RN61 – Mons – Tournai Road – Bury Braffe Section
A modest renovation becoming a long life pavement

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Summary

The Mons Highways Department has been researching and applying cement concrete road pavements for several decades, and one outcome of this is a particularly remarkable section of roadway which, after almost 40 years, still provides all the required characteristics of stability, comfort, and safety, in return for very low maintenance costs.

In 1968, the state of the road, of which the pavement consisted of either simple cobblestones or cement concrete slabs, with no base layer, was quite appalling.

The conditions for an experimental rehabilitation, consisting of laying a CRCP overlay over a length of 3 km, were defined jointly with the BRRC (Belgian Road Research Centre) and the Cement Industry Research Centre.
This overlay was divided into 6 sections, all with different reinforcement characteristics.

In 1996, in other words almost 30 years after this work had been carried out, a few localised repairs were carried out and the road, which by then had become regional highway N50, was covered with RUMG, an ultra-thin bituminous granular overlay 2 cm thick.

This paper describes all the technical aspects of this project, the relevance of which is then examined using the design software designed in recent years by the Highways Maintenance and Transport Department of the Walloon Region, an application of which was presented at the 8th Colorado Springs Conference in 2005.

Preparation of the Project

In 1968, a delegation of Belgian engineers went on a study mission to the United States, under the aegis of the Ministry of Public Works.
Their aim was to increase their knowledge by studying the methods of overlaying reinforced concrete coatings.
The first Belgian experiment in this field had already been carried out in 1950, at Leuze, on a section of the main road between Brussels and Tournai.
After this mission, several experimental roadworks were planned, one of which was the 1969 renovation work on the RN61.
As can be seen from Photo No. 1, dating from 1968, the state of the roadway, of which the pavement consisted of either simple natural stone cobbles or cement concrete slabs, with no base layer, was particularly bad.
No other photos exist from that time showing the part with the concrete slabs.

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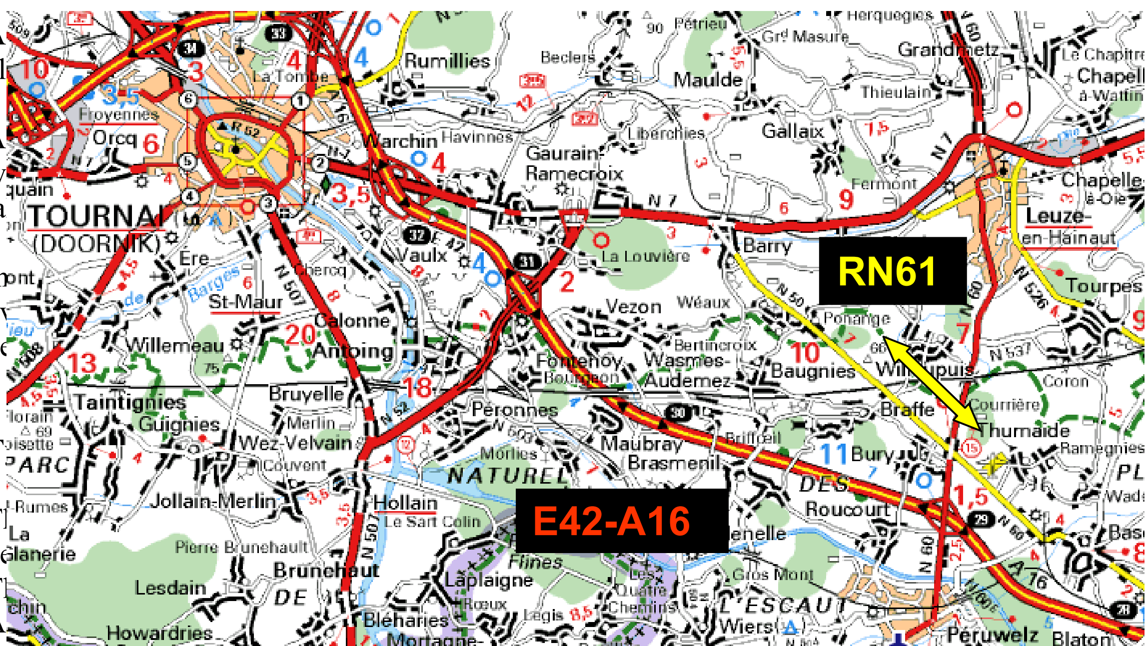
Photo 1 (1968)

The RN61 is on the route between the cities of Mons and Tournai.
This is a region where the operation of limestone quarries, the presence of cement factories, concrete mixing plants, and asphalt plants for the preparation of bituminous products cause intense heavy traffic on the road system.
This is also an agricultural area, with periodic increases in heavy traffic, in particular during the beet season.



all the traffic for their zones.

According to forecasts, this network and the E42-A16 motorway in this region in particular, would only become operational during the following decade, and it was extremely urgent to take action before the RN61 could become completely unusable.

In 1968, the conditions for an experimental rehabilitation, consisting of 3 km of cement concrete overlay, were defined jointly with the Belgian Road Research Centre and the Research Centre of the Cement Industry.

Typical cross-section

The restoration technique decided on was an overlay, which meant giving the existing road a new concrete pavement without having to demolish and replace the existing structure.
The existing pavement was to be used as a foundation, with an intermediate bituminous course at least 4 cm thick to restore the road profile.
Where the road had to be widened, a base course of reinforced lean concrete 30 cm thick was used.

The first 300 metres (on the Tournai side) were made up of slabs of cement concrete to serve as the base for the new surface, again with an intermediate bituminous course.

The overlay was continuously reinforced concrete 20 cm thick, laid in 2 strips 3.5 m wide.

1. **Technical data**

Reinforcement

All the reinforcing bars had improved adhesion, the steel having an elastic limit equal to or greater than 50 kg/mm^2.
The site, exactly 2857 m long, was divided into 6 sections, each having different reinforcement characteristics:

Section 1
- factory-welded mesh: longitudinal bars LB Ø 20mm, spaced at Ls =15 cm and cross bars CB Ø 10mm, spaced at Cs = 31.5 cm.
- narrow mesh (4 meshes over a width of 3.5 m)
- lengthwise staggering of overlapping, making it possible to reduce the number of bars covering a single cross section to 25%
- supports of wire Ø 8 welded to the transverse reinforcements
- total weight of steel in kg/m^2 of pavement: 18.6

Section 2
- tied mesh: LB Ø 20, Ls = 15cm, CB Ø 12, Cs = 100 cm
- crossbars oblique to the line of the road
- total weight of steel in kg/m^2 of pavement: 17.4

Section 3
- factory-welded mesh: LB Ø 20, Ls = 15 cm, CB Ø 10, Cs = 31.5 cm
- wide mesh (2 meshes over a width of 3.5 m)
- longitudinal overlapping following an oblique of 60° in relation to the line of the road
- supports of wire Ø 8 welded to the transverse reinforcements

- total weight of steel in kg/m² of pavement: 18.4

Section 4
- tied mesh: LB Ø 20, Ls = 15 cm, CB Ø 12, Cs = 100 cm
- total weight of steel in kg/m² of pavement: 17.3

Section 5
- factory-welded mesh: LB Ø 20, Ls = 15.cm, CB Ø 12, Cs = 50 cm
- wide mesh (2 meshes over a width of 3.5 m)
- longitudinal overlapping following an oblique of 60° in relation to the line of the road
- supports of wire Ø 8 welded to the transverse reinforcements
- cross bars oblique to the line of the road
- total weight of steel in kg/m² of pavement: 18.7

Section 6
- factory-welded mesh: LB Ø 20, Ls = 15 cm, CB Ø 10, Cs = 40 cm
- narrow mesh (4 meshes over a width of 3.5 m)
- staggering of longitudinal overlapping making it possible to reduce the number of bars covering a single transverse section to 25%
- supports of wire Ø 8 welded to the transverse reinforcements
- total weight of steel in kg/m² of pavement: 18.2

It should be noted that, due to the lack of any cross-covering, the weight of steel per m^2 of tied mesh was always less than that of the welded mesh.

Longitudinal joint

The overlay was to be concreted in 2 strips 3.5 m wide.
The specification required a longitudinal joint between the two strips with tie bars of 15 mm diameter, 600 mm long, spaced at 75 cm.
In order not to pierce the formwork, bars bent to 90° were tied under the layer of reinforcements when concreting the first strip.
The bent part of the bars was enveloped in a polyethylene sheet for ease of removal after dismantling of the formwork.

Transverse joints

The only transverse joints were construction joints, vertical and perpendicular to the road axis. At these joints, the longitudinal reinforcement was doubled over 75 cm on either side by rebars of the same characteristics.

Reinforcement sheet level

The specifications required the main reinforcements to be placed at the upper third of the slab, on a single plane parallel to the surface.
The tolerances admitted were 0 cm upwards and 2 cm downwards.

In practice, this requirement meant locating the upper plane of the reinforcement between 60 and 80 mm under the pavement surface

Concrete

The cement used was an ordinary Portland cement P400.
The sand was river sand.
The aggregates were either porphyry (fractions 2/8 and 8/22), or limestone (22/40).
However, over 300 m, the limestone fraction was replaced by a 22/40 fraction of porphyry.

Surface Treatment

The fresh concrete surface was treated by grooving, except over a length of 300m, where the grooving was replaced by shotblasting, carried out at the initiative of the BRRC.
The grade used was either 16/22 or 12/16 mm.

Terminal constructions

As the experimental section with the reinforced concrete overlay was isolated, special terminal devices were designed to absorb expansion at the ends, using 2 different techniques.

These joints essentially consisted of wide rubber joint profiles.
At these joints, the loads were transferred by means of underlying reinforced concrete slabs of 2 m wide and 20 cm thick.
Beyond the end joints, two lightly reinforced concrete slabs, 8 m long, separated by a dowelled expansion joint, took up, by means of friction on the foundation, the longitudinal compressive forces transmitted by the elastic sections.

On one side, the elastic joint consisted essentially of a sheet of neoprene 5 cm thick and 50 cm long, fixed in the reinforced concrete overlay by anchors of 14 mm diameter every 25 cm.

As neoprene is not very compressible, it was essential for the end movements due to the expansion of the concrete to be absorbed by the bond with the base layer and/or transmitted to the first conventional expansion joint, beyond the overlay.

At the other end, the joint, made up of an elastic section, reinforced by a metal plate and anchored into the reinforced concrete by dowels, permitted absorption of movements of 5 cm total amplitude.
It worked either by traction or compression, round a neutral position corresponding to its nominal dimensions.
The maximum horizontal stresses transmitted by this joint were 1.7 T/m.

2. Execution of the Work

Site

The mixing plant had an hourly capacity of 40m^3 concrete positioned and vibrated.
The concrete was applied in a single layer through the reinforcement sheet between fixed formwork and by means of a traditional construction line consisting of:

- one cross spreader
- one vibro-finisher
- one oblique finisher
- one machine carrying out the cross-grooving and automatic spraying of the curing product.

The work took from June to October 1969 and the maximum daily progress of the concreting was 300 m, i.e. 230 m^3 of concrete positioned and vibrated.
On the 300 m where the grooving was replaced by shot-blasting, the shot was spread by shovel casting.
On one of the 2 strips, the damp shot was pre-coated with cement.
Two methods of setting the shot were compared: ramming with wood and a high speed pass with the vibro-finisher with the spreader raised.

Transporting cross-reinforcements

Inspection and monitoring of the site

Many tests and inspections were carried out as the work went on, in particular:
- With regard to the cement: calculation of the specific weight and surface, trials on plastic mortar, chemical analysis of the components
- With regard to the sand: fineness modulus, sand equivalent, water content, granulometric curves
- For the aggregates: granulometric curves, water content

- For the fresh concrete: consistency by slump and VB, water/cement ratio (generally between 0.437 and 0.476)
- With regard to the progress of the work: detailed statement of the quantities produced daily, positioning of joints at end of day, recording of air temperatures throughout the duration of the work

- On the finished pavement: note taken of cracks, and distribution histograms drawn up.

3. Surface renovation

In 1996, almost 30 after the renovation by means of continuously reinforced concrete overlay, the most significant spalling was repaired, and the road, now regional highway N50, received a covering of RUMG, a granular ultra-thin bituminous coating 2 cm thick.
Over the previous years, the whole of the N50 had, little by little, been restored by means of a new CRCP.
In due course, during these works, the end joints of the Barry-Bury experimental section had been dismantled and the concrete made fully continuous.

Photo N50 (2008)

4. Thickness design and evaluation

Over recent years, in cooperation with FEBELCEM, (Belgian Federation of Cement Industry), and the BRRC (Belgian Road Research Centre), the MET (Walloon Ministry of Equipment and Transport) has developed a new design software applicable to rigid, semi-rigid, and flexible roadways.
This tool also makes it possible to handle reinforcing projects using overlay and inlay techniques, with cement concrete or bituminous pavements.

One of the aspects of this software was presented at the 8th International Conference on Concrete Pavements held at Colorado Springs in August 2005 (1).
It was thought to be of interest to test out the relevance of the CRC overlay used in 1969 using the design software developed almost 40 years later.

This test is based on the following hypotheses:

Traffic:
- 1000 lorries per day
- 300 working days a year
- 3% annual growth rate
- 40 years service life
- 3 axles on average per HGV

The climate in the Tournai region:
- average temperature 10.1°C
- frost index 179 in ^{O}C.days
- subgrade assumed not to be susceptible to frost heave

The existing structure:
- the pavement, which is seriously deformed in places, is assimilated to a bituminous pavement 10 cm thick, of modulus equal to 600 N/mm².
- The subbase under the pavement is 20 cm thick and is type 1, i.e. made up of sand or cinders, the upper 10 cm possibly being a non-homogenous mixture of stones and sand
- The underlying subgrade is silty sand.

The performances of 5 structures were calculated:
- 3 with a cement concrete overlay: continuously reinforced concrete, doweled and undoweled slabs (20 cm thick on a 4 cm bituminous reprofiling course)
- 2 with a bituminous overlay: 5 cm wearing course on base courses of thickness of either 12 cm (nominal thickness) or 19 cm (same total thickness as the cement concrete coating on reprofiling layer).

The table below shows the estimated performance of each overall structure, based on the total number of HGVs during the 40-year life-span will be $2,26.10^{7}$

Type of overlay	**Thickness in cm**	**Failure probability (%) after 40 years**	**For a failure probability of 50%**	
			Number of years	**Number of HGVs**
Continuously Reinforced Concrete	20 + 4	0	> 40	$1,83.10^{10}$
Doweled slabs	20 +4	2,9	> 40	$8,34.10^{7}$
Undoweled slabs	20 + 4	100	3	$1,02.10^{6}$
Asphalt	5 + 12	100	5	$1,85.10^{6}$
Asphalt	5 + 19	44,2	> 40	$2,50.10^{7}$

From these data, it seems clear that the projected reinforcement using an overlay of continuously reinforced concrete should, for the 40 year lifespan, make it possible to guarantee a road with no sign of failure.
This is the precise positive result that can now be seen.

5. Conclusions

The modest rehabilitation on the RN61, carried out nearly 40 years ago, provide indisputable evidence of the relevance of the choice of reinforcing technique consisting of an overlay of continuously reinforced concrete, especially in the presence of considerable heavy traffic.
The observations on site, as well as the tests carried out using the design software, are undeniable arguments for this approach.

The basic investment in an overlay is certainly higher at the outset than would be the case of a minor repair.

However, the basic positive aspects of the overlay technique should be remembered:

- the existing roadway does not have to be demolished, which is a bonus in terms of cost and speed of execution
- the re-use of the old structure as a foundation makes a healthy saving in comparison with using new materials
- the new roadway now has a structural capacity which means that it will have a long, or even very long service life.

The various reinforcement projects used in 1969 have been harmonised, leading to considerable technological simplification.
Thus, the welded mesh is no longer factory-made, and the network of reinforcements for the CRC is systematically made up on site by depositing and assembling longitudinal bars on cross supports.

Finally, even though the documents of the time don't mention this, several additional precautions, which are vital for successful overlay reinforcement, should be remembered.
In particular, we should mention:

- taking preliminary measurements of the residual bearing capacity of the roadway, in order to obtain the best data for dimensioning;
- if the road is made up of concrete slabs, these should be stabilised;
- the good condition and, if necessary, improvement of the drainage system of the road-structure.

References

(1) A method introducing deteriorating bond at the interfaces and declining load transfer at the joints in the existing design methods for concrete pavements – A. Jasienski and F. Van Cauwelaert – 8th ICCP – Colorado Springs – August 2005