TWIN-LAYER CONTINUOUSLY REINFORCED CONCRETE SURFACING AT ESTAIMPUIS ON THE N511

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SYNOPSIS

Durability, the absence of deformations and a low level of maintenance when the road structure has been correctly designed and implemented are the features which are generally unanimously approved as regards the qualities of cement concrete surfacing.
In contrast, comfort and driving noise are the characteristics which lead to the most controversy.
A great deal of significant progress has been made in these areas in recent decades and we can notably think of improvements in surface treatments (super-smoothing beam and chemical stripping), the use of fine granulates and fine draining concrete.
In this instance, the options for an experimental twin-layer continuously reinforced concrete surfacing were defined so that the problem referred to could be tackled more effectively.
The main variable was the size of the upper-layer granulates.
Comfort measurements (longitudinal profile analyser) and a series of acoustic soundings will make it possible to evaluate the appropriateness and efficiency of the construction approaches selected.

KEY WORDS

CONTINOUS REINFORCED CONCRETE / MACROTEXTURE / EVENNESS / NOISE

1. INTRODUCTION

The N511 Dottignies (Mouscron district) – Wattrelos (France) is a cross-border link which connects the Belgian and French motorway networks.
It serves developing economic zones and is called on to support significant local and transit traffic.
A section of +/- 1,250 m has already been underway for several years in the commune of Estaimpuis starting from the French border.
Works are underway on end roundabout junctions with continuously reinforced concrete surfacing and these will be finished during 2003.
The surfacing of the road itself was only temporary and it was becoming essential and urgent to lay the definitive surface.
The environment is a country plain, an open rural space which is quite suitable for testing the acoustic performance of road surfacing in good conditions.

2. PROJECT DATA

The total length of the section is 1250m, divided into 4 experimental zones.

The total thickness of the continuously reinforced concrete is 20 cm
The width of the surfacing is 9.50m, concreted in 2 phases : 6.5m for the right side and 4m for the left side.
The essential characteristics of the 4 zones are listed in table 1:

Table 1

Section no.	Length		Lower layer		Upper layer	
	Right side Width 6.5m	Left side Width 4m	Thickness	Size of the granulates	Thickness	Size of the granulates
1	348.85 m	380.85 m	15 cm	0/32	5 cm	0/7
2	321 m	322 m	14 cm	0/32	6 cm	0/10
3	303 m	270 m	12 cm	0/32	8 cm	0/14
4	291.65 m	291.65 m	12 cm	0/32	8 cm	0/20

Apart from compliance with the rules of the RW99 standard specifications in force in the Region of Wallonia, the main technical contractual provisions of the special specifications were as follows:

- The channel was to be concreted simultaneously with the driving surface
- There was no anchoring abutment – This function was to be fulfilled by the continuously reinforced concrete rings of the end roundabouts.
- Concreting was to occur in 2 layers, with fresh concrete on fresh concrete. Implementation was to be undertaken by 2 sliding formwork machines and the distance separating these 2 machines during concreting could not be greater than 20 m. Only the second machine, which had to progress continuously without stopping, was to be equipped with a smoothing beam.
- An air entraining agent was compulsory for the second-layer concrete and the W/C (water on cement) ratio was to be lower than 0.40.
- The surface treatment was to involve a chemical stripping of the stone skeleton. The quality and quantity of the setting delayer had to be adapted to each of the granulometries of the surface concrete. A test range of at least 20 m² has to be implemented.

3. MATERIALS AND COMPOSITION OF THE CONCRETE

The cement used was specified as CEM III/A 42.5 N LA.
The crushed materials of the lower and higher layers were porphyry.
The concrete compositions as communicated by the concrete centre are listed in table 2.

Table 2

Concrete	Lower	Upper			
	0/32	0/20	0/14	0/10	0/7
20/32 crushed porphyry	450	-	-	-	-
2/20 crushed porphyry	720	-	-	-	-
7/20 crushed porphyry	-	750	-	-	-
7/14 crushed porphyry	-	-	730	-	-
7/10 crushed porphyry	-	-	-	730	-
2/7 crushed porphyry	-	375	355	345	1060
0/4 large river sand	385	485	485	485	485
0/1 fine sand	300	200	200	200	200
Cement	395	420	435	440	450
Plasticiser	2.4	2.5	2.6	2.6	2.7
Air-entraining agent	0.15	0.15	0.2	0.2	0.2

The air-entraining agent and plasticiser additives were added at the centre.

3. EXECUTION

This site was specially planned to coincide with a visit to Belgium by a technical mission on the design and construction of concrete roadways, organised by the AIPCR-Quebec Committee and the Quebec Ministry of Transport.
This mission, which lasted from 9 to 13 June 2002, was led by Ms. Anne-Marie Leclerc, assistant deputy minister and general director of Infrastructure and technologies at the Ministry of Transport.
The mission's technical coordinator was Mr. Nelson Rioux, Head of the Roadways appraisal section and chairman of the AIPCR C7/8 committee on roadways.
Prior to implementing the continuously reinforced concrete, the road, which had been in service for several years with a temporary bituminous surface, was repaired on a search-out basis.
These repairs covered the thin concrete foundation and the existing surfacing was profiled by milling.
Moreover, the entire item was covered with a new layer of a 6 cm thick bituminous coating (intermediate layer).
The work was undertaken in atmospheric conditions which could be viewed as favourable overall for a cement concrete surfacing site, to the extent that the temperatures were hardly clement in a generally quite summery period.

4. TESTS ON CONCRETE

Several tests were carried out, both on the materials and on fresh and hardened concrete. The tests carried out on the concretes, as well as the references for the methods adopted are listed below:

4.1. Tests on fresh concrete

These tests were carried out with the help of a mobile laboratory located at the execution site.

- Slump-Subsidence NBN B15-232 (1st edition March 1982)
- Vébé NBN B15-234 (1st edition March 1982)
- Wet Volume Mass (WVM) NBN B15-213 (2^{nd} edition March 1982)
- Air content: NBN B15-224 variable pressure method (1st edition October 1970)
- Water content by rapid burning (< 45 min) on a gas stove (T > 350 °C) of a ± 12 kg sample of concrete

4.2 . Manufacture of specimens for tests on hardened concrete and conservation

- Cubes with 15 cm rib (steel moulds)
- Slabs of (40 x 30 x 15) cm^3 (wooden moulds)
- Manufacture on site on a vibrating table
- Test tubes kept in covered mould for 24 h on site, then in the laboratory after removal of mould at T = 20 °C and H.R. ≥ 95 %

4.3 . Tests on hardened concrete

- NBN B15-220 compression (2nd edition January 1990) on cubes and cylinders (S=100cm²) drilled in the slabs. The butt ends of the cylinders were adjusted with a diamond grindstone.

5. TEST RESULTS ON CONCRETE

The average results obtained from fresh and hardened concrete are summarized in tables 3 and 4.

Table 3 – Tests on fresh concrete

	Slump (mm)	VeBe (s)	WVM (kg/m^3)	Air (% vol.)	Water (l/m^3)
Lower concrete 0/32	15	5,5	2358	3,5	183
Upper concrete 0/D	31	4	2346	3,4	202

For a road of the first network (heavy traffic more than 2000 vehicles every day and for each direction), the contractual requirements (resistance to compression, after 90 days on cylinders, in MPa) are :

- Characteristic resistance R'bk : 50
- Minimum average resistance R'bm,min : R'bk + 1,645 Sr
  (Sr = standard deviation)
- Minimum individual resistance R'bi,min : 0,85 R'bm,min

Table 4 – Tests on hardened concrete

	Requirements (min.)	Results
R'bm	56,54	68,62
R'bi	48,06	62,4

6. TESTS ON FINISHED SURFACING

The different finished surfacing sections were subjected to traditional tests to measure roughness (TFC – transversal friction coefficient measured with the odoliograph equipment) and evenness (EC – evenness coefficient measured with the longitudinal profile analyser).

The first obtained results are summarized in the tables 5, 6 and 7.

Table 5 – Roughness measurements

	Section 1 0/7	Section 2 0/10	Section 3 0/14	Section 4 0/20
Average TFC	0,66	0,70	0,69	0,62

Table 6 : Evenness measurements – EC 2,5 m by 10 m

	Section 1 0/7	Section 2 0/10	Section 3 0/14	Section 4 0/20
Average EC	15,15	16,2	14,7	17,05

Table 7 : Evenness measurements – EC 10 m by 20 m

	Section 1 0/7	Section 2 0/10	Section 3 0/14	Section 4 0/20
Average EC	33,3	31,4	28,95	41,05

7. ACOUSTIC MEASUREMENTS

As annouced in the introduction, the N511 road is a cross-border road link between France and Belgium.
At the moment to stop writing this paper, the works of the border section between the two countries are still running and the traffic is very local.
The acoustic measurements to compare the noise levels of the different sections will be relevant after putting the road link into service.
However, a reference situation has been recorded during June 2003 by placing stand microphones, on each side of the pavements (7,50 m from the measured lane axis and 1,20 m high – Norm ISO 11-819-1).
The obtained results are given in the table 8.

Table 8

	Lane France to Belgium				Lane Belgium to France			
Section 0/D	4/7	7/10	10/14	14/20	4/7	7/10	10/14	14/20
Noise level dBA	79,5	80,9	80,0	80,6	78,7	80,3	79,6	80,1

8. CONCLUSIONS

8.1. Materials

The results with the materials laid can be considered as very satisfactory.
They undoubtedly reflect a high degree of vigilance and a constant concern for quality in preparing and monitoring the work.

8.2. Finished surfacing

The roughness and evenness results certainly show that the surfacing is offering an excellent security level and a very high-performance driving comfort.
The best evenness values are obtained with the 0/14 concrete. Following an initial analysis, this seems to be directly linked to the option of concreting in 2 layers.

By only working on a reduced thickness, the machine with the smoothing beam for the upper layer was able to use more of its energy to complete the finish.

8.3. Acoustic performance

As far as the acoustic measurements are concerned, the results of the reference situation seem to be the best with the 4/7 and 10/14 concretes.
The comparison will have to be more analysed after putting the road link into service.