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Test report no 454121

Test assignment:	Low temperature behaviour of the joint by means of movement simulator test
Client:	Bouwbedrijf Salverda BV Postbus 4, 8084 ZG 'T Harde, the Netherlands
Test object:	Prefab Silent Joint
Client's reference:	Mr Ron Haverland
Reference order:	Email R.Haverland@salverda.nl from October 22th 2009
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Expert:	Head of Laboratory:
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1 Order

The company Bouwbedrijf Salverda BV, 8084 ZG 'T Harde, the Netherlands placed an order on October 22th 2009 with EMPA, Laboratory for Road Engineering/Sealing Components, to test one specimen of the flexible plug expansion joint system "Prefab Silent Joint" by means of the movement simulator test in accordance with Chapter 3.

Remark:

The specimen used for this investigation originates from the order of Rijkswaterstaat (EMPA no 452822). On this specimen, a similar test by means of the movement simulator was already carried out for Rijkswaterstaat, as it is described in Chapter 3. The only difference is because of the maximum joint movement (before 13mm instead of now 32.5mm). After 10 cycles joint movements of 13mm, at -10°C, with an extension speed of 10mm/h, the specimen stayed intact.

Mr. Voskuilen of Rijkswaterstaat permitted to use this specimen for additional investigation purposes.

The chosen maximum joint movement of 32.5mm in this investigation corresponds to approx. 65% of a permissible annual joint movement of 50mm for the Netherlands.

2 Test specimen of the joint system Prefab Silent Joint

2.1 Joint system Prefab Silent Joint

Figure 2.1 shows a cross section of the joint system Prefab Silent Joint.

The Silent Joint system consists of a row of springs which are embedded in binder at spaces of approx. 100 mm then, anchored to two opposite steel T-shaped sections. The device for covering the joint gap consists of a cover plate 5 mm thick, which rests on a sliding bearing.

For the Prefab Silent Joint, the joint module was prefabricated by Salverda and delivered to the fabrication site for the installation. This joint module consisted of two T-shaped steel sections where the springs were fixed. The springs are then embedded in aggregates and binder.

For the installation, the prefab joint module was removed from its fixation plate and fixed onto the concrete slabs using metal anchor rods using a chemical resin. After fixation, both gaps between the joint module and the adjacent bridge pavement were filled with the joint mixture (hot aggregates and binder) until the height of the joint module was reached. Finally, the last layer (approx. 30mm) was applied between both bridge pavement plates.

Normally, small sized aggregates were applied on the surface of the last layer as a surface dressing to provide texture and skid resistance of the surface of the joint.

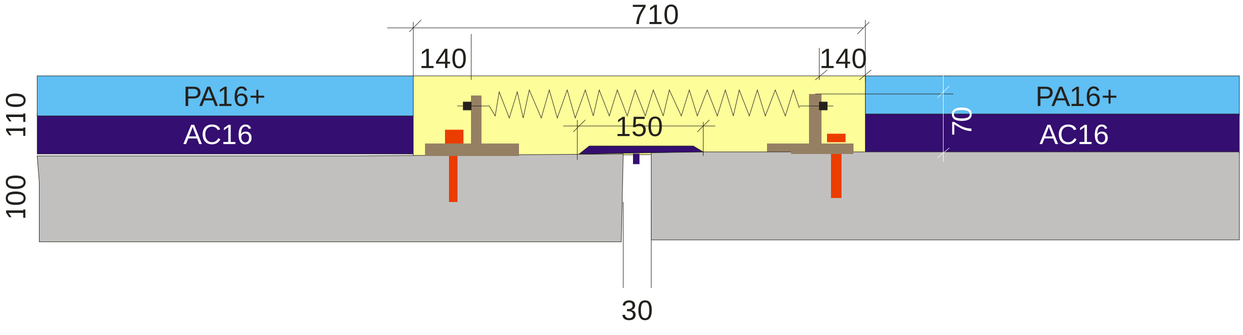

Fig. 2.1: Cross section of the joint system Prefab Silent Joint

2.2 Construction of the test specimen

For the investigation research of Rijkswaterstaat (EMPA no 452822), the specimen was constructed to a 1:1 scale of the actual joint complete with gap filling and sealing devices, mounted on two bridge concrete base slabs and between two adjoining surfaces of asphalt bridge deck construction (see *Figure 2.2 B*).

For the installation of the specimen, fresh but not younger than 28 day old concrete slabs were used. The surface of the concrete slabs was sandblasted. For each specimen two concrete slabs were fixed together by two metal frames (see *Figure 2.2 A*). The concrete slabs were paved according to the specific asphalt bridge deck construction used in the Netherlands consisting of tack coat, 50mm AC16 and 50mm PA16+, which was produced by Heijmans in Zwijndrecht in the Netherlands. After paving, the pavements were cut to size ready for the installation of the joint (see *Figure. 2.2* B).

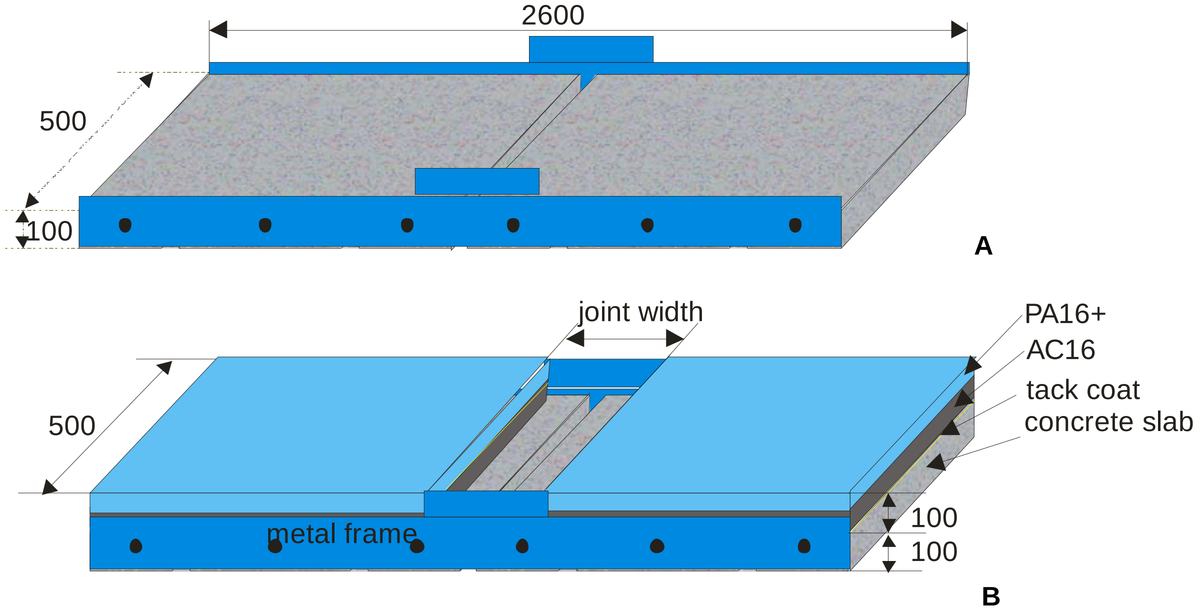

Figure 2.2: Cross section of the test slab for producing of the specimen
All dimensions in mm

2.3 Joint installation

The joint specimen was installed by Schagen infra BV, 8000 AP Zwolle on July 15th 2009 in Zwijndrecht (the Netherlands). This installation was monitored by EMPA (see installation's data and the photos documentation in sections *6.1.2* … *6.1.5*).

3 Test principle and conditions

The joint system's movement capacity (quasi-static fatigue behavior) of the specimen was tested by horizontally opening and closing the joints repeatedly at low temperatures (–10°C) and using a special testing device called Joint Movement Simulator (JMS). The JMS is a horizontal stretching bench that consists of two parts: a stationary and a moving part that slides on rails (*Figure 3.1*). One side of the joint was fixed on the concrete substrate and on the stationary part of the testing device. The other side was fixed on the concrete substrate that was mounted on the moving part of the JMS and moved horizontally by a spindle motor in displacement-controlled mode.

The local expansion of the joint during loading is measured by determining the change in position of optical line markings that were drawn at spacing of 50 mm both on the surface and on the side of the asphaltic joint filling material (see *Figure 3.2*).

The force is continuously recorded while the joint is expanded with 10 mm/h from an original joint gap width of approx. W_o = 30 mm to a maximum joint opening of W_o +32.5mm and then at the same rate (10 mm/h) pushed back to the original value W_o in order to simulate one maximal opening and closing the joint at cold temperature during one year. This triangular movement cycle is repeated at least 10 times.

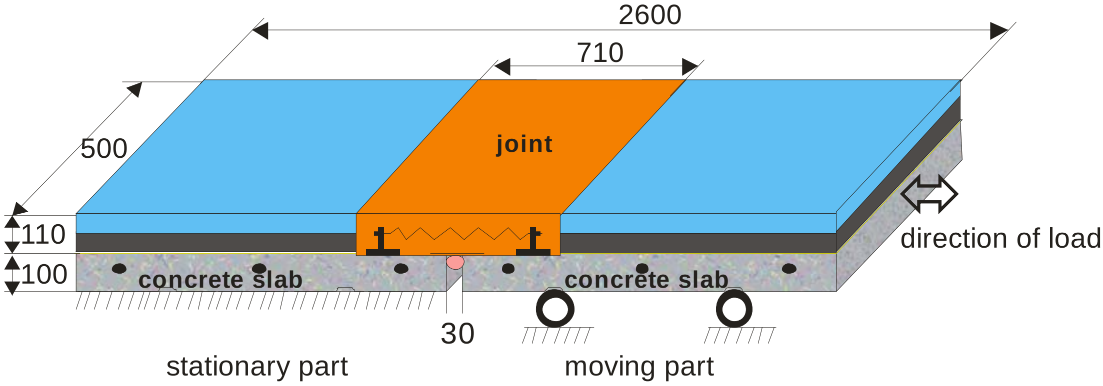

Figure 3.1: Test specimen mounted in the JMS testing device
All dimensions in mm

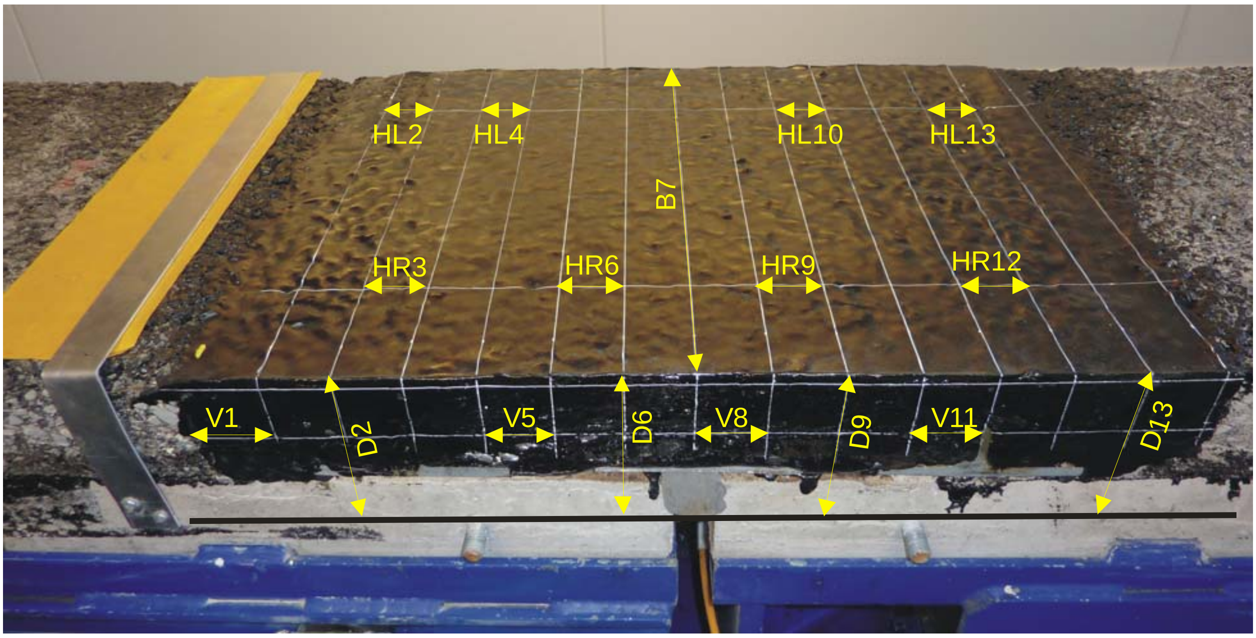

Figure 3.2: Marking lines for the measurement of the local expansion of the joint during the first load cycle

4 Test results

The test results are listed in detail in appendix (Chapter 5.2) and are summarized in *Table 4.1*. The force-elongation-time diagram appears in *Figure 5.2.1.* The picture in *Figure 4.1* demonstrates the good condition of the specimen after the test.

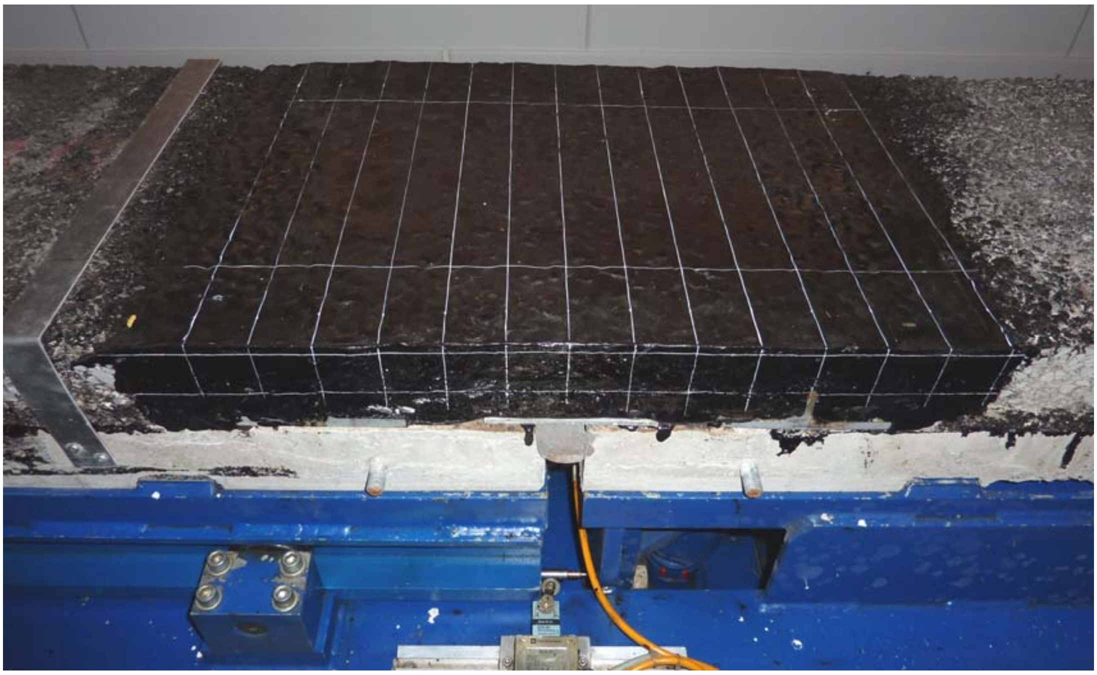

Figure 4.1: Appearance of the specimen after the test

Characteristics of the specimen	Results
	Damage
Cracking of the joint filling mixture	none
Debonding of the joint filling mixture from the adjacent pavement surface	none
	Maximal force
1st cycle	22.4 kN
2nd cycle	15.6 kN
10th cycle	11.2 kN
	Expansion and deformation of the joint during the 1st cycle
Stress distribution	between both bridge pavement plates. On the moving side, the stress was a little larger than on the other part of the specimen
Maximal reduction of thickness	3 mm
Maximal lateral contraction	14 mm

Table 4.1: Prefab Silent Joint. Summary of the results

5 Appendix

5.1 Installation of the joint specimens

Two joint specimens of the system "Prefab Silent Joint" were constructed in Zweijndrecht (the Netherlands) on July 15th 2009 by the company Schagen/Salverda for the investigation research of Rijkswaterstaat (EMPA no 452822).

The installation took place in an open-air area of Heijmans and was monitored by EMPA. *Tables 5.1.1* and *5.1.2* show the used materials resp. the condition of the installation.

5.1.1 All those present

RWS:	J. Voskuilen
Schagen infra BV:	H. W.E. Oosterwijk
Installation team:	H. Prins (Schagen), J. Schoonhave (Eiland), J. errets (Stelling)
EMPA:	S. Hean and H. Kienast

5.1.2 Installation procedure

1. Removing the prefab joint module from its fixation plate and barrier plate
2. Drilling the anchor holes and fixing the anchor rods with chemical resin
3. Sand blasting of the surfaces of the deck joint gap (concrete surface and adjoining surface of the pavement)
4. Activation of the adjoining surface of the pavement by heating with compressed hot air
5. Stuffing a foam caulking into the expansion joint gap
6. Priming the surfaces of the joint gap (adjoining surface of the bridge pavement and concrete surface in the middle of the joint and in the area between the joint module and the bridge pavement)
7. Put down the bridging plate and fixing the joint module onto the concrete slab
8. Applying the hot binder to all exposed horizontal and vertical surfaces between the joint module and the bridge pavement
9. Application of joint between the joint module and the pavement:
   - the aggregates were heated in a rotary drum using compressed hot air to about 205°C and premixed with a small amount of binder
   - the premixed aggregates were poured into the joint gap until the same height of the joint module and compacted with a hand driven compactor
   - pouring the binder into the aggregates
10. Application of the last layer:
    - heating the surface of the prefab joint module with a gas-flam
    - pouring the binder in layers of approx. 1 cm on to the previous layer
    - filling the hot aggregates into the gap until the required height is reached
    - pouring immediately the hot binder in to the aggregates

11. Application of the surface dressing:
    - after reaching the approximate temperature of 50 … 60°C, the surface of the last layer was flamed carefully to relieve the air blisters from the binder
    - pouring the binder on the surface of the third layer and allowed to cool

5.1.3 Materials used

Materials	
Deck joint gap	Dimension see Figure 3.1. Adjacent pavement surface: bridge deck construction (tack coat, AC16 and PA16+)
Joint module	500mm x 420mm; with 4 springs (∅ 40 mm; made of stainless spring steel; spacing between two springs: 100 mm)
Joint binder	Continental joint C from Colas UK (batch no 76-3 224.09)
Aggregates	Blast furnace slag 11/16 mm (batch no unknown)
Spread chippings	At EMPA's wish; not used. This makes the measurement of the displacement of the marks on the joint surface easier.
Primer	Polymer spray (unknown)
Tanking	Used joint binder
Polymer grid	None
Metal plate	Steel, thickness 5mm, width 150mm

Table 5.1.1: Details of installation materials used

5.1.4 Temperatur condition during installation

Installation steps	Temperature [°C]		
	Joint binder	Aggregates	
		Before coating with the binder	*During filling the deck joint gap*
Tanking	230	- - -	- - -
1st layer	225	203	180
2nd layer	223	205	189
Surface dressing (without small size aggregates)	223	- - -	- - -

Table 5.1.2: Temperature of the binder and the aggregates during installation

5.1.5 Pictures of the installation

Figure 5.1.1:
The prefab joint module was removed from its fixation's plate

Figure 5.1.2:
Removing the metal barrier plate from the prefab joint module

Figure 5.1.3:
Placement of the joint module onto the middle of the joint gab

Figure 5.1.4:
Drilling anchore holes with rotary hammer to fix the joint module onto the concrete slabs using chemical anchor

Figure 5.1.5:
After inserting the capsule (with chemical resin) into the holes, the metal anchor rods were installed with a rotary hammer

Figure 5.1.6:
After fixing, the anchor rods were let cure during the curing time of approx. 30 min

Figure 5.1.7:
Sand blasting the surface of the concrete slabs and of the vertical surface of the bridge pavement

Figure 5.1.8:
Activation of the adjoining surface of the pavement using hot air

Figure 5.1.9:
Priming the T-metal profile of the prefab joint module

Figure 5.1.10:
After stuffing the foam caulking, hot binder was poured onto the surface of the concrete slab, and then a metal bridging plate was placed

Figure 5.1.11:
The prefab joint modules were fixed onto the concrete slabs

Figure 5.1.12:
Pouring the hot binder into the gap between the joint module and the bridge pavement

Figure 5.1.13:
Application of both joint stripes between the joint module and the bridge pavement

Figure 5.1.14:
Heating the surface of the prefab module with a gas-flam

Figure 5.1.15:
After pouring the hot binder on the surface of the prefab module and both new build joint stripes

Figure 5.1.16:
Application of the last layer

Figure 5.1.17:
Pouring the hot binder onto the compacted aggregates

Figure 5.1.18:
Application of the surface dressing without the use of small sized aggregates

5.2 Detailed test results

5.2.1 Movement capacity

After 10 cycles and loading at -10°C (joint opening up to 32.5mm and afterwards closing up to the original joint gap size with a speed of 10mm/h), the specimen stayed intact. No visible damage such as cracking in the joint filling mixture or debonding of the joint filling mixture from the adjoining surface of the bridge pavement was oserved.

A2.2 General behavior during the horizontal opening of the joint

- ***Force decrease after the first cycle and the course of the forces over 10 cycles***

The maximum force observed during the test were relatively low (22.4kN). The maximum force in the second cycle was still about 70% of the first cycle. After 10 cycles the maximum force reached about 50% of the first cycle. The maximum forces are specified in *Table 5.2.1*.

Figure 5.2.1 shows the force characteristic during the test up to 10 cycles.

	Maximum forces [kN]
Cycle no.	Specimen O1
1	22.4
2	15.6
3	14.0
4	13.2
5	12.8
6	12.4
7	12.0
8	11.6
9	11.6
10	11.2

Table 5.2.1: Maximum forces during the test

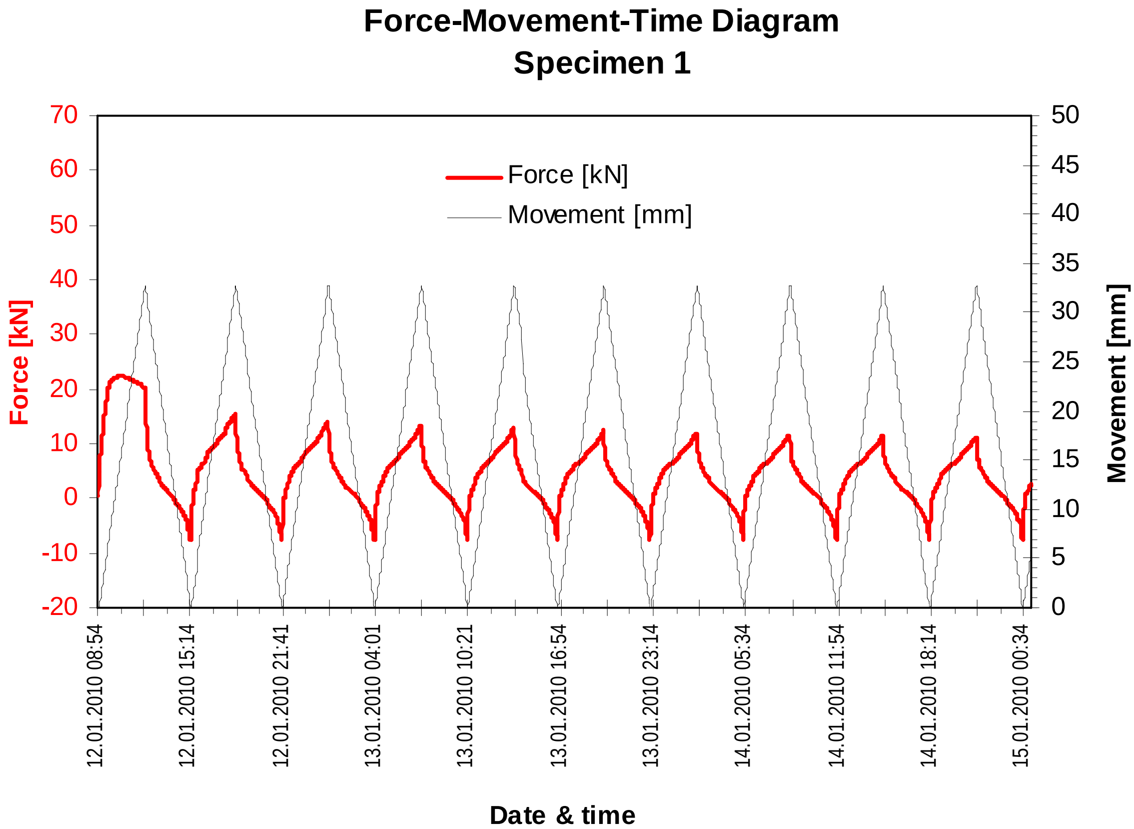

Figure 5.2.1: Graphic of the measured force progression of the specimen over 10 cycles at –10°C

• ***Stress distribution during the joint opening***

During the joint opening up to 32.5mm, the stress distribute between both bridge pavement plates. On the moving side, the stress was a little larger than on the other part of the joint. *Figures 5.2.2* to *5.2.3* illustrate the typical stress distribution at the specimen side and surface during the elongation at the first cycle.

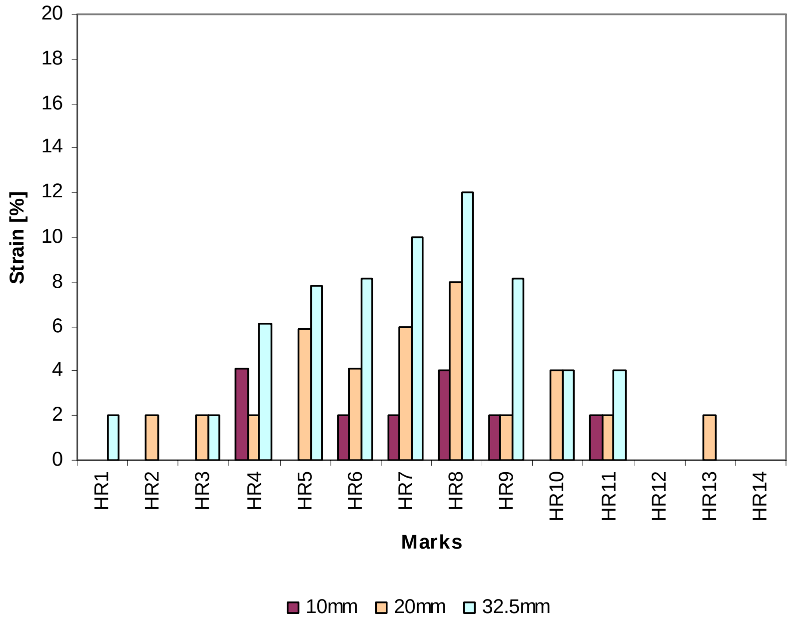

Figure 5.2.2: Strain distribution [%] on the specimen surface during the joint opening at the first cycle. Distance between two adjacent lines: approx. 50mm

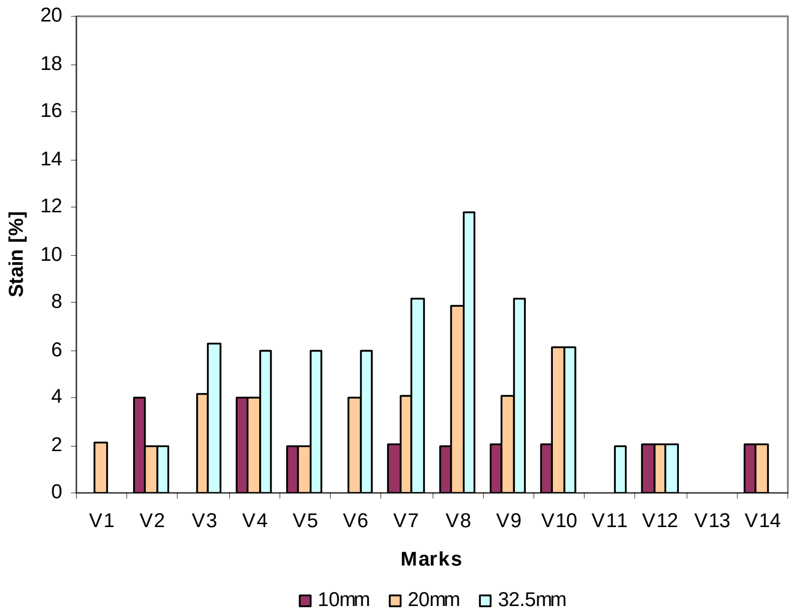

Figure 5.2.3: Strain distribution [%] on the specimen side during the joint opening at the first cycle. Distance between two adjacent lines: approx. 50mm

• *Reduction of the joint thickness*

During elongation of the joint at –10°C, the thickness of the joint filling mixture decreased mostly on the moving part. After joint compression to the original gap width, the original thickness was restored. The reductions of the thickness during the joint movement in the first cycle are shown in *Figure 5.2.4*. The maximum reduction in thickness, at a joint elongation value of 32.5mm, was 3mm.

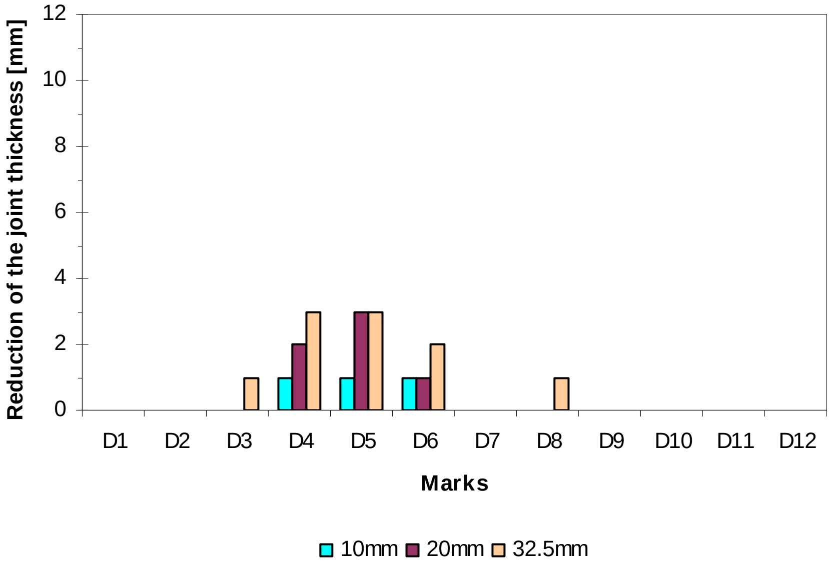

Figure 5.2.4: Reduction of the thickness during the joint opening at the first cycle

• *Lateral contraction of the joint width*

The specimen width (originally 500mm) was reduced during the joint elongation. When joint was compressed to the original joint gap width, the original dimensions were restored. *Figure 5.2.5* shows the contraction behavior of the specimen during the joint elongation in the first cycle. The maximum reduction of the width in the first cycle was 14mm. It was o bserved that the reduction of the width occurred mostly in the middle of the joint.

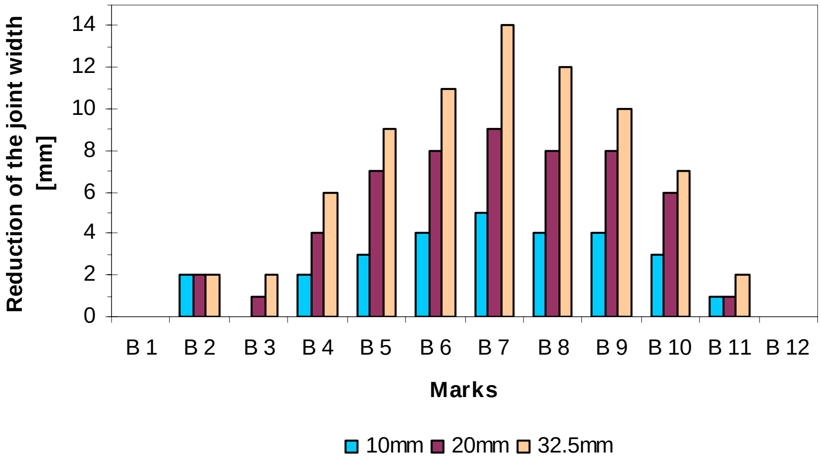

Figure 5.2.5: Lateral contraction of the joint width during the joint opening at the first cycle