanent deformations, fatigue cracking and low temperature cracking appear on flexible asphalt pavements. These degradations reduce road structures life time and increase maintenance costs.
The present paper aims to highlight the laboratory measurements of one of the asphalt mixture characteristics, namely the dynamic creep test studying the influence of loading conditions on the values obtained. The results obtained from calculus are presented as influence graphs.

Keywords: asphalt mixture, permanent deformations, dynamic creep, creep modulus, creep rate

1 Introduction

With an increasing demand in road's construction, engineers are constantly trying to improve the performance of bitumen pavement. In recent years, with the increase of traffic combined with various environmental effects, the road surfaces have been exposed to high loads that cause constant and excessive stress that leads to permanent deformation.
In an asphalt mixture bitumen links the aggregates, providing some stability and ensuring resistance from traffic and environment efforts, so that asphalt mixture performance is a function of bitumen properties, aggregate and volumetric properties of the mixture.
Dynamic tests developed over time study the state of stress and strain in the road structure under external loads (traffic, temperature). Thus the origin of degradation is established and after that the understanding of the propagation degradation mechanism.

2 Research objective

The goal of this paper is to test the new polymer–modified bitumen that is recommended for asphalt mixtures in wearing courses. Effective binder specification should be based on a mixture behaviour scale.The benefits of using the new polymer–asphalt mixture, in comparison with other asphalt mixtures, are in loading conditions referring to rutting, one of the main flexible pavement distress.
This study was carried out in Roads Laboratory of Faculty of Railways, Roads and Bridges (Technical University of Civil Engineering of Bucharest).

3 Materials and asphalt mixture recipes

In order to achieve the goal, two wearing course asphalt mixtures were chosen: high modulus asphalt mixture (MAMR16) and stone mastic asphalt (MASF16) with three types of binders, noted from A to C. Both asphalt mixtures were designed in accordance with national and European norms with C type bitumen. Bitumen A and C are polymer–modified binders and bitumen B is an original one, used as a base for the C type bitumen. The A and B bitumen types have similar penetration class. Another part of the study consists of changing the fibre type for MASF16 mixture with c bitumen, the cellulose fibre was replaced with polypropylene fibre. The materials (aggregates, fibre and bitumen) used to prepare the asphalt mixtures and the asphalt mixtures recipes are presented in Table 1 and 2.

Table 1 The used asphalt mixtures materials and the recipes for the used asphalt mixtures

Asphalt Mixture	Source /type and %	Crushed Stone			Filler	Fibre by Mixture	Bitumen by Mixture
		8/16	4/8	0/4			
MAMR16	Source /type	Revărsarea			Limestone Holcim	-	A: 45/85-65 PMB B: 50/70 C: 25/55-65 PMB
	%	35	29	25	11	-	4.12
MASF16	Source /type	Turcoaia			Limestone Holcim	Topcel	A: 45/85-65 PMB B: 50/70 C: 25/55-65 PMB
	%	45	25	13	11	0.3	5.7
MASF16	Source /type	Turcoaia			Limestone Holcim	Polypropylene	C: 25/55-65 PMB
	%	45	25	13	11	0.3	5.7

Table 2 Bitumen properties

Properties	Bitumen A (Pmb)	Bitumen B	Bitumen C (Pmb)
Penetration at 25°C (0.1mm)	68	64	35
Ring and ball soft point (°C)	83	51	81
Ductility at 25°C, cm	92	>100	95

4 Laboratory tests and testing conditions

The following test will be considered in order to compare mixtures characterization against the main distress that occurs in situ–rutting: Triaxial Cyclic Compression test on cylindrical samples according to SR EN 12697-25 test method B: 500C test temperature, 300kPa axial load, 1 bar confining pressure, 1s/1s frequency (block pulse). For MASF16m mixture with polypropylene fibre three temperatures were chosen: 40°C, 50°C, 60°C. Principle of this test is the evaluation of the dynamical creep of test specimens by the three axle compression, where the cylindrical specimen is exposed to a confining pressure, simulating the conditions of a real road, and simultaneously exposed to the vertical cyclic loading, simulating loading from traffic.
MASF16 asphalt mixture bulk density was equal to 2370 Kg/m^3, and 2550 Kg/m^3 for MAMR16 asphalt mixture.

5 Experimental results

The laboratory studies gave experimental results plotted in figures 1 – 6 and presented in tables 1–4. According to the binder type the cumulative axial strain values (figure 1, 2 and 5, table 1 and 2) and creep modulus (figure 3, 4 and 6, table 3 and 4) for creep behaviour can be highlited.

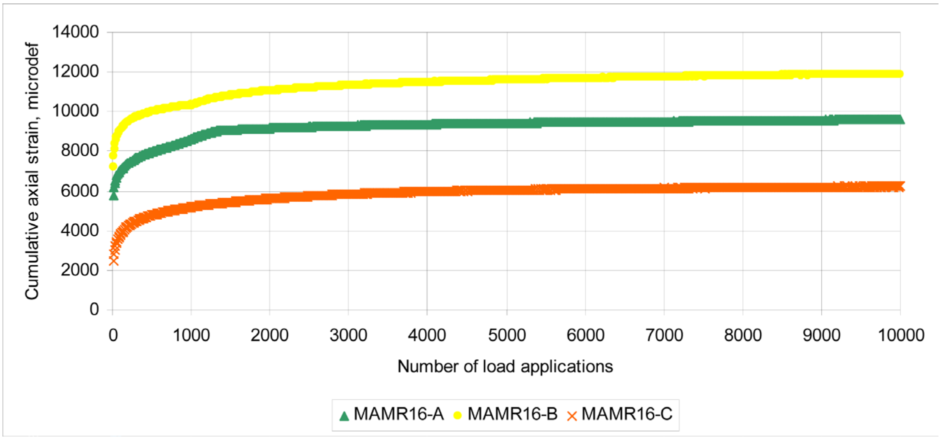

Figure 1 Creep curves for MAMR16 asphalt mixtures

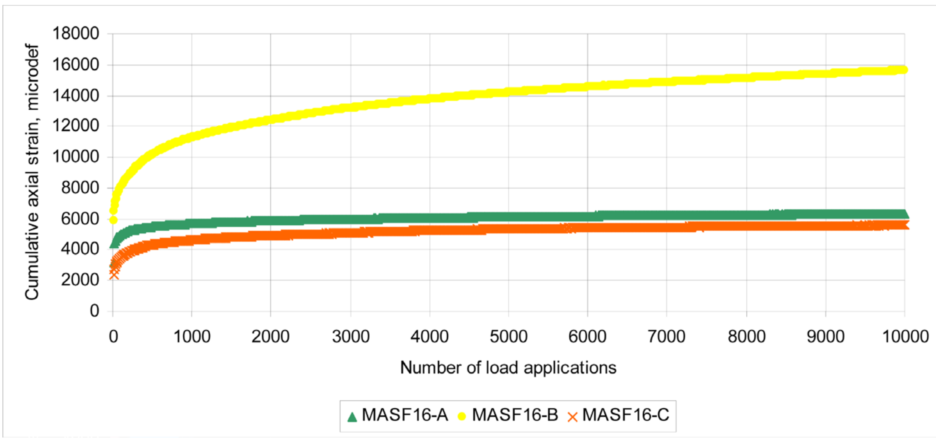

Figure 2 Creep curves for MASF16 asphalt mixtures

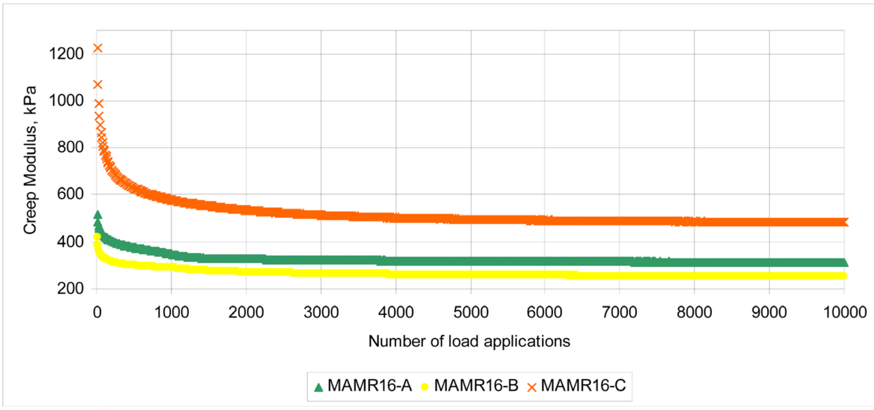

Figure 3 Creep modulus values for MAMR16 asphalt mixtures

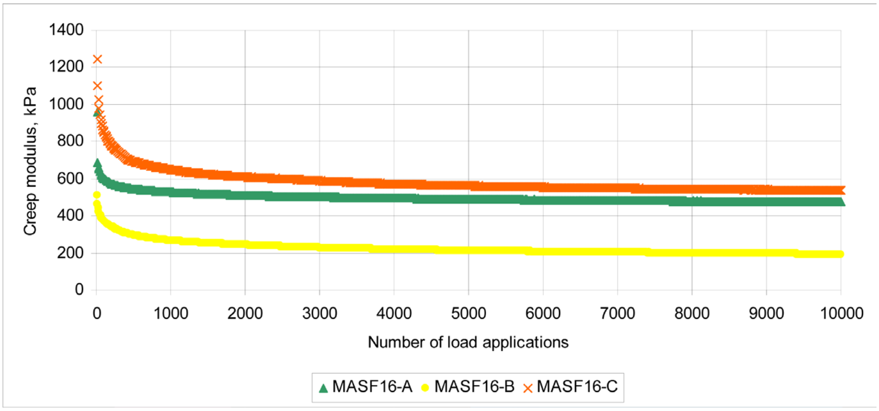

Figure 4 Creep modulus values for MASF16 asphalt mixtures

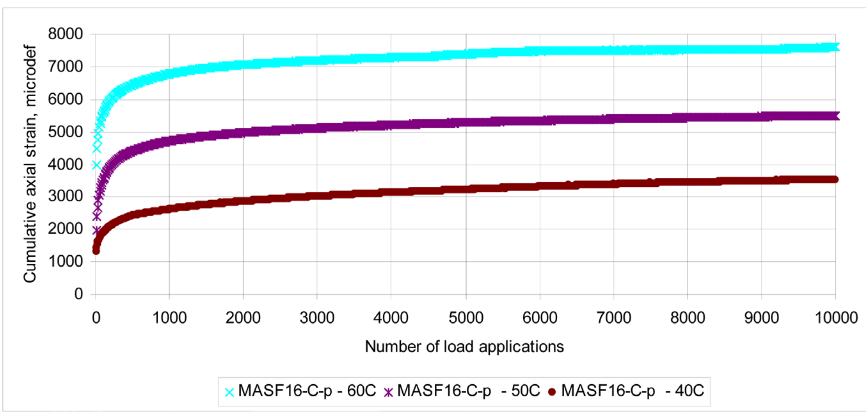

Figure 5 Creep curves for MASF16 – C with polypropylene asphalt mixture at different temperatures

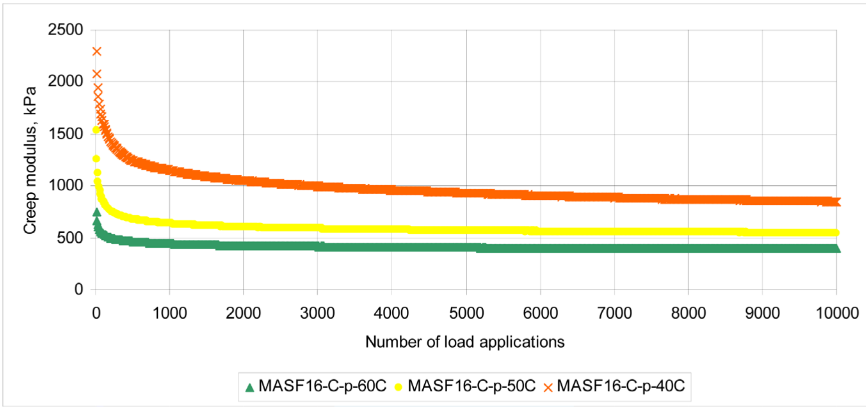

Figure 6 Creep modulus values for MASF16 – C with polypropylene asphalt mixture at different temperatures

Table 3 Creep results, method I and creep modulus values

Type of Mixture	Parameters of equation on (quasi) linear stage II Method I ($\varepsilon n=A_1+B_1 n$)		Creep rate $f_c=B_1$	Creep modulus, $E_n=\sigma/\varepsilon n$, kPa		
	A1	B1		initial	1000	10000
MAMR16-A	9252.7	0.0349	0.0349	518	348	313
MAMR16-B	11307	0.0615	0.0615	418	291	252
MAMR16-C	5895.1	0.0333	0.0333	1227	579	482
MASF16-A	5951.7	0.0386	0.0386	961	527	474
MASF16-B	12837	0.2835	0.2835	512	266	192
MASF16-C	5129.1	0.0478	0.0478	1243	649	536
MASF16-C, p-40oC	2941.9	0.0607	0.0607	2298	1146	850
MASF16-C, p-50oC	5100.6	0.0409	0.0409	1528	636	545
MASF16-C, p-60oC	7296.2	0.029	0.029	753	442	394

Table 4 Creep results, method II

Mixture type	Parameters of Equation on (quasi) Linear Stage II Method II ($\log\varepsilon_n=\log A+B\log n$)		Calculated Permanent Deformation ε_{1000}: $\varepsilon_{1000,calc}=A1000^B$	Calculated Permanent Deformation ε_{10000}: $\varepsilon_{10000,calc}=A10000^B$
	A	B		
MAMR16-A	7497.22	0.0268	9022	9596
MAMR16-B	8357.95	0.038	10867	11860
MAMR16-C	4314.2	0.0397	5675	6219
MASF16-A	4167.73	0.0454	5703	6331
MASF16-B	4339.1	0.139	11334	15610
MASF16-C	3096.71	0.0643	4828	5599
MASF16-C, p-40°C	1048.09	0.1321	2610	3538
MASF16-C, p-50°C	3295.34	0.0556	4838	5499
MASF16-C, p-60°C	5827.74	0.0285	7096	7577

6 Conclusions

The conclusions that result from this study are the following:

a Bitumen type can have significant influence on creep behaviour;

b Referring to permanent deformation resistance of the studied mixtures the following is taken into consideration: interpretation of the creep curve result, the creep rate (f_c), the creep modulus (E_n), the calculated permanent deformation after 1000 and 10000 cycles ($\varepsilon_{1000\ calc}$, $\varepsilon_{10000\ calc}$) and the slope from the least square linear fit (B parameter):

- Creep rate rise for MAMR16 asphalt mixture with 80% passing from polymer modified binder (PmB) A and C to the original binder B; for MASF16 asphalt mixture, values are very closed;
- Creep modulus value rise with the increment of bitumen rigidity (average 100% for a mixture with bitumen PmB C or a mixture with bitumen PmB B) and decreases with the increment of applied loads number in accordance with bitumen type and mixture recipe (average 2.5 times for MASF16 and 1.6 times for MAMR16, exception MAMR16 with bitumen C for which the loss is 2.5 times, similar happens with MASF16);
- Permanent deformation calculated after 1000 cycles and after 10000 cycles decreases with bitumen hardening increment; mixture with bitumen PmB A has a better behaviour at permanent deformations comparatively with bitumen PmB B mixture: in case of the MAMR16 mixture values for $\varepsilon_{1000,calc}$ and $\varepsilon_{10000,calc}$ are 10% smaller and 25% smaller in case of the MASF16 mixture; instead, the contribution of the modified bitumen A can be seen in comparance with the original bitumen B: loss of deformation by avarage 50% in case of using the bitumen PmB A and C;

c As it can be seen, for a good creep behaviour of an asphalt mixture, using polypropylene fibre can be a good option, (at the same temperature, the results obtained are better than with cellulose fibre). The improvement of asphalt mixture properties shows the positive effect of polypropylene fibres. Also it can be seen that the increment of testing temperature by 200C results with an increment of $\varepsilon_{1000,calc}$ and $\varepsilon_{10000,calc}$ with 60% and respectively 50%. Temperature rise of100C from 400C to 500C results in an increment of permanent deformation, in average with 40%, comparatively with the same temperature increasing by 100C from 500C to 600C for which the increment of permanent deformation calculated after 1000 and 10000 cycles is about 30%. Creep modulus decrease with 50% when temperature rises by 200C.

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