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7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

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AIRPORT ASPHALT MIXTURES BEHAVIOUR TO FATIGUE AND PERMANENT DEFORMATION

Claudia Petcu, Carmen Răcănel
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Abstract

The study of bituminous mixtures behaviour is of very old origins. Taking into account various factors, many scholars in the field tried to explain the degradation causes. In road structures design, fatigue and permanent deformations were always the main factors that had to be taken into account. Fatigue occurs and develops because of the deformation from repeated tensile loads of traffic data which determined tensile stress in the road layer; and permanent deformations occur due to repeated traffic loads superimposed/combined with high temperatures. Both phenomena, fatigue and permanent deformation play an important role in pavement design.
The objective of this research is to estimate the fatigue behaviour and permanent deformations of bituminous mixtures designed for airport, BBA 16 (the design of airport asphalt mix whose recipe was made by both the Marshall and SUPERPAVE method and framed according to the French Norm NF P 98-131, LCPC French Design Manual–2007 and European Norm SR EN 13108-1), framed according to European Standard SR EN 12694-24 as 'Resistance to fatigue', European Standard SR EN 12694-25 as 'Cyclic compression test' and European Standard SR EN 13108-20 as 'Type testing'.

Keywords: airport asphalt mixture, fatigue, permanent deformation

1 Introduction

The main mechanisms of road structures degradation are the cracking mechanism and the permanent deformation mechanism.
Concerning cracking, there are four types of mechanisms: fatigue cracking due to repeated loading; fatigue cracking due to temperature variations; thermal cracking; cracking due to transmission of substrate cracks.
Fatigue occurs and develops because of repeated tensile strains coming from traffic loads that determine the pavement layer tensile stress. Permanent deformations occur because of repeated traffic loads superimposed to high temperature.
Main mechanisms leading to the appearance of permanent deformations are: permanent deformation structure (profile type 'V'); creep permanent deformation (profile type 'W'); permanent deformations of wear.
The airport pavement and road pavement belong to the same structural family. Both are required to build a platform to resist a given level of traffic and the traffic must be conducted in safe and comfortable conditions. Some aspects due to which the use of flexible structures on airfield area is becoming more and more current are: to have proper adhesion, execution is easier than with the rigid road structures, the structure can be put into exploitation more quickly and it has no joints.

Among the materials the flexible road pavement component or mixed bituminous mixture is considered to be the most important material to be characterized accurately. As is it is well known, the asphalt mixture should be flexible at low temperatures to prevent cracking and rigid enough at high temperatures to prevent rutting. Good asphalt mixture behaviour in exploitation requires a well designed asphalt mixture recipe and a proper compaction in situ.

2 Objective

The objective of this research is to estimate the fatigue and permanent deformations behaviour of asphalt mixture designed for airport pavement, namely the BBA 16 and MAMR 16 (the design of mix recipe was made by both the Marshall and SUPERPAVE method and framed according to French Norm NF P 98-131, NF P 98-140, LCPC French Design Manual–2007 and European Norm SR EN 13108-1), framed according to European Standard SR EN 12697-24 as 'Resistance to fatigue' and European Standard SR EN 13108-20 as 'Type testing'.
Laboratory studies were conducted in Roads Laboratory from Faculty of Roads, Railways and Bridges, Technical University of Bucharest.

3 Materials

The recipe is designed for asphalt mixtures used in wearing course of the airport pavement (runways, taxiways and platforms); the mixture has 16 mm nominal maximum size. The used filler was a HOLCIM limestone with characteristics shown in Table 1. Aggregates used (8/16, 4/8, 0/4 sort) were from REVĂRSAREA quarry and their characteristics are shown in Table 2. The bitumen was an OMV one, special for airports, with the characteristics shown in Table 3. Having the presented materials two asphalt mixtures were designed with the recipes shown in Table 4.

Table 1 Filler characteristics

Characteristics	Values
Calcium carbonate content (%)	93.75
Humidity (%)	0.34
Hydrophilic coefficient	0.69
Apparent density after sedimentation in benzene or toluene (g/cm3)	0.67
Air voids coefficient in compacted state (%)	0.34

Table 2 Aggregates characteristics

Characteristics		4/8 sort	8/16 sort	0-4 sort
Apparent density (g/m^3)		-	2.79-2.86	-
Apparent porosity (%)		-	1.45-1.54	-
Bulk density	in loose state	1370-1371	1396-1437	1610
(kg/m^3)	in compacted state	1618-1621	1599-1659	1708
Air voids (%)		41	39	-
Los Angeles wear (%)		16-16.2	12-12.6	-
Resistance to frost and taw (%)		-	0.62	-
Resistance to crush – dry (%)		-	92.4-93.2	-
Resistance to crush – saturate (%)		-	90-90.4	-

Table 3 Bitumen characteristics

Properties	Results
Softening point - Ring and ball (°C)	90
Penetration at 25°C (0.1mm)	48.6
Ductility (cm)	91.5

Table 4 Asphalt mix recipe

Mix	Source / type	Aggregates			Filer	Bitumen
		8/16	4/8	0/4		
BBA 16	Source / type	Revărsarea			Holcim	45/80 Fr A
	%	29	23	37	11	5.3
MAMR 16	Source / type	Revărsarea			Holcim	45/80 Fr A
	%	35	29	25	11	4.12

4 Fatigue

The conducted tests were in accordance with the European norm SR EN 12697-24, and are the following:

- two–point bending test on trapezoidal samples at a 25 Hz frequency and at temperatures of 10°C and 15°C;
- four–point bending test on prismatic samples at two frequencies: 25 Hz and 30 Hz and two temperatures: 15°C and 30°C.

The results obtained from the two–point bending test on trapezoidal samples are presented in Fig. 1.

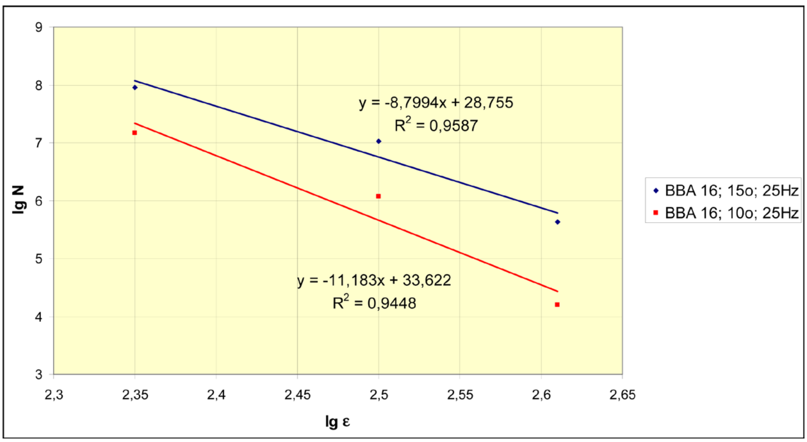

Figure 1 Fatigue lines of BBA16 asphalt mixtures obtained on trapezoidal samples

The straight lines slope of the two point bending fatigue test was determined from a double–lg scale representations in Fig. 1 and also in accordance with the EN 12697-24, Annex A. The equation is the following:

$$\lg N = a + (\frac{1}{b}) \cdot \lg(\varepsilon) \quad (1)$$

where Y = log(N), X = log(ε/10.000), N = number of charge cycles, ε = strain.

The values obtained for the slope are presented in Table 5.

Table 5 Slope values for fatigue lines

Temperature (°C)	Frequency (Hz)	Parameter (1/b)	Equation
10	25	-11.183	Y= -11.183X + 33.622
15	25	-8.80	Y= -8.80X +28.755

The results obtained from the four point bending test on prismatic samples are shown in Fig. 2. The straight lines slope of the four points bending fatigue test was determined from a double–ln scale and it is plotted in Fig. 2 and is also in accordance with EN 12694-24 Annex D equation. The equation is the following:

$$\ln N = A_0 + A_1 \cdot \ln(\varepsilon) \tag{2}$$

where Y = lnN), X = lnε/10.000), N = number of charge cycles, ε = strain.
The values obtained for the slope are presented in Table 6.

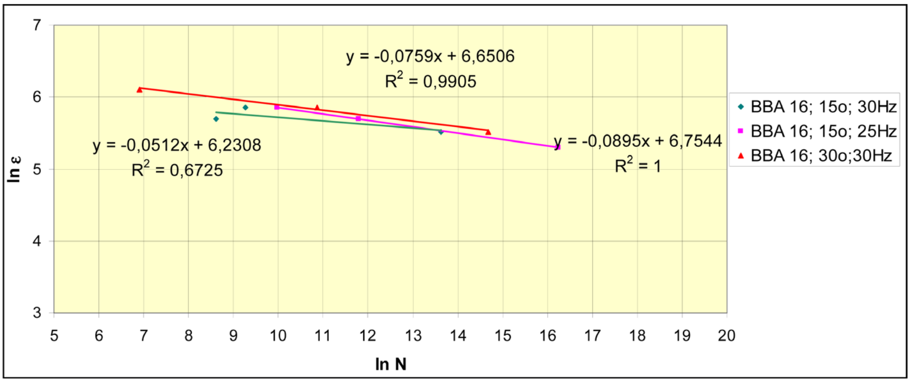

Figure 2 Fatigue lines of BBA16 asphalt mixtures obtained on prismatic samples

Table 6 Slope values for fatigue lines

Temperature (°C)	Frequency (Hz)	Parameter (1/b)	Equation
15	30	-0.0512	Y = -0.0512X + 6.2308
15	25	-0.0895	Y = -0.0895X + 6.7544
30	30	-0.0759	Y = -0.0759X + 6.6506

5 Permanent deformation

For permanent deformation resistance (creep), on two studied asphalt mixtures, the European norm EN 12697 -25, method B (test temperature 50°C, 300 kPa axial force, pressure 1 bar, 1s/1s frequency) was followed. The results are shown in Fig. 3 and Fig. 4 and Table 7 and 8.

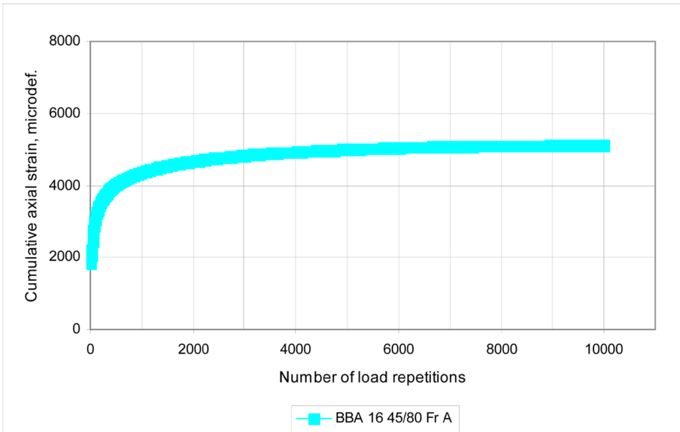

Figure 3 BBA 16 asphalt mixture creep curve

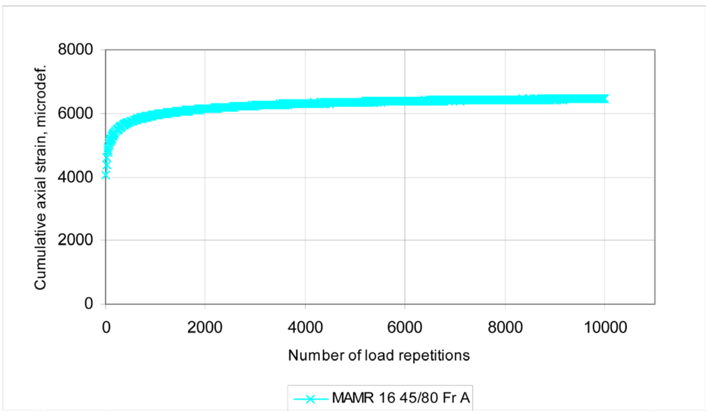

Figure 4 MAMR 16 asphalt mixture creep curve

Table 7 Creep results using method I

Mixture	Equation parameters and stage II Method I ($\varepsilon n=A_1+B_{1n}$)		Creep rate fc=B_1	Creep modulus En=$\sigma/\varepsilon n$, kPa		
	A_1	B_1		initial	1000	10000
BBA 16 45/80 Fr A	4905	0.0213	0.0213	1650	687	587
MAMR16 45/80 Fr A	6260.4	0.0208	0.0208	741	503	464

Table 8 Creep results using method II

Mixture	Equation parameters and stage II Method II ($\log\varepsilon_n=\log A+\log Bn$)		Permanent deformation ε_{1000}: $\varepsilon_{1000,\,calc}$=A1000B	Permanent deformation ε_{10000}: $\varepsilon_{10000,\,calc}$=A10000B
	A	B		
BBA 16 45/80 Fr A	4028	0.026	4821	5118
MAMR16 45/80 Fr A	5188	0.0239	6119	6465

6 Conclusions

The conclusions drawn from this study are as follows.
Both in the case of two points bending test on trapezoidal samples (2PB-TR) and in the case of four–point bending test (4PB-PR), the number of cycles decreases with temperature increment, regardless of the imposed strain.
The four–point bending test on prismatic samples shows that with the frequency increment the number of fatigue cycles, ate the same temperature, decreases regardless of the imposed strain.
For number of cycles at 10^6, a temperature of 15°C and a frequency of 25 Hz, for four–point bending test on prismatic samples the strain is 260 µdef and for two points bending test on trapezoidal samples the strain is 370 µdef.
Taking into account the specified conditions that are in accordance with the SR EN 13108–20 for the 4PB-PR test (30°C, 30Hz) and the 2PB-TR test (10°C, 25Hz) we can observe the following:

- the strain for 10^6cycles, ε^6 is approximately equal in both tests;
- for the 2PB-TR test the ε^6 strain is about 300 mdef and for the 4PB-PR test the e6 strain is about 280 mdef.

In comparison with the MAMR16 asphalt mixture, the BBA16 asphalt mixture for airports has a better resistance to permanent deformation. In comparance to the MAMR16 asphalt mixture, there is a significant increase in creep modulus for the BBA16 airport asphalt mixture. Stiffness modulus value depends on the shape of the specimen.
The designed asphalt mixtures have better fatigue behaviour at 2x10^6 cycles and could apply a strain much larger than that required by the SR EN 13108-1, SR EN 13108-5 and French Norm NF P 98-131;
The both results received from triaxial compression test are in good agreement with the SR EN 13108-1 and the SR EN 13108-5.

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