CONCRETE ROUNDABOUTS

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SYNOPSIS
As is the case in several European countries, Belgium is also constructing more and more roundabouts at busy intersections. They offer a better guarantee of a fluent, but at the same time safer, flow of traffic.

The road surface of a roundabout is placed under a heavy load. In addition to horizontal forces, the inclining vehicles also exert large vertical forces which affect the edge of the paving in particular.

To prevent the road surface from distorting through these heavy loads and to prevent the top layer from shifting as the result of horizontal forces, it is recommended to construct the road surface from concrete, concrete slabs and, if possible, continuously reinforced concrete.

1. ROUNDABOUT IN COLOURED, WASHED CONCRETE IN SCHERPENHEUVEL.

The roundabout is located at the intersection of the Basilieklaan (N10) and the Vesten (N212).

1.1. Characteristics
The recent redesign of the centre of Scherpenheuvel largely relates to the renewal of the Noorder and Zuidervest, in which extensive use is made of concrete paving stones which are available in numerous shapes and colours, such as green. By virtue of the heavy traffic resulting in torsional forces, it was decided to make the roundabout, which was actually a small but very important and difficult part of the works, from durable monolithic paving in reinforced cement concrete.

To make the concrete more attractive and street-friendly, coloured washed concrete was used with granulates which have a natural colour of their own, such as grey and green. The main purpose of this technique, which usually involves the use of dyes too, is to obtain colourfast paving.

By using the colours found in the adjacent materials it was possible to integrate the roundabout in the overall project, which was particularly successful thanks to the striking presence of trees.

1.2. Symbolic 7
Since the number 7 has a symbolic significance in Scherpenheuvel, the basilica and surrounding streets are laid in the form of a heptagon, the designer wanted to depict a seven-pointed star in the paving of the roundabout. This was achieved by laying the seven points in washed natural green-coloured concrete.

The roundabout has an inner diameter of 14m and a road width of 6m.

Account being taken of the special configuration of the concrete paving and the relatively high torsional stress that can be created by the traffic, the many partners involved in the project, including the Scherpenheuvel City Council, the Road and Traffic Section for Flemish-Brabant, FEBELCEM/OCCN and the designer, opted for the following construction:
- 7 cm washed coloured concrete;
- 18 cm base concrete C30/37;
- 4 cm bituminous intermediate layer type IIIC;
- 18 cm rough concrete;
- 25 cm sub-foundation type 1.

Due to the special design of the paving, with many sharp corners, it was thought necessary to provide a heavy reinforcement net, i.e. 150 x 150 x 12 mm. This reinforcement was interrupted level with the traffic islands to achieve dowelled contraction joints. Contraction joints, 7-8 cm thick, have been placed in the relatively large areas of grey concrete. A longitudinal joint was also sawn into the middle of the lane.

Since the concrete is heavily reinforced and as it was laid in relatively hot weather, it was not considered necessary to use expansion joints. An insulation joint was applied between the natural stone of the central island and the concrete paving, as well as between the concrete paving stones of the road drains and the concrete paving.
We should also note that to avoid sharp corners around the edge of the paving, the points of the star were truncated.

1.3. Execution

Before starting, a number of preparatory discussions were held with all the parties involved, which certainly appeared highly necessary for a trouble-free and appropriate execution.

The coloured washed concrete was composed as follows:
- Crushed stone (coloured) 4/7 980 kg
- River sand 0/3 720 kg
- Cement, CEM IIIA 42,5 LA 425 kg
- Agent (pigment - air entrainer - plastifier) 25 kg
- Water (total) ± 180 l

1.4. Air Content

This composition gives an air content of a little over 3%, which is normally enough to make concrete with a very high cement content resistant to salt solution; the compression strength measured after 7 days on cores drilled from 40 x 30 x 15 cm slabs made from this concrete, was well over 30 Mpa. After seven days, the compression strength of the base concrete was above 40 Mpa.

The concrete was applied in two layers between two solid formworks, one 18 cm base layer and one 7 cm layer of coloured concrete. First of all the green star points were laid. Despite the complicated design of the paving, the contractor was able to apply the reinforcement carefully. To create a good joint between the green and grey concrete the reinforcement was led through two beams. The concrete was compacted using vibrating heads and a double vibrating beam.

When finished a solvent-free surface inhibitor was sprayed onto the fresh concrete. One day after the inhibitor was sprayed the concrete was washed to give the coloured granulates an aesthetic appearance. To protect the natural stone of the central island, part of which was also laid in washed decorative grey, a “protector” was successfully applied to function as an anti-adhesive layer and facilitate easy cleaning of the adjacent stones.

1.5. Conclusions and Recommendations

Roundabouts with a diameter of less than 15m can be laid permanently in reinforced concrete slabs, whereby they should be placed between solid formworks. By using the dual-layer system it is possible to achieve reliable and particularly decorative concrete paving in a satisfactory economic and technical manner. Due to the fairly high forces at the edges and the torsional stress caused by the traffic it is recommended that the concrete be fairly thick.

The surface texture can easily be chosen in harmony with the environment. Dyes and coloured granulates offer numerous possibilities.

2. Roundabout in continuously reinforced concrete on the R27 - Tienen ring road

A roundabout has been constructed in Tienen from continuously reinforced concrete. It was successfully completed on 30 March 1998.

The roundabout is located on the new section linking the N3 from Kumtich with the N221, thereby providing a further finishing touch for the R27.

2.1. Characteristics

The roundabout has an inner diameter of 33m. The road width is 7 m (2 x 3.5m). It is constructed as follows:
- 23 cm continuously reinforced concrete
- 4 cm intermediate layer type III C
- 20 cm rough concrete
- 20 cm sand for foundations.

The longitudinal reinforcement consists of bars with a diameter of 16 mm. The diameter of 16 mm was chosen in order to bend the reinforcement bars properly, as was the spacing of 12 cm, instead of the usual 15 cm. The overlap is 56 cm. In this design the percentage of longitudinal reinforcement amounts to ca. 0.72%.

The transverse reinforcement on which the longitudinal reinforcement rests was applied to supports of 12 cm in height. The transverse reinforcement has a diameter of 14 mm and is placed at a 60° angle to the longitudinal joint.

An extra transverse reinforcement of 5 m in length with a diameter of 14 mm was also provided for the right-hand lane. The transverse reinforcement spacing is:
- 0.40 m at the outer circumference;
- 0.34 m at the longitudinal joint;
- 0.56 m at the inner circumference.

The extra transverse reinforcement was thought necessary as extra strengthening and also to keep any longitudinal cracks closed.
This reinforcement concept was decided in consultation between FEBELCEM/OCCN and the Road and Traffic Section for Flemish-Brabant. The contractor BETONAC of St-Truiden carried out this reinforcement plan.

2.2. Execution

Since the Tienen orbital is made from sound absorptive concrete slabs, sound absorptive concrete was also recommended for the roundabout (washed concrete 0/20 with min. 20% 4/7). This is not actually necessary for roundabouts because the speed is restricted. However, washed concrete increases stiffness and gives an aesthetic appearance.

The composition of the concrete was studied by the OCCN/CRIC lab and is as follows:
- Sandstone in 3 fractions 4/7 (413 kg), 7/14(338 kg), 14/20 (337 kg)
- River sand 682 kg
- Cement, CEM III/A 42,5 LA: 400 kg
- Plastifier, P 200N: 0.2 kg
- Water: 174l

This composition gives an air content of about 4%. The compression strength measured on cores in the lab after seven days reached an average of 40.3 N/mm².

The company DRION-glijbouw laid the entire roundabout using a DRION paver (sliding shuttering machine) in a single run over a width of 7.5m. Only one strip of a good 1m in width was compacted manually at the end of the work.

A longitudinal joint was sawn in the middle of the paving.

The concrete was manufactured in the main contractor’s own concrete mixing plant. This mixing plant was set up close to the works.

2.3. Conclusions and Recommendations

Heavy traffic is a severe test for the road surface of a roundabout. Paving in concrete, both (reinforced) concrete slabs and continuously reinforced concrete, are particularly suitable for this. If the inner diameter is greater than 20 m, continuously reinforced concrete can be laid by means of siding shuttering.

The longitudinal and transverse reinforcements have to be adapted and the thickness is preferably at least 23 cm, depending on the traffic. A bituminous intermediate layer type III, 4-6 cm thick is certainly recommended.

It is also desirable to provide a foundation of at least 20 cm mixed concrete.

Finally, the texture of the surface can easily be chosen in harmony with the environment, and this choice can also ensure a safe flow of traffic.

3. City roundabouts in Vilvoorde

In Vilvoorde, the Heldenplein, the meeting of roads or the heart of Vilvoorde, has been completely redeveloped as a real square, just as it was 100 years ago. The intersection of the N1 - the J.B. Nowélei and the Scharbeeklei - with the N211 - Heldenplein is a major intersection for the Brussels - Mechelen and Grimbergen - Machelen traffic axes. The aim of the redevelopment was to make the Heldenplein and its connecting roads safer and more endurable.

To achieve this objective two roundabouts were constructed on the Heldenplein. The largest roundabout has to lanes and acts as a portal for traffic from Brussels, while the roundabout on the Vuurkruisenlaan is designed to inhibit the traffic coming from Grimbergen.

3.1. Characteristics

Both roundabouts have been laid in continuously reinforced concrete of a red-brown colour, which is chemically washed. The inner diameters are 17 m and 25 m respectively. The road width is 6 m for the small roundabout and 8.5m for the dual-lane roundabout. The 1 m hard shoulder is made of paving stones, on a mixed concrete foundation, into which a cement mortar has been washed.

The road is constructed as follows:
- 25 cm continuously reinforced concrete
- 6 cm bituminous intermediate layer, type III B
- 30 cm continuous crushed stone foundation, type II B
- 20 cm sand for sub-foundation type I

The longitudinal reinforcement ∅ 16 was placed every 10 cm, in view of the thickness of the paving. The transverse reinforcement has a diameter of 14 mm and was placed at a 60° angle to the longitudinal reinforcement. An extra transverse reinforcement was provided, 7m long with a diameter of 14 mm for the outermost lane. This supplementary transverse reinforcement was needed as extra strengthening and to keep any
longitudinal cracks closed. A longitudinal joint was sawn into the middle of the paving.

The funnel shaped joints are also made of reinforced concrete. A reinforcement net of 150 x 150 x 12 mm was provided. In these sections contraction joints of 7 to 8 cm in depth were applied, and filled with a joint filling agent.

3.2. Execution

The overall project (J.B. Nowélei thoroughfare and redevelopment of the Heldenplein) was divided into 7 phases, the first being started on 2 May 1999. Due to the heavy traffic and practical impossibility of offering an adequate traffic diversion, the traffic was diverted in no more than one direction at a time. As a result it was necessary to complete the large roundabout in two parts. The first half was laid on 20 September 1999, the second on 8 November 2000. The small roundabout was laid in a single run in the month of December 2000, and traffic was guided along a narrow lane beside the works.

As the large roundabout was laid in two halves, it was necessary to provide interim reinforcement of the appropriate overlap length.

For an advance idea of the result of the surface a test slab of ± 4m² was laid. Due to temperature variations at the time of processing and different slab thicknesses, it was not possible to use the same joint inhibitor.

The concrete was laid manually by the contractor Mols nv. In view of the accessibility of the roundabout the concrete slurry was applied with a pump. It was compacted using vibrating heads and the finish was achieved with a double aluminium vibrating beam. The concrete was chemically washed by the contractor Robuco nv using a surface inhibitor, Hebaunal RSE Linie W, type WS 25. The level depth was then determined using the sand spot test and reached an average of 1.3 mm.

The concrete is composed as follows:
- cement type CEM III/A 42,5 LA: 425 kg/m³, consistency class F3
- broken gravel (7/20)
- porphyry 2/7
- river sand 0/4
- super plastifier: Tixo Sup: 2,0% (site mix: 5 min)
- dye in the mass: Bayferrox 222 Red: 2% of the cement mass, added to the mixer when loading
- air entrainer: Micro-Air 100: air content of 5 to 6%

The compression strength was measured on cubes with a nominal side of 15 cm and on cylinders with a section of 100 cm², height 10 cm, drilled from slabs measuring 40 x 30 x 15 cm. All test samples were kept in their covered form on site for 24 hours and thereafter in the lab at 20°C and a relative humidity of 95% minimum. After seven days the compression strength on the cubes reached 32.8 N/mm² and on the cores 40.1 N/mm². After 28 days the figures of 45.4 N/mm² and 53.6 N/mm² respectively were reached.

The average scaling resistance values for surfaces subject to chemical fluxes were defined using the ISO/DIS 4846.2 method and are shown in the table below.

<table>
<thead>
<tr>
<th>Cycle:</th>
<th>N=5</th>
<th>n=10</th>
<th>N=15</th>
<th>n=20</th>
<th>n=25</th>
<th>n=30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of mass: (g/dm²)</td>
<td>1.9</td>
<td>3.4</td>
<td>4.2</td>
<td>4.9</td>
<td>5.0</td>
<td>5.7</td>
</tr>
</tbody>
</table>

Table 1: Resistance to chemical fluxes
Cumulated loss of mass after performance of “n” cycles expressed in g/dm².

3.3. Conclusion and Recommendations
Roundabouts in urban environments can equally be made from continuously reinforced concrete. With this choice of construction we achieve a very long life with minimum maintenance. Moreover, through the choice of surface texture, granulates and dyes we can alter the appearance in harmony with the environment.

To gain a good idea of the final result it is recommended to lay a large enough reference slab in the materials chosen prior to starting the works.