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Objekt Nr. 599.3

PostParc Berne
Berne railway station development project

Expansion joints
Evaluation of pilot project with *Polyflex Advanced* system

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1. Introduction

The PostParc in Berne, Switzerland is surrounded by bridges (e.g. Schanzen Bridge, SBB Welle, SBB platform structures), and in fact is even itself a bridge structure in various places (Reiterbau, GSAG, Post Bridge, Bogenschützen Street). These bridge structures require expansion joints in their movement gaps, particularly at their ends, in order to accommodate structure expansions and contractions while also sealing the movement gaps. The total length of external expansion joint is approximately 450 m.

The existing expansion joints (prior to commencement of construction in 2011) were located inside buildings (Reiterbau), and therefore did not require to be waterproof. Other expansion joints, mostly bituminous, had already been leaking for a long time (Post Bridge, Schanzen Bridge, GSAG). With the PostParc project, new expansion joints were installed along the Schanzen Bridge and as far.

As a result of the very complicated expansion joint geometry and the phasing restrictions imposed by traffic requirements, only a poured expansion joint could realistically be considered.

Expansion joints of this type have been installed in Switzerland since 1991. After initial very successful applications, the systems on offer have been continually further developed and used to accommodate ever-increasing movements. For movements of up to +/- 15 mm, these systems practically became the standard solution in Switzerland, with greater movements of up to +/- 35 mm being possible thanks to spring-reinforced inserts.

From 2006 on, however, bituminous expansion joints suffered damages that could not at first be explained. Intensive investigations by the manufacturers, in cooperation with EMPA (the Swiss Federal Laboratories for Materials Science and Technology), showed that the bitumen quality varied considerably. Small changes in the chemical composition of the raw materials led to big reductions in expansion joint quality. As a result, construction project clients and expansion joint manufacturers became increasingly concerned about the ongoing suitability of the systems for use.

Manufacturers from across Europe then began to develop systems using raw materials they could produce themselves or could acquire from suppliers in the required quality. The system used in the pilot project was developed in Austria, and has not yet been used on many bridges in Switzerland. According to the manufacturer's product documentation, the system has been certified by the *Bundesanstalt für Materialforschung und –prüfung*, Berlin, by the *Prüfamt für Verkehrswegebau* of the Technical University of Munich, and by the MAPAG testing institute, Austria.

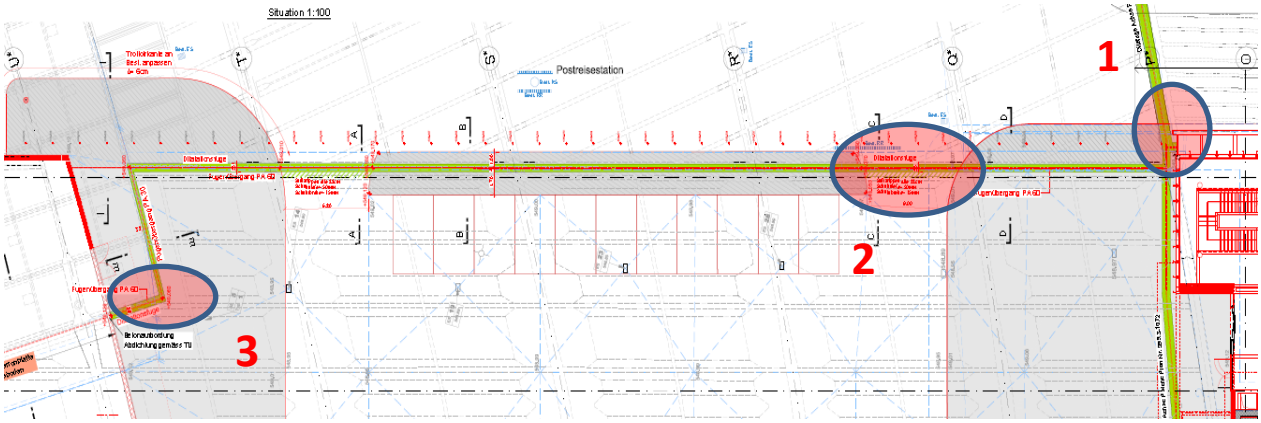
Since the demands on the expansion joints at PostParc do not correspond well to the demands on joints in typical road bridges (movements parallel to joint, complicated geometry with turns and bends, static point loading), we requested the client's civil engineers to conduct testing on site.

In June / July 2013, the Baumeister joint venture installed three test strips of expansion joint using the *Polyflex Advanced* system of the company Mageba SA, in the location of the PostParc development project.

The basis for their design, relating to the movements to be accommodated, was the data available from the Schanzenpost engineering partnership dated 17.04.2012 and the design drawing for the test strips 599.3 – 1090a as well as the Baumeister joint venture's quotation No. 61 dated 31.12.2012.

2. Demands on the expansion joints from June / July 2013 to 31.07.2014

The three test strips were situated at the building site's perimeter, at locations with varying demands on the expansion joints and where the construction work would not be hindered:



Joint 1: The largest longitudinal movements, no traffic loading, step

Joint 2: Small longitudinal and transverse movements, heavy traffic loading (construction site traffic at site entrance)

Joint 3: Corner point with movements in two directions, no traffic loading

Locations where all parameters arise with their maximum values were not available due to the construction project's state of progress and its ongoing activities.

The temperatures, and thus the movements to which the expansion joints were subjected, unfortunately did not reach the desired values during the testing period to the end of July 2014. Although temperatures exceeded 30° C on several days in the summer of 2013, the winter of 2013/14 was extremely mild, with just a few days with sub-zero (negative), single digit temperatures on the Celsius scale. In the summer of 2014 as well, temperatures did not go very high, with few days having temperatures of over 30°C.

However, considering the state of progress of the PostParc construction project, an evaluation is now required in order to enable a decision to be made on which system to use on the project, so that the necessary preparatory measures can be taken. It is not possible to wait for another winter / summer temperature cycle.

3. Test programme

Criterion	Requirement	Method	Who
Watertightness	Watertight	Visual checking from below of all expansion joints.	H&W
Movement	Crack-free	Visual checking from above of all expansion joints. Checking by calculations of the observed dimensional changes.	H&W
Rutting	Only minor rutting	Measure with a straight edge.	H&W
Penetration of point load	Only minor penetration when warm	Testing device with a load of 0.7 kN applied to an area of 3.1cm^2 for several weeks at Test Strip 3.	JV / H&W
Adhesion to subsurface	No detachment	Drilling of cores at the edge of the joints, to the concrete subsurface. Visual checking of cores with respect to bond (concrete / steel / poured expansion joint material / pavement). Materials testing by Geotest AG.	JV / H&W
Bonding of asphalt strengthening ribs	Bonding with asphalt	Drilling of cores to the concrete subsurface. Visual check.	JV / H&W

4. Evaluation of tests

4.1. Watertightness

Visual control during heavy rain.

Test Strip 1: Underside could not be directly viewed, adjacent areas not watertight → no conclusions possible.

Test Strip 2: Underside could only be viewed with difficulty due to temporary metal gutters. The gutter in the south connection area was wet, directly beneath the new expansion joint it was dry. It may be assumed that the expansion joint is watertight and that the observed water got in from the south side.

Water in the metal gutter

Gutter dry beneath the new expansion joint

Test Strip 3: Underside dry, exposure of the expansion joint is low.

Conclusion: The undersides that could be inspected remained dry even after heavy rainfall.

4.2. Movements

The lowest temperatures in the winter of 2013/14 were approximately -5°C, and such low temperatures were of short duration so it is not sure that the massive concrete structures cooled down to this temperature.

The highest temperatures in the summer of 2014 were approximately 31°C, and a similar comment regarding duration and effect must apply.

We estimate that the difference between the maximum and minimum temperatures of the concrete structure during the test period was 30° C. The demands were thus significantly lower than the temperature difference of +/- 20°C = 40°C specified by the standard, as can be expected to arise in “normal” years.
So unfortunately, the expansion joints were not tested to the limit. They were only exposed to ¾ of the appropriate movement.

None of the three test strips showed any signs of damage which might be attributed to overstretching or over-compression. No cracking of the material could be found.

4.3. Rutting

Test Strip 2, at the entrance to the PostParc construction site, was exposed to heavy construction traffic during the entire duration of the test programme.
Due to this expansion joint's location directly at the site entrance checkpoint, the wheels of trucks will have stood directly on the expansion joint, for extended periods, many times during the testing period.
After a year of intense loading, the expansion joint showed nothing more than colour changes. Neither rutting nor plastic deformations, of the type known from other systems, could be seen.

No rutting or plastic deformation could be seen

4.4. Penetration of point loads

Point load tests were carried out with various durations.

A) Duration 4 weeks, temperature max. 28°C, Loaded surface area 3.1 cm2, Load 700 N (70 kg).
The penetration bar pushed approx. 20 mm into the joint's material, until all its support points were resting on the surface, at which point the test frame did not sink in any further.

B) Duration 1 week, temperature max. 23°C, Loaded surface area 3.1 cm2, Load 700 N (70 kg).

Also with a shorter duration and at lower temperatures, the penetration bar pushed into the joint's material until all its support points were resting on the surface.

C) Duration: Several seconds, temperature 20°C, pointed object (scabbling pick) Only a small penetration. No lasting damage to the joint's material.

Penetration test with an iron bar of diameter 20 mm and a load of 70 kg

The impression made by the iron bar has flattened out again

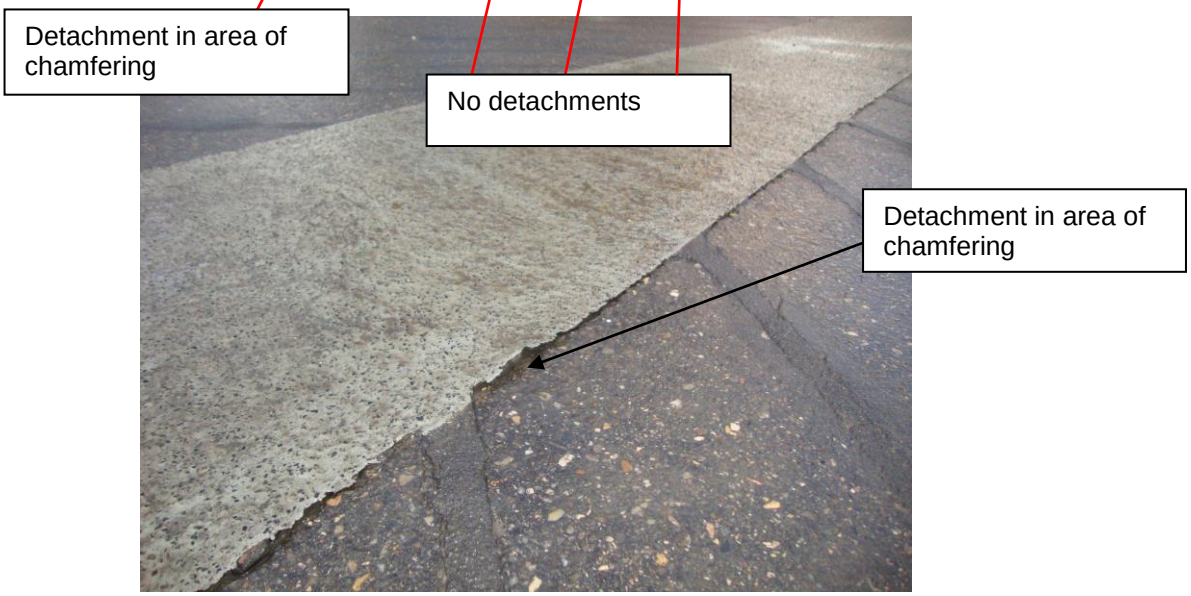
Penetration test with scabbling pick C)

Conclusion:
The point loading resulted in the loaded bar pressing into the joint's material. Under this form of loading, the material behaved elasto-plastically, with the impression left by the loaded bar disappearing within a day. The expansion joint did not lose its watertightness. The applied load of 70 kg (0.7 kN) resulted in a pressure of 2.25 N/mm2 on the expansion joint.
In comparison with competitor products, the *Polyflex Advanced* system is stiffer, particularly under intense solar radiation, and therefore better than competitor products. But we cannot guarantee that motorcycle kickstands, if standing on the joint for an extended period of time, will not press into the material.

4.5. Adhesion to subsurface

Visual evaluation:
The adhesion to the concrete of the horizontal and vertical connection surfaces was perfect. The connection surfaces to the steel profiles also showed no sign of detachment.

In the area of the chamfer (approx. the upper 8 mm), the joint material detached itself from the concrete. According to the manufacturer, this chamfering is part of the expansion joint system and is provided in order to prevent this apparently inevitable detachment from extending down into the area with vertical surfaces. Presumably, additional maintenance work such as cutting and re-pouring is required in this area.



Laboratory examination
Laboratory examinations (thin section analyses) by the company Geotest AG showed, for Test Strip 1, good adhesion to the concrete. The joint material could not be tested in a tensile test to its limits, because the testing equipment had a limited testing range. The laboratory testing thus verified the very high stretchability of the material.

Specimen 2 had no adhesion or only poor adhesion between the joint material and the asphalt surfacing. The removal of the cored specimen in the asphalted surfacing was difficult. We assume that the specimen became unusable as a result of mechanical damage during core removal.

4.6. Bonding of asphalt strengthening ribs

The asphalt strengthening ribs that were cut into the road surfacing showed detachments from the surfacing within a short period of time in the areas of intense traffic loading. The stiff ribs detach themselves from the relatively soft surfacing.

The purpose of these ribs is to prevent the development of rutting in the surfacing immediately adjacent to the expansion joint, because such rutting is responsible for most of the detachments of the joint material.

The asphalt strengthening ribs fulfilled their function in the testing at Test Strip 2. No detachments could be identified at this intensely loaded expansion joint.
If need be, additional maintenance work by way of cutting and re-pouring may be required at the asphalt strengthening ribs.

5. Comparison with competitor products

The *Polyflex Advanced* system was selected in the early part of the year for the test strips at the PostParc because it was the only new-type system available on the market and already had testing certifications. The installation went smoothly, without any problems, including even the formation of the step at the postal car ramp.

The only available competitor product has been installed in test locations since the end of 2013. The experiences here are also positive, but this system could not be tested at PostParc for programme reasons. Furthermore, this system requires deeper, wider recesses than the tested *Polyflex Advanced* system. As necessitated by the state of construction progress at PostParc, it was decided to use the *Polyflex Advanced* system at the expansion joint locations. A change of system to the competitor's product would require adaptations to the already prepared concrete structures, and would only be justified if the tested system had transpired to be unsuitable for use or much more expensive.

According to the quotations provided to us by the Baumeister JV in relation to the systems to be compared (*Polyflex Advanced* and *Silent-Joint*), there is little difference in the unit pricing.

6. Recommendation

The engineering partnership recommends the use of *Polyflex Advanced* for the expansion joints, for the following reasons:

- The system has been widely used, especially in Austria, and can present the most references to date.
- No problems were experienced during the installation of the test strips.
- The most important requirements were satisfied by the test strips (watertightness, bonding to different materials, movement capability).
- The system is practically the only one which can be recommended today, even if a certain degree of maintenance can be expected during its service life. Expansion joints are mechanical parts that are subjected to heavy wear and tear. The systems of other suppliers may well offer the same properties in the near future, but are not yet ready to be recommended for such a large application.