

TEST SECTIONS OF NOISELESS CEMENT CONCRETE PAVEMENTS

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INTRODUCTION

At Herne and Galmaarden, situated at 30 km southwest of Brussels, the pavement of the N255 "Edingen-Ninove", had to be renewed on a length slightly over 3 km.

It is a regional road in a rural environment (less than 5,000 vehicles per day, yet with 12 % heavy freight vehicle traffic) with a single lane of 3 m in each direction.

The Ministry of the Flemish Community, Environment and Infrastructure department, Flemish Brabant Roads Division, seized the opportunity to test noiseless cement concrete pavements by constructing test sections and to compare its acoustic, roads constructional and financial aspects with those of noiseless bituminous pavements. In cooperation with the Belgian road research centre, the research centre of the Belgian cement industry and the civil engineering laboratories of the Louvain and Ghent universities, some concrete mixtures were studied. The contractor improved on the construction techniques which are being implemented for the Flemish Region.

Four different upper layers, each 4 cm thick, were cast upon a continuously reinforced cement concrete pavement with a thickness of 18 cm. Each of these 4 test sections has a width of 2 x 3 m :

1. on the first test section, 834 m long, a porous asphalt 0/14 layer is cast on the continuously reinforced cement concrete pavement with intermediate Stress Absorbing Membrane Interlayer(SAMI), which meanwhile has become a very classical composite pavement;
2. on the second test section, 286 m long, a stone mastic asphalt SMA 0/14 layer is cast on the continuously reinforced cement concrete pavement;
3. on the third test section, 832 m long, an upper layer in fine concrete 0/7 is cast, wet on wet, this being a technique which was already applied in Austria in 1990. The surface treatment of the upper layer is carried out according the "washing-out" method which was improved in Belgium;
4. on the fourth test section, and equally wet on wet, a porous concrete 0/7 is applied. Such an upper layer was already studied in the Netherlands from 1987 on and constituted the subject of an European study project -the BRITE/EURAM project BE 3415- in which the Netherlands as well as Germany and Spain have cooperated.

This test section has a length of 537 m.

The four sections are delimited on both sides by test sections with bituminous construction, yet with different bituminous upper layers.

On one side, a test section, 269 m long, with an upper layer in dense asphalt 0/10 with chippings 10/14. On the other side, a test section, 407 m long, with an upper layer in stone mastic asphalt SMA 0/10.

The results of the test sections with noiseless cement concrete pavements will be commented upon.

CONTRACT SPECIFICATIONS

First, a survey will be given of the principles which are included in the particular contract specifications concerning the under layer in continuously reinforced concrete, the upper layer in fine concrete as well as the upper layer in porous concrete.

When the specifications were formulated regarding the porous concrete, the Dutch contribution "Experiments with porous concrete in the Netherlands" by H.J.C.M. ONSTENK (1) was highly appreciated. It is an interim report of the above mentioned European BRITE/EURAM project BE 3415 of which the final report "State of the art report and recommendations for practice and further developments, BRITE/EURAM project BE 3415, Surface properties of concrete roads in accordance with traffic safety and reduction of noise" (2) was made public in the Netherlands on "Concrete-day" on November 2nd, 1994.

On the basis of the Dutch experience of casting porous concrete top layers on top of the hardened underlayer in continuously reinforced concrete, thus wet on dry, it has been decided to apply the "wet on wet" method only in the test project.

As far as the fine concrete is concerned, the publication in the "Bouwkronek" of January 24th, 1992, "Noiseless pavements in cement concrete - New developments - Austrian experiences" by ir. L. HENDRIKX - VCN (3), was gratefully consulted.

Major Contract Specifications concerning the Underlayer in continuously reinforced concrete with a nominal thickness of 18 cm

- **cement:** CEM I 42,5 LA or CEM III/A 42,5 LA, yet of the same nature as the one used in the top layer in porous concrete or fine concrete; quantity : 375 to 425 kg/m³ of concrete
- **chippings:** porphyry, maximum grain size 32 mm
- **air entraining agent:** the addition is compulsory; the enclosed air content is 3,5 to 6 %, with a distance factor smaller than 0,2 mm
- **longitudinal reinforcement:** diameter 18 mm with a 15 cm intermediate distance, the upper part of the longitudinal bar being 12 cm above the foundation surface
- **transversal reinforcement:** diameter 12 mm with a 70 cm intermediate distance anchorage joints: 4 joints each 0,65 m wide and 0,90 m high at each end
- **compression strength:** the characteristic compression strength amounts up to 52,5MPa; the required average compression strength amounts up to a minimum of (52+1,645.s)MPa (in each case after 90 days and on cores Ø100 cm²)

Major Contract Specifications concerning the Upper Layer in Fine Concrete

- **cement:** CEM I 42,5 LA or CEM III/A 42,5 LA; quantity : 425 kg/m³ of concrete ($\pm 15\text{kg/m}^3$)
- **chippings:** porphyry 4/7, a minimum of 55 % of the sand - aggregates mixture
- **sand:** fine, round grains, in an as low as possible percentage, however without hampering its good processing
- **air content:** 5 %, with a distance factor smaller than 0,2 mm
- **compression strength:** 50MPa (after 28 days and on cubes of 15,8 cm)
- **flexural tensile strength:** 5,5MPa (after 28 days and on prisms of 10cm x 10cm x 40cm)
- **supersmoother:** longitudinal wiper beam compulsory
- **surface treatment:** washing out, during which an average levelling depth of 1,2 mm is aimed at
- **levelness:** with Length Profile Analyser (LPA) : Levelness Coefficient (LC)_{10m} ≤ 70 LC_{2,5m} ≤ 35
- **skid resistance:** with odoliograph: Transverse Skid Resistance Coefficient (TSRC) $\geq 0,45$ at 50km/h.

Major Contract Specifications concerning the Upper Layer in Porous Concrete

- **porosity (accessible hollow spaces):** minimum 25%, maximum 30%
- **chippings:** porphyry 4/7 or 7/10
- **grading:** the grading of the aggregates shows signs of discontinuity
- **polymer emulsion:** polymer mass : 10 to 12 % of the cement mass
- **compression strength:** 18MPa (after 28 days and on cubes of 15,8 cm)
- **flexural tensile strength:** 4MPa (after 28 days and on prisms of 10cm x 10cm x 40cm)
- **splitting strength:** 2MPa (after 28 days and on cores of 100 cm²)
- **dynamic modulus of elasticity:** 20 to 25 GPa
- **compaction index:** 1,20
- **processing:** within the half hour after the mixing
- **protection against dehydration:** waterproof foil during at least 72 hours
- **levelness:** with LPA : $LC_{10m} \leq 70$ $LC_{2,5m} \leq 35$
- **skid resistance:** with odoliograph $TSRC_i \geq 0,45$ at 50km/h.

ACOUSTIC ASPECTS OF THE DIFFERENT TEST SECTIONS

Significant Characteristics of Road Pavements

Literature on acoustics (4),(5) learns that the significant characteristics of road pavements which produce rolling noise are :

- the sound absorption
- the texture
- the levelness, the evenness

The Sound Absorption:

The sound absorption is characterized by the sound absorption coefficient α which is a function of the following parameters :

- the sound frequency;
- σ : the porosity of the upper layer of the pavement in which porosity should be understood as the accessible hollow spaces in the upper layer.
The porosity should be as high as possible, i.e. 20 to 25 % in case of open asphaltic pavements and more than 25 % in case of cement concrete pavements;
- Ξ : the specific flow resistance or the resistance experienced by the air in the upper porous layer of the pavement.
The flow resistance should not be too high, but certainly not too low;
- d : the thickness of the upper porous layer of the pavement;
the thicker the layer, the more the peak of the maximum absorption coefficient will tend to the lower frequencies. It is accepted that the thickness of the upper porous layer, in case of motorways, should be around 40 mm (maximum absorption around 800 Hz);
- χ : the structure factor : this is the number which indicates how much lower the air speed is in the upper porous layer of the pavement than in the air, in other words

$$C_{wearing-course}^2 = \frac{C_{air}^2}{\chi}$$

The Influence of the Texture (5):

- the microtexture, with texture wavelengths $< 0,5$ mm, has no influence on the sound emission (it has on the skid resistance);
- the macrotexture, with texture wavelengths of 0,5 to 50mm, has an influence, especially at high frequencies of 800 to 1000 Hz.
Ideal would be a macrotexture with a high amplitude in case of short texture wavelengths and a low amplitude in case of long texture wavelengths (over 10 mm); a texture wavelength (or a grain size)

shorter than 8 to 10 mm, is considered to be acoustically ideal, a similar texture depth of 1 to 1,5 mm could certainly be considered as a high amplitude;

- the megatexture, with texture wavelengths of 50 to 500 mm, has an influence, especially at low frequencies (under 800 Hz).

The Levelness, the Evenness

in which chiefly the megastructure, and especially the texture wavelengths of 100 to 150 mm, play an important part. In this case, a low amplitude should be aimed at.

The use of a supersmoothen (a longitudinal wiper beam) during the construction of cement concrete pavements, reduces for instance this megastructure.

Acoustical Measurements

In order to compare the acoustical characteristics of the different test sections, the following acoustical measurements were carried out :

Measurements according to the SPB (Statistical Pass By) Method

The principle of this method consists in measuring the noise level peaks of vehicles chosen out of a normal traffic flow as well as the speed of these vehicles as a function of their type (light, average, heavy), using a microphone which is set up at 7,5 m out of the axis of the lane at a height of 1,20 m above the surface. At least 100 cars and 30 other vehicles have to be measured.

The results lead to a regression graph, i.e. noise level peak versus (log)speed, derived from the formula $L_{A,max} = A + B \cdot \log v$ [dB(A)] which in turn leads to a SPBI, a statistical pass by index. The measuring method has been laid down in standard ISO/DIS 11819-1 of 06.02.1995.

The advantages of this method are, amongst others : it can easily be carried out and it is simple; it is representative of the noise of the real traffic; it is accurate and background noises can easily be measured.

The disadvantages of this methode are, amongst others : the method is restricted to a particular area; it only measures values in a section situated opposite to the microphone; the set up conditions imposed by the standard can not always be met with.

Measurements according to the Trailer Method :

The principle of this method consists of 4 different test tyres, on 2 hydraulically adjustable axles, mounted in an acoustically insulated trailer, which passes on each lane at a given constant speed. Microphones are installed above the road surface at 70cm in front of the axle as well as at 70 cm behind it in order to record the rolling noise continuously.

The test tyres are unequivocally laid down in the German publication GEstro-92. The measuring values are the average values taken from 2 rides, recorded by the 2 microphones near the 4 test tyres.

The advantages of this method are chiefly of a practical nature; indeed, this methode allows the swift and continuous measurement, almost without disturbing traffic flows, of long road sections and thus the research on the homogeneity of the acoustic characteristics of a road section.

The disadvantages of this method are, amongst others : there is no unequivocal relation between the noise level recorded by the microphone and the noise level experienced by the adjoining landowners (the so-called house front nuisance) as a result of the interferences occuring during the noise transmission; lorry tyres are not tested.

Measurements according to the α In Situ Measuring System :

The principle of this method consists of an impedance tube installed vertically on a porous road surface; around this tube an additional outer tube, the so-called protectif ring, is installed in such a way that the source signal affects the space between both tubes in the same way as it does affect the space within the impedance tube. As a result, it seems, from an acoustical point of view, that the material, which has to be measured, is enclosed within the inner tube. The absorption coefficient α as a function of the frequency is determined by the cepstrum technique.

The advantages of this method are, amongst others : the method is a non destructive one; it can be carried out by one person, and even under less favorable acoustical conditions (e.g. surrounding noises, wind) it produces results which are immediately usable and reproducible and which are comparable to those of a standard impedance tube (DIN 52215).

The most important disadvantage of this method consists of the fact that it is not (yet) standardized; it has been presented in 1994 during the second international symposium "Transport Noise and Vibration", St. Petersburg, Russia.

The Dynamic Laser Profilometer

Following on the acoustical measuring, the texture of the different road pavements was measured with a Dynamic Laser Profilometer.

The principle of this method consist of an infrared laser distance measuring device, suspended in the bottom of a car which travels at a speed of 36 km/h, scanning the road pavement at 2 mm intervals.

The zone is scanned over a length of 4 m and the distance between the sections is 16 m, in other words 20% of the road pavement is scanned.

The device covers, considering the short scanning interval of 2 mm, both the megatexture and the macrotexture.

The test method is set down in the ISO standard ISO/DIS 13473-1 of 24.04.1996.

The test has the advantage to allow the continuous quantification with high output and amidst traffic of wave lengths which are beyond the reach of the conventional measuring devices and which are related to the megatexture and macrotexture.

The method also allows to reproduce the results of sand patch tests with an accuracy of $\pm 0,2$ mm.

CHARACTERISTICS AND RESULTS OF THE TEST SECTIONS

The main characteristics and results of the test sections are reproduced in the tables at the end of these report.

FIRST CONCLUSIONS

The test sections in cement concrete were cast in April and May 1996, the bituminous upper layer in August 1996.

It would be premature to jump to definitive conclusions with regard to the behaviour of the different test sections; especially the behaviour on the long term of the pavements with porous concrete and fine concrete as upper layer remains to be seen.

The following conclusions regarding acoustical, road constructional and financial aspects are thus to be considered as first, partly provisional conclusions.

Conclusions regarding Acoustical Aspects

The average arithmetical value of the rolling noise, measured according to the trailer method over the total length of each test section and at 4 different testing speeds, is represented in figure 2.

The rolling noise measured according to the SPB method has been represented as an example in figure 3 with values calculated at 70 km/h; most of the observations were carried out at this speed.

The results of the test sections SMA(0/10) and SMA(0/14) show no appreciable difference. The fine concrete pavement offers positive acoustical results, not only in relation to more coarse concrete pavements but also in relation to bituminous pavements. The constructed cement concrete pavements can certainly be qualified as noiseless pavements and can be compared with noiseless bituminous pavements (figure 2 and figure 3).

The spectral composition of the rolling noise measured according to the SPB method (yet with the microphone installed at a height of 5 m) is represented in figure 4. The results are based upon measurements at 80 km/h with the exception of the test section dense asphalt where they were based upon measurements at 50 km/h, adjusted as the speed increases up to 80 km/h.

The porous asphalt and porous concrete pavements show large variations over the longitudinal section, the extend of the absorption maximum of both porous pavements being rather low; the noise reducing effect, especially with porous asphalt, shows only at high frequencies (>1250 Hz) and too little at low frequencies (<1000 Hz) (figure 4), precise level at which the optimum noise absorbing porous asphalt should compensate the more important part of texture induced vibration.

Conclusions with regard to the Road Constructional Aspects

The continuously reinforced concrete pavement acting as a base course of the 4 different upper layers, has been cast with conventional slipform paver over a width of 3.25 m. The fine concrete upper layer was cast wet on wet on the base course, in other words immediately following on the casting of the base course, equally with a slipform paver with vibrating heads yet over a width of 3 m. The outer edge of 0.25 m is used as a water drain. The works were carried out without any appreciable problems.

The porous concrete wearing course was equally cast wet on wet with a slipform paver with a vibrating beam over a width of 3 m. The length of time between the casting of the continuously reinforced and of the porous concrete had to be adapted in function of the setting of the concrete underneath, in other words strongly depending on weather conditions. A maximum of 4 hours 15 minutes time difference was registered, whereas a minimum of 2 hours appeared to be necessary to avoid the mixing of the base and wearing courses. It has to be noted that the temperature during the casting remained under 15°C which is an advantage when casting porous concrete; this kind of concrete is very heat-sensitive due to the polymer present in the concrete mixture. Laying a plastic sheet on the base course during this interval might lessen the dependence of weather conditions (such as rain). Anyway, the danger subsists that for any reason (such as a mechanical or electric failure of the slipform paver) the casting of porous concrete can not be carried out wet on wet, which would result in an hardened unfinished zone of at least 200 m base course!

Fortunately, the works at Herne and Galmaarden were not hampered by any appreciable problem.

Conclusions regarding the Financial Aspects

Certain road constructional limiting conditions obviously have an indirect influence on the cost of the pavements. The location of the concrete mixing plant, which has to be as close as possible to the construction site (processing within ½ hour), will play a part in the price determination of a porous concrete pavement. These hard to define limiting conditions are left out of consideration when comparing prices which only leaves the material and constructing costs to be taken in account.

A 22 cm thick fictitious continuously reinforced cement concrete pavement is regarded as a reference pavement.

The construction cost of a porous concrete wearing course with a thickness of 4 cm on a continuously reinforced concrete pavement with a thickness of 18 cm can be estimated at 1,4 times the cost of the reference pavement. Adding polymer to the porous concrete mixture means a 25% cost increase. The construction cost of a fine concrete wearing course with a thickness of 4 cm on a continuously reinforced concrete pavement with a thickness of 18 cm can be estimated at 1,1 times the cost of the reference pavement.

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TABLE 1 Characteristics and results of the POROUS CONCRETE					
project		paving width:	2 x 3	m	
		length of test section:	537	m	
mix composition	porphyry crushed aggregate	calibre:	4/7R		
		dry weight:	1350	kg/m ³	
	sand	kind:	0/1		
		dry weight:	50	kg/m ³	
	cement	kind:	CEM IIIA 42,5		
		weight:	320	kg/m ³	
	polymer	emulsion (in water):	64	l/m ³	Mowilith (Hoechst)
		solids:	32	l/m ³	10% by weight of cement
	water		45	l/m ³	
processing		mixer capacity:	1,5	m ³	
		kind of mixer:	forced action mixer		with vertical shaft
		mixture time:	55	s	
		kind of transport concrete:	truck		with open platform
		transport time:	5 to 10	minutes	
		delay between mixing and paving:	10 to 20	minutes	
		delay between paving base and top layer:	2,5 to 4	hours	
		air temperature:	11 to 13	°C	
		curing:	sheet		
		compaction index:	1,39		
		wet density:	2085	kg/m ³	
hardened concrete		layer thickness porous concrete:	44	mm	
		compressive strength:	26,0	MPa	28 days - cubes 15,8cm
		compressive strength:	29,5	MPa	90 days - cubes 15,8cm
		compressive strength:	44,7	MPa	90 days - cylinders 100 cm ²
		flexural tensile strength:	4,4	MPa	28 days - prisms 10cmx10cmx40cm
		splitting tensile strength:	3,9	MPa	28 days - cylinders 100cm ²
		statical modulus of elasticity:	24,2	GPa	
		dynamic modulus of elasticity:	27,2	GPa	28 days - longitudinal
		outflow time:	>14	s	drain capacity
acoustical characteristics		accessible porosity:	19	%	
		max. noise absorption coefficient:	0,65		
		frequency max. absorption:	860	Hz	
		peak width max. absorption:	270	Hz	

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		rolling noise trailer-method:	98,4	dB(A)	120 km/h - 20°C
		rolling noise trailer-method:	94,3	dB(A)	90 km/h - 20°C
		rolling noise trailer-method:	90,8	dB(A)	70 km/h - 20°C
		rolling noise trailer-method:	86,0	dB(A)	50 km/h - 20°C
		SPB-index (microphone at 1,2m height):	76,0	dB	road speed category: medium
		SPB-index (microphone at 5m height):	75,0	dB	road speed category: medium
	texture	MPD (mean profile depth): (laser-profilometer)	2,69	mm	39 km/h
		ETD (estimated texture depth):	2,22	mm	
		L _T (texture level) - 80 mm:	54,3	dB	
		L _T (texture level) - 5 mm:	51,9	dB	
	surface	skid resistance (odoliograph):	0,51		50 km/h - 20°C
		skid resistance (SCRIM):	0,66		50 km/h
		levelness (LPA) LC _{10m} :	52		54 km/h
		levelness (LPA) LC _{2.5m} :	20		54 km/h
		average distance between transverse fissures:	1,63	m	2/12/96

TABLE 2 Characteristics and results of the FINE CONCRETE

project		paving width:	2 x 3	m	
		length of test section:	832	m	
mix composition	porphyry crushed aggregate	calibre:	4/7R		
		dry weight:	995	kg/m ³	
	sand	kind:	0/5		
		dry weight:	700	kg/m ³	
	cement	kind:	CEM IIIA 42,5		
		weight:	425	kg/m ³	
	water		180	l/m ³	
	air entraining agent	kind:	Micro air 100		Master Builders
		volume:	0,6	l/m ³	
	various	kind:	plasticizer		Master Builders 200N
		volume:	0,6	l/m ³	
processing		mixer capacity:	1,5	m ³	
		kind of mixer:	forced action mixer		with vertical shaft
		mixture time:	45	s	
		kind of transport concrete:	truck		with open platform
		transport time:	5 to 10	minutes	
		delay between mixing and paving:	10 to 20	minutes	
		delay between paving base and top layer:	20 to 30	minutes	
		air temperature:	10 to 20	°C	
		curing:	retarding agent +sheet		citric acid
			washing out		
			curing		Rehwa
		consistency (slump):	25	mm	
		VEBE-time:	4,0	s	
		compaction index:	1,27		
		air content:	4,2	%	
		wet density:	2335	kg/m ³	
hardened concrete		layer thickness fine concrete:	42	mm	
		compressive strength:	63,6	MPa	28 days - cubes 15,8cm
		compressive strength:	73,3	MPa	90 days - cubes 15,8cm
		compressive strength:	79,3	MPa	90 days - cylinders 100cm ²
		flexural tensile strength:	5,8	MPa	28 days - prisms 10cmx10cmx40cm
		splitting tensile strength:	5,2	MPa	28 days - cylinders 100cm ²
		statical modulus of elasticity:	39,0	GPa	28 days

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		dynamic modulus of elasticity:	43,5	GPa	28 days - longitudinal
		adhesive strength:	> 5	MPa	to concrete 0/32
		freeze test with deicing	6,9	g/dm ²	losses after 30 cycles
acoustical characteristics		rolling noise trailer-method:	100,8	dB(A)	120 km/h - 20°C
		rolling noise trailer-method:	96,4	dB(A)	90 km/h - 20°C
		rolling noise trailer-method:	92,6	dB(A)	70 km/h - 20°C
		rolling noise trailer method:	87,6	dB(A)	50 km/h - 20°C
		SPB-index (microphone at 1,2m height):	76,0	dB	road speed category: medium
		SPB-index (microphone at 5m height):	76,3		road speed category: medium
	texture	levelling depth (sand patch test):	0,98	mm	
		MPD (mean profile depth): (laser profilometer)	0,74	mm	39 km/h
		ETD (estimated texture depth):	0,60	mm	
		L _T (texture level) - 80 mm:	38,4	dB	
		L _T (texture level) - 5 mm:	39,3	dB	
surface		skid resistance (odoliograph):	0,66		50 km/h - 20°C
		skid resistance (SCRIM):	0,70		50 km/h
		levelness (LPA) LC _{10m} :	61		54 km/h
		levelness (LPA) LC _{2,5m} :	24		54 km/h
		average distance between transverse fissures:	2,15	m	5/12/96

TABLE 3 Characteristics and results of the POROUS ASPHALT

project	paving width:	2 x 3	m	
	length of test section:	834	m	
pavement	layer thickness ZOA-B2:	42	mm	
	outflow time:	>29	s	drain capacity
acoustical characteristics	accessible porosity:	15	%	
	max. noise absorption coefficient:	0,55		
	frequency max. absorption:	1030	Hz	
	peak width max. absorption:	260	Hz	
	rolling noise trailer-method:	98,9	dB(A)	120 km/h - 20°C
	rolling noise trailer-method:	95,0	dB(A)	90 km/h - 20°C
	rolling noise trailer-method:	91,6	dB(A)	70 km/h - 20°C
	rolling noise trailer-method:	87,0	dB(A)	50 km/h - 20°C
	SPB-index (microphone at 1,2m height):	77,1	dB	road speed category: medium
	SPB-index (microphone at 5m height):	76,5	dB	road speed category: medium
	texture MPD (mean profile depth): (laser-profilometer)	2,71	mm	39 km/h
	ETD (estimated texture depth):	2,23	mm	
	L _T (texture level) - 80 mm:	54,1	dB	
	L _T (texture level) - 5 mm:	52,7	dB	
surface	skid resistance (odoliograph):	0,62		50 km/h - 20°C
	skid resistance (SCRIM):	0,76		50 km/h
	levelness (LPA) LC _{10m} :	76		54 km/h
	levelness (LPA) LC _{2,5m} :	23		54 km/h

TABLE 4 Characteristics and results of the STONE MASTIC ASPHALT 0/14					
project		paving width:	2 x 3	m	
		length of test section:	286	m	
pavement acoustical characteristics		layer thickness SMA-B3:	42	mm	
		rolling noise trailer-method:	101,3	dB(A)	120 km/h - 20°C
		rolling noise trailer-method:	97,2	dB(A)	90 km/h - 20°C
		rolling noise trailer-method:	93,7	dB(A)	70 km/h - 20°C
		rolling noise trailer-method:	88,9	dB(A)	50 km/h - 20°C
		SPB-index (microphone at 1,2m height):	80,5	dB	road speed category: medium
		SPB-index (microphone at 5m height):	78,5	dB	road speed category: medium
	texture	levelling depth (sand patch test):		mm	
		MPD (mean profile depth): (laser profilometer)	1,71	mm	
		ETD (estimated texture depth):	1,41	mm	
surface		L _T (texture level) - 80 mm:	52,1	dB	
		L _T (texture level) - 5 mm:	49,1	dB	
		skid resistance (odoliograph)	0,51		50 km/h - 20°C
		skid resistance (SCRIM):	0,72		50 km/h
		levelness (LPA) LC _{10m} :	51		54 km/h
		levelness (LPA) LC _{2,5m} :	20		54 km/h

TABLE 5 Characteristics and results of the STONE MASTIC ASPHALT 0/10					
project		paving width:	2 x 3	m	
		length of test section:	407	m	
pavement acoustical characteristics		layer thickness SMA-C3:	32	mm	
		rolling noise trailer method:	101,1	dB(A)	120 km/h - 20°C
		rolling noise trailer method:	97,1	dB(A)	90 km/h - 20°C
		rolling noise trailer method:	93,5	dB(A)	70 km/h - 20°C
		rolling noise trailer method:	88,8	dB(A)	50 km/h - 20°C
		SPB-index (microphone at 1,2m height):	81,0	dB	road speed category: medium
		SPB-index (microphone at 5m height):	78,7	dB	road speed category: medium
	texture	levelling depth (sand patch test):		mm	
		MPD (mean profile depth): (laser-profilometer)	1,63	mm	
		ETD (estimated texture depth):	1,34	mm	
surface		L _T (texture level) - 80 mm:	51,7	dB	
		L _T (texture level) - 5 mm:	49,3	dB	
		skid resistance (odoliograph)	0,57		50 km/h - 20°C
		skid resistance (SCRIM):	0,75		50 km/h
		levelness (LPA) LC _{10m} :	51		54 km/h
		levelness (LPA) LC _{2,5m} :	17		54 km/h

TABLE 6 Characteristics and results of the DENSE ASPHALT

project		paving width:	2 x 3	m	
		length of test section:	269	m	
pavement		layer thickness:	46	mm	
acoustical characteristics		rolling noise trailer-method:	102,9	dB(A)	120 km/h - 20°C
		rolling noise trailer-method:	98,5	dB(A)	90 km/h - 20°C
		rolling noise trailer-method:	94,7	dB(A)	70 km/h - 20°C
		rolling noise trailer-method:	89,6	dB(A)	50 km/h - 20°C
		SPB-index (microphone at 1,2m height):	80,7	dB	road speed category: medium
		SPB-index (microphone at 5m height):	78,1	dB	road speed category: medium
	texture	levelling depth (sand patch test):	0,93	mm	
		MPD (mean profile depth): (laser-profilometer)	1,07	mm	39 km/h
		ETD (estimated texture depth):	0,88	mm	
		L _T (texture level) - 80 mm:	49,3	dB	
		L _T (texture level) - 5 mm:	44,9	dB	
surface		Skid resistance (odoliograph):	0,59		50 km/h - 20°C
		Skid resistance (SCRIM):	0,78		50 km/h
		levelness (LPA) LC _{10m} :	86		54 km/h
		levelness (LPA) LC _{2,5m} :	28		54 km/h

LIST OF FIGURE TITLES

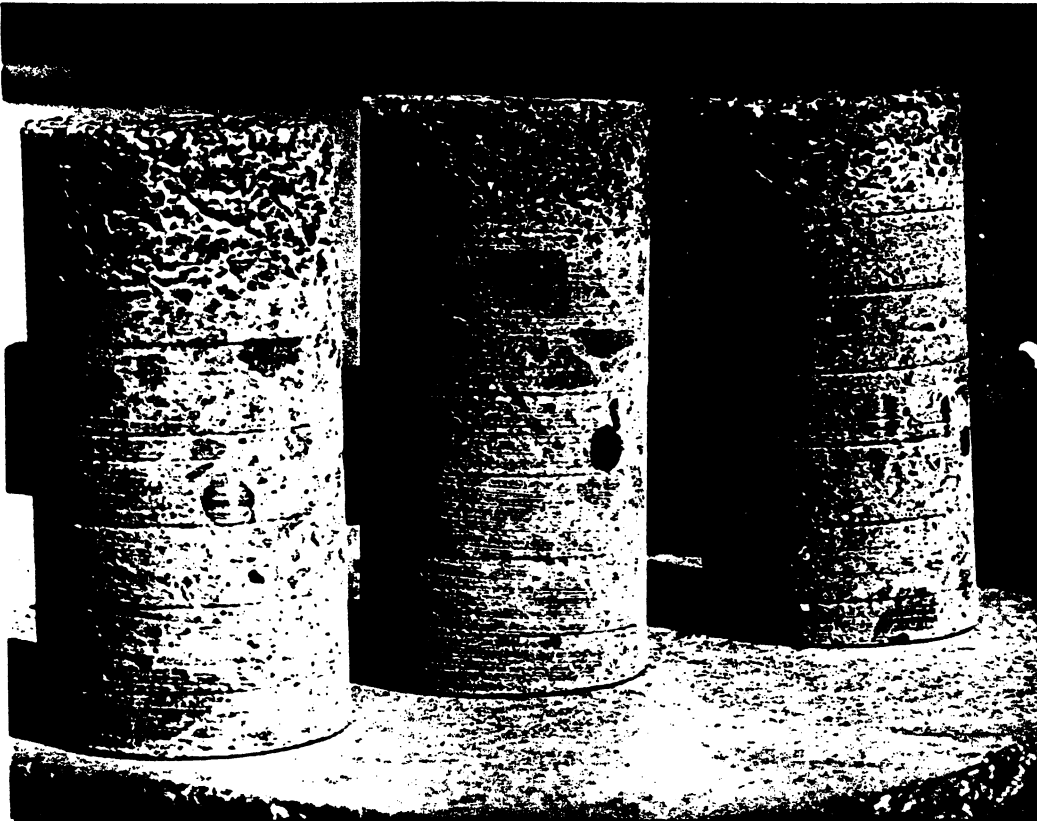
FIGURE 1 Wearing course of 4 cm POROUS CONCRETE

FIGURE 2 ROLLING NOISE according to the TRAILER-METHOD 16.9.1996

FIGURE 3 ROLLING NOISE according to the SPB-METHOD 1996 at 70 km/h

FIGURE 4 SPECTRUMS according to the SPB-METHOD 27.11.1996

FIGURE 1 Wearing course of 4 cm POROUS CONCRETE



ROLLING NOISE according to the TRAILER-METHOD 16.9.1996

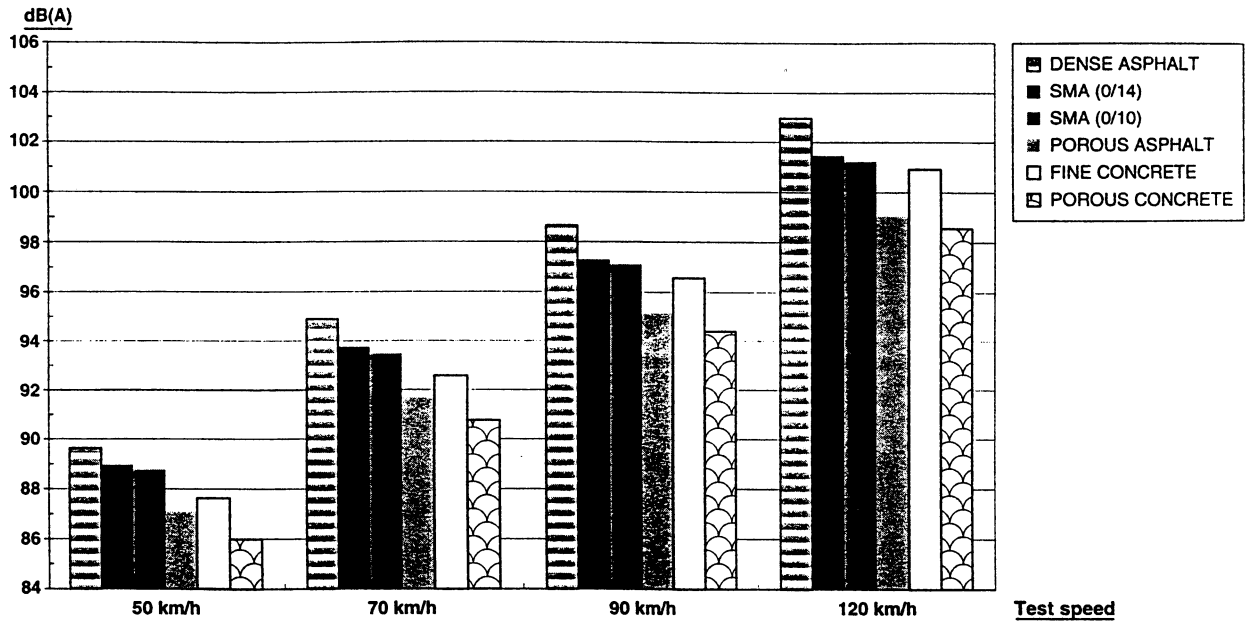


FIGURE 2

ROLLING NOISE according to the SPB-METHOD 1996 at 70 km/h

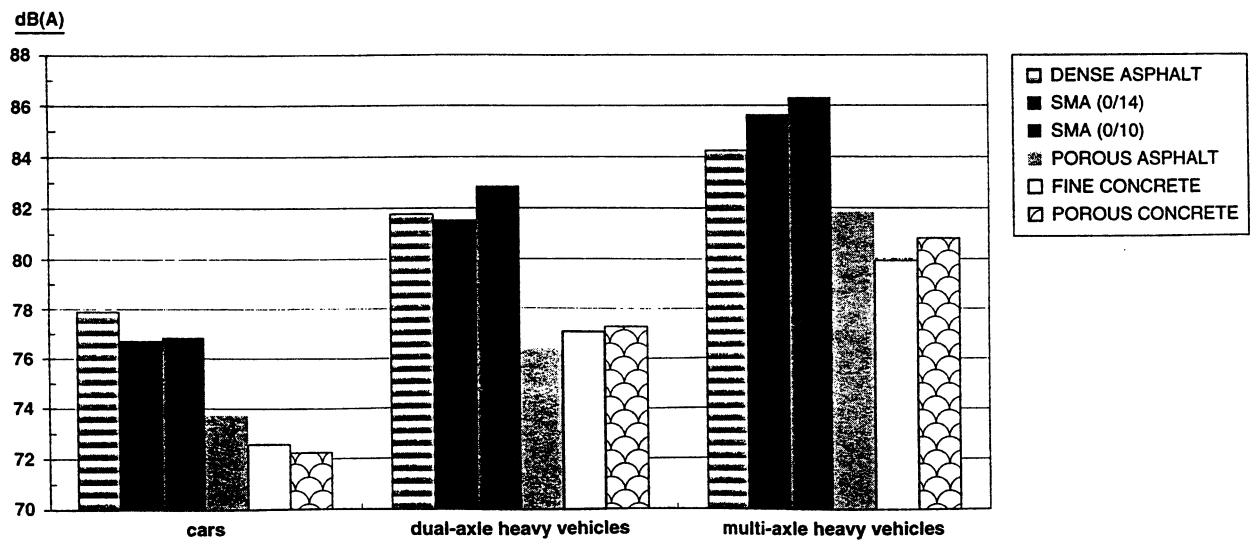


FIGURE 3

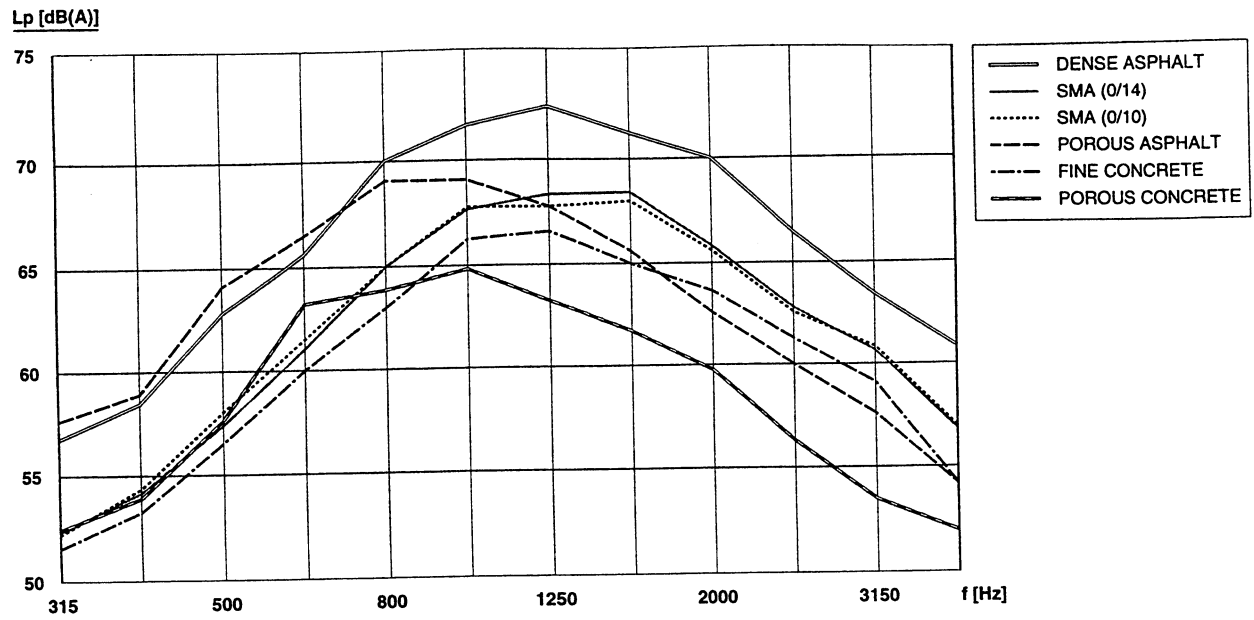
SPECTRUMS according to the SPB-METHOD 27.11.1996

FIGURE 4

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