

Tunnel Markovec

Construction of a concrete pavement

Manfred Sturm

Österreichische Betondecken-ARGE, Graz, Avstrija



Abstract

In the year 2013 our company, the Österreichische Betondecken ARGE (ÖBA), has buildt the concrete pavement in the tunnel Markovec. In this paper we present the way how we build concrete pavements on the example of the tunnel Markovec, describing the machinery and the operational procedure. Further we present a technical overview of concrete pavements, concerning details like materials, joints and exposed aggregate surface.

Povzetek

V letu 2013 je naše podjetje Österreichische Betondecken ARGE (ÖBA) gradilo betonsko vozišče v tunelu Markovec. V predavanju predstavljamo, kako gradimo betonska vozišča na primeru tunela Markovec, opisujemo potrebno opremo in postopek izvedbe. Nadalje predstavljamo tehnični pregled betonskih vozišč z upoštevanjem detajlov kot so materiali, fuge in površina izpostavljenih zrn.

Overview

The Markovec tunnel is a 2,160 m long twin-tube tunnel and a central part of the expressway H6 at the section between Koper and Izola. In this tunnel the road surface is a concrete pavement with an exposed aggregate surface, which was constructed in March 2013.

This paper is about the construction of concrete pavements, using the example of the concrete pavement in the Markovec Tunnel.

Facts and Figures

two tubes:

Northern Tube (desna cev)

Koper -> Izola

length: 2.145,2 m

Southern tube (leva cev)

Izola -> Koper

length: 2.174,2 m

longitudinal slope: max. 1.7 %

transversal slope: 2,5 %

concrete pavement:

width: 7,00 m

theor. thickness: 29 cm (upper layer 7 cm, lower layer 22 cm)

exposed aggregate surface

amount of concrete: ca. 9.100 m³ (lower layer: 6.600 m³, upper layer 2.500 m³)

duration of construction:

northern tube: 4.3.2013 – 12.3.2013 (7 working days)

southern tube: 13.3.2013-20.3.2013 (6 working days)

daily output: average ca. 340 m / 714 m³
maximum 446 m / 640 m³

Why concrete pavements?

The costs for the construction of concrete pavements may be a little more expensive than the costs for asphalt pavements, so where is the advantage?

The advantages of concrete pavements are first of all:

- ▶ A high durability and a lifetime of 30 years and more
- ▶ There is nearly no maintenance work necessary, the lifecycle-costs are cheap.
- ▶ There are no lane grooves or other deformations, also in hot weather conditions.
- ▶ In case of fire, no toxic gases will develop from the pavement

Concrete Pavements – general information

Design

Generally a concrete pavement is built in two layers, which get placed “fresh in fresh”, so that the result is a monolithic structure. The lower layer reaches up to about $\frac{3}{4}$ of the thickness and has not as high requirements to fulfill than the upper layer, which is exposed to the mechanical and chemical attack. The thickness of concrete pavements on highways is usually between 25 cm and 30 cm.

If an exposed aggregate surface has to be built, the size of the aggregates of the upper layer has to be limited to 8 or 11 mm, and also the requirements on the durability of the aggregates is very high (LA₂₀, PSV₅₀).

A concrete pavement does not use any reinforcing steel. Contraction joints get cut to control the cracking, so that no reinforcement is needed.

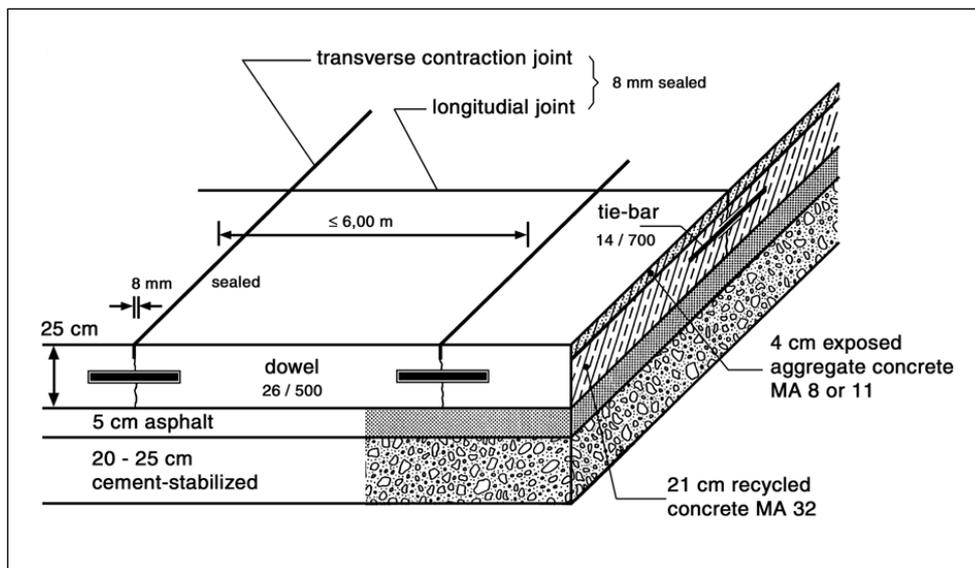


Figure 1: general design of a concrete pavement

Joints

Contraction joints, which are cut in longitudinal and transversal direction, are used to control cracking.

Where the joints will be cut, dowels and tie-bars get placed in the fresh concrete.

The dowels are used in transverse joints – they have a diameter of 26 mm and assist in load transfer, so that there will not occur any vertical movement between the concrete slabs. Because they have a smooth coat of plastic, a movement in longitudinal direction (caused from the contraction of the concrete) is possible.

The tie-bars are placed in the longitudinal joints. They allow the cracking under the cut of the longitudinal joint, but they prevent a horizontal movement of the concrete slabs, so that they will not drift apart.

Exposed aggregate surface

After the concrete is placed, it has to be sprayed with an evaporation protection, so that the water in the fresh concrete will not evaporate, which will cause cracks. If a concrete pavement has to be built with an exposed aggregate surface, the evaporation protection get mixed up with a retarding agent, so that the first millimeters on top of the pavement will not cure as fast as the rest. When the concrete is hard enough to walk on it, the retarded film (cement, sand, evaporation protection) has to be brushed away, so that the aggregates of the concrete get exposed for some millimeters.



Figure 2: exposed aggregate surface

To achieve a proper result, the size of the aggregates in the upper layer has to be limited to 8 or 11 mm. After the making of the exposed aggregate surface, the joints get cut.

The advantages of such a surface are a noise reduction and a long-lasting surface structure.

Construction of a concrete pavement

A concrete pavement can be placed by hand, which is done on small sites or where irregular slabs have to be built, or it can be placed with finishers, which is done on roads or air fields. For thicknesses up to 30 cm, usually slipform pavers will be used, for bigger thicknesses the use of formworks is advantageous, although not essential.

Roads usually get built with slipform pavers, where the whole width of the road get placed at once. Pavers can be built with a width up to 15 m.

A paving unit consist of 3 machines: a finisher for the lower layer, a finisher for the upper layer and a curing machine, that sprays on the evaporation protection.

The first finisher places the first layer of

concrete and automatically presses the dowels and tie-bars into this layer. The second finisher places the upper layer and is equipped with gadgets to create an even surface.

These three machines drive directly one after the other, so that the placing of the layers is done fresh in fresh and that the concrete gets protected against evaporating as soon as possible.



Figure 3: paving unit

The concrete for the lower layer is brought to the finisher by dump trucks and gets dumped directly in front of the finisher.

The concrete for the upper layer can be delivered on dump trucks or in mixing trucks. If there is enough space on the site, the dump truck can stop beside the finishers and an excavator will shovel the concrete between the first and the second finisher on the already placed first layer.

If there is not enough space beside the finishers (as it is in tunnels, for example), also the concrete for the upper layer has to be unloaded in front of the first finisher, and it will be transported by a belt that runs over the first finisher and pile up the concrete in front of the second finisher. In this case the concrete can be delivered by a mixing truck that empty directly on the belt, or by a dump truck, that gets unloaded by an excavator, which shovels the concrete on the belt.

Before the placing of the concrete gets started, a guide wire has to be placed in a precise high above and distance from the edge of the concrete pavement, that is to build. From this guide wire the machine reads the direction, in which it has to go and also the high, in which the concrete has to be placed.

It is extraordinary important, that no person and no machine or truck gets in contact with this wire, because every little change of its position causes an unevenness in the pavement.

When the concrete is hard enough – depending on the weather conditions and temperature, that can be between 5 and 25 hours after the concrete is placed – the surface has to be brushed und the joints have to be cut.

The brushing is done with a grader, that got equipped with balloon tires and brushes instead of the shields. This work has to be done by a very experienced man, because he

has to determine the right time for doing this work and he has to handle the machine with care.



Figure 4: making of the exposed aggregate surface

Soon after the brushing of the surface, the joints have to get cut. The first cut is the contraction joint. Its depth is about 1/3 of the thickness of the concrete pavement and it gets placed exactly above the dowels and tie bars.

The second cut is to widen up the upper section of the first cut, so that a sealing can be filled in.

After the sealing of the joints, the concrete pavement is ready for use. This should not be before 5 days after the placing of the concrete. For doing repair works, there are special kinds of concrete available that can be allowed to be used by the traffic 6 hours after the placing of the concrete.