MAINTENANCE OPERATIONS IN ORDER TO INCREASE THE COMFORT AND SAFETY OF DRIVERS AND NEIGHBOURS ON HIGH CAPACITY ROADS WITH POROUS ASPHALT SURFACE LAYERS.EXPERIENCES ON THE A-52 RIAS BAJAS MOTORWAY.OURENSE.SPAIN

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ABSTRACT

Given the proliferation in the last decade of roads with porous asphalt surface layers, the concern of the Spanish Road Network Administration insofar as maintenance and repairation works in order to meet the growing demands of drivers and neighbours is ever greater. In this paper the maintenance works carried out on the A-52 Rías Bajas motorway by the Public Works Ministry's State Road Network Unit in Ourense are analysed.The work carried out has consisted on the one hand of the auscultation of the road surface of the motorway mentioned above carried out over a three-year period in order to measure the skid-resistance coefficient, the surface texture and the on-site permeability of the draining surface layer and its evolution throughout time.The surface of the motorway was also repaired several times by means of repair methods that did not reduce the values of skid resistance, texture and on-site permeability obtained. In this paper, the results obtained from the auscultation measurements will be developed.The repair methods, which depend as much on the volume of surface to be repaired as well as the conditions of use of the road, will also be carried out. Lastly, a comparison between both methods will be made, studying the texture and permeability of the repairs carried out, recommending a porous asphalt surface layer repair method which respects the initial parameters of the layer of the wearing surface layer in order to meet drivers' comfort and safety needs.

KEY WORDS
MAINTENANCE /COMFORT /SAFETY /TEXTURE /PERMEABILITY.

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1. BACKGROUND.

One of the main concerns of a road engineer is the adhesion of the vehicle's tyres to the road surface.

The characteristics of the surface which contribute to skid resistance and accidents prevention are the main surface irregularities known as micro-texture and macro-texture.

In order to ensure a high level of tyre adhesion to the surface, a certain micro-texture or rugosity of the road surface is necessary, as well as a sufficiently thick macro-texture at high speed and in wet conditions so that excess water can drain away quickly.

2.- OBJECT OF THE STUDY.

From May 2001 to the present day the Unit of State Roads in Ourense has carried out a series of tests on the A-52 Rías Bajas Motorway in Ourense (Spain) in order to analyse both its micro-texture, macro-texture and permeability values as well as their evolution over time.

Several test campaigns were carried out on the surface of this Motorway, using repair methods aimed at not reducing skid resistance, texture and permeability values obtained "on site”. During the repair work it was possible to measure on site the abovementioned skid resistance coefficient, surface texture and permeability values of the sections repaired and the adjoining sections which have served to study the suitability of the repairs carried out.

The on-site tests carried out were the following:

- Skid Resistance Coefficient (pendule TRRL, in accordance with NLT-175/98).
- Surface texture (Sand circle method, in accordance with NLT-335/87).
- On-site permeability (Permeameter LCS, in accordance with NLT-327/88).

These tests complete the texture values obtained during the SCRIM programmes carried out by the Spanish Road Administration in February 1999, as well as the the CPA values obtained during the construction of the different stretches of the abovementioned A-52 Motorway.

3.- METHODOLOGY OF THE AUSCULTATION PROGRAMME.

It was necessary to follow the methodology set out below in order to carry out this study:

3.1. The establishment of homogenous stretches.

Six homogenous stretches were established in accordance with the following data:

- Nature of the aggregates.
- Similar IMD
- Date on which the stretch of Motorway came into service.
- Similar layout.

3.2. Study of the road wearing surface characteristics of the different stretches.

In the 6 stretches chosen the following aspects were studied:

- Characteristics of the aggregates used in each mixture.
- Granulometric spindles used.
- CPA of the aggregates.
- CRT obtained in the previous SCRIM programme carried out.
- Type of binder used in each mixture.

Table 1.- Characteristics of the homogeneous stretches.

STRETCH	DIRECTION	LENGTH	TYPE OF MIXTURE	BITUMEN	ARIDES
(219+640-218+000)	Ourense-Benavente	1640	Draining PA-12	BM-3a	Silicious
(208+900-209+380)	Benavente-Ourense	480	Draining PA-12	BM-3a	Silicious
(217+960-218+980)	Benavente-Ourense	1020	Draining PA-12	BM-3a	Silicious
(171+640-172+500)	Benavente-Ourense	860	Draining PA-12	BM-3a	Quartzite with slate
(131+300-131+040)	Ourense-Benavente	260	Conventional D-12	B 60/70	Quartzites
(127+900-127+600)	Ourense-Benavente	300	Conventional D-12	B 60/70	Quartzites

Table 2.- Characteristics of the homogeneous stretches.

STRETCH	DIRECTION	DATE IT CAME IN SERVICE	CRT (%)		TEXTURES mm	
			Average	Range	Average	Range
(219+640-218+000)	Ourense-Benavente	1977	72	+/- 2	1,5	+/- 0,1
(208+900-209+380)	Benavente-Ourense	1977	83	+/- 2	1,4	+/- 0,1
(217+960-218+980)	Benavente-Ourense	1977	71	+/- 2	1,5	+/- 0,1
(171+640-172+500)	Benavente-Ourense	1988	66	+/- 2	1,3	+/- 0,1
(131+300-131+040)	Ourense-Benavente	1977	61	+/- 2	0,7	+/- 0,1
(127+900-127+600)	Ourense-Benavente	1977	63	+/- 2	0,9	+/- 0,1

Table 3.- Characteristics of the homogeneous stretches.

STRETCH	DIRECTION	CPA	GRANULOMETRY SIEVE (% WHITCH PASSES)								
			20	12.5	10	5	2.5	.63	.32	.16	.08
(219+640-218+000)	Ourense-Benavente	.49	10	82	65	21	13	8.6			6.0
(208+900-209+380)	Benavente-Ourense	.49	10	81	64	20	12	8.4			5.8
(217+960-218+980)	Benavente-Ourense	.49	10	81	65	20	13	8.5			8.9
(171+640-172+500)	Benavente-Ourense	.48	10	84	70	18	15	11			4.8
(131+300-131+040)	Ourense-Benavente	.51	10	88	77	56	40	21	15	11	8.1
(127+900-127+600)	Ourense-Benavente	.51	10	87	77	55	41	20	15	10	7.5

3.3.- Monitoring of the adhesion and drainability of the Motorway.

The campaigns carried out and the range of temperatures indicative of the weather conditions prevailing during the work carried out on site were as follows:

Campaign 1 – May 2001 : from 20ºC to 40ºC.
Campaign 2 – November 2001: from 10ºC to 15ºC.
Campaign 3 – May 2002: from 16ºC to 19ºC.
Campaign 4 – June 2002: from 23ºC to 40ºC.
Campaign 5 – November 2002: from 9ºC to 16ºC.
Campaign 6 – March 2003: from 7ºC to 28ºC.

Several readings were made within the test stretches starting from a certain kilometric point and following the direction of the traffic, in 10 sections each one 10m apart. In each section 3 readings were made in the "fast" lane: the outer one, the central one and the inner one.

4.- ANALYSIS OF HOMOGENOUS STRETCHES. CHOICE OF TEST POINTS.

In accordance with what has been commented on above, the following 6 homogenous stretches were taken into consideration:

Table 4.- Homogeneous stretches.

Point	K.P.	Side (Road direction)	Type of mix
1	219+640	Left (Vigo-Benavente)	Drainage PA-12
2	131+400	Left (Vigo-Benavente)	Conventional D-12
3	127+850	Left (Vigo-Benavente)	Conventional D-12
4	172+000	Right (Benavente-Vigo)	Drainage PA-12
5	209+000	Right (Benavente-Vigo)	Drainage PA-12
6	218+840	Right (Benavente-Vigo)	Drainage PA-12

5. RESULTS OF THE ON-SITE TESTS.

The following pages contain tables showing a summary of the results, as well as charts showing evolution in the six points mentioned above.

Table 5.- Skid Resistance Coefficient (Pendule TRRL NLT 175/98)

RIAS BAIXAS A-52 MOTORWAY								
Evolution of the Skid Resistance Coefficient CRD (Pendule TRRL, s/ NLT-175/98)								
Campaign	Date	Point >	1	2	3	4	5	6
		Side >	Left	Left	Left	Right	Right	Right
		KP >	219+640	131+400	127+850	172+000	209+000	218+840
		Type of mixture	PA-12	D-12	D-12	PA-12	PA-12	PA-12
		CPA >	0,49	0,51	0,51	0,48	0,49	0,49
		CRT (%) >	72	61	63	66	83	71
		Range of Temperatures (*)						
1	may-01	20º-40º	63,0	56,2	53,9	64,9	45,8	43,2
2	nov-01	10º-15º	64,3	61,3	57,0	71,8	42,3	40,9
3	may-02	16º-19º	63,0	61,7	65,3	62,7	59,0	54,2
4	jun-02	23-40º	65,5	66,4	56,4	62,7	56,8	63,2
5	nov-02	9º-16º	71,4	71,9	71,8	73,4	59,1	58,3
6	mar-03	7º-28º	64,2	74,1	74,2	69,6	65,1	59,8

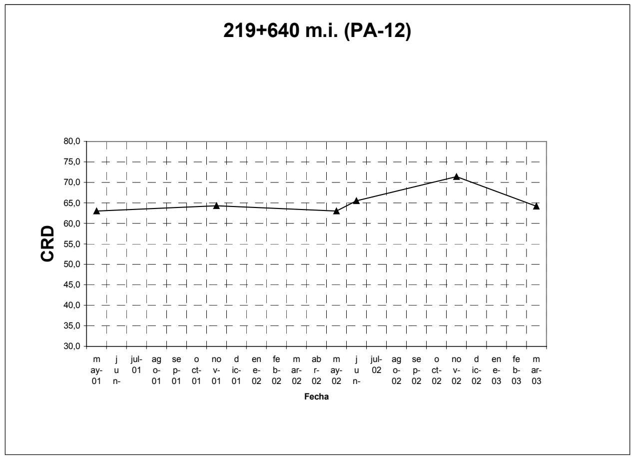

Figure 1- Graphics of the CRD K.P.219+640 MI

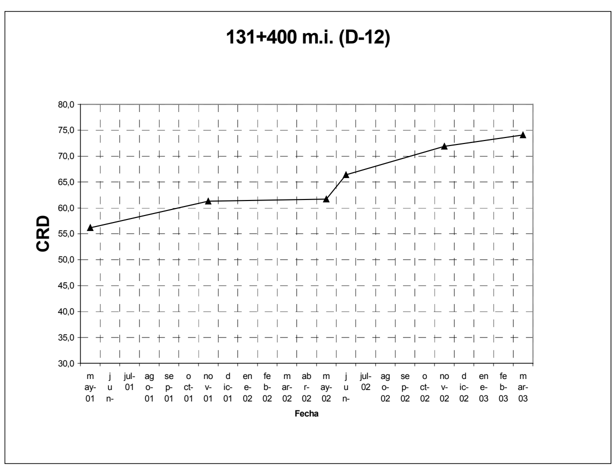

Figure 2- Graphics of the CRD K.P.131+400 MI

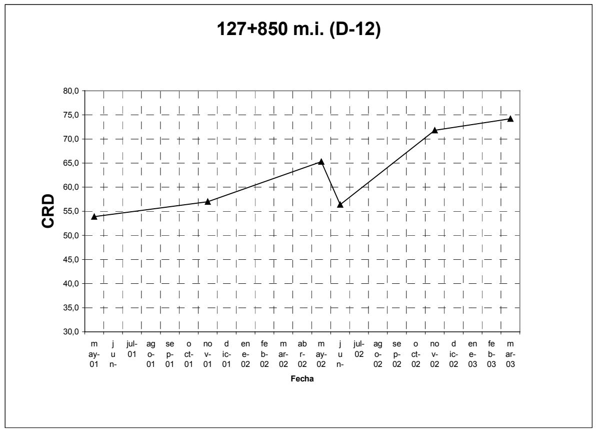

Figure 3- Graphics of the CRD K.P.127+850 MI

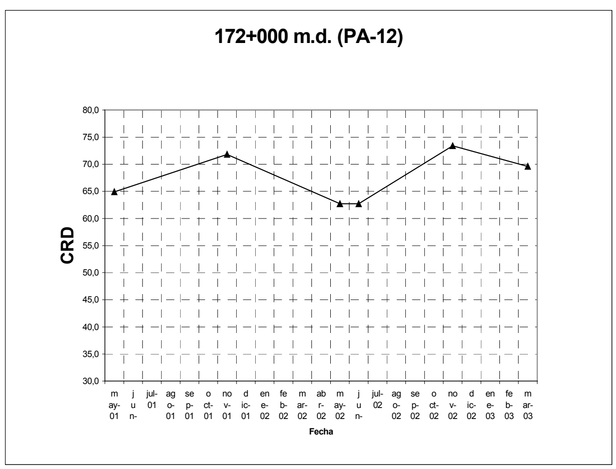

Figure 4- Graphics of the CRD K.P.172+000 MD

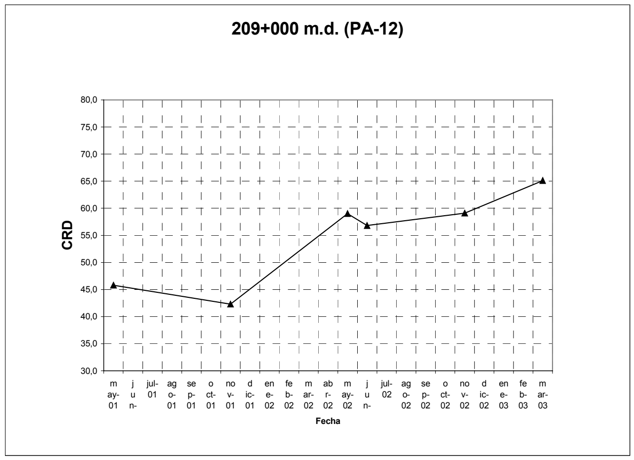

Figure 5- Graphics of the CRD K.P.209+000 MD

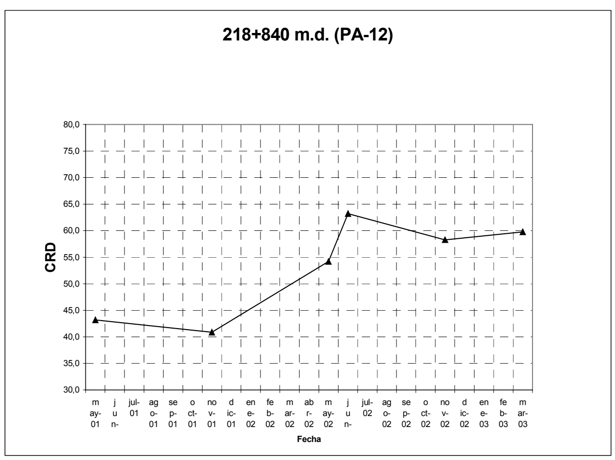

Figure 6- Graphics of the CRD K.P.218+840 MD

Table 6.-Macro-texture measurements (Sand circle method NLT 335/87)

RIAS BAIXAS A-52 MOTORWAY								
Evolution of the macro-texture (Sand circle method s/ NLT-335/87)								
Campaign	Date	Point >	1	2	3	4	5	6
		Side >	Izdo	Izdo	Izdo	Dcho	Dcho	Dcho
		KP >	219+640	131+400	127+850	172+000	209+000	218+840
		Type of mixture	PA-12	D-12	D-12	PA-12	PA-12	PA-12
1	may-01	H (mm)=	2,313	0,386	0,414	2,259	1,844	1,772
2	feb-02		2,606	0,372	0,737	2,279	2,311	2,788
3	may-02		3,756	0,468	0,629	2,087	1,993	1,948
4	jun-02		4,636	0,517	0,611	1,603	2,421	2,075
5	nov-02		3,673	0,647	0,645	1,765	2,315	4,264
6	mar-03		4,074	0,576	0,602	1,841	2,156	1,966

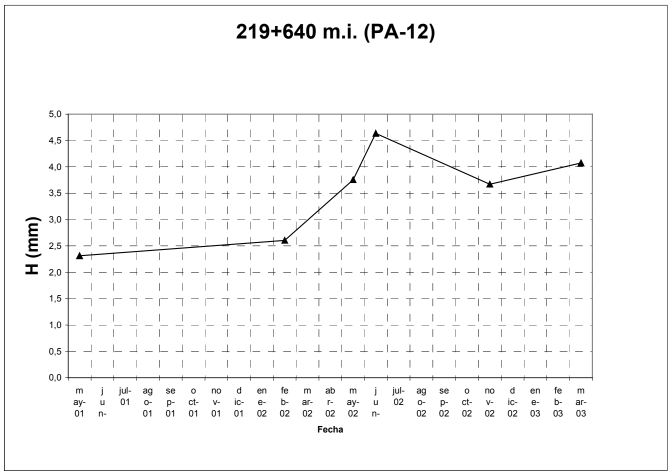

Figure 7- Graphics of the macro-texture K.P.219+640 MI

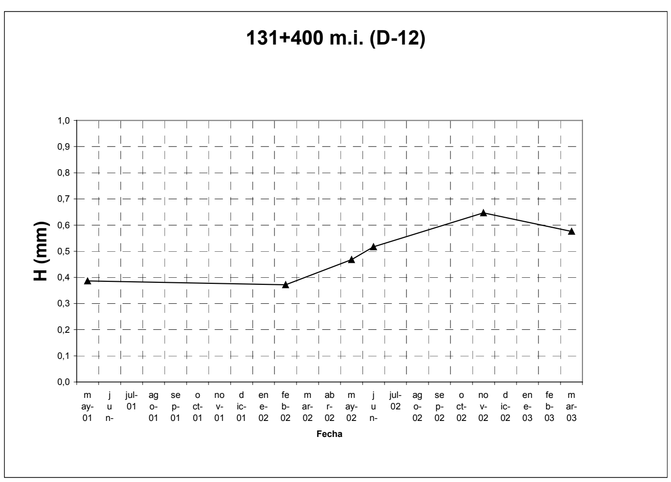

Figure 8- Graphics of the macro-texture K.P.131+400 MI

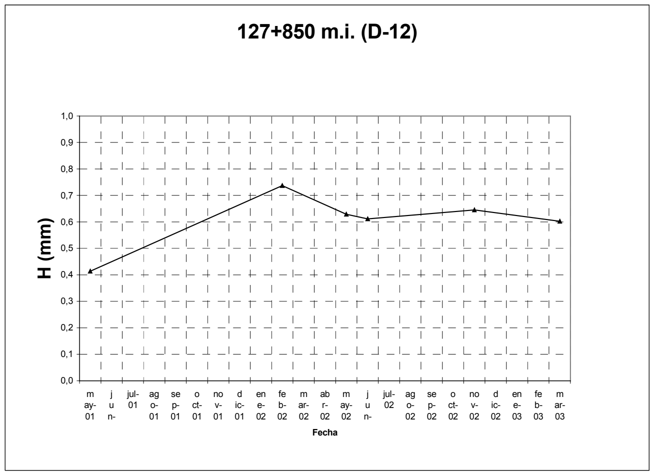

Figure 9- Graphics of the macro-texture K.P.127+850 MI

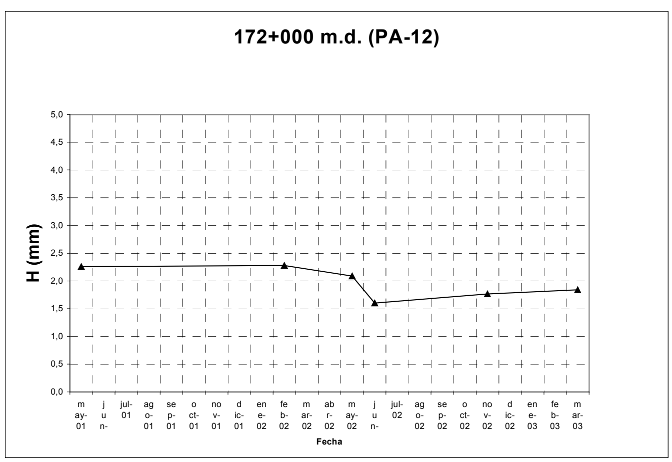

Figure 10- Graphics of the macro-texture K.P.172+000 MD

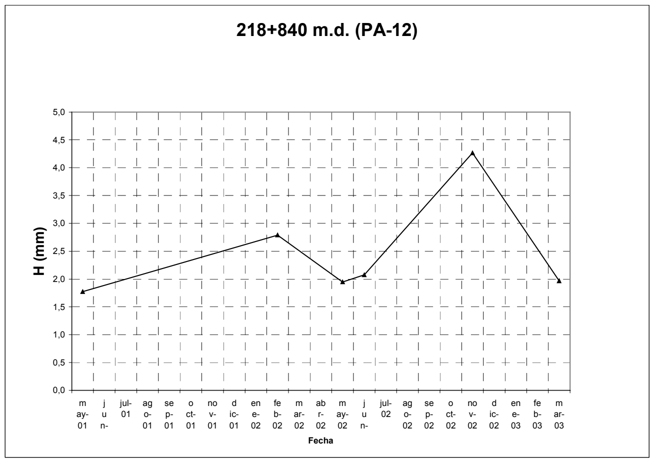

Figure 11- Graphics of the macro-texture K.P.218+840 MI

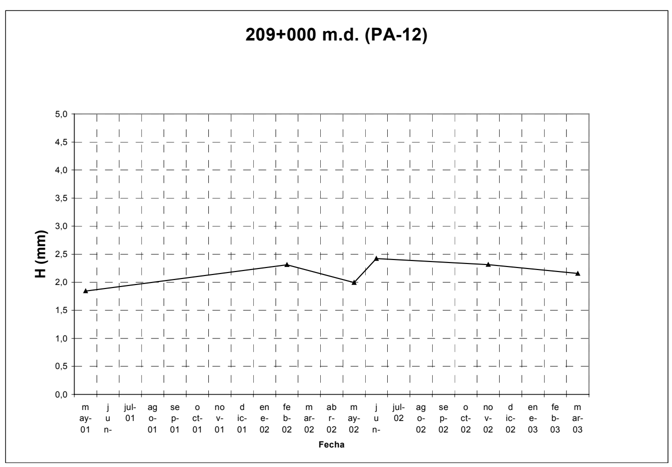

Figure 12- Graphics of the macro-texture K.P.209+000 MD

Table 7.- Permeability on site (NLT-327/88)

RIAS BAIXAS A-52 MOTORWAY								
Evolution of the permeability on site (Permeameter LCS, s/ NLT-327/88)								
Campaign	Date	Point >	1	2	3	4	5	6
		Side >	Left	Left	Left	Right	Right	Right
		KP >	219+640	131+400	127+850	172+000	209+000	218+840
		Type of mixture	PA-12	D-12	D-12	PA-12	PA-12	PA-12
1	may-01	K (cm/s*10^{-2})=	35,46	-	-	38,83	11,89	12,75
2	nov-01		35,16			31,95	10,99	14,11
3	may-02		83,71			16,63	19,33	13,48
4	jun-02		56,51			12,75	10,94	14,46
5	nov-02		117,65			19,09	20,60	19,52
6	mar-03		77,64			20,80	23,32	19,54

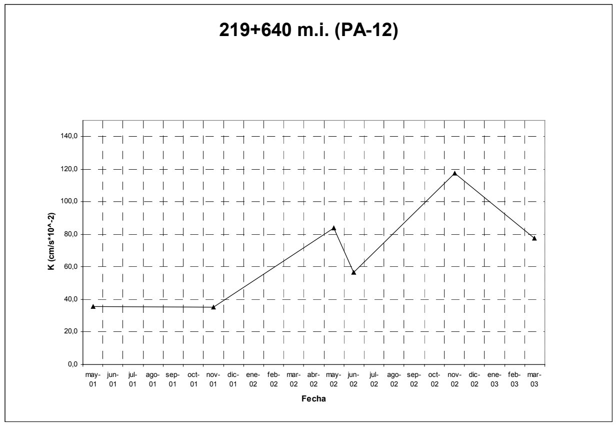

Figure 13.-Graphics of the permeability on site K.P. 219+640 MI

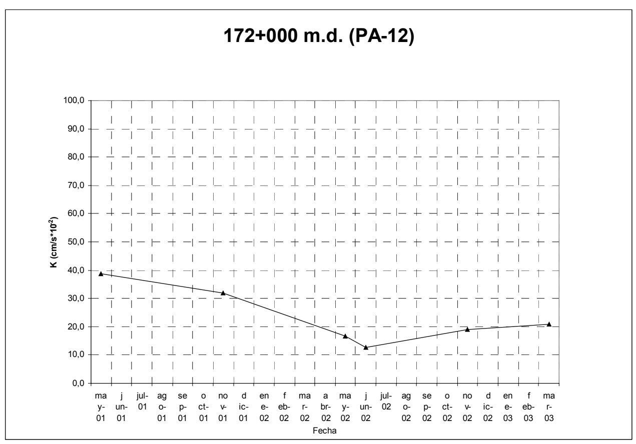

Figure 14.-Graphics of the permeability on site K.P. 172+000 MD

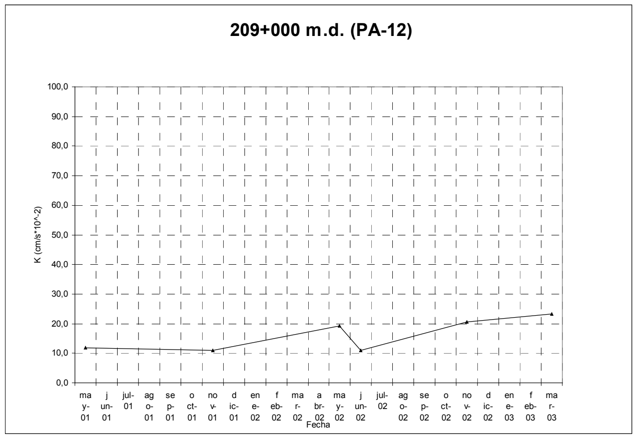

Figure 15.-Graphics of the permeability on site K.P. 209+000 MD

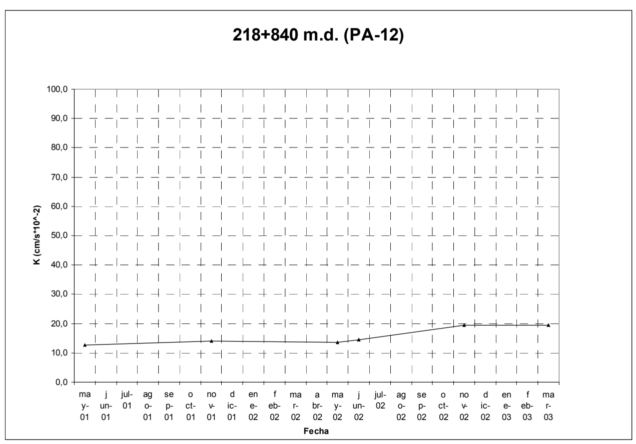

Figure 16.-Graphics of the permeability on site K.P. 218+840 MD

6.- REPAIRS CARRIED OUT TO THE A-52.

Two types of repairs of the A-52 porous asphalt surface layers were done:

Repairs of the surface layer using hot bituminous draining mixture.

Repairs of the surface layer using semi-heated bituminous mixture.

6.1. -Repairs of the surface layer using hot bituminous draining mixture.

A PA-12-type draining mixture was used to carry out the repair work.

The aggregates used in making the mixture were silicious which have a CPA (NLT-174/93) value of 0.51.

The bitumen used was a BM-3b in accordance with the Instructión of hydraulic and hydrocarbon binders of the PG-3.

The bituminous emulsion used as adhesion irrigation was a ECR-2m in accordance with the abovementioned Instruction.

Whilst the repair work was taking place, a manufacturing check was carried out in order to ensure that the work formula was correct.

The sequence set out below was used for the repair work:

- The surface was cut with a milling machine, preventing the formation of fines which are produced by a radial cut, so as not to block the gaps in the draining mixture.
- Thorough cleaning of the open pot with a compressor in order to ensure that any fine left over that might fill the holes is eliminated.
- Use of modified emulsion ECR-2m.
- Organisation of the works to ensure that the mixture reaches the site at the correct temperature.
- Spreading and compacting of the draining mixture.

After these steps were carried out, various series of tests were carried out on three points in order to obtain:

- Skid Resistance Coefficient (NLT-175/98).
- Surface texture (NLT-335/87).
- On-site permeability (NLT-327/88).

The values thus obtained were compared with those tested on adjoining sections, the results being as follows:

Table 8.- Values of the Skid Resistance Coefficient in repairs with draining mixture: pendule TRRL (NLT 175/98)

K.P.	195+735 MD		227+775 MI		240+020 MI	
Campaign	Repaired	Not Repaired	Repaired	Not Repaired	Repaired	Not Repaired
Nov. 2002	80,8	77,7	82,0	81,1	83,2	79,0

Table 9.- Values of the macro-texture in repairs with draining mixture: Sand circle method (NLT—335/87)mm.

K.P .	195+735 MD		227+775 MI		240+020 MI	
Campaign	Repaired	Not Repaired	Repaired	Not Repaired	Repaired	Not Repaired
Nov. 2002	1,74	1,76	1,50	1,57	2,31	1,41

Table 10.- Values of the permeability evolution in repairs with draining mixture (cm/s) x 10^{-2}.

K.P.	195+735 MD		227+775 MI		240+020 MI	
Campaign	Repaired	Not Repaired	Repaired	Not Repaired	Repaired	Not Repaired
Jan. 2002	26,35	13,70	44,83	8,01	43,98	2,27
Nov. 2002	18,74	14,38	26,04	5,25	22,57	$\simeq 0$

As a result of the test campaigns carried out on the repairs it can be observed that the CRD values in the new surface are higher than in the older one.

At the same time, the macro-texture values are similar both before and after the repair work with the exception of k.p. 240+020 MI at which point the difference is considerable.

We can also observe an improvement in drainability in the areas repaired in comparison with those not repaired and a notable decrease in the values obtained as the traffic passes over the sections repaired.

6.2. -Repairs of the surface layer using semi-heated bituminous mixture.

For the repairs carried out a semi-heated type PA-10 bituminous mixture was used.

The aggregates used in making the mixture was of a metamorphous nature (hornfels) which has a 0.57 CPA (NLT 174/93) value.

The emulsion used was a ECMm in accordance with the Instructión of hydraulic and hydrocarbon binders of the PG-3.

The bituminous emulsion used as adhesion irrigation was a ECR-2m-type in accordance with the abovementioned Instructionn.

As the work was being carried out a manufacturing check was made in order to ensure that the work formula was correct.

The repair work was carried out in the following sequence:

- Semi-heated asphaltic mixtures formed by mixing the aggregate heated at 80ºC with the asphaltic emulsion also heated at 60ºC were made.
- Storage of the semi-heated asphaltic mixture for a maximum of 24 hours before being used in the repair work.
- Surface cut with a milling machine, preventing fines from forming.
- Use of ECR-2m emulsion.
- Spreading and compacting of the semi-heated mixture at a minimum temperature of 60º C.

When the repair work was finished, test campaigns were carried out at three points in order to obtain:

- Skid Resistance Coefficient (NLT-175/98).
- Surface texture (NLT-335/87).
- On-site permeability (NLT-327/88).

The values obtained were compared with those tested on adjoining sections, the results being as follows:

Table 11.- Values of the Skid Resistance Coefficient in repairs with semi-heated mixture: pendule TRRL (NLT 175/98)

K.P.	229+300 MD		236+200 MD		189+050 MI	
Campaign	Repaired	Not Repaired	Repaired	Not Repaired	Repaired	Not Repaired
May. 2003	56.4	49.8	47.7	46.8	51.9	52.7

Table 12.- Values of the macro-texture in repairs with semi-heated mixture: Sand circle method (NLT—335/87)mm.

K.P .	229+300 MD		236+200 MD		189+050 MI	
Campaign	Repaired	Not Repaired	Repaired	Not Repaired	Repaired	Not Repaired
Nov. 2002	1.40	1.51	1.42	2.04	1.01	1.81

Table 13.- Values of the permeability evolution in repairs with semi-heated mixture (cm/s) x 10^{-2}.

K.P.	229+300 MD		236+200 MD		189+050MI	
Campaign	Repaired	Not Repaired	Repaired	Not Repaired	Repaired	Not Repaired
May 2003	5.02	6.12	10.17	16.13	Not tested	9.35

As a result of the test campaigns carried out it can be observed that the CRD values for the new surface are higher than in the old one, a lower, although comparable, value being observed at k.p. 189+050 MI.

Furthermore, the macro-texture provides us with widely differing values between the sections repaired and the adjoining ones. This is due to the fact that the semi-heated mixes have a greater draining capacity than the old drainage mix.

At the same time, a higher level of drainability was observed in the repaired sections in comparison with the adjoining non-repaired sections.

As a coda to this method, it has to be said that the repairs show reasonable texture values, even when the permeability of the repair decreases in comparison with the non-repaired adjoining sections. With regard to future repairs using this method, considerably more economical than repairing the surface layer with draining mixtures, more open mixes would have to be designed in order to try to improve permeability in the areas repaired.

7. CONCLUSIONS.

The auscultations of the surface of the A-52 Motorway over the last three years have served to obtain skid resistance coefficient, surface texture and on-site permeability values of the draining surface layer , as well as to study their evolution over time.

Several repair campaigns were designed for the A-52 Motorway's surface, with the aim of not reducing the skid resistance, texture and on-site permeability values obtained. The repair work was carried out using, on the one hand, draining mixtures and, on the other, semi-heated mixtures; in both cases, the quality standards of the surface of the sections repaired were improved with respect to the non-repaired adjoining sections, giving users greater road safety and driving comfort, in accordance with the objectives set out initially.

Lastly, the Unit of State Roads in Ourense will continue to carry out test campaigns on the stretches of motorway mentioned in this study in order to continue analysing the evolution of the quality standards of the surface studied.

Furthermore, the surface repair campaigns to be carried out will be the object of on-site testing in order to ensure that surface quality standards are not lowered, studying their evolution over time in order to be able to choose in each case the motorway surface repair method that best contributes to increasing road safety and driver comfort.