# UTW: TEST SECTIONS IN FLANDERS

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## 1. Introduction

In recent years, very thin cement-concrete pavements (so-called Ultra-Thin Whitetopping or UTW) have increasingly been applied to asphalt pavements as a maintenance measure in case of surface damage in America, Sweden, France and other countries. The experience gained has been extremely positive and offers considerable potential for application. The technique has attracted attention partly as a result of the problems associated with the formation of ruts and corrugations with which large numbers of road maintenance authorities are faced at areas for stop lines at junctions and bus lanes. A thick topcoat is often not necessary because the damage is actually a surface problem and the road still retains sufficient load-bearing capacity.

## 2. What is UTW?

The technique consists of milling off the worn asphalt layer to a suitable thickness (2 to 10 cm) and covering it with a thin layer of cement concrete (between 5 and 15 cm) that beds firmly into the underlying asphalt layer. UTW is characterised by excellent adhesion between the concrete and asphalt and by the short intervals between joints (between 0.60 and 1.80 m). The repair technique tries to bond the two layers (topcoat in concrete and underlying asphalt pavement) to obtain a composite structure. This allows the concrete layer to be much thinner for the same load compared with a non-adhesive layer.

The monolithic composite structure offers considerable durability for two reasons:

- Thanks to the high material rigidity of concrete, the wheel loads are distributed to the underlying asphalt layer
- The concrete provides thermal protection for the existing structure.

In 2000, the Office of Roads and Transport for Flemish Brabant of the Ministry of the Flemish Community had a test project carried out for the first time in Flanders in this new repair technique at the junction of Woluwelaan and Houtemsesteenweg in Vilvoorde. In 2003, a second junction was repaired in UTW at the junction of Woluwelaan and Kerklaan.

## 3. First UTW test project on the R22 (Woluwelaan) in Vilvoorde

The test section is situated on the R22 Woluwelaan at the junction with Houtemsesteenweg. The junction is equipped with a three-colour traffic-light system and has 2 x 2 lanes 7 m in width with a broad central reservation.

The test section on the R22 had a pavement with a wearing course of 5 cm AB type II and three beds type III of 7, 7 and 5 cm respectively. The sub-base consisted of 25 cm of chippings with continuous grading, on top of 35 cm of sand for sub-grade type 1 with a drain. This section of road dated from 1991. Ruts were clearly visible on the right-hand lane, especially in front of the traffic lights.

Deflection measurements were carried out by the Roads Department using a falling weight deflectometer. At the junction, a cross-section was mapped in both directions using a transverse profilograph and a number of cores were drilled across the axis of the road. Ruts can clearly be seen.

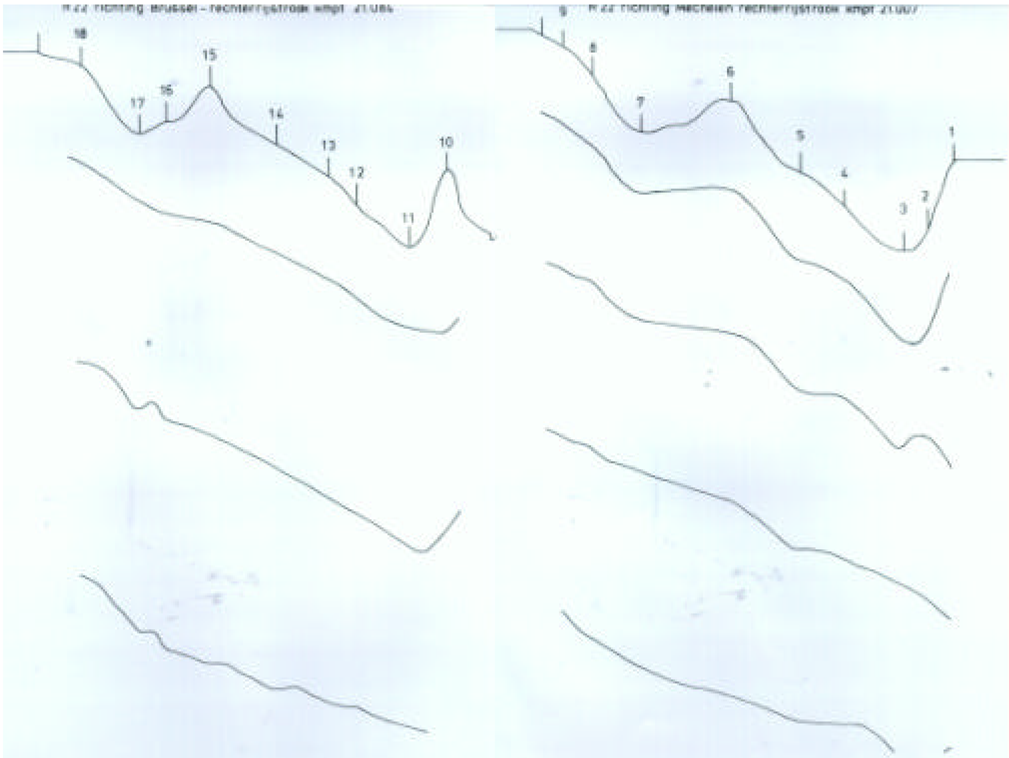


**Figure 1:** Cross-sections at Woluwelaan - Houtemsesteenweg junction mapped using a transverse profilograph. Left: direction Brussels - right-hand lane, km point. 21,084. Right: direction Mechelen - right-hand lane, km point. 21,007.

The results of these measurements show that the formation of ruts is attributable to, and only to be found in the wearing course and that no ruts can be seen in the beds and the foundation. The construction of the road appeared to still be adequate according to the traffic and the base.

### 3.1. The design of the test section

In place of the classic milling off and replacement of the lowest layers by asphalt, it was decided to apply a thin layer of concrete.

Since there is little if any experience of this in Belgium, the project was conducted as a test section. Together with the Roads Department, the Research Centre for Road-Building and the Federation of the Belgian Cement Industry (Febelcem) it was decided to carry out the tests using 3 test thicknesses (10, 12 and 15 cm) and 2 joint intervals (1.16 m and 1.75 m). We thus obtained 5 different combinations:

- d = 10 cm; dimension 1.16 m x 1.16 m (test section 1: Mechelen - Machelen + test section 2: Machelen - Mechelen)
- d = 10 cm; dimension 1.75 m x 1.75 m (test section 1)
- d = 12 cm; dimension 1.16 m x 1.16 m (test section 2)
- d = 12 cm; dimension 1.75 m x 1.75 m (test section 2)
- d = 15 cm; dimension 1.75 m x 1.75 m (test section 1+2)

The general design guidelines for joints in concrete slabs apply to the design of joints in UTW pavements. Thus, for example, the joints in the pavement must be bonded with the joints in the adjacent kerb or road gully, in order to avoid simultaneous cracks in the latter . Various projects in America revealed a wheel load on the joints to be extremely damaging in each case.

The recommended mesh width of the joints follows a square pattern with sides being equal to 12 to 15 times the thickness of the slab. The width of the joints is approximately 3 mm and the depth of the joint is equal to $^{1}/_{3}$ of the thickness of the slab. According to the literature there is no need to fill in the joints.

In UTW, loads are transferred between the slabs via the slide resistance between the granules on the irregular shear surface below the serrated joint. This form of load transfer is highly effective due to the small spaces between joints. Also, the load transfer is not so critical for UTW compared with conventional pavements because the load is transferred to the underlying asphalt pavement. This means there is no need to use dowels, which in any event would be impossible on a practical level. Also, the slabs are not reinforced.

## 3.2. Concrete composition

Apart from one or two differences, the composition of the concrete for a UTW project is the same as that for traditional pavements:

- It is recommended that hard porphyry chippings from stone quarries be used
- A continuous grading with sufficient 4/7 and a limited fraction 7/14. Grains up to 20 mm are also possible, although the use of fine grains makes the concrete easier to work
- The composition is frequently determined by the requirements of re-opening the road to traffic, which means quick-drying concrete is often used, i.e., 425 to 450 kg cement per m³.

The composition of the concrete used is as follows:

- A low water-cement factor, which increases the durability of the concrete;
- Addition of plasticisers to improve the seal
- River sand 0/4 ± 700 kg
- Porphyry chippings 4/7 ± 460 kg
- Porphyry chippings 7/14 ± 555 kg
- Cement CEM III 42.5 LA 450 kg
- Plasticiser ± 1 l
- Super-plasticiser 3 to 4 l
- Water ± 185 l

## 3.3. Points to consider during construction

### 3.3.1. Preparation of the upper asphalt surface

When carrying out the work, particular attention must be paid to the roughness of the asphalt surface (see Figure 2), and the edges must be intact and straight. Milling will produce a sufficiently rough surface, promoting adhesion between the concrete and the asphalt. The milling off must be done in accordance with the granules in the asphalt.

**Figure 2: Flat-milled asphalt surface**

If the milled surface lies between 2 asphalt layers, the milling must be taken a little deeper.

Before the concrete is applied, the planed surface must be thoroughly cleaned, preferably with water and under pressure (see Figure 3).

**Figure 3: Cleaning the planed surface under pressure**

The transition between 2 different thicknesses of the test section was achieved gradually over the length of 1 slab.

Between the UTW pavement and the existing asphalt pavement it is necessary to allow for an over-thickness to allow stress to build up gradually. This transition is necessary at all points in the direction of travel of the traffic (see Figure 4).

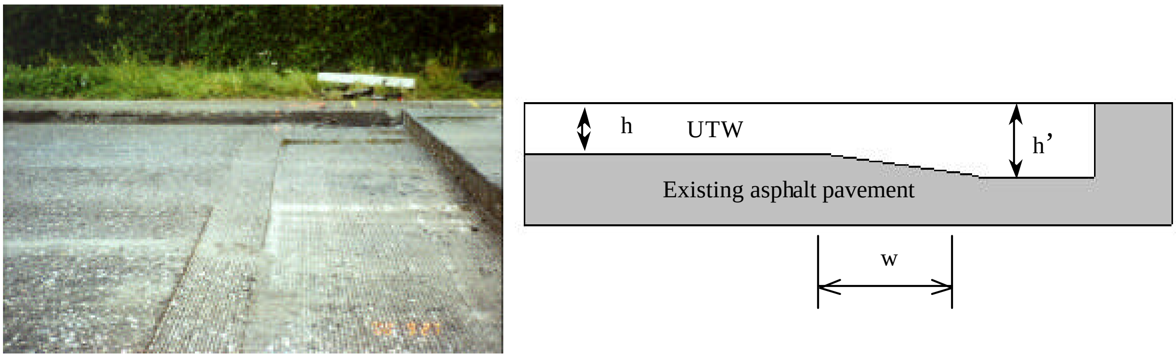


**Figure 4: Transition from UTW to the adjacent asphalt pavement**
**w = ± 2 m; h' = h + 75 mm and min. 150 mm**

### 3.3.2. Concreting

Installing UTW pavements is no different from other concrete pavements. Before pouring the concrete, it is recommended that the asphalt surface be dampened (see Figure 5), so that no water is absorbed out of the concrete.

**Figure 5: Dampening the asphalt surface just before concreting**

Depending on the extent of the repairs, the concrete is laid with a slipformpaver or with a vibrating beam. In Vilvoorde, the test section was produced with a slipformpaver (see Figure 6).

**Figure 6: Production with a slipformpaver**

### 3.3.3. Surface finishing

As far as surface finishing is concerned, all traditional surface treatments can be applied to a UTW pavement. The test section was brus hed transversely.

However, to protect the green concrete properly, the amount of curing compound has to be doubled compared with the normal guidelines.

**Figure 7: Curing the green concrete with curing compound.**

### 3.3.4. Joints

Transverse and longitudinal joints must be cut as quickly as possible to avoid initial stress. If the delay is too long this can lead to uncontrolled edge cracking. Cutting too soon can lead to local chipping of the joints.

It is recommended that cutting be begun as soon as the concrete is dry enough to walk on and that several joint cutters be used simultaneously. The best thing is to first make one or more test cuts to see how the edges of the cut behave.

The contraction joints in the pavement were not filled. The longitudinal and transverse junction between bituminous and cement concrete pavements were carried out by taking away, at the edge of the bituminous pavement and the adjacent cement concrete pavement, of a rabbet with a width of 8 mm and a depth of 20 mm ; the rabbet was filled with a cast filler up to a few mm of the upper surface.

**Figure 8: Appearance of the UTW pavement**

## 3.4. Production

The test section was produced in September 2000.

### 3.4.1. Mechelen - Machelen section: length 177 m (test section 1)

The test section was produced on 19 September 2000. The weather was sunny with a temperature of around 25° C and it was windy.

As a result of supply problems, the road finisher stood idle on several occasions. During the afternoon, a number of diagonal wind cracks were found.

It was decided to first cut 1 joint in 5 to absorb the initial contraction (this was approximately 8 hours after the concrete was poured), and the intervening joints were cut the next morning.

Since the first joints cut had absorbed most contraction, these are wider than the intervening joints. Consequently, these wide joints were filled. The intervening joints were not joint-filled. The joints between the asphalt and concrete were also filled with cast joint filler to prevent water infiltration as much as possible.

Apart from the aforementioned wind cracks, no further cracks were found. The section was re-opened to traffic after 3 days.

### 3.4.2. Machelen - Mechelen section: length 177 m (test section 2)

This section was produced on 27 September 2000. Because the weather conditions were practically identical to those when the first test section was produced, it was decided to reduce the cement content to 425 kg/m³ and add an air-entraining agent at a ratio of 4%.

The supply of the concrete was flawless. The joints were produced in identical fashion. The section was re-opened to traffic after 4 days.

Approximately one month after the section was re-opened to traffic, six cracks were noticed. All but one of the cracks are situated in the first strip or first and second strips alongside the road drain. All these cracks originate in a transverse joint or crack in this drain. Since the UTW pavement was concreted right up to the concrete drain, these behaved as a single whole. The expansion and contraction movements of the concrete road drain caused the crack in the UTW pavement at the joints in the drain. In future it would be better to cut a sound joint across the entire thickness between the drain or marginal strip that is being retained and the UTW pavement.

Due to the improved weather conditions, the addition of an air-entraining agent and the reduced cement content, no cracks appeared in this section after production. The average compression strength measured on cylinders with section S = 100 cm² after 28 days was 66.6 N/mm², compared with 72 N/mm² for the first section. After 5 days, however, an average compression strength of 39.6 N/mm² had already developed.

### 3.5. Behaviour of the first test section

After 3 years, the UTW pavement has behaved reasonably. The wind cracks that appeared in the first section, due to the wind and the large amount of cement (450 kg/m³), did not develop and are stable. In the second section, the sympathy cracks caused by the movements of the joints of the adjacent road drain are also stable.

However, serious cracks appeared in both sections after the junction. There the thickness of the pavement is 10 cm. Some slabs are loose.

The cracks were examined by means of core drilling. This revealed a sufficient adherence between the concrete pavement and the asphalt pavement underneath but also showed that the asphalt layers underneath lost their mutual adherence. An asphalt layer of 1 to 2 cm stuck to the concrete pavement but not to the regulating course.

## 4. Second UTW project on the R22 (Woluwelaan) in Machelen

The second UTW project in Flanders was produced on the same regional road, at the junction with Kerklaan. The junction has the same configuration and road structure as the junction with Houtemsesteenweg. It is the first junction coming off the Brussels ring road at the Vilvoorde exit. Woluwelaan is the main connecting road to a number of industrial estates in Machelen, Vilvoorde and Grimbergen. The junction with Kerklaan is also a major link to a large wholesale centre, distribution firms and the centre of Machelen. Each day there are around 11,500 vehicles in each direction, of which approximately 15% are lorries.

This test section was produced in April 2003. Based on the experiences of the previous test section, a number of changes were made to the design of the pavement.

### 4.1. Geometrical characteristics

Because of the large amounts of traffic, it was decided to increase the thickness of the UTW. One section has a thickness of 14 cm, the other direction a thickness of 12 cm. The thickness of the asphalt pavement (24 cm) allowed this. The remaining thickness of the asphalt pavement is ±10 cm. Deflection measurements here also revealed that the formation of ruts was solely attributable to the top layer and the topmost base. The underlying structure appeared sufficiently strong.

The longitudinal and transverse contraction joints were cut every 1.75 m in a square pattern. Because of the number of joints, several joint cutters were used simultaneously in order to keep the width of the joints to a minimum. Grinding wheels 2.2 mm thick were also used. The contraction joints were sewn up to $^1/_3$th of the thickness of the slabs and were not filled. The joints between the asphalt and the concrete pavement were produced by removing, at the edge of the bituminous pavement and the adjacent cement concrete, a rebate 8 mm wide and 20 mm deep. The rebate was filled with a cast joint filling compound. Strips of bitumen felt were laid across the entire length of the joint in the longitudinal joint between the concrete and the linear elements.

### 4.2. Concrete composition

The Fast-Track principle was also applied here, with a required compression strength of 40 MPa after 72 hours. This meant the junction could be re-opened to traffic 72 hours after the concrete was poured. The composition was as follows:

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|---|---|
| ▪ River sand 0/4 | ± 650 kg |
| ▪ Porphyry chippings 4/7 | ± 480 kg |
| ▪ Porphyry chippings 7/14 | ± 680 kg |
| ▪ Cement: 50% CEM I 42,5 LA + 50% CEM III 42,5 LA | 425 kg |
| ▪ Plasticiser | ± 0,85 l |
| ▪ Super-plasticiser | 4,5 l |
| ▪ Water | ±165 l |

### 4.3. Surface treatment

It was decided to wash the concrete surface. A chemical setting retarder was used that had a protective effect on the concrete. After the setting retarder had been sprayed on the concrete, the surface was still protected by a plastic sheet. The joints were cut around 8 hours after concreting. For this, the plastic sheet had to be removed. Immediately after sawing the joints, the surface was washed by a road-sweeper. The concrete was then protected by means of a curing compound.

## 5. Conclusions and recommendations

The experience of America, Sweden, France and other countries shows that the UTW pavement generally behaves well, even under heavy traffic and is very durable, provided that all preconditions were met.

A thorough preliminary investigation of the existing road structure and the careful application of the following basic principles are an absolute necessity:

- The bond between the concrete overlay and the underlying asphalt is one of the critical elements in reducing stress and guaranteeing durability. For this, it is necessary to start with a clean but rough surface by milling and cleaning with compressed air. The use of a plasticiser and good compaction of the concrete (through the use of sliding shuttering) can also have a positive effect on the bond.
- A second basic principle is the short gaps between joints, between 12 and 15 times the thickness of the pavement. This reduces bending stress in the slab and shear stress between the overlay and the asphalt pavement.
- The remaining asphalt pavement must still be structurally sound (primarily the quality of the asphalt layer), as the asphalt pavement forms the actual load-bearing structure.

In particular, the composition of the concrete and the positioning of the joints must be studied carefully at the design stage. In America, a wheel load in each case on the joints appeared to be extremely damaging. It must also be investigated whether there is any difference in foundation in the area to be repaired.

During production, particular attention must also be paid to the following aspects:

- Dampening the asphalt surface just before concreting
- If fixed shuttering is used, the edges must be well-sealed with a vibrating needle, but preference is to be given to sliding shuttering
- Protection of the green concrete against drying out by spraying on a sufficient quantity of curing compound (min. 200 g/m²)
- Cutting the joints as early as possible, as soon as the concrete is dry enough to walk on
- Joints must be cut to a depth of $^1/_3$ of the concrete pavement and the width of the joints may not exceed 3 mm. Due to the high number, sufficient cutting equipment must be present on site. The best thing is to first make one or more test cuts to see how the edges of the cut behave
- The composition of the concrete must be studied carefully.

Thin overlays/inlays produced with quick-drying concrete can offer interesting prospects for the future. However, this requires a sound preliminary study and a perfect realisation. The rapid re-opening to traffic and the possibility of choosing a surface structure and colour according to the intended use also offer interesting applications in urban environments. The test sections will be monitored in the future in order to draw more reliable conclusions regarding the behavior on the long term.

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