# CONCRETE ROUNDABOUTS

- WHY CHOOSE A CONCRETE PAVEMENT FOR A ROUNDABOUT ?
- DESIGN OF ROUNDABOUTS IN JOINTED AND CONTINUOUSLY REINFORCED CONCRETE
- CONSTRUCTION ASPECTS

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# INTRODUCTION

Examples of a typical layout of a roundabout and its access roads (right : Flemish Agency for Roads and Traffic AWV, Belgium – left : the Netherlands)

In many European countries, traffic at major junctions is increasingly managed by constructing right-of-way roundabouts, which allow safer and smoother traffic flow. An example of typical layout and cross section of a roundabout are shown in figure 1.

Intense and heavy traffic at these roundabouts induces extreme stresses in the pavement, both as a result of centrifugal forces as well as the overloading exerted by the offside wheels of tilting vehicles. The effects of such stresses include rut formation, deformation of the wearing course, the loss of surface aggregate, and cracking as a result of insufficient bearing capacity in the road structure beneath the offside wheels.

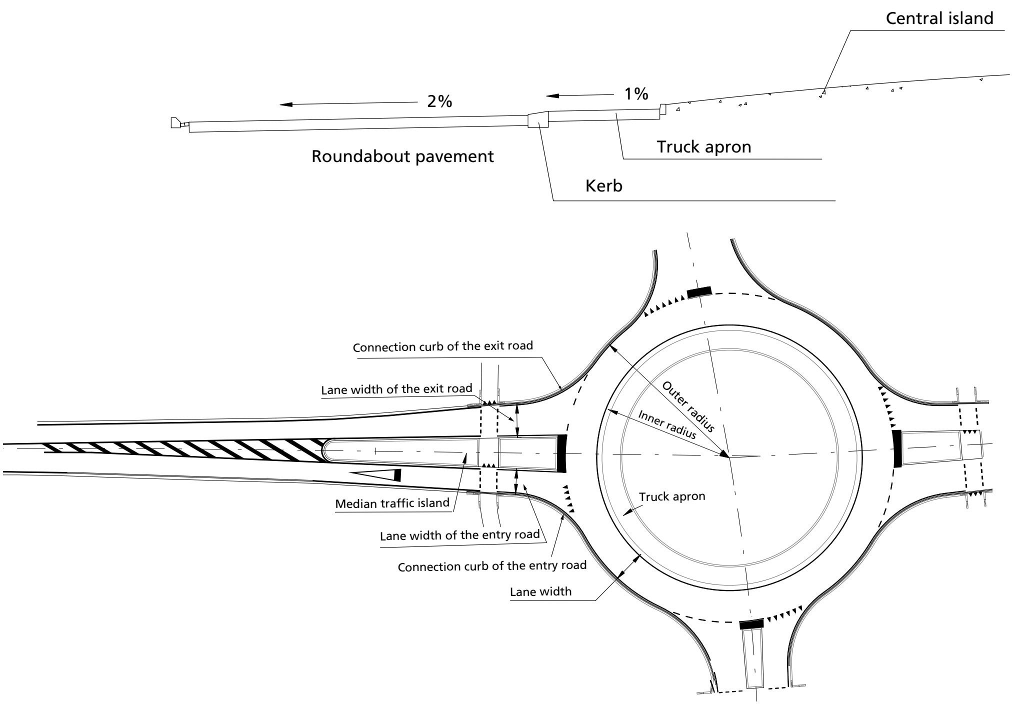
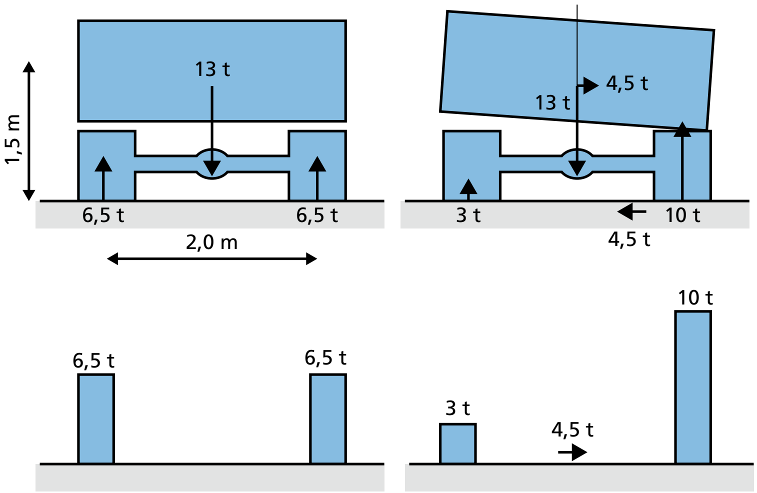



Figure 1 : General layout and cross section of a roundabout (Ref 11)


Figure 2 : change of axle load distribution of a heavy goods vehicle on a roundabout (Ref 1)




These findings encourage designers to use concrete for the construction of roundabouts, either as a jointed plain or a jointed reinforced concrete pavement (JPCP or JRCP), or as a continuously reinforced concrete pavement (CRCP). This publication deals with design and construction aspects for both solutions. JPCP (or JRCP) has been used already for many years for roundabouts and is still the standard option in most countries (Austria, Germany, Switzerland,…). CRCP was only used for the first time in 1995 in Belgium. The first examples are now almost 20 years old and are still in excellent condition today. Many others have been built in the meantime in Belgium, France and the Netherlands, demonstrating the suitability of this technique for application on a larger scale.

## > WHAT LIFETIME CAN BE EXPECTED FROM A CONCRETE ROUNDABOUT ?

Many examples can be found of concrete pavements older than 50 years, even when they are subjected to heavy traffic loading. Roundabouts, however, are only built since the 1990's and the oldest ones are now about 20 years old.

In the Netherlands, a nice example can be found at the intersection of Reekermolen in the Province of North-Brabant. In 1995, traffic volumes were situated between 13.000 and 20.000 of which 15% heavy vehicles. A high accident rate and frequently needed repairs of the asphalt surface due to deformation and rutting were the reasons for turning the intersection into a concrete roundabout. It was built in 1995 following a peculiar design, combining CRCP and JRCP by the use of longitudinal steel reinforcement together with transverse joints.

Today, after 18 years of service, the pavement is in excellent condition and no damage at all is visible. The theoretical design criteria for this project were chosen for a 40 year design life. Taking into account this concept and the experience with other pavements in continuously reinforced concrete, a 40 to 50 year service life can be easily achieved. Such a service life, linked to a absolute minimum of necessary maintenance, is of significant importance in economic and environmental assessments, turning this solution into the best possible choice.

# 2. WHY CHOOSE A CONCRETE PAVEMENT FOR A ROUNDABOUT?

Light coloured and aesthetically pleasing roundabouts at Saint Jean de Cardonnay, France (Ref 9) and in Austria (Ref 5)

Choosing for concrete offers a number of benefits that are typical for concrete pavements in general :

- durability and robustness;
- long service life (30 to 40+ years);
- low maintenance requirement;
- economical over long term;
- light coloured surface;
- good and durable skid resistance;
- aesthetic appearance.

Two reasons in particular justify the choice of a concrete pavement for roundabouts, namely :

- the elimination of rutting due to the loads imposed by heavy goods vehicles moving at a moderate speed;
- the elimination of deformation of the wearing course as a result of loads caused by centrifugal forces.

Illustration of the intense traffic loadings on a roundabout pavement (Ref 1)

Example of a roundabout in CRCP in Airvault – Deux Sèvres, France (Ref 9)

One of the main advantages of continuously reinforced concrete is the elimination of the conventional contraction joints required in unreinforced concrete pavement and thus to avoid loading of the slab corners.

Reinforcement by a steel mesh or by the use of structural fibres in the concrete (steel or synthetic fibres) also makes it possible to reduce the number of transverse joints.

Steel mesh reinforcement (Febelcem)

# 3. DESIGN OF ROUNDABOUTS IN JOINTED CONCRETE PAVEMENT

For the design and construction of a roundabout with a pavement of in situ cast concrete slabs, there are the following options:

- jointed plain concrete with dowelled or non-dowelled joints;
- jointed steel mesh reinforced concrete with dowelled or non-dowelled joints;
- jointed steel fibre reinforced concrete with dowelled or non-dowelled joints;
- jointed synthetic fibre reinforced concrete with dowelled or non-dowelled joints.

The use of dowels contributes largely to the load transfer between adjacent slabs and helps prevent pumping, curling of the slab and faulting of the joints. Dowels allow a thinner pavement design for a same traffic or a higher traffic volume for the same thickness. When it is predicted that the roundabout will have to bear higher volumes of heavy traffic, the joints need to be dowelled. The correct and stable positioning of the dowels during the construction work is vital if the joints are not to become locked up.

The reinforcement of the concrete (steel mesh/steel fibres/synthetic fibres) allows a reduction of the pavement thickness or an increase of the slab length. In the case of a steel mesh reinforcement, a typical mesh is: diam. 10 mm x diam. 10 mm x 150 mm x 150 mm, placed in the upper third of the slab and cut through in the contraction joints in order to allow the joint to function.

If steel fibres are added to the concrete mix, typical dosages are between 30 and 50 kg/m³. The steel quality and the shape of the fibres also play an important role in the final characteristics of the pavement concrete. Steel fibres also enhance the post-cracking behaviour of the pavement by keeping the cracks closed. Another benefit is the increased flexural strength of the concrete.

Even for reinforced concrete, the stresses induced at the edge of the pavement are still large and the dimensions of the structure and reinforcing must take this into account. One solution might be the provision of extra thickness in the base layer on the outer perimeter of the roundabout, which makes it possible to strengthen the road structure in the most heavily loaded area. Another way of preventing the loading of the edges consists of careful placing of the road markings or the installation of surface-mounted kerbs at a distance from the outer radius of the roundabout (see also § 5.3 about kerbs and gutters).

The general design rules for jointed concrete pavements are applicable. Therefore consideration is required of the following issues:

Roundabout in coloured steel fibre reinforced concrete (Ref 1)

Detail of a steel fibre concrete mix

Example of a roundabout with well-constructed matching joints near Madison, Wisconsin ,U.S

- maximum joint spacing should be limited to 6 m for a thickness ≥ 25 cm; 5m for a thickness between 20 and 25 cm and even 4 m for a thickness < 20 cm. Reinforced slabs can be made about 25 to 50% longer, depending on the amount of reinforcement;

- maximum slab width should be limited to 5m; if necessary a longitudinal joint (construction or contraction joint) is needed;

- length/width ratio of the slab should be limited to 1,5. This means slabs should have a rather square shape (or pie shaped in the circular part of a roundabout);

- slab surface should be limited to 30 m² for plain concrete;

- joint angles should be greater than 75°. Acute angles lead to stress concentrations in the slab and increase the risk of random cracking.

Those are rather conservative design rules which result in a low probability of early or long-term damage, even under heavy traffic. If one of these criteria cannot be met, it is recommended to provide reinforcement in the odd-shaped slabs, either steel mesh or steel fibre reinforcement.

When designing a concrete slab pavement for a roundabout, special attention must be given to the joint design, specifically the positioning of the contraction, isolation and construction joints. The project designer must therefore carefully define the location of all the joints during the project design phase. The jointing for concrete roundabouts is different from a normal intersection (square plan layout) and is based on the idea that the circle is isolated from the legs. The "transverse" joints in the circular portion radiate from the centre while an eventual "longitudinal" joint follows a concentric circle.

Basically, two solutions can be adopted for the radial joint pattern:

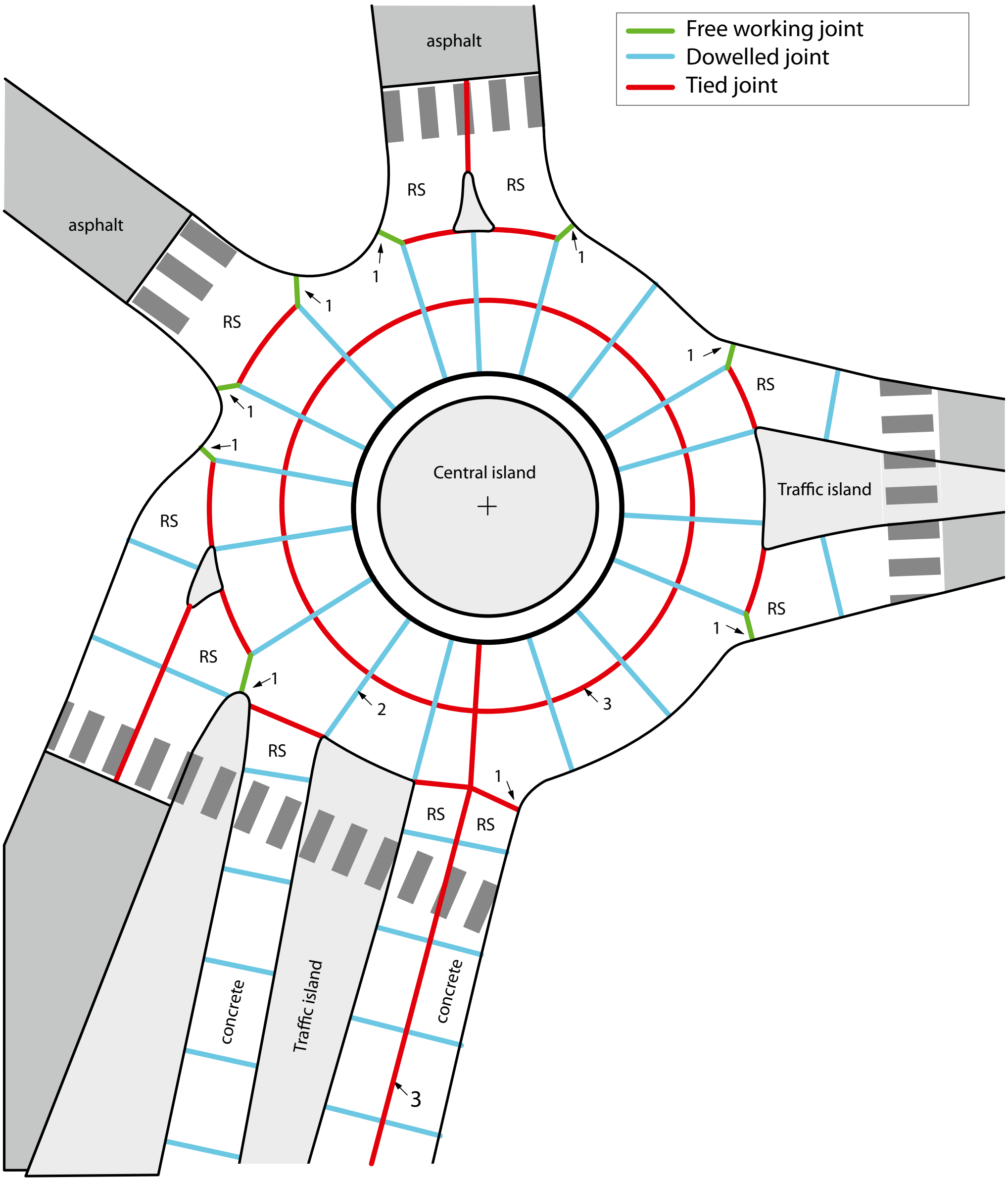
- Solution A. Make the radial joints of the circle match with the longitudinal joints of the legs;

- Solution B. Isolate the circle from the legs by means of an isolation joint.

No country has adopted a single solution but we can see that solution A is mostly adopted in Austria, Belgium and also in the U.S. and solution B is common in France, Germany, Switzerland and also in Australia.

Solution A is more complex during construction and requires a more detailed design study in advance. The radial joints do not only have to match with the longitudinal joints of the legs but also with the traffic islands. With this solution it is possible to tie the legs to the roundabout, e.g. with ribbed tie bars diam. 16 mm spaced at 50 to 75 cm.

Solution B is easier since mismatching of the radial joints with the longitudinal joints in the access roads is allowed. Because of the isolation joint, it is no longer possible to put tie-bars between circular part and legs, possibly resulting in opening of this joint and need for maintenance of the joint sealant. A solution to improve the load transfer between access road and roundabout is the construction of a concrete beam beneath the isolation joint. This technique is applied in Germany.




RS : Reinforced slab

URS : Unreinforced slab

1 : triangular area concreted simultaneously with the circular part in CRCP

2 : dowelled construction joint

3 : tied longitudinal joint

Figure 3 : example of solution A (Ref 1 & 2)

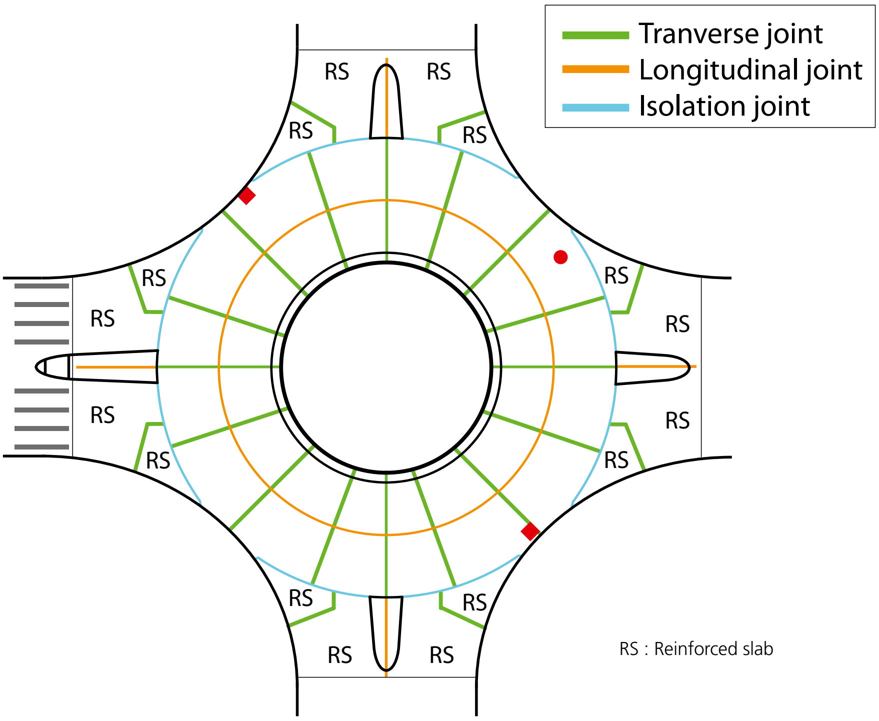



Figure 4 : example of solution B

Example of a roundabout with an isolation joint between the circular part and the approach legs and non-matching joints, Switzerland (Ref 4)

A concrete beam under the joint between access road and roundabout ensures a better load transfer in case of a non-tied isolation joint

Whatever solution is chosen, the joint plan must also take into account the presence of in-pavement structures such as manholes and gullies. They can be located in the middle of a heavily reinforced slab or they can be intersected by a joint.

Example of extra reinforcement bars around in-pavement structures (Ref 4)

Example of a case where the orange-coloured mark indicates the position of the contraction joint to be cut towards the centre of the manhole (Photo by FEBELCEM)

## > JOINT TERMINOLOGY

**Transverse and longitudinal contraction joints (or control joints)**

Contraction joints are induced by saw cutting the concrete to $^1/_3$ the thickness of the slab's depth. For steel fibre reinforced concrete, it is recommended to saw up to ½ of the thickness. The joints allow the contraction and the bending of the concrete pavement, due to shrinkage, thermal movements and traffic loads. Transverse joints are perpendicular and longitudinal joints parallel to the axis of the road.

**Transverse and longitudinal construction joints**

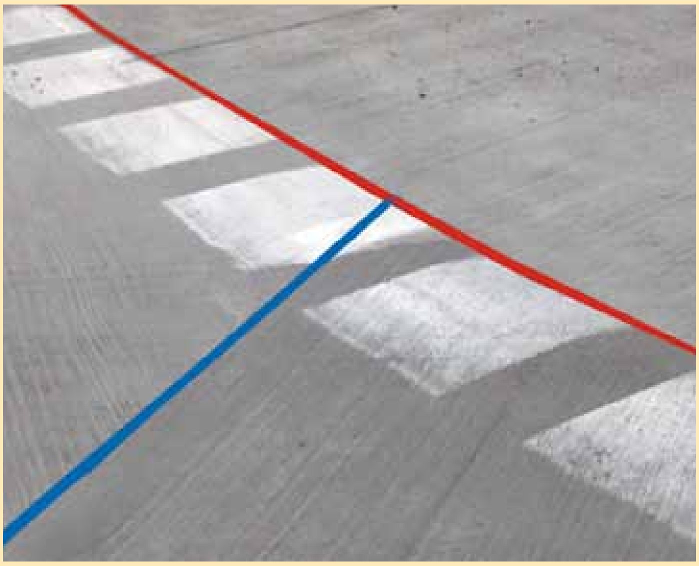
A transverse construction joints lies between two consecutive slabs constructed at two different times; a longitudinal construction joint between two lanes that are paved in two separate passes.

**Expansion joint**

An expansion joint is a special transverse joint in which a preformed and compressible joint filler material (polyethylene foam or bitumen-treated fibre board) is placed over full depth and full width in order to accommodate a horizontal movement of the concrete pavement. Expansion joints are often 20 to 30 mm wide.

**Isolation joint**

An isolation joint is a special (longitudinal) joint that is placed to prevent existing (transverse) joints from extending into the weaker newly placed concrete pavement. They are used when matching the existing joints is not practical. They are also placed to separate dissimilar rigid pavements/structures in order to reduce compressive stresses that could cause uncontrolled cracking or pavement buckling. An isolation joint is similar to an expansion joint but its width is often limited to ca. 10 mm.



Example of a concrete roundabout in Germany. The circular part is separated from the access road by means of an isolation joint, so that the transverse joints need not align (Photo by Febelcem)

# 4. DESIGN OF ROUNDABOUTS IN CONTINUOUSLY REINFORCED CONCRETE

All the general principles that apply to conventional continuously reinforced concrete (CRC) pavements apply with equal force to roundabouts. The recommendations and specifications applicable to CRC must be complied with.

The longitudinal reinforcement in a roundabout should exactly follow the curve of the roundabout. In order to facilitate the bending of the longitudinal (concentric) reinforcement bars, it is recommended to limit the diameter to 16 mm. The amount of longitudinal steel should be between 0,60 and 0,70 % of the section of the concrete. Table 1 gives some possible configurations which are standard in Belgium and which are based on a steel percentage of 0,67 %.

The length of overlap of the reinforcing elements should be at least 35 times the nominal diameter of the reinforcing steel, although it is difficult to maintain a constant angle of splicing a (to the perpendicular of the tangent of the axis of the road i.e. the radius). This means that the length of overlap should be varied as a function of the radius of the circle formed by the longitudinal reinforcement, or that, in other words, the length of the longitudinal reinforcement should be reduced towards the inner edge of the roundabout ring. It is important to avoid a concentration of splices in the same radial section, so that not all the splices lie on the same radial line.

Figure 5 : Example of cross section of a roundabout in CRCP (Ref 1)

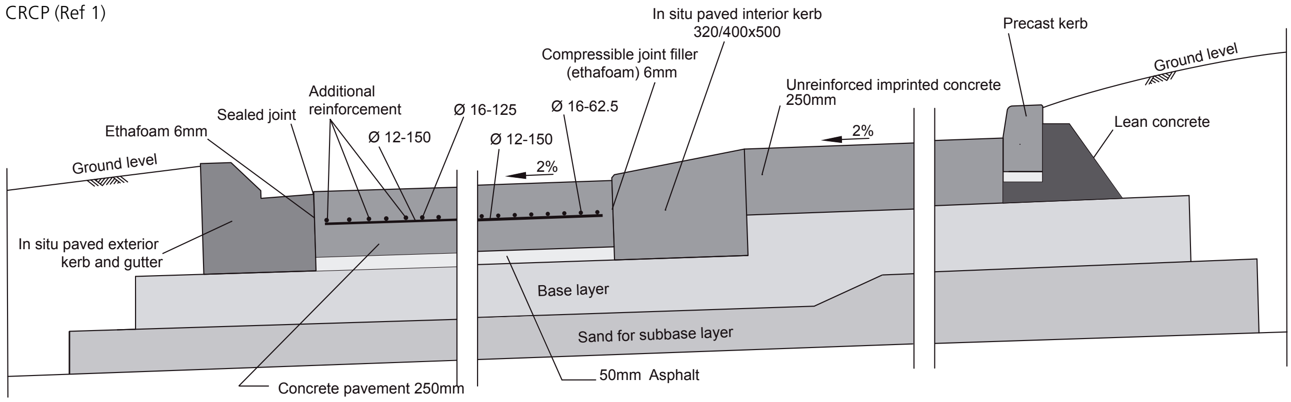
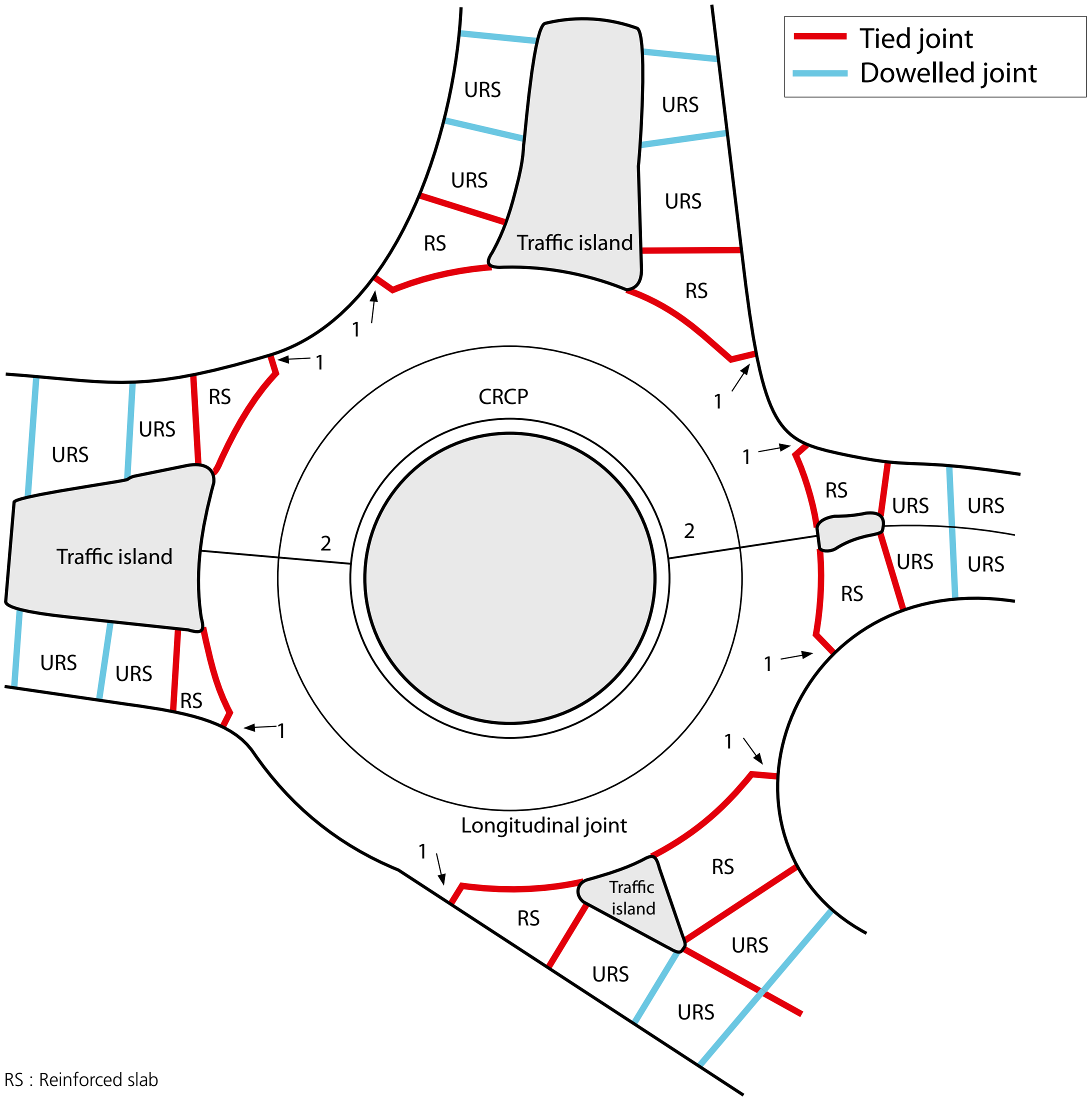


**TABLE 1 - POSSIBLE CONFIGURATIONS FOR THE REINFORCEMENT OF CRCP ON A ROUNDABOUT**

| Pavement thickness (mm) | 200 | 230 | 250 |
|---|---|---|---|
| Nominal diameter of the longitudinal reinforcement (mm) | 16 | 16 | 16 |
| Nominal diameter of the transverse reinforcement (mm) | 14 | 14 | 14 |
| Spacing (e) of the centrelines of the longitudinal reinforcement (mm) | 150 | 130 | 120 |
| Distance between the upper surface longitudinal reinforcement and the surface of the finished pavement (mm) | 80 | 80 | 80 |
| Height of the support (mm) | 90 | 120 | 140 |

The transverse reinforcement can be installed as a radial reinforcement perpendicular to the longitudinal; or, as it is done in Belgium, it makes an angle of 60° to the tangent of the centreline of the road. Various configurations are possible halfway between the transverse bars. The first possibility for avoiding excessive spacing at the outer edge of the ring, is to leave a space of 70 cm between two transverse bars one third of the way across the width of the circulatory carriageways measuring from the outer edge. Additionally when building roundabouts with an internal radius of more than 20 m, an extra transverse bar is provided on the outer half of the circulatory carriageway in order to avoid any sudden changes in the thickness of the steel. These additional bars are staggered by one metre. A second alternative is to allow a space (orthogonal between two transverse bars) of no more than 70 cm at the outside edge of the circulatory carriageway and at least 20 cm at the inside edge. The length of the bars may thus be reduced in order to achieve this spacing of at least 20 cm at the inside edge.

If the roundabout has a diameter of more than 20 m, additional transverse bars can be placed in the outer half of the ring, these are staggered by one metre (Ref 2 & 3)




RS : Reinforced slab

URS : Unreinforced slab

1 : triangular area concreted simultaneously with the circular part in CRCP

2 : construction joint of the circular part in CRCP, always ending at a traffic island

Figure 6 - Diagram showing the layout of a CRCP roundabout and the slabs on the approach legs: reinforced slabs, unreinforced slabs, tied joints and dowelled joints (Ref 1 & 2)

# 5. CONSTRUCTION ASPECTS

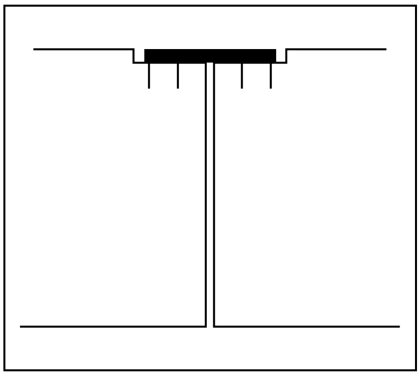
The principles applied to the construction of concrete roads are also applicable to roundabouts as well as the different types of concrete mixes and surface finishing techniques. Nevertheless, some particular aspects will be discussed in the following sections, including formwork, manual concreting / use of a slipform paver, as well as a number of more specific details.

## 5.1. FORMWORK

If the concrete is laid with the help of a slipform paver, the concrete pavement is laid prior to the other linear elements. On the other hand, if the concrete is laid with a vibrating beam, the linear elements may be used as formwork, both on the inside and the outside of the roundabout. The wooden formwork at the approach legs to the roundabout is as high as the thickness of the concrete to be used. These wooden elements may be linked firmly together using fastenings embedded in the wood, so that the vibrating beam can slide over them without hindrance (Figure 7). They are held in place on the outer side by stabilised sand.

Even better is the use of flexible formwork materials which allow the exact curvature of the roundabout perimeter to be followed.

Figure 7 : linked formwork with embedded fastenings (Ref 2)



Fixed formwork made of sturdy planks installed on the access roads (Ref 2)

Example of a flexible formwork consisting of polyethylene rectangular tubes

## 5.2. CONCRETING

### 5.2.1 CONCRETE MIX

The specifications for the concrete mix are not different from those for other concrete pavements. Reference can be made to the European Standards EN 13877-1 and -2 related to materials and functional requirements for concrete pavements.

Hard and polishing-resistant coarse aggregate together with rounded siliceous sand are the best materials for a durable and skid resistant surface.

Common strength classes are CC30 to CC50 (characteristic compressive strength on cores after 28 days) and are obtained through relatively high cement contents and low water-cement ratios. Air entrainment (3 to 6%) is recommended in areas where freeze-thaw cycles occur and de-icing salts are used.

The desired workability of the fresh concrete is linked to the construction technique: a consistence of S1 for concrete placed with a slipform paver and S2 to S3 for manual construction jobs between fixed formworks.

### 5.2.2 CONCRETING USING A VIBRATING SCREED

This technique has most often been used because of the possibility of adapting the vibrating screed to the width of the concreting work. The screed slides round on the inside of the ring on the edge of half-batter kerb or on the inner edge of the roundabout. In order to absorb any differences in the level of these edges, the vibrating screed bears on the kerb via an articulated intermediate beam with a length of at least 2 m. It has to be possible to adjust the height of the screed with respect to the kerb in order to overcome the height of the upstand of the kerb.

After pouring and levelling the concrete using a crane, and prior to the passage of the vibrating screed, the concrete is consolidated by means of poker vibrators. The provision of one poker vibrator for every 1,50 m of width of the concrete is recommended. A bull float can be used to get rid of any small differences in level due to stops made by the beam

Sequences of the concreting work using a vibrating screed (Ref 2 & 4)

Concreting with a slipform paver (Ref 2 & 3)

### 5.2.3 CONCRETING USING A SLIPFORM PAVER

There are several obstacles in using this technique. A machine capable of placing widths of from 8 to 10 m is needed for large roundabouts. It is difficult to construct the starting points of access and exit roads as part of the same operation. If the concrete of the roundabout is laid all in one day, the cleaning of the machine after completing the concreting work must be done on pavement that has not completely hardened and the machine will be stuck on the roundabout for several days, i.e. the time required for the concrete to become sufficiently hard for it to bear traffic.

This problem can be avoided by concreting one segment of the roundabout between fixed formworks. A first option is to start with that segment, for instance as an extension of an access road. After hardening of that segment, the paver can make use of that slab to leave the roundabout at the end of the work. A second possibility is to leave out a segment so that the paver can leave the jobsite and to concrete that part manually afterwards as a “keystone”.

### 5.2.4 CONCRETING USING A ROLLER-FINISHER

In the Netherlands, a roller-finisher is normally used for the construction of roundabouts. This can be considered as an intermediate solution between the vibrating screed and the slipform paver. The roller, which is mounted on a frame, moves transversely and strikes off the concrete on the surface. A set of two poker vibrators ensures the internal compaction.

Concreting with a roller-finisher (Photo : W. Kramer)

## 5.3. KERBS AND GUTTERS

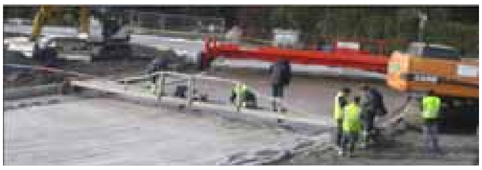
Kerbs and/or gutters are placed on the inner and outer edges of the roundabout. As stated above, they can be used as formwork for the manual placing of the concrete. Concrete kerbs cast in-situ can be considered as the most robust solution, particularly at critical places where contact with the wheels of heavy vehicles can be expected. However, precast elements may sometimes be more practical with regard to installation. An easy solution is fixing precast elements upon the concrete pavement, either by vertical tie-bars, or by gluing. The advantage is that the concreting of the slabs can be done independently of the position of the kerbs and that difficult formwork or the presence of sharp angles can be avoided.

Examples of kerbs cast in-situ in the Netherlands

## 5.4 SPECIAL MEASURES

### 5.4.1. CONCRETING CARRIED OUT AS SINGLE OPERATION IN ONE DAY

Because the completion of the pavement of the roundabout has to be carried out on concrete which has not yet hardened, it will be necessary to provide a catwalk so that the transverse construction joint can be finished without walking on the concrete. Moreover if the volume of concrete is more than 150 m³, two construction teams will be required, with one relieving the other after about 10 hours of work.



Working over unhardened concrete to complete the roundabout (Ref 2)

### 5.4.2. CONCRETING CARRIED OUT AS SINGLE OPERATION IN TWO DAYS

When the volume of concrete is greater than 150 m³, the provision of an end-of-day joint may be considered. Like the initial joint, this joint should be formed close to one of the traffic islands of the access roads to avoid greater stresses at the entry and exit zones.

### 5.4.3. CONCRETING IN TWO OPERATIONS

If the junction cannot be isolated for traffic reasons, concreting in two separate operations may be considered. Generally speaking movements at the extremities due to contraction and temperature variations are limited. Consequently no precautions need be taken in this respect unless the radius of the roundabout is extremely large. In this case, however, problems posed by traffic requirements will not usually arise. Problems may occur though when the time between the two concreting operations is extremely long (a year or more). In such cases the two ends of the pavement must be loaded and/or insulated (with wet sand for example) in order to prevent the ends from moving. The recommended load should be spread over the entire width of the pavement. Its thickness should be at least 50 cm and it should extend 15 m. An anchoring beam (or thrust block) may be used as an alternative to loading.

The length of the previously placed longitudinal reinforcing steel calls for some attention. It is important to vary their length in order to avoid any significant concentration of splices in the same radial sector. Repeatedly extending the longitudinal reinforcing steel by 1, 2, 3, 4 and 5 metres (see Figure 8) offers a solution.

Concreting in 2 separate operations (Ref 2)

If different lanes of the roundabouts are cast as separate concrete strips, it is clear that the operation also will be split over several days.

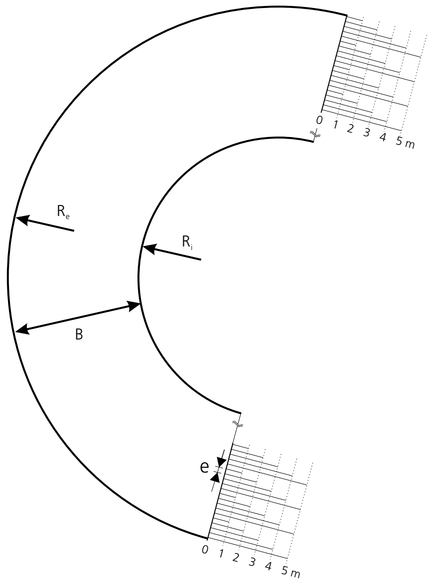



Figure 8 : Illustration of varying the length of the longitudinal reinforcement in a construction joint in order to avoid a significant concentration of splices in the same radial line (Ref 2 & 3)

Concreting of different lanes in separate operations (Ref. : Flemish Road and Traffic Agency AWV)

### 5.4.4. CONCRETING THE STARTING POINTS

To prevent a corner of a slab in the approach area from being excessively loaded, the starting points of the accesses and exits are formed up, provided with reinforcing steel and concreted at the same time as the actual pavement of the roundabout. The starting point must be such that the dimension of its smallest side is at least 1 m.


Concreting the starting points (Ref 2 & 3)

Access roads to roundabout in Oberwart and Schwechat, Austria (Ref 5)

The slabs of the approach legs are reinforced and anchored to the roundabout carriageway (Ref 2)

**5.4.5. CONCRETING THE APPROACH LEGS**

The approach legs of a roundabout crossing are always subject to particularly large stresses (braking, acceleration, tangential forces). For this reason it is desirable for the pavement of the approach leg to be in concrete. This can be one or two slabs, or it can be a longer section of concrete pavement., In the case of longer sections, attention should be given to the transition between concrete and asphalt. An easy way of reducing the thrust forces of concrete, pushing against the asphalt pavement, is the installation of one expansion joint (20mm) between the last and second last slab.

Concrete approach legs should be anchored to the circulatory carriageway to ensure continuity with the concrete pavement. For a CRCP roundabout, this is not a problem but in case of jointed slabs, anchoring the legs to the circular part is only possible with matching joints. With an isolation joint, it would be too difficult to execute.

Anchoring can be done using 1 m lengths of 16 mm diameter reinforcing steel located every 40 cm at half the height of the construction joint. The transverse joints are then provided, although these use conventional dowelling. The slabs are unreinforced or reinforced if their shape is complex. The reinforcement in the reinforced slabs is usually with a diam. 10 mm – 150 mm x 150 mm mesh, which is placed in the upper third of the concrete slab.

If no variable width vibrating beam is available, one of the access sides will have to be provided with formwork so that the beam can stretch over the formwork in the confined area. On the other hand if the concreting is done using a variable width beam, the concreting may be carried out between linear elements.

The approach to the roundabout junction may also be highlighted by adjusting the colour of the concrete.

Protecting gullies
(Ref 2)

### 5.4.6. PROTECTING GULLIES

Any gullies should be protected to prevent any laitance or concrete itself, if the surface is stripped, from getting into the water drainage system.

When a vibrating beam is used, the formwork should be raised to the correct height using a plank attached to the edge of the gulley to ensure that the rolling path is uninterrupted.

### 5.4.7. DELIVERING THE CONCRETE

Regardless of whether the concreting work is carried out in one or two stages, the space available outside the circulatory carriageway often does not permit access to cranes and concrete delivery vehicles. This is why the concrete is sometimes supplied from the centre of the roundabout. In that case a way through the reinforcement must be left open. This way is closed when the concreting works are finished and the crane left at the centre of the roundabout for the completion of the works will only be able to leave after several days.

The other obvious solution is placing the concrete by pump, which is possible over considerable distances (up to 60 m for trailer mounted boom pumps). In order to maintain the quality of the pavement concrete, the consistence of the fresh concrete should be limited to S3 (maximum slump of 150 mm).

Delivery of concrete from the centre of the roundabout
(Ref 2)

Delivery of concrete by pumping

## 5.5 SURFACE FINISHING

The most important surface characteristic for roundabout pavements is skid resistance. The texture should indeed provide sufficient friction in order to prevent slipping of the wheels. Small surface irregularities are a lesser problem since driving comfort or noise are not predominant criteria for the traffic on a roundabout. Therefore the two surface finishing techniques that are most often used are transverse brushing and using an exposed aggregate finish in the concrete.

## 5.6 PROTECTION OF THE CONCRETE

It is clear that all other technological requirements related to the use of concrete for exterior pavements need to be met. The protection of the freshly poured concrete always deserves attention: i.e. protection against wind and sun to avoid plastic shrinkage cracks and also protection against rain, frost and mechanical impacts (like pedestrians or bicycles!).

For protection against drying out of the surface and plastic shrinkage, the most common methods are the use of a curing compound with proven efficiency, or, in the case of exposed aggregate concrete surfaces, covering with a plastic sheet.

# CONCLUSIONS

## CONCRETE ROUNDABOUTS OFFER:

- **sufficient strength to stand up to the stresses induced by intense and heavy traffic;**
- **a range of different solutions, such as slabs in plain concrete or in continuously reinforced concrete, small or large radii of curvature, a multiple choice of textures and colours, satisfactory integration into all kinds of environments;**
- **rapid execution and low maintenance.**

In all cases, concrete roundabouts require detailed preliminary study and careful construction.

Roundabout in Switzerland (Ref 4)

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**Published by:**

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Paving Association
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December 2013

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