

Construction practices and details in CRCP

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Abstract

Belgium has a long tradition and a large experience with continuously reinforced concrete pavements. The regional technical specifications describe the design and construction for the regular straight sections in standard situations, as well as for the construction of roundabouts. However particular design and construction details are not provided. In general they are solved with practical empirical solutions.

The paper will focus on the technical aspects and construction details such as :

- the longitudinal joints in case of a pavement with variable width,
- the joint and reinforcement layout at intersections or exit lanes (auxiliary lanes),
- the position of anchoring abutments and the number of lugs for shorter sections and widened lanes.

The different practical solutions are illustrated by case-studies of finished and planned projects.

Introduction

In most countries where CRCP is applied, technical specifications exist with regard to the conventional design and construction. These specifications mainly concern geometrical limitations, the longitudinal reinforcement rate, the diameter and position of the longitudinal and transverse reinforcement bars and the construction of terminals. In Belgium, all this is written down in the so called Standard Specifications for Road Construction. However, situations may occur in practice where the standard specifications do not give an answer and where a creative, intelligent and practically feasible solution is needed. Some of these solutions have been tried out a first time, have been copied in following worksites and have become generally adopted methods. Although a mechanistic calculated approach can be considered, the presented solutions are mainly based on an empirical approach and practice experience. The relevance of this paper is to provide these practical solutions to designers and practitioners of CRCP.

Longitudinal joints in case of a pavement with variable width

The Belgian specifications mention a maximum lane width of 4.50 m. In case of larger widths, a longitudinal contraction joint is to be sawn. In the U.S. the FHWA design guide on CRCP mentions a similar maximum width of 14 inch or about 4.20 m. For CRCP, this may be a rather conservative approach. Indeed, this geometrical constraint is mainly imposed because of the effect of curling/warping and its related risk of cracking but does not take into account the presence of longitudinal and transverse reinforcement. In addition, most of the CRCP lanes are built as highways/motorways and are enclosed within other lanes, water gutters or concrete strips in the median reserve. Another reason is that when a 5m wide concrete lane is divided by a longitudinal joint into two lanes of 2.50 m each, the risk of a systematic loading of the longitudinal joint by heavy traffic is considerable and may have a detrimental impact on the pavement behaviour. Taking into account these considerations, a width up to 5.5 m or even to 6.0 m can still be considered as acceptable. The specifications in the UK are even less conservative and stipulate for CRCP that “bay widths are not greater than 4.2 m (or 5.0 m with limestone aggregate) for unreinforced slabs, or 6 m (or 7.6 m with limestone aggregate) for reinforced concrete slabs with transverse reinforcement...”.

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In case of a pavement of variable width “w” with parts where $w \leq 5.0$ m and parts where $w > 5.0$ m, the situation is more difficult to handle. The practical solution – see figure 1 - consists of saw cutting a longitudinal contraction joint in the part where $w > 5.0$ m and to let this joint stop in the middle of the pavement. In order to keep this joint tightly closed and preventing it from developing further beyond the saw cut, the transverse reinforcement is increased in that area, e.g. doubled by reducing the spacing of the transverse bars from 70 to 35 cm a few meters before and after the end of the saw cut.

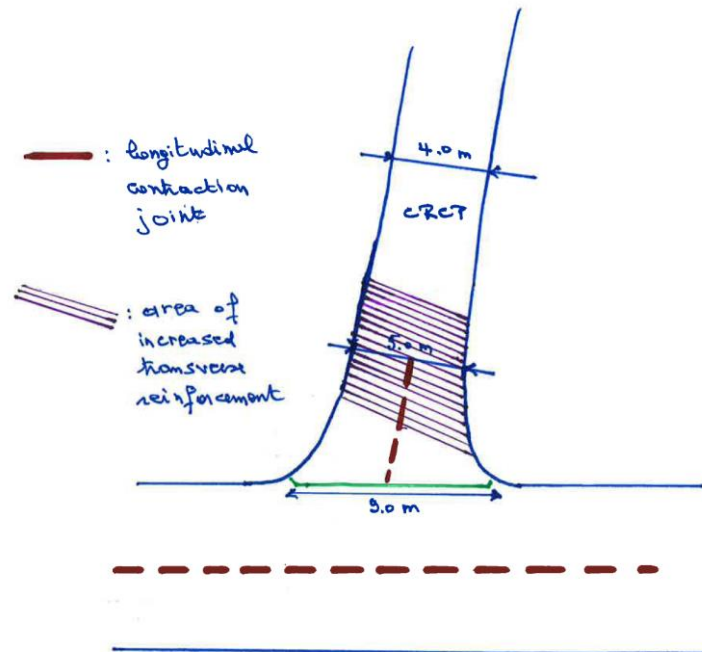


Figure 1. Schematic solution for a pavement with variable width exceeding the maximum allowed width

This technique has been applied on several worksites, mainly for CRCP ramps of motorways with variable width, a method that will be further described in this paper (motorways E40 Groot-Bijgaarden, Ternat, Affligem; E17 Haasdonk – see figure 2) and also for CRCP lanes connected with a roundabout, similar to figure 1 (Gent Schansakker).



Figure 2. View of a longitudinal contracting joint ending in the middle of the CRCP-lane

Joint and reinforcement layout at intersections or exit lanes (ramps)

There are several reasons why the horizontal lay-out of a road needs to be locally adapted. Mostly this is the case at intersections where an extra lane is being created for the turning traffic. Three different solutions will be presented to deal with this situation.

CRCP local widening with concrete slabs This is the simplest solution consisting of adding a number of concrete slabs next to the mainline in CRCP – see figure 3. The main advantage is that the CRCP construction doesn't need any interruption and can be done over full width over the entire length. The length and width of the JPCP sections are determined by the desired layout of the road, related to the traffic management. The length of the individual slabs is determined by the basic design rules for JPCP ($\text{Length/width} \leq 1.5$ to 1.75) either a steel mesh can be used to allow for longer lengths. The JPCP must be tied to the mainline in CRCP and should be dowelled in case of heavy traffic (what normally is the case when the road is built in CRCP). The JPCP is built when the concrete of the mainline has hardened and probably the first cracks in the CRCP have appeared. Normally there is only a limited risk for crack initiation from the hardened CRCP to the fresh concrete of the JPCP. When large temperature differences (day/night) are expected, an isolation joint can be provided between CRCP and JPCP.

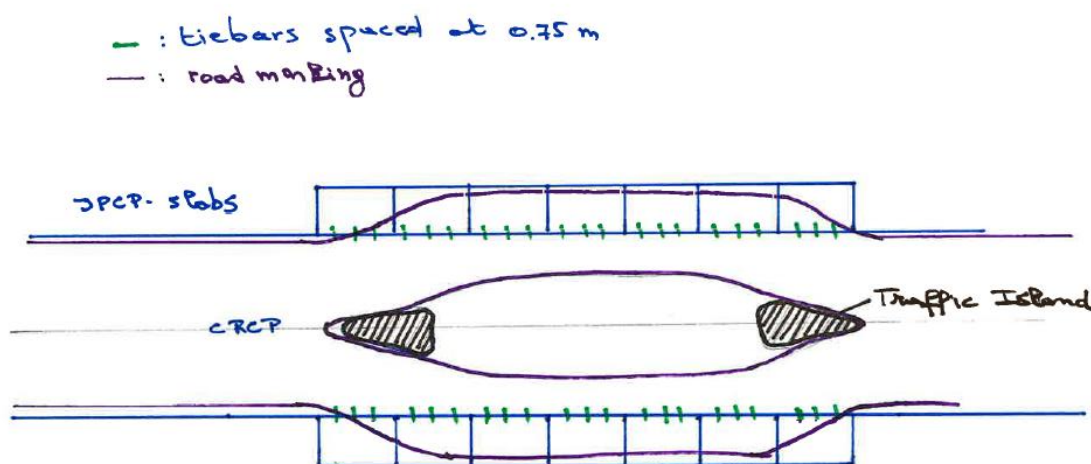


Figure 3. Schematic solution for a locally widened CRCP with concrete slabs

In figure 4 an example is shown from the regional road N10 between Scherpenheuvel and Diest. This was a CRCP overlay, built in 1994 and one of the first applications of low noise exposed aggregate concrete.



Figure 4. A CRC road, locally widened with concrete slabs

CRCP local widening by splitting and shifting the mainline If one wants to avoid the use of JPCP, it is possible to achieve a same result with CRCP – see figure 5. In this case the mainline is no longer continued in a straight way but the two driving lanes are split up and shifted to the outside in order to create a central island. This is a convenient solution when the two lanes are built separately, what is often the case for regional and rural roads in order to allow the concrete supply for the CRCP construction because of the limited space available. It is clearly less interesting when the mainline is built in full width. Indeed, that would mean that the concreting work needs to be stopped and restarted with construction joints and the short deviating lanes need to be built separately, requiring extra construction time. The central island can also be built in CRCP. At both ends of this island it must be avoided to end in a shallow sharp angled part. Therefore a small triangle is to be concreted with one of the two shifted lanes. As the circumference of the island does not remain parallel to the axis of the road and thus the longitudinal reinforcement, it is recommended to place two additional longitudinal steel bars along the edge of the island, spaced at 70 mm from the edge. A tight connection between the island and the driving lanes is ensured with tie-bars.

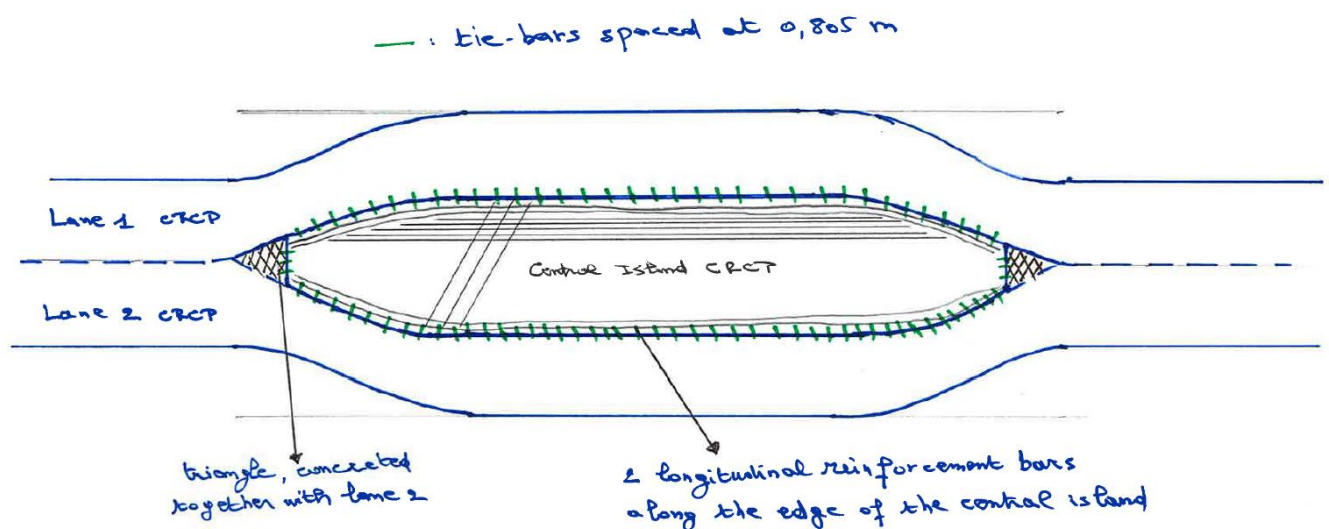


Figure 5 Schematic solution for a locally widened CRCP by splitting and shifting the mainline

This technique has already commonly be used on CRCP regional roads (Leerbeek, Asse, Ham –see figure 6).



6a. Leerbeek



6b. Asse



6c.& d. Ham



Figure 6 Examples of locally widened CRCP by splitting and shifting the mainline, after and during construction

CRCP local widening with CRCP or creation of an auxiliary lane in CRCP A road in CRCP can obviously be widened by adding an extra CRCP lane over a short or longer distance – see figure 7. This extra lane can serve as auxiliary lane. The difficulty here is that the CRCP of the extra lane will move at its ends while the mainline in CRCP is immobilized, as the thermal movement forces are compensated by the friction between concrete pavement and subbase (or asphalt interlayer. The movement of the extra lane happens over a distance called the active length, which depends mainly on the temperature variations and the friction with the subbase. The proposed solution consists of linking the two lanes by extra tie-bars over the active length and installing a reduced anchoring abutment of 3 or 4 lugs. The aim is to minimize the movement of the extra lane and to connect it with the mainline. Over the active length, around 150 m, the number of tie-bars is doubled (spaced at 40 cm). It should be noted that the presence of an asphalt interlayer between concrete pavement and subbase creates a bonding between the layers and reduces the thermal movements of the pavement.

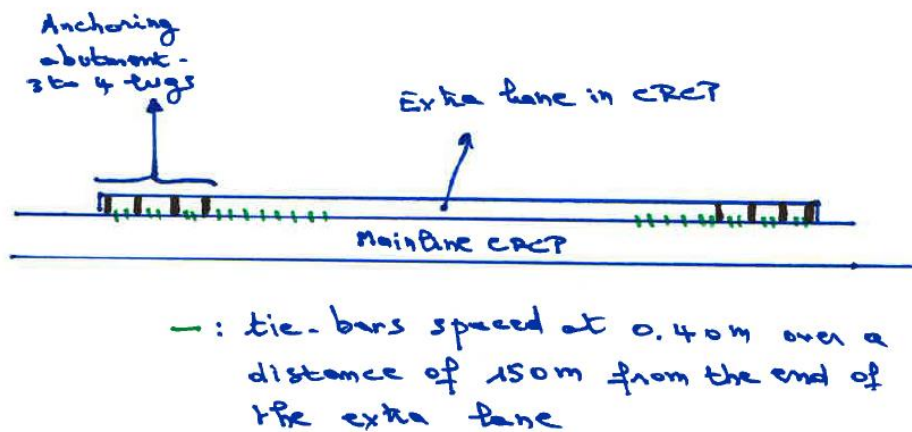


Figure 7 Schematic solution for a locally widened CRCP by adding an extra lane in CRCP

A nice example of this solution is the creation of an auxiliary lane and access ramp to a new science estate along the Boudewijn Avenue in Leuven, Belgium in 2007. The existing pavement of the Boudewijn Avenue (2 x 2 lanes CRCP + hard shoulders in asphalt) was built in 1971 together with the motorway E40 between Brussels and Liège. For the new auxiliary lane, which replaced the asphalt hard shoulder over about 600m, CRCP was chosen to remain coherent with the existing road. The new pavements in the science estate were built in jointed concrete and paving blocks with exception of the CRCP roundabouts. In 2015, both the mainline and the auxiliary lane in CRCP have been overlaid with stone mastic asphalt for reasons of noise abatement due to the transverse grooved texture of the 44 year old road.

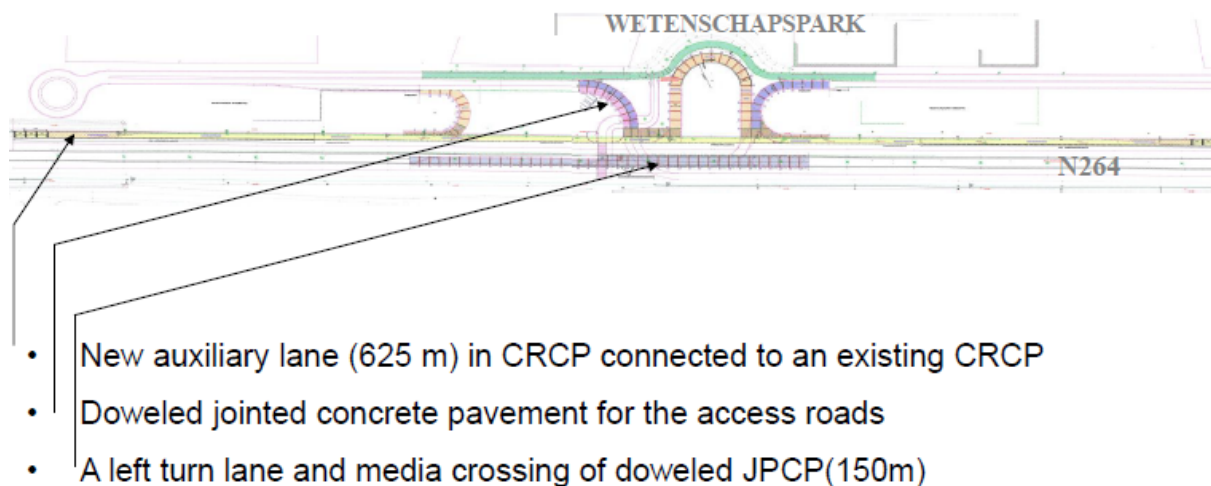


Figure 8 Leuven, Boudewijn Avenue : example of widened CRCP by adding an extra lane in CRCP



Figure 9 Leuven, Boudewijn Avenue : images during and after construction

CRCP local widening with CRCP over a short distance On CRP motorways the hard shoulder can serve as auxiliary lane and only an exit ramp needs to be added to the hard shoulder. A practical solution is to add a triangle of about 30 to 50 m long to create the exit and a transverse transition from concrete to asphalt.

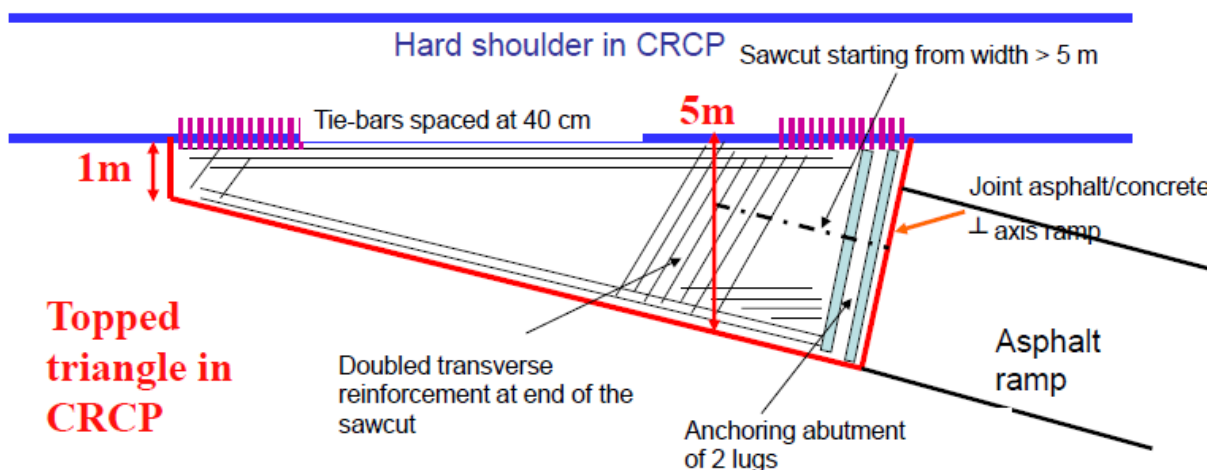


Figure 10 Schematic solution for a locally widened CRCP by adding a triangle in CRCP

The different principles, used in the previous techniques, all come back in this configuration:

- topping of the triangle in order to avoid a sharp angled part;
- doubling of the tie-bars in order to connect the triangle to the hard shoulder;
- an anchoring abutment of reduced width;

- extra reinforcement bars along the sides of the triangle;
- a saw cut in the part with a width > 5 m;
- doubled transverse reinforcement in the area where the saw cut stops.



Figure 11 View at a locally widened CRCP by adding a triangle in CRCP

Conclusions

In countries like Belgium where CRCP is commonly applied, the general design and construction rules are well-known by road authorities, engineering bureaus and road construction companies. However, when situations occur where the standard specifications do no longer apply, guidance is needed to come to a practical and successful solution. Some basic principles are to be respected :

- respecting the maximum lane width;
- determining the right position of the longitudinal joint in order to avoid systematic traffic loading on it;
- connecting CRCP parts and immobilizing the active length;
- avoiding shallow parts with sharp angles.

The choice of the appropriate solution will also be influenced by the experience of the company, the available equipment, phased work periods and other possible constraints during construction. One should always keep in mind that, like any other system, a pavement is only as strong as its weakest link. Therefore special attention must be given to the design and execution of construction details;

References

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