

**LISBOA 2010**  
MAY 25/28  
**16th World Meeting**



LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL



galp energia

***STUDY OF THE BEHAVIOUR OF BITUMINOUS MIXTURES  
RESISTANT TO FUEL***

***Ana Cristina Freire; Maria de Lurdes Antunes***  
Laboratório Nacional de Engenharia Civil (LNEC)

***Susana Maricato; Jorge Moura***  
PETROGAL, S.A.



[www.irf2010.com](http://www.irf2010.com)



# INTRODUCTION

Evaluation of the performance of asphalt mixtures applied on wearing courses of road and airport pavements when subjected to the action of fuel spillage

Asphalt mixtures produced with different types of bitumen were studied.

Experimental program based on the test method EN 12697-43 "*Bituminous mixtures - Test methods for hot mix asphalt - Part 43: Resistance to fuel*", complemented with other laboratory tests to determine the performance of asphalt mixtures

The study was conducted using materials provided by Petrogal (aggregates, filler, bitumen and fuel)

The asphalt mixtures were made with one type of aggregate combined with three types of bitumen: a grade pen 35/50 (conventional), a polymer modified bitumen and a bitumen especially modified for fuel resistance

The resistance to fuel was determined for three different types of fuels: gasoline 95, diesel and Jet A1.



# WORK PROGRAM

Manufacture and compaction of asphalt mixtures with the different types of bitumen selected for the study

Evaluation of resistance to fuel on asphalt specimens - EN 12697-43:2005

Complementary laboratory tests to assess the asphalt mixtures performance related - modulus, fatigue and permanent deformation - EN 12697-26:2004, EN 12697-24:2004 + A1: 2007 and EN 12697 -22:2003 + A1: 2007, respectively

Complementary tests for assessing the water sensitivity of bituminous specimens - EN 12697-12:2008

Prismatic specimens compacted in the laboratory - EN 12697-33:2004 + A1: 2007, using the roller compactor (5.3 of the standard test specification)

Specimens for testing (4 point bending) obtained by sawing the slabs.  
These tests are still going on



# BITUMINOUS MIXTURE COMPOSITION

- The manufacture of the bituminous mixtures used in the study included 10/14, 6/12 and 0/4 fractions, obtained from crushed granite rock, from the Secil Britas quarry in Penafiel.
- The added filler used was provided by Eurocálcio. These materials were used in the following proportions:

Aggregate 10/14 – 19,0%

Aggregate 6/12 – 30,4%

Aggregate 0/4 – 42,7%

Filler – 2,9%

Bitumen – 5,0%

- The three different types of bitumens used in the manufacture of the asphalt mixtures were supplied by Petrogal:
  - Penetration grade bitumen 35/50 (**Galp 35/50**)
  - Polymer modified bitumen PB 1,5 with a penetration grade 35/50 (**Galp PB 1,5 (35/50)**)
  - Kero bitumen, resistant to fuel, with 35/50 penetration grade (**Galp Kero (35/50)**)
  - The corresponding asphalt mixtures are identified as MB 35/50, MB PB 1,5 and MB Kero.



galp energia



LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

[www.irf2010.com](http://www.irf2010.com)



# PRESENTATION AND ANALYSIS OF RESULTS

## Resistance to fuel

EN 12697-43:2005 – “ Bituminous mixtures  
– Test methods fo hot mix asphalt – Part  
43: Resistance to fuel”

**1st Phase** – specimen is partially immersed in fuel and its loss of mass is measured afterwards

Loss of mass greater than 5%

test finished and the specimen is awarded a  
“low resistance” to fuel

Loss of mass lower than 5%

sample undergoes a brushing procedure made  
with a wire brush, which constitutes the second  
phase of the test



1. Test samples parcialy soaked in fuel



2. After soaking in fuel



3. Samples after soaking in fuel



4. Samples after soaking and washing



# PRESENTATION AND ANALYSIS OF RESULTS

## Resistance to fuel

EN 12697-43:2005 – “ Bituminous mixtures  
– Test methods fo hot mix asphalt – Part  
43: Resistance to fuel”

**2nd Phase** – classification of the resistance to fuel performed on the basis of the average loss in mass (B) during the second phase and the average value (A) obtained in the first stage



a) good resistance to fuel if  
 $A \leq 5\%$  and  $B < 1\%$

b) moderate resistance to fuel  
if  
 $A \leq 5\%$  and  $1\% \leq B < 5\%$

c) poor resistance to fuel if  
 $A > 5\%$  or  $B > 5\%$



# PRESENTATION AND ANALYSIS OF RESULTS

Asphalt mixture	FUEL								
	JET A 1			DIESEL			GASOLINE 95		
	1st phase (soaking in fuel)	2nd phase (brushing)	Classification	1st phase (soaking in fuel)	2nd phase (brushing)	Classification	1st phase (soaking in fuel)	2nd phase (brushing)	Classification
MB 35/50	A <sub>1</sub> = 2.7 A <sub>2</sub> = 1.5 A <sub>3</sub> = 2.7	B <sub>1</sub> = 3.0 B <sub>2</sub> = 1.2 B <sub>3</sub> = 3.3	-	A <sub>1</sub> = 1.5 A <sub>2</sub> = 1.8 A <sub>3</sub> = 1.3	B <sub>1</sub> = 2.8 B <sub>2</sub> = 1.6 B <sub>3</sub> = 1.9	-	A <sub>1</sub> = 3.5 A <sub>2</sub> = 9.0 A <sub>3</sub> = 6.2	B <sub>1</sub> = 2.7	-
	A = 2	B = 3	RM	A = 2	B = 2	RM	A = 6	B = 3	RF
MB PB 1,5	A <sub>1</sub> = 2.7 A <sub>2</sub> = 3.8 A <sub>3</sub> = 2.4	B <sub>1</sub> = 1.4 B <sub>2</sub> = 3.6 B <sub>3</sub> = 2.5	-	A <sub>1</sub> = 1.4 A <sub>2</sub> = 1.7 A <sub>3</sub> = 1.7	B <sub>1</sub> = 1.6 B <sub>2</sub> = 1.2 B <sub>3</sub> = 1.9	-	A <sub>1</sub> = 6.4 A <sub>2</sub> = 6.9 A <sub>3</sub> = 5.5	----	-
	A = 3	B = 3	RM	A = 2	B = 2	RM	A = 6	---	RF
MB Kero	A <sub>1</sub> = 3.0 A <sub>2</sub> = 4.2 A <sub>3</sub> = 3.0	B <sub>1</sub> = 1.4 B <sub>2</sub> = 1.5 B <sub>3</sub> = 1.1	-	A <sub>1</sub> = 2.1 A <sub>2</sub> = 2.9 A <sub>3</sub> = 3.1	B <sub>1</sub> = 0.9 B <sub>2</sub> = 1.2 B <sub>3</sub> = 1.2	-	A <sub>1</sub> = 3.8 A <sub>2</sub> = 3.9 A <sub>3</sub> = 4.3	B <sub>1</sub> = 1.0 B <sub>2</sub> = 1.1 B <sub>3</sub> = 1,5	-
	A = 3	B = 1	RM	A = 3	B = 1	RM	A = 4	B = 1	RM

## LEGEND:

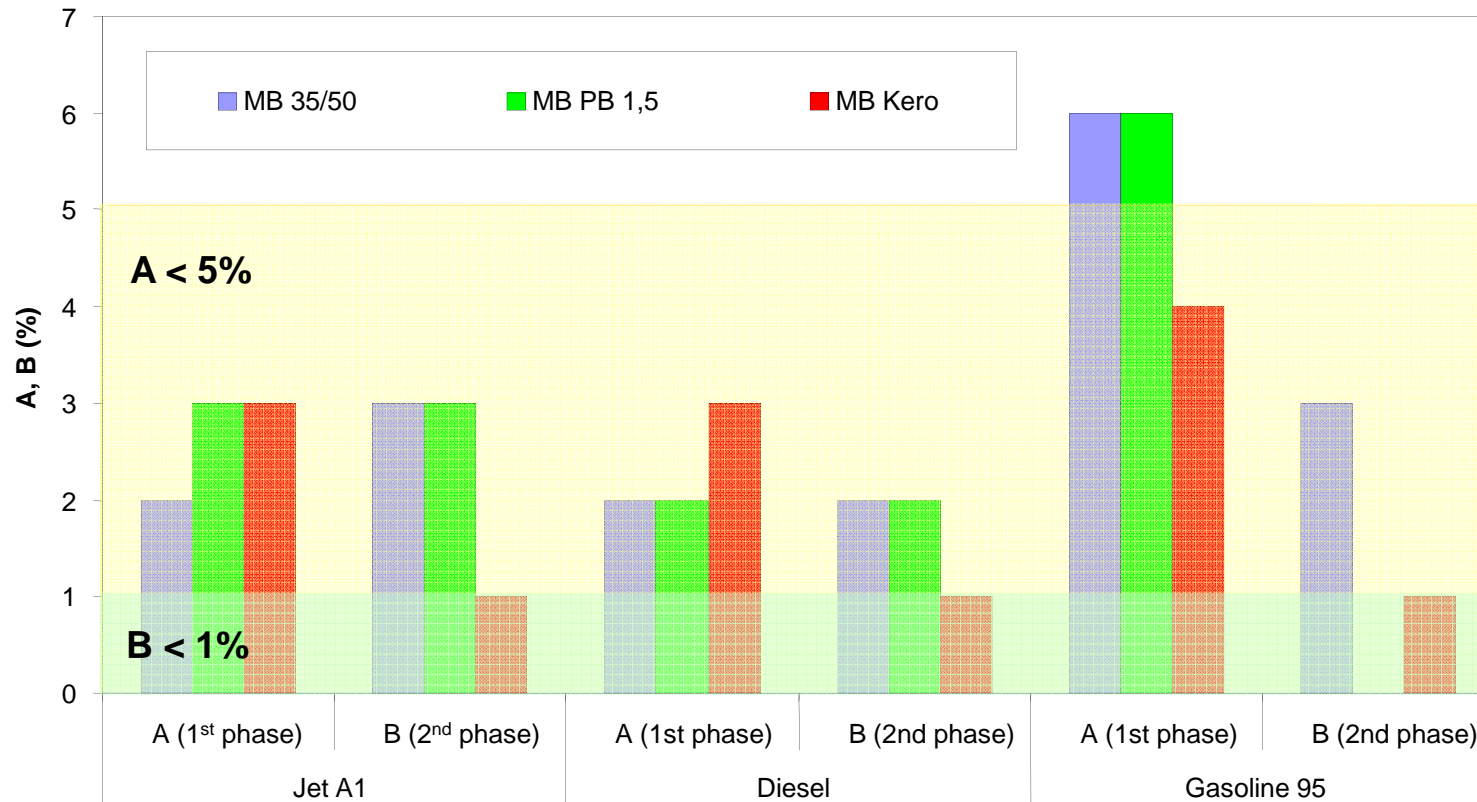
A<sub>i</sub> – Individual values of the loss of mass after soaking in fuel; B<sub>i</sub> – Individual values of the loss of mass after the brush test;

A – Mean value of the loss of mass after soaking in fuel; B – Mean value of the loss of mass after the brush test;

RM – Moderate resistance; RF – Poor resistance.



# PRESENTATION AND ANALYSIS OF RESULTS



LEGEND:

$A_i$  – Individual values of the loss of mass after soaking in fuel;  $B_i$  – Individual values of the loss of mass after the brush test;  
 A – Mean value of the loss of mass after soaking in fuel; B – Mean value of the loss of mass after the brush test;  
 RM – Moderate resistance; RF – Poor resistance.







# PERMANENT DEFORMATION BEHAVIOUR

Two slabs prepared in laboratory using the roller compactor - EN 12697-33:2004 + A1: 2007

Sawing and correction to obtain prismatic specimens for testing.

Assessment of resistance to permanent deformation  
EN 12697-22:2003 + A1: 2007, small size device, procedure B, on air.

The specimen submitted for testing had a thickness of 50 mm

$$4h < t_{\text{prep slabs - test}} < 24h$$

$$T_{\text{test}} = 60^{\circ}\text{C}.$$

Bulk density - EN 12697-6:2003 + A1: 2007 (method B)



Sharing the road

16th  
World Meeting  
International Road Federation

# PERMANENT DEFORMATION BEHAVIOUR

Parameter	MB 35/50		MB PB1.5		MB Kero	
	Specimen 1	Specimen 2	Specimen 1	Specimen 2	Specimen 1	Specimen 2
Bulk density (kg/m <sup>3</sup> )	2396	2398	2392	2396	2390	2388
Maximum deformation (mm)	4.71	6.70	3.98	5.54	1.62	1.71
Mean rut depth at 10000 cycles (mm) (RD <sub>10K</sub> )	5.7		4.8		1.7	
Wheel-tracking slope in air (mm/10 <sup>3</sup> cycles)	0.26	0.35	0.17	0.22	0.03	0.04
Mean wheel-tracking slope in air (mm/10 <sup>3</sup> cycles) (WTS <sub>10K</sub> )	0.30		0.20		0.04	
Rut proportional depth at 10000 cycles (%)	9.4	13.4	8.0	11.1	3.2	3.4
Mean proportional rut depth (%) (PRD <sub>10K</sub> )	11.4		9.5		3.3	





# WATER SENSITIVITY

## Water sensitivity of asphalt mixtures

EN 12697-12:2008 - "Bituminous mixtures - Test method for hot mix asphalt. Part. 12 - Determination of the water sensitivity of bituminous specimens

6 cylindrical specimens of each type of asphalt mixture prepared

For each type of mixture 3 specimens with similar characteristics according to their height and bulk density were assigned to two groups

All specimens are compacted within the same week, and thereby have similar ages when tested, as required in the standard

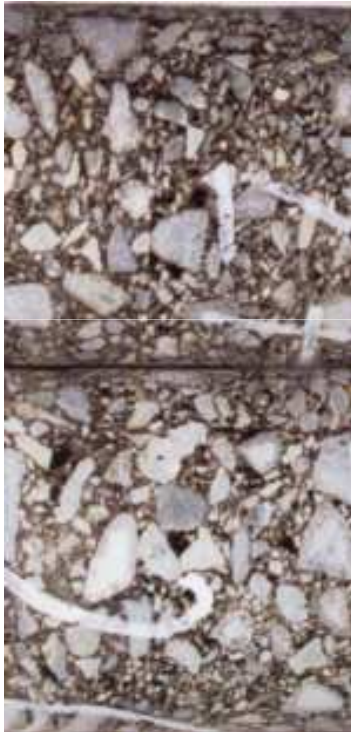
One of the test group conditioned in air at a temperature of 20°C

The specimens from the other group were immersed in water at 20°C and subjected to vacuum, so that the water penetrated into every pore

They were subsequently kept in a water bath at 40 ° C, for a period of 68 to 72 h

After conditioning, the specimens were tested to determine the indirect tensile strength at a temperature of 15°C, as recommended in EN 13108-20

# WATER SENSITIVITY



Bituminous mixtures	Quantities	Dry specimens	Wet specimens
MB 35/50	Mean bulk density (SSD) (kg/m <sup>3</sup> )	2397	2399
	ITS (kPa)	1259	1123
	ITSR (%)	89	
MB PB 1,5	Mean wet bulk density (kg/m <sup>3</sup> )	2390	2396
	ITS (kPa)	1498	1074
	ITSR (%)	72	
MB Kero	Mean wet bulk density (kg/m <sup>3</sup> )	2401	2397
	ITS (kPa)	1378	1289
	ITSR (%)	94	

**LEGEND:**

IRS – indirect tensile strength

ITSR - retained strength



# FINAL REMARKS

The use of modified bitumen specially developed to improve resistance to fuel allow for the use of asphalt mixtures in areas where fuel spillage is likely to occur.

The resistance to fuel spillage of these mixtures was evaluated with EN 12697-43 test method, where 3 asphalt mixtures with different bituminous binders were compared.

The improvement of resistance to fuel was more significant in the second test phase – the brushing phase - which simulates the abrasive effect of traffic on the surface of the pavement layers subjected to the action of fuel.

The results obtained from complementary tests showed that the use of this type of bitumen does not compromise other performance characteristics, such as permanent deformation performance or water sensitivity.

In fact, MB Kero presented a better behaviour than the asphalt mixtures made with conventional bitumen or with the PB 1.5 modified bitumen.

