CONSTRUCTION DESIGN OF THE JOINTS IN THE CONCRETE PAVEMENT OF THE ROUNDABOUTS IN AUSTRIA

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ABSTRACT

The roundabouts have become very popular and besides the roundabouts with asphalt pavement, there are also roundabouts with concrete pavement. The reason for this is that roundabouts with concrete pavements can simply "bear" more traffic loads because concrete is a rigid building material unlike asphalt, which is flexible. At higher temperatures, asphalt constructions can cause rutting.

Keywords: Dummy (Dowelled) Joints, Compressed Joints, Free Working Joints, Expansion Joints, Isolation Joints, Longitudinal Construction Joints, Tranverse Construction Joints.

INTRODUCTION

These are, among other things, the reasons why the design period n[1] (RVS 03.08.63;, 2016, S. 4) as a rule, 20 years is assumed for bituminous pavements and 30 years for concrete pavements. The aim of this work is to present the construction design of joints in concrete pavements in roundabouts in Austria with practical examples.

RESULTS

Road construction with concrete pavement in Austria

The road body with concrete pavement usually consists of the following (Blab, Hoffmann et al.;, o.J., S. 36)(Fig.2):

- Subgrade
- ≥ 20 cm unbound lower base course
- 20 cm bound or unbound upper base course
- 5 cm bituminous base course (AC16 trag, 70/100, T3, G4)
- 25 cm non-reinforced concrete pavement (concrete C30/37/B7/XM2/GK22)

[1] Design period (n): *Number of years until the structural fatigue of the superstructure is calculated. Used to compare technically equivalent road structures, but does not have to correspond to the actual service life.*

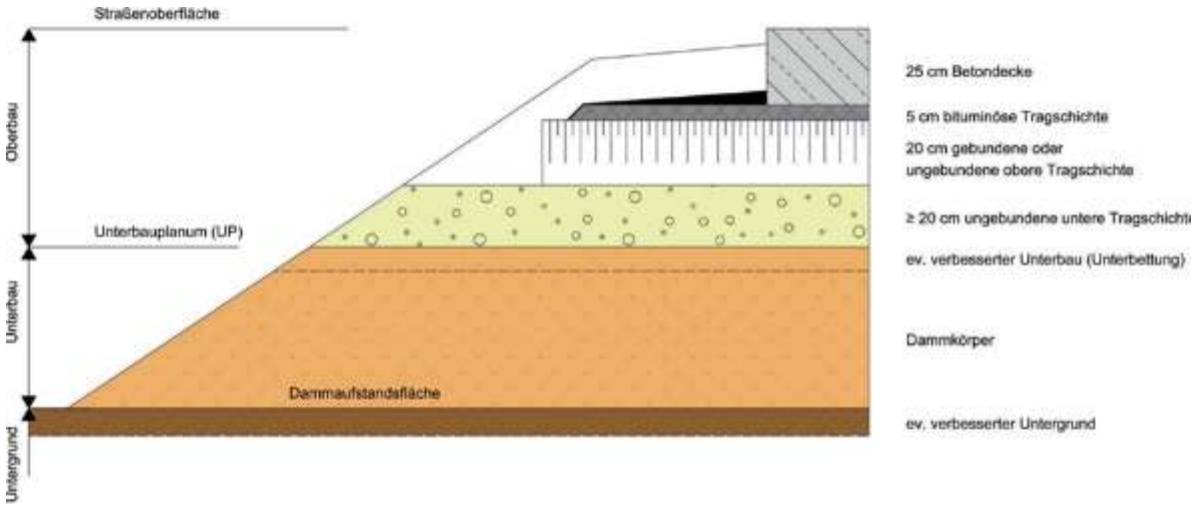

Figure 1: Street body with concrete pavement (schematic) (Blab, Hoffmann et al.;, o.J., S. 36)

How this structure looks like in practice can be seen in Fig.3: Paving the fresh concrete using a concrete finisher over the 5 cm thick asphalt base at the Stapfenedt B127 roundabout in Upper Austria (Hrapović 2, 2020).

Figure 2: Paving the fresh concrete using a concrete finisher over the 5 cm thick asphalt base at the roundabout (Hrapović 2, 2020, S. 265)

Joints

As the roundabout pavement, in contrast to a straight roadway, is also subject to shear and torsional stress as a result of centrifugal forces, the joints in concrete road must be planned and executed very carefully. The anchors and dowels in the joints (steel inserts) should be able to sufficiently transfer the transverse and also the longitudinal forces. These steel inserts ensure the evenness of the concrete carriage slabs.

Concrete is a rigid building material with great rigidity and changes in temperature cause shrinkage (contraction at low temperatures) or expansion (at high temperatures) of the concrete slabs. As a result of these movements, unwanted cracks can develop in unproven concrete pavements. For this reason, joints are provided in concrete slabs as predetermined breaking points (dummy joints) at precisely defined distances to allow the concrete surface to crack in a controlled manner. In the case of transverse joints the dowels are installed and in the case of longitudinal joints the anchors.

There are the following types of joints in concrete pavements (Blab, Hoffmann et al.;, o.J.):

- Dummy (dowelled) joints (*germ. SF-Scheinfugen*)
- Compressed joints (*germ. PF- Pressfugen*)
- Free working joints: connection and end joints - working joints (*germ. ANF-Anschlussfugen, AF-Abschlussfugen*)
- Expansion joints (*germ. RF-Raumfugen*)
- Isolation joints (*germ. TF-Trennfugen*)

With regard to the road axis, joints are distinguished on:

- Longitudinal joints (longitudinal construction joints)
- Tranverse joints (tranverse construction joints)

The valid guideline for the construction of concrete pavement in Austria is guideline for standardization of pavements of traffic surfaces (RVS 08.17.02;, 2011).

According to Austrian guideline for standardization of pavements of traffic surfaces (RVS 03.08.63;, 2016) for all very heavily loaded traffic areas of load classes S, I, II and III with concrete pavements, the tranverse joints are executed as dummy, room and press joints with dowels in the centre of the concrete slab, while all longitudinal joints are equipped with anchors. Dowels have the function of transferring the load between the concrete fields, while anchors are used to prevent the concrete ceiling fields from moving apart.

Dummy (dowelled) joints (SF)

Dummy joints in concrete pavements serve as predetermined breaking points for controlled concrete cracking and are produced as tranverse joints and longitudinal joints. First the concrete is cut in a slot width of 2.0 to 3.5 mm and a depth of 0.24 to 0.33 h (h = slab thickness). This first slit is subsequently widened (milled) again in the upper part, this time in a width of 8.0 mm and a depth of 20 - 30 mm. After thorough cleaning, this joint chamber is first primed with a primer, sealed with an underfill of heat-resistant and non-rotting joint inlay and then sealed with a sealing compound. (Blab, Hoffmann et al.;, o.J.) (fig. 3 and 4).

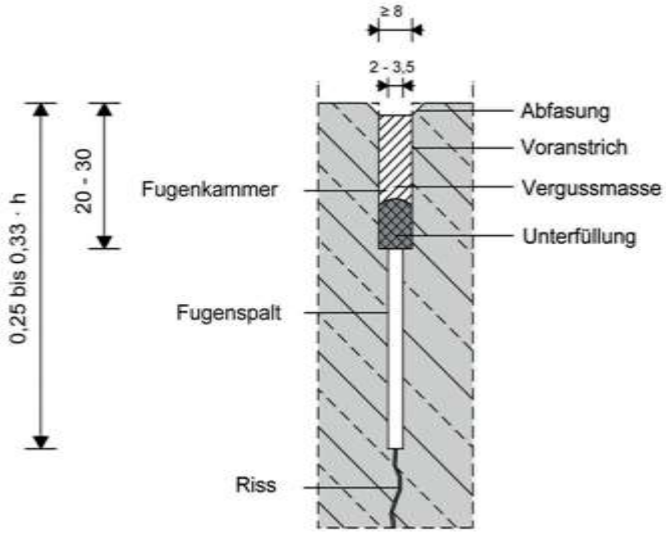

Figure 3: left: schematic representation of a dummy joint (masses in mm) (Blab, Hoffmann et al.;, o.J., S. 43)
Figure 4: right: dummy joint (Hrapović 2, 2020, S. 258)

In the first phase of the dummy joint production, the concrete slab is cut by means of a cutting machine in a slot width of 2.0 to 3.5 mm and a depth of 1/3 of the concrete slab (fig.5 and 6).

Figure 5: left: cutting the concrete ceiling in a slot width of 2.0 to 3.5 mm (Alte-Teigeler)
Figure 6: right: detail of the incision (ÖAT 1;, 2020)

In the second phase of joint production, the narrow slit is subsequently widened or brushing with a diamond disc. After thorough cleaning, the joint is closed either with a sealing compound or with an elastic profile (fig. 7 and 8).

Figure 7: Milling the dummy joint using a special brushing machine (Alte-Teigeler)
Figure 8: Diamond disc (Alte-Teigeler)

Joint profiles

According to (RVS 08.17.02;, 2011) the joint profiles should not damage the concrete, be resistant to alkalis and de-icing agents, insoluble in water, not absorb water and be evenly compressible.

These compressible, elastic joint profiles are installed by machine in all weather conditions, except for frost due to the possible icing of the joint flanks (Fig.5).

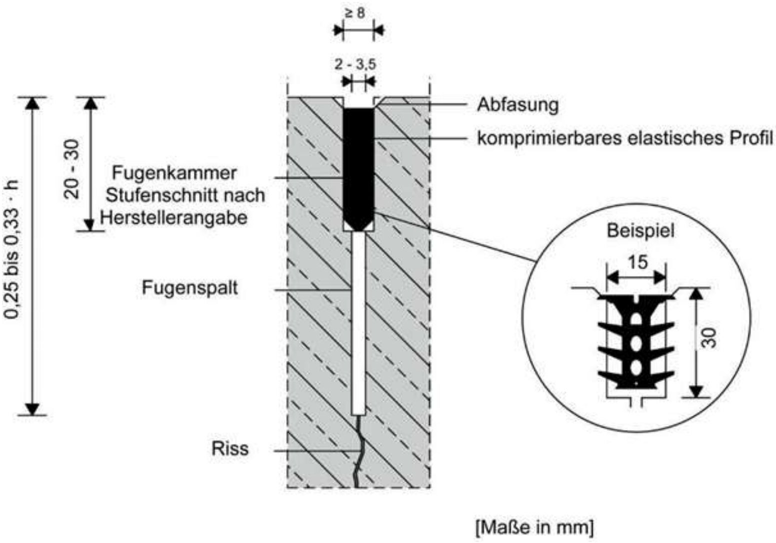

Figure 9: (Tranverse) dummy joint closure by means of a joint profile (Blab, Hoffmann et al.;, o.J., S. 44)

An example of the joint profile, which among other things prevents surface water from penetrating the joint and thus frost damage to the concrete pavement, is shown in Fig. 10.

Figure 10: Example of an elastic jointing material (ÖBA, 2020)

On the highways and motorways in Austria, the tranverse joints are normally closed mechanically using joint profiles (Fig. 11) and the longitudinal joints are sealed with a hot bitumen compound. In this way, the cross joints with built-in joint profiles can simply be sealed with a joint sealing compound in the event of any subsequent renovation work.

Figure 11: Joint profile installation equipment for tranverse joints of a highway in Austria (ÖAT 2;, 2020)
Figure 12: Elastic joint profile (Alte-Teigeler)

Compressed joint (PF)

Pressure joints are made when the new ceiling panels are concreted onto existing ones. As with dummy joints, the upper joint gap must be milled 8.0 mm wide and 20.0 mm deep and closed with suitable joint dimensions. The press joints can be executed as longitudinal joints with anchors as well as transverse joints with dowels. (Blab, Hoffmann et al.;, o.J.) (Fig.6).

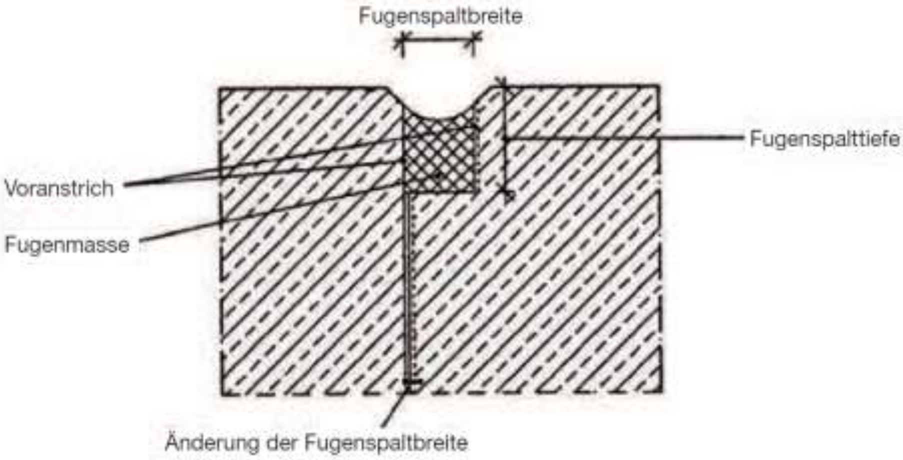

Figure 13: Schematic representation of the press joint (ZTV Fug-StB 15;, 2015)

There are two types of joint sealing:

- Joints in hot sealing
- Joints in cold sealing

Hot grouting: During this bonding process, the hot grouting compound is heated in double-walled, indirectly heated joint grouting vessels and is applied with a grouting lance into the appropriately pre-treated joint chambers for permanent sealing of the joints in concrete pavement (ÖAT GmbH;, 2020) (Fig.14).

Cold sealing: In this process, the joints are sealed with a durable, mineral oil-resistant two-component polysulphide-based cold sealing compound. In this system, a computer-controlled dosing system is used to apply an automatically mixed two-component polysulphide-based casting compound via a casting lance into the appropriately pre-treated joint chambers. (ÖAT GmbH;, 2020) (Fig.15).

Figure 14: Grouting of joints in the hot grouting process (ÖAT 3;, 2020)
Figure 15: Sealing of joints in the cold sealing process (ÖAT 4;, 2020)

Isolation joints[2] (TF)

Isolation joints are the joints following e.g. curbe stones (Fig.7) or various installations such as gully, manhole, etc. Isolation joints have neither dowels nor anchors and are designed so that a continuous, compressible insert (e.g. softwood fibreboard) is inserted in the lower part of the joint. The upper part of the joint must then be sealed with a suitable 20 x 20 mm sealing compound. (Blab, Hoffmann et al.;, o.J.) (Fig.7).

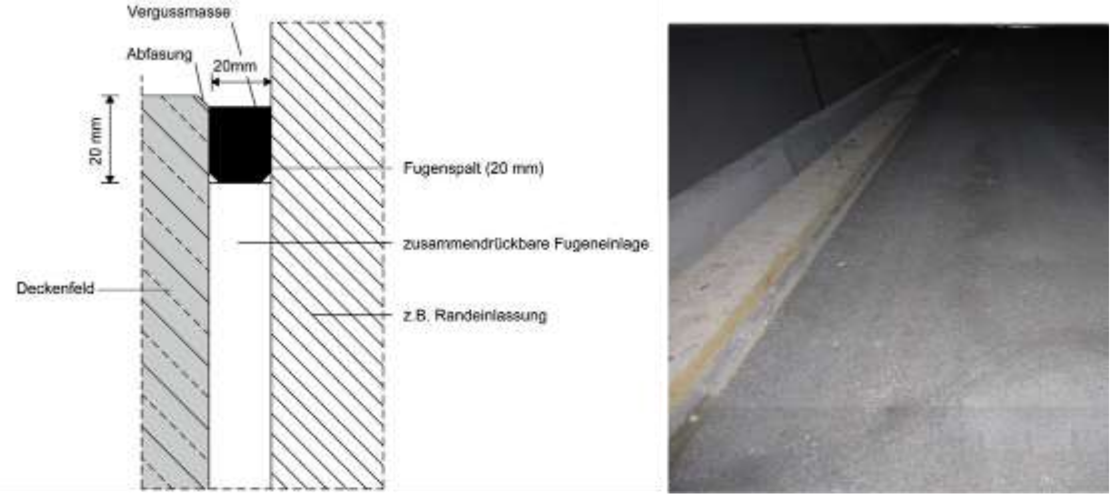

Figure 16: Formation of a separation joint between the edge trim and the concrete ceiling (Blab, Hoffmann et al.;, o.J., S. 47)

Figure 17: Example of a parting line around the manhole cover (ECPA, 2013, S. 12)
Figure 18: Example of a parting line around the gully (Wedl, 2007, S. 25)

Working joints (ANF, AF) (free working joint)

The construction joints are divided into *connection joints* (ANF) and *end joints* (AF):

Free working connection joints (ANF)

The connecting joints must be formed at the transition between the asphalt and concrete slabs, because concrete is a rigid and asphalt is a flexible building material. The connection joints have neither anchors nor dowels. Just as with dummy joints, the upper joint gap is milled 8.0 mm wide and 20.0 mm deep and closed with suitable joint dimensions (Blab, Hoffmann et al.;, o.J.) (Fig.19).

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[2] (ECPA, 2013, S. 13): *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.*

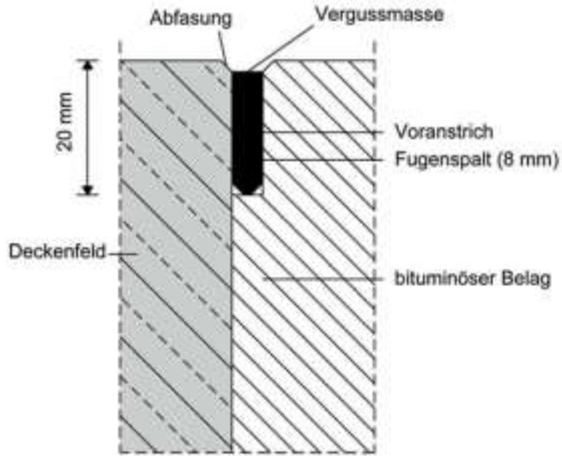

Figure 19: Connecting joint to bituminous superstructure (Blab, Hoffmann et al.;, o.J., S. 46)

Free working end joints (AF)

The end joints are the construction joints, which are also called end of day joints, because they are formed as transverse press joints at the end of a day section. These joints are therefore created at the end of the day's work by cutting back the concrete slab when the concrete finisher is driven out. In contrast to connection joints, the end joints are fitted with dowels.

Expansion joint (RF)

Expansion joints separate the whole width of the concrete pavement to allow the shrinkage (shortening) and expansion of the concrete caused by temperature. The displacement of the concrete slabs is prevented by the installation of dowels. To (RVS 08.17.02;, 2011) a continuous joint inlay must be arranged for expansion joints and the upper gap must be milled 8.0 mm wide and 20.0 mm deep and closed (Fig. 20 and 21). The expansion joints are provided e.g. between old and new concrete field, whereby the dowels with slip-on sleeve are half concreted into the existing concrete field.

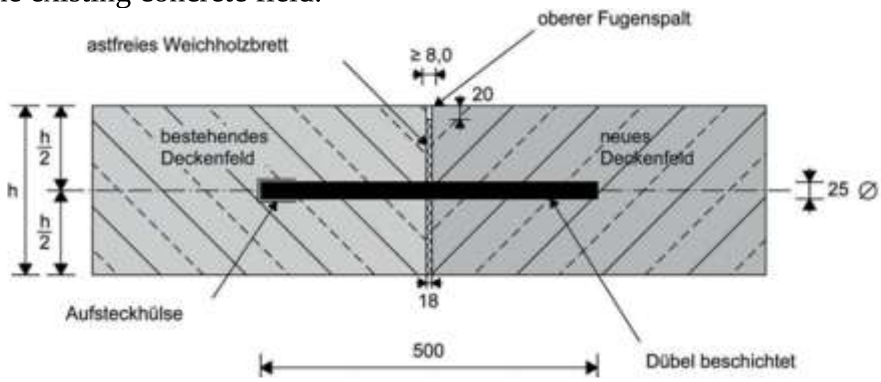

Figure 20: Formation of a dowelled expansion joint (Blab, Hoffmann et al.;, o.J., S. 46)

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Figure 21: Dowels with softwood insert for expansion joints (Hrapović 1;, 2020, S. 130)

Dowel

In Austria, anchors for concrete pavements are made of steel with a length of 50 cm and a diameter of Ø 25 mm. Dowels are only used for tranverse joints and must be completely coated with a corrosion protection. They have to transfer the load between the concrete fields and are provided with or without slip-on sleeve (Fig.22 and 23). To (RVS 08.17.02;, 2011) these sleeves leave an expansion space of 20 mm and they are made of solid material that is not compressed during concreting.

In Austria, dowels are installed in the middle of the concrete slab height at a horizontal distance of 25 cm.

Figure 22: left: Dowel without slip-on sleeve, right: Dowel with plastic cover (Hrapović 1;, 2020, S. 129)

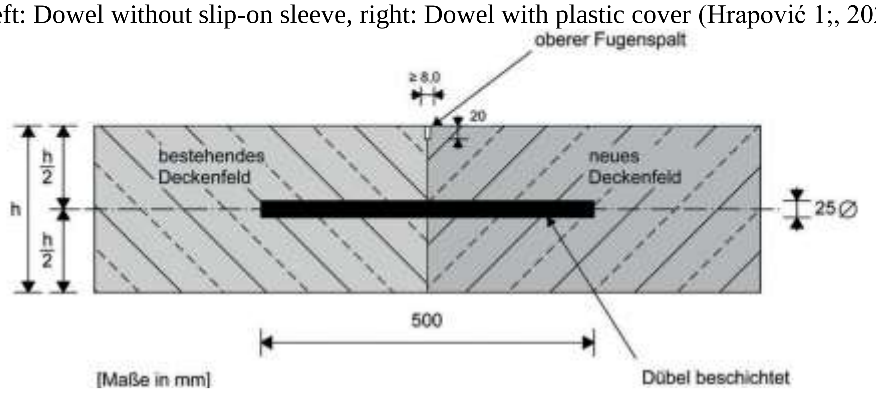

Figure 23: Dowel for the press joints between old and new concrete field (Blab, Hoffmann et al.;, o.J., S. 44)

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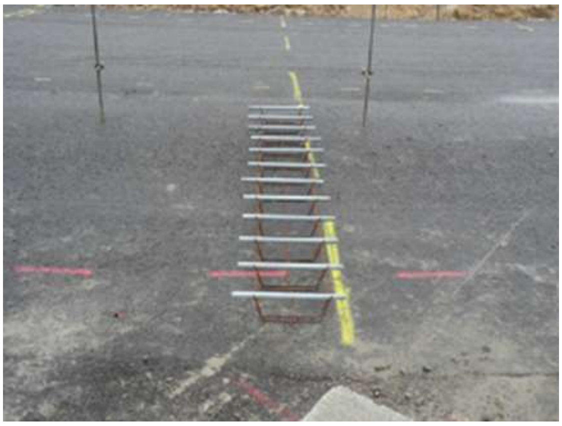

Figure 24: Dowels installed for the tranverse joints of a roundabout in Upper Austria (Hrapović 2, 2020, S. 248)
Figure 25: Dowels are prepared to the height of the centre of the concrete ceiling by means of spacers (Hrapović 2, 2020, S. 248)

Anchor

To (RVS 08.17.02;, 2011) in Austria, anchors are placed at a distance of no more than 1.5 m from each other for longitudinal joints. The function of the anchors in concrete pavements is to prevent the concrete slab panels from moving apart or to hold the concrete panels together along the longitudinal joints. For anchors, concrete ribbed steel according to ÖNORM EN 10025-2 in a length of 50 cm or 70 cm diameter of Ø 14 mm is used for concrete pavements in Austria. The corrosion protection in the anchor centre is 20 cm long (Fig.26).
In contrast to dowels, which are manufactured with round steel and a diameter of Ø 25 mm, the anchors are slimmer, because the forces to be absorbed by the anchor along longitudinal joints are considerably smaller than the transverse forces to be absorbed by the dowels (Blab, Hoffmann et al.;, o.J.).

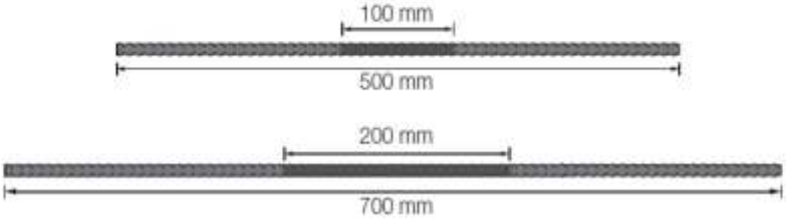

Figure 26: Anchor made of ribbed steel with a corrosion protection coating in the middle (Hrapović 1;, 2020, S. 131)

In Austria, the following methods for anchor installation are used for longitudinal joints of concrete pavements:

a) Drill-in adhesive anchor:

First the holes are drilled into the side wall of the already produced, hardened concrete ceiling, cleaned and then the cartridges together with the two-component swelling mortar mass are inserted into the holes. The anchors are then inserted into the cartridges, creating a non-positive connection (Blab, Hoffmann et al.;, o.J., S. 49) (Fig.27).

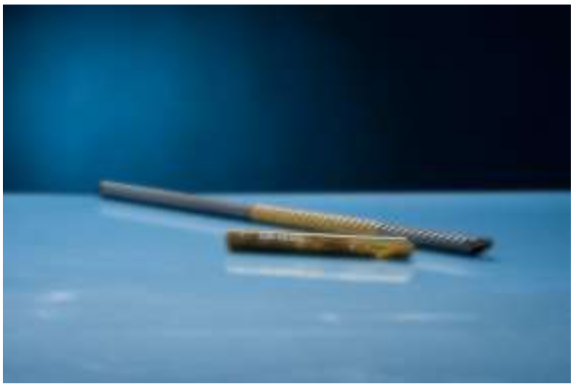

Figure 27: Anchor including cartridge with special adhesive - adhesive anchor (Hrapović 1;, 2020, S. 132)

b) Bent anchor:

First, half of the tie is inserted through the sliding formwork into the freshly concreted slab, with the second half of the tie being bent downwards by 90 ° so as not to impede construction work. After curing and before the new slab strip is produced, the bent part of the anchor is bent up or straightened. (Blab, Hoffmann et al.;, o.J., S. 50) (Fig.28 and 29).

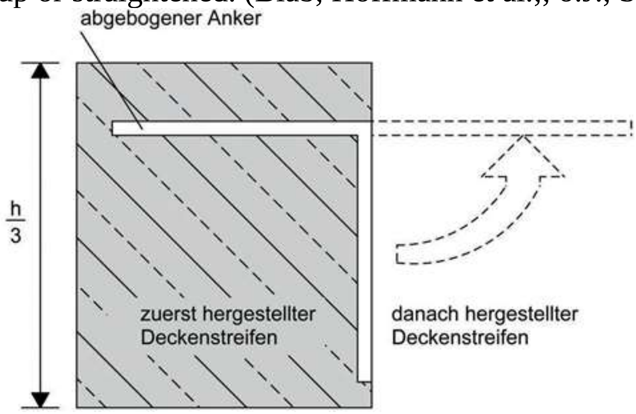

Figure 28: Bent anchor at press joints (Blab, Hoffmann et al.;, o.J., S. 49)
Figure 29: Bent anchor (Blab, Hoffmann et al.;, o.J., S. 49)

c) Screw anchor:

The screw anchor consists of two parts: the first part is with the threaded sleeve and the second part is the actual anchor. This part with the threaded sleeve is pressed or vibrated into the young concrete of the first produced lane, and the sleeve is closed with a plastic cover to protect it from pollution. Before concreting the second, adjacent lane, this cover is removed and the screw anchor is screwed in. Like the other types of anchors, the screw anchor is coated in the middle with an anti-corrosion paint over a length of 20 cm. (Blab, Hoffmann et al.;, o.J., S. 50) (Fig.30 and 31).

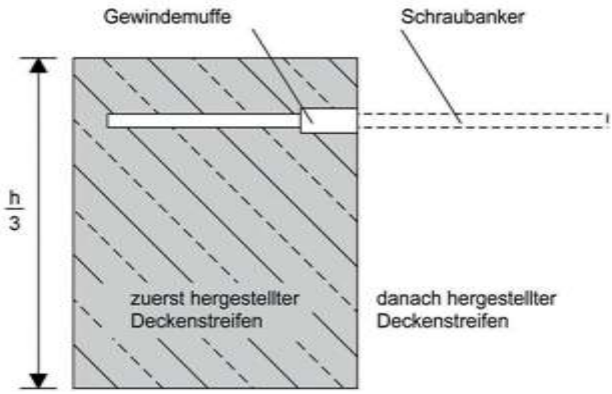

Figure 30: Screw anchors at pressure joints (Blab, Hoffmann et al.;, o.J., S. 49)

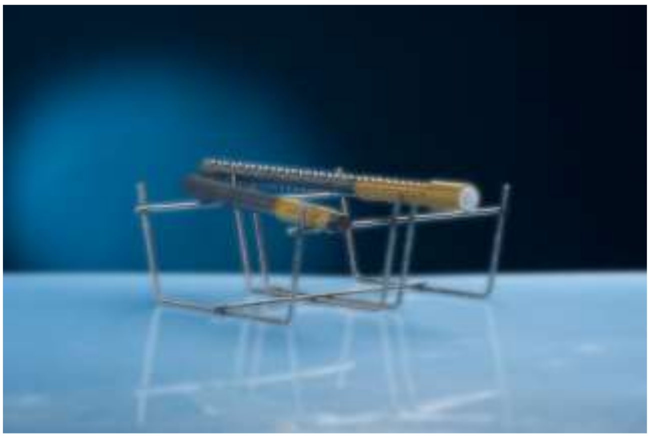

Figure 31: Screw anchor, plastic-coated, with a plastic cover for a longitudinal compression joint (Hrapović 1;, 2020, S. 134)

d) Drop-in anchor

The drop-in anchor consists of a ribbed steel of 400 mm, Ø 20 mm (M 20) or Ø 16 mm (M 16), 1-piece with thread M 20 x 35 mm or M 16 x 35 mm, which is plastic-coated over a length of approx. 100 mm from the centre with a layer thickness of at least 0.3 mm (Otto Brentzel;, 2020) (Fig.32).

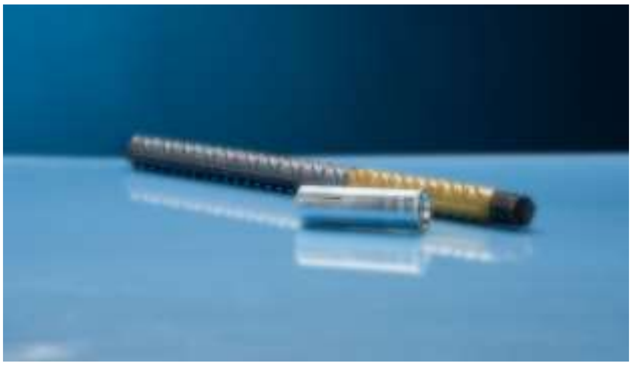

Figure 32: Drop-in anchor with sleeve, plastic coated, for a longitudinal press joint (Hrapović 1;, 2020, S. 134)

This sleeve is 80 mm long and it is driven into a previously drilled hole in the concrete slab, then the anchor is screwed into it (Fig.33, 34, 35 and 36).

Figure 33: Built-in sleeve for hammer-in anchors for longitudinal press joints (Hrapović 2, 2020, S. 253)
Figure 34: Sleeves for hammer-in anchors (Hrapović 2, 2020, S. 254)


Figure 35: Ingenious system for drilling holes for hammer-in anchors (Hrapović 2, 2020, S. 254)
Figure 36: Screwing in the hammer-in anchors (Hrapović 2, 2020, S. 254)

Fig. 37 shows the different types of joints using the example of a roundabout in Upper Austria:

- Tranverse dummy joints - shown in yellow
- Longitudinal press joints - shown in red
- Working joints - shown in blue.

Figure 37: Different types of joints using the example of a roundabout in Upper Austria (Hrapović 2, 2020, S. 259) (supplemented by author)

CONCLUSIONS

In contrast to other countries, e.g. Germany, Belgium and Switzerland, the concrete pavements of roundabouts in Austria are not reinforced. The joints in concrete pavements of a roundabout must be made very carefully. Basically, dowels made of round steel are used for transverse joints and ribbed steel anchors for longitudinal joints. The joint cut must be completely clean and the production of dummy joints is carried out when the concrete is still young, 6 - 24 h after the production of the concrete slab. In the upper part of the joint, either the elastic joint profiles are installed or the joints are cast in hot or cold sealing.

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