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Investigation of the rutting behaviour of asphaltic plug joints on the bridges A18 Bielheimerbeek and A58 Daesdonc using Model Mobile Load Simulator MMLS3

Test Report No 444110

CH-Dübendorf **February 2007**

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Test Report No 444110

Test assignment:	Investigation of the rutting behaviour of asphaltic plug joints using Model Mobile Load Simulator MMLS3
Client:	Intron B.V., 61306 PD Sittard, Netherlands
Test object:	Four asphaltic plug joints (Thorma Joint and Silent Joint 500) on the bridges A18 Bielheimerbeek and A58 Daesdonc in the Netherlands
Client's ref.:	Mr. Marc Eijssen
Order dated of:	September 28th and October 20th 2006
Test object received:	- - -
Test performed:	November 13th 2006
Number of pages:	26
Attachments:	none

Swiss Federal Laboratories for Materials Testing and Research
Dübendorf, February 8th 2007

Expert:
Sivotha Hean

Head of Laboratory:
Prof. Dr. Manfred N. Partl

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1 Order

Intron B.V., 61306 PD Sittard, Netherlands commissioned Empa, Laboratory Road Engineering/ Sealing Components, to investigate the rutting behaviour of four asphaltic plug joints (APJ) on the bridges A18 Bielheimerbeek and A58 Daesdonc using a Model Mobil Load Simulator MMLS3.

2 Object data

2.1 Asphaltic plug joints on the bridge A18 Bielheimerbeek

On the bridge A18 Bielheimerbeek the tests were performed on the right main roadway in the direction Doetinchem-Varseveld (*figure 2.1.1*). On this bridge there are two different asphaltic plug joints placed about 45° to the driving direction. The first APJ A18-1 in the direction to Varseveld is a standard APJ (Thorma Joint) and the second APJ A18-2 is a Silent Joint 500, which is equipped with springs. In this case springs of the system Silent Joint 700 were used. The APJ system Silent Joint 500 is suitable for a bridge movement up to 50mm. The real width of both APJs is 55cm … 58cm. The width in the travel direction is 80cm. The distance between the two APJs is 21m. The adjacent wearing course is porous asphalt (ZOAB). For the tests the passing lane and one half of the traffic lane were closed. The test track was situated on the median lane (*figure 2.1.2*).

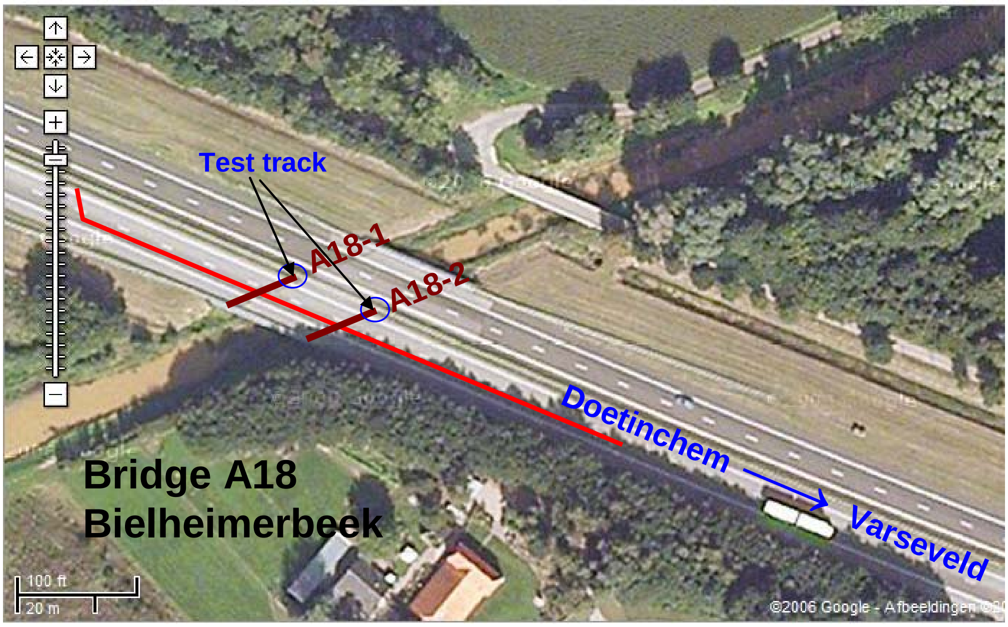

Figure 2.1.1: Situation of the APJs on the bridge A18 Bielheimerbeek

APJ A18-1: First APJ with Thorma Joint
APJ A18-2: Second APJ with Silent Joint 500

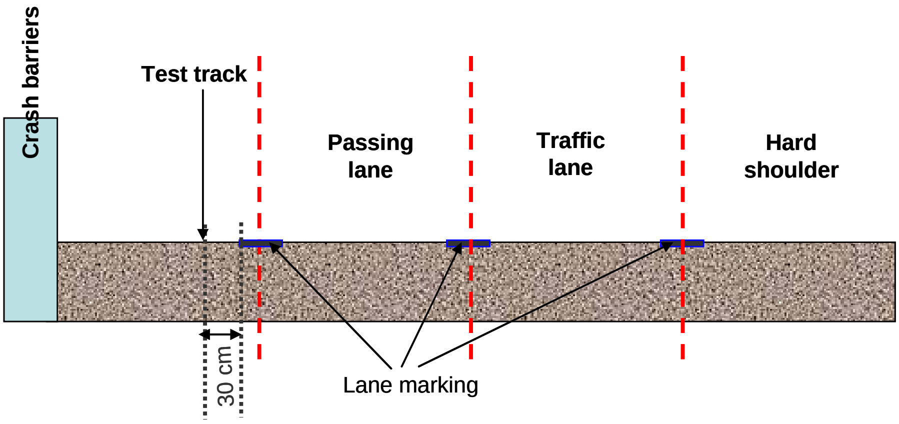

Figure 2.1.2: Test track on the bridge A18 Bielheimerbeek

2.2 Asphaltic plug joints on the bridge A58 Daesdonc

On the bridge A58 Daesdonc the tests were performed on the left main roadway in the direction from Rotterdam to Eindhoven (*figure 2.2.1*). This bridge has two identical asphaltic plug joints (Silent Joint 500) installed perpendicular to the driving direction. The width of both APJs is about 55cm. The distance between the two APJs amounts to 28m. The wearing course on this bridge is porous asphalt (ZOAB). About 2m on both sides of the APJ A58-1 the wearing course is strengthened with cement grout Densith. For the tests only the hard shoulder was closed. The test track was situated on the hard shoulder and about 1.70m from bridge concrete edge.

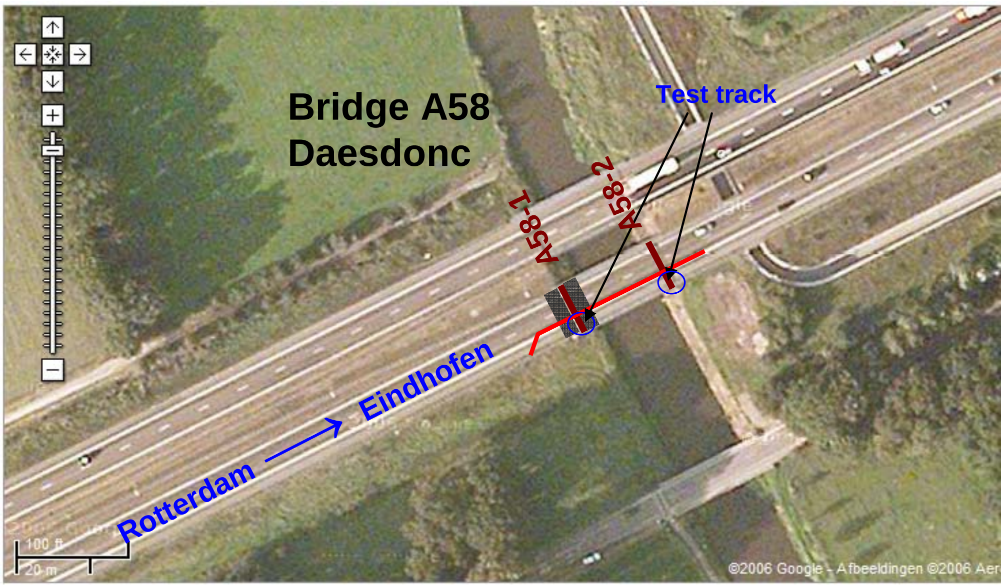

Figure 2.2.1: Situation of the APJs on the bridge A58 Daesdonc

A58-1: First APJ with Silent Joint 500. Wearing course: ZOAB and Densith
A58-2: Second APJ with Silent Joint 500. Wearing course: ZOAB

3 Test principle and conditions

3.1 MMLS3 test principle

The Model Mobile Load Simulator MMLS3 (*Figure 3.1.1*) is an Accelerated Pavement Testing device (APT). It is used for accelerated testing of road surfaces and to determine the mechanical properties under wheel load, particularly for rutting investigating of wearing courses. The device consists of a rigid steel frame with four adjustable feet. The load is applied via 4 wheels with a diameter of 300mm, which move like a chain saw in one direction along a rotary rail. The MMLS3 applies a load of up to 2.7kN on each of its tires that are inflated up to 800kPa. The distance between the tires is 1.05m, and the MMLS3 operates at a speed of 2.6m/sec that corresponds approximately to a 4Hz frequency of loading for a measured tread length of 110mm.

The MMLS3 device is placed in a climate chamber. The temperature of the test track is regulated with a heating system, which blows hot air across the surfacing of the APJ underneath the machine from a nozzle attached to a plenum duct along one side of the machine. On the opposite side a similar nozzle and duct sucks up the air and returns it via an electric heater in a closed loop to the first nozzle. To ensure an even temperature over the pavement surface the flow direction is reversed every 15 minutes.

During heating, temperature of the APJ and of the air in the climate chamber was measured by thermocouples and recorded by a data logger at 20mm and 50mm distance from the surfacing of the wearing course.

The profilometer is used to accurately measure the deformation (rutting) of the test pavement. The profilometer has a low profile to fit underneath the MMLS3 without having to raise or remove the machine for taking measurements. The z-(vertical) and x-(horizontal, across the track) measurements are taken automatically. Positioning in the y-(horizontal, along the track) direction is done by reference slots, 50mm apart, in two index bars which are attached to the pavement.

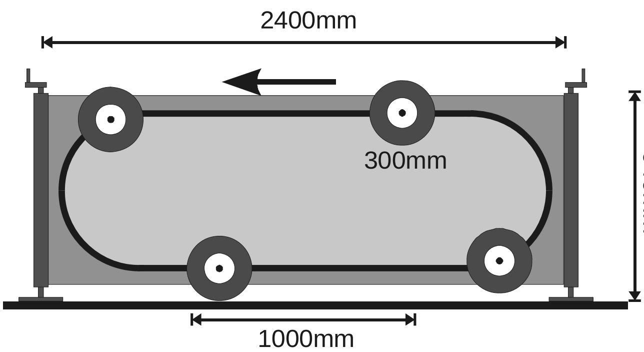

Figure 3.1.1: Schematic of MMLS3 testing rig

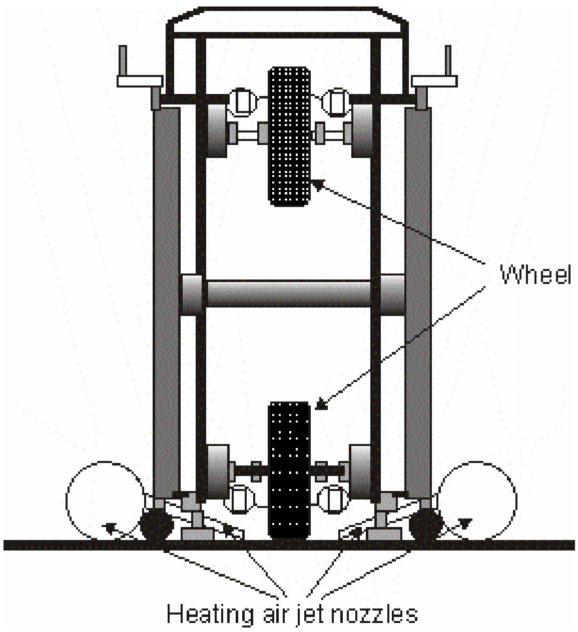

Figure 3.1.2: Position of the heating air jets

3.2 Test conditions for the bridge A18 Bielheimerbeek

The test conditions on the bridge A18 Bielheimerbeek are given in *table 3.1.1*. Rut depth was measured with a profilometer at three different profiles (in the middle of the APJ and 7cm from both sides of the adjacent pavement surfacing (see *figure 3.2.1*).

Wheel diameter	300mm
Tire pressure	600kPa
Axle load	2.1kN
Passing speed	78m/s (120 passes per minute)
Lateral wandering of the wheels	no
Test temperature	30°C ± 2°C (at 20mm distance from the surfacing of the wearing course)
Profile measurement	with a profilometer at three different location profiles (*figure 3.2.1*) after 0, 600, 1800, 2400, 3600, 6000 passes

Table 3.1.1: Test conditions for both APJs on A18 Bielheimerbeek

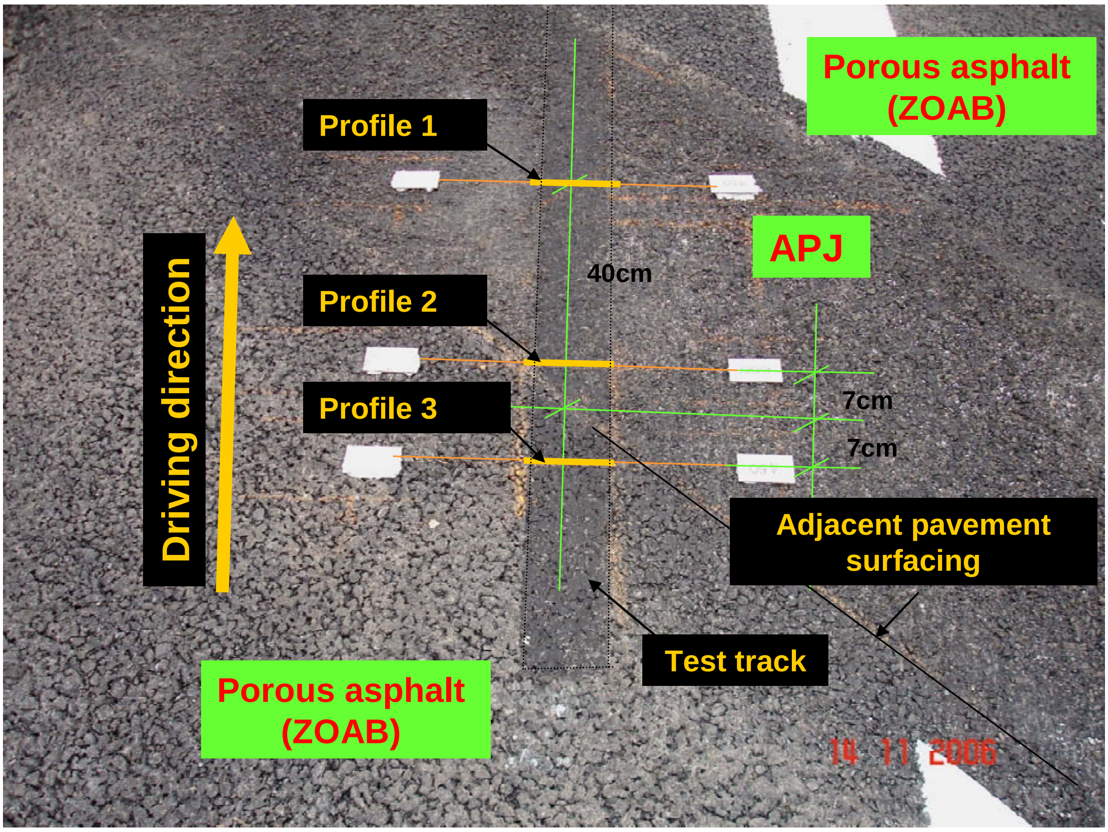

Figure 3.2.1: Location of the profile measurements

Profile 1: in the middle of the APJ (40cm from the adjacent pavement surfacing)
Profile 2: on the APJ (7cm from the adjacent pavement surfacing)
Profile 3: on the wearing course (7cm from the adjacent pavement surfacing)

3.3 Test conditions for the bridge A58 Daesdonc

The test conditions on the bridge A58 Daesdonc were similar on the bridge A18 Bielheimerbeek (*table 3.1.1*). The rut depth was measured at three different profiles: in the middle of the APJ and about 5cm from both sides of the first adjacent pavement surfacing at A58-1 and of the second adjacent surfacing at A58-2 (see *figure 3.3.1*). The measurement took place after 0, 600, 1200, 2400, 3600, 6000 passes.

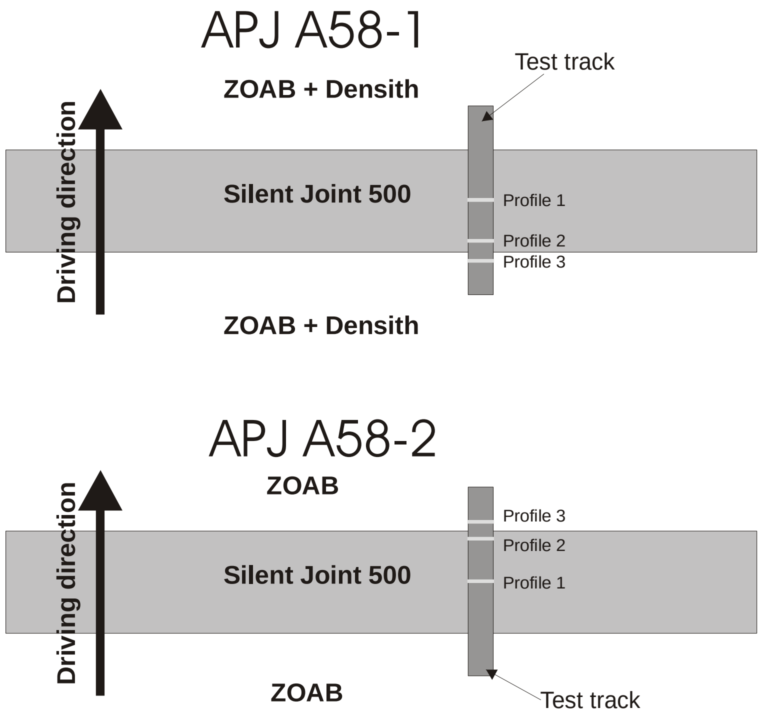

Figure 3.3.1: Location of the profile measurements of the APJ A58-1 and A58-2 on the bridge A58 Daesdonc

Profile 1: in the middle of the APJ (27.5cm from the adjacent pavement surfacing)
Profile 2: on the APJ (5cm from the adjacent pavement surfacing)
Profile 3: on the wearing course (5cm from the adjacent pavement surfacing)

4 Test results

Test results are presented in this chapter. The diagrams of the depth and temperature measurements and the photo documentation can be found in the appendix.

4.1 Bridge A18 Bielheimerbeek

4.1.1 Asphaltic plug joint A18-1 (Thorma Joint)

Rut depth data are given in *table 4.1.1* and *figure 4.1.1*. At the end of the test no irregularities at the test track such as unevenness or spalling of the edge of the adjacent pavement surfacing were observed.

Load repetitions	Maximum rut depth [mm]		
	APJ middle	APJ (7cm from the adjacent pavement surfacing)	wearing course (7cm from the adjacent pavement surfacing)
600 passes	-2.71	-0.91	-0.89
1800 passes	-2.98	-2.07	-1.05
2400 passes	-2.96	-2.04	-1.06
3600 passes	-3.10	-2.46	-1.11
6000 passes	-3.37	-2.97	-1.21

Table 4.1.1: Result of rut depth measurements of the APJ A18-1 (wearing course: ZOAB)

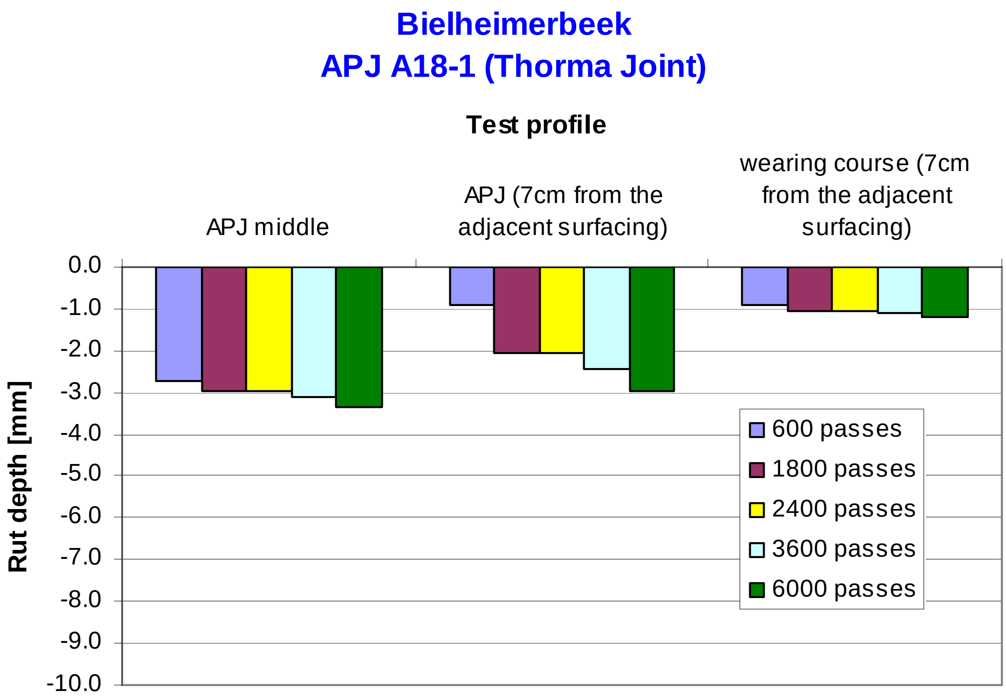

Figure 4.1.1: Result of rut depth measurements of the APJ A18-1 (wearing course: ZOAB)

4.1.2 Asphaltic plug joint A18-2 (Silent Joint 500)

Rut depth data are presented in *table 4.1.2* and *figure 4.1.2*.
At the end of the test no irregularities at the test track such as unevenness due to the structural components of the APJ (springs, L-shaped steel anchors) or spalling of the edge of the adjacent pavement surfacing were observed.

Load repetitions	Maximum rut depth [mm]		
	APJ middle	APJ (7cm from the adjacent pavement surfacing	wearing course (7cm from the adjacent pavement surfacing)
600 passes	-2.46	-2.72	-0.83
1800 passes	-3.30	-3.55	-1.01
2400 passes	-3.59	-3.71	-0.94
3600 passes	-3.97	-4.21	-1.13
6000 passes	-4.56	-5.00	-1.18

Table 4.1.2: Result of rut depth measurements of the APJ A18-2 (wearing course: ZOAB)

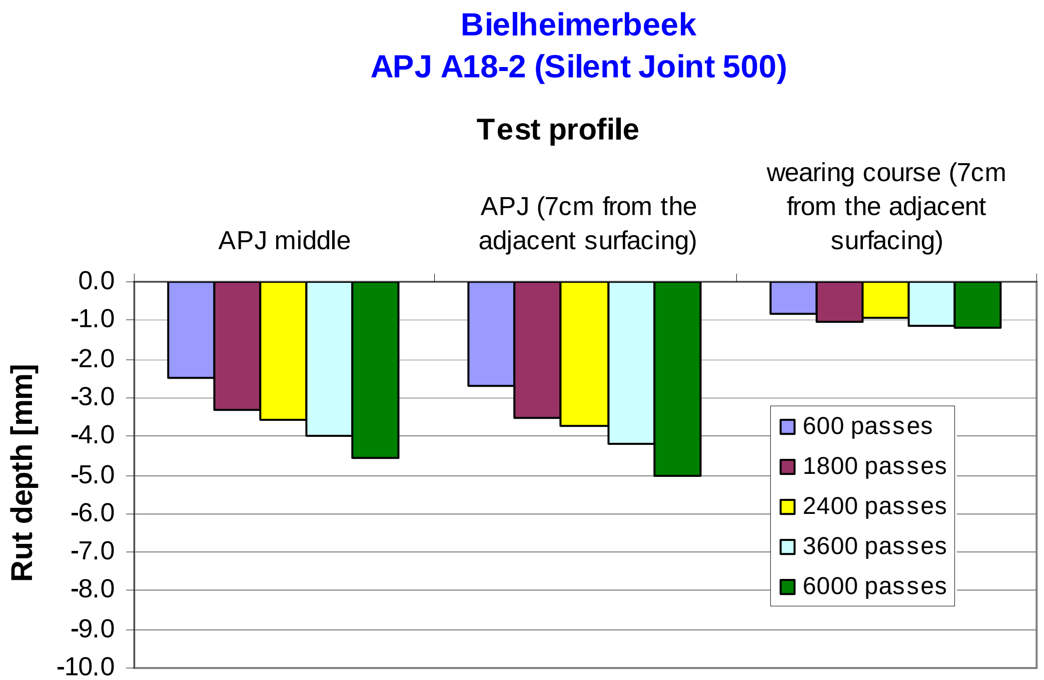

Figure 4.1.2: Result of rut depth measurements of the APJ A18-2 (wearing course: ZOAB)

4.2 Bridge A58 Daesdonc

4.2.1 Asphaltic plug joint A58-1 (Silent Joint 500)

Rut depth data are given in *table 4.2.1* and *figure 4.2.1*. At the end of the test no characteristics at the test track such as unevenness due to the structural components of the APJ (springs, L-shaped steel anchors) or spalling of the edge of the adjacent pavement surfacing were observed.

Load repetitions	Maximum rut depth [mm]		
	APJ middle	APJ (5cm from the adjacent pavement surfacing)	wearing course (5cm from the adjacent pavement surfacing)
600 passes	-1.89	-2.80	-0.45
1200 passes	-2.21	-3.14	-0.53
2400 passes	-2.67	-3.22	-0.58
3600 passes	-3.10	-3.22	-0.60
6000 passes	-3.20	-3.41	-0.62

Table 4.2.1: Result of rut depth measurements of the APJ A58-1 (wearing course: ZOAB and Densith)

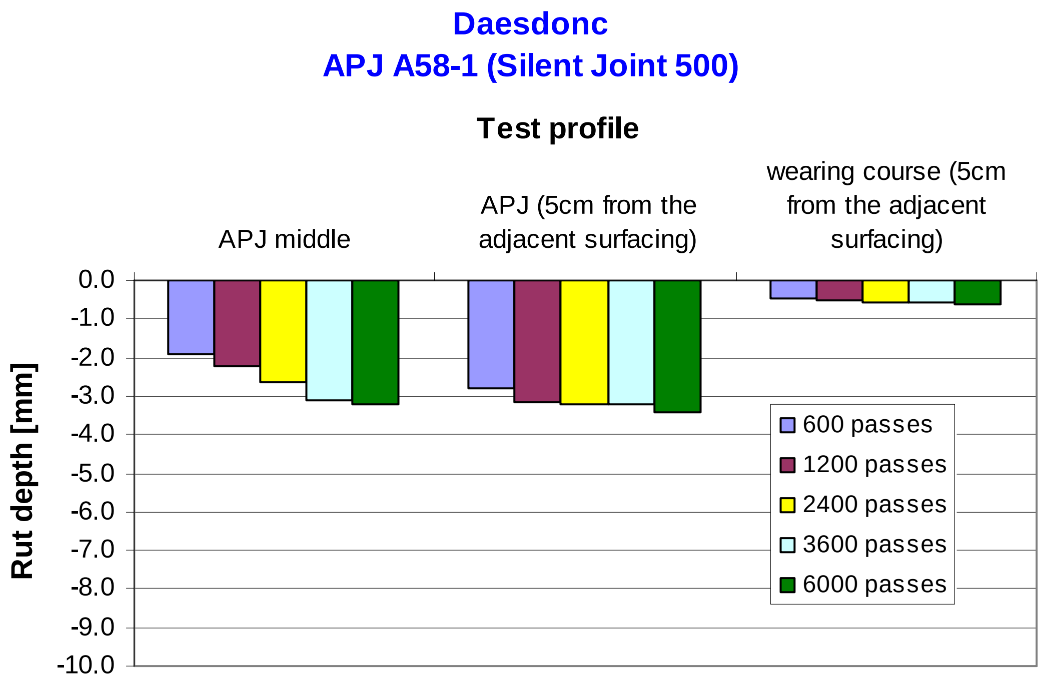

Figure 4.2.1: Result of rut depth measurements of the APJ A58-1 (wearing course: ZOAB and Densith)

4.2.2 Asphaltic plug joint A58-2 (Silent Joint 500)

At the end of the test no characteristics at the test track like unevenness due to the structural components of the APJ (springs, L-shaped steel anchors) or spalling of the edge of the adjacent pavement surfacing were observed. Rut depths as well as its diagrams are given in *table 4.2.2* and *figure 4.2.2*.

Load repetitions	**Maximum rut depth [mm]**		
	APJ middle	APJ (5cm from the adjacent pavement surfacing)	wearing course (5cm from the adjacent pavement surfacing)
600 passes	-1.26	-2.18	-0.88
1200 passes	-1.69	-2.55	-1.00
2400 passes	-2.10	-2.75	-1.06
3600 passes	-2.80	-2.86	-1.11
6000 passes	-2.91	-3.08	-1.26

Table 4.2.2: Result of rut depth measurements of the APJ A58-2 (wearing course: ZOAB)

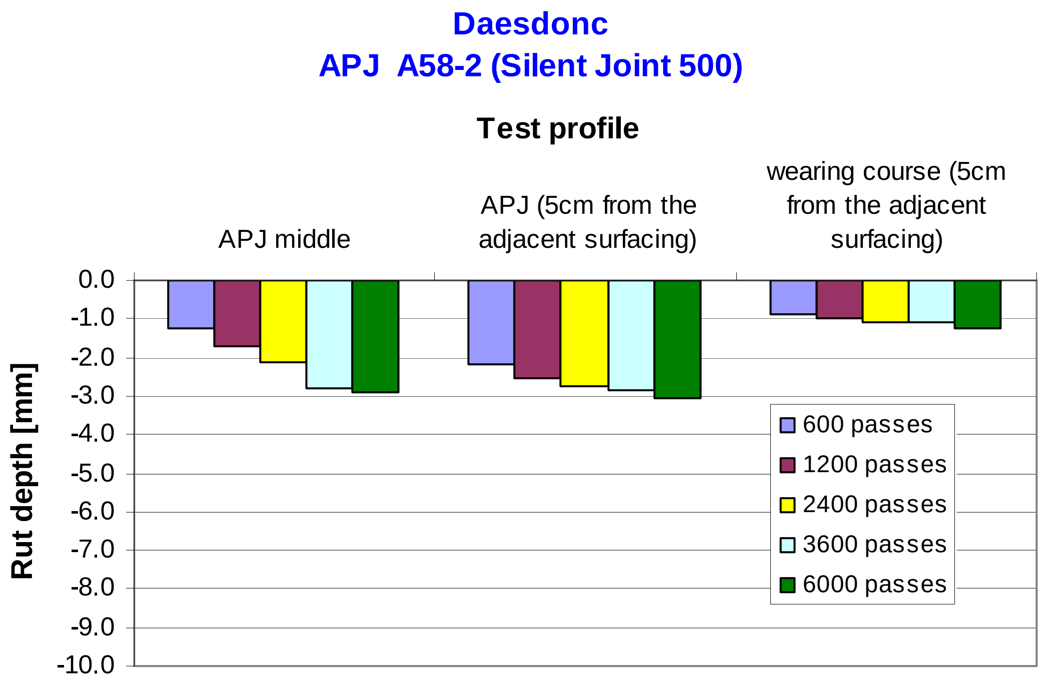

Figure 4.2.2: Result of rut depth measurements of the APJ A58-2 (wearing course: ZOAB)

5 Summary and conclusions

5.1 Bridge A18 Bielheimerbeek

APJ A18-1, Thorma Joint:

- Rut depths in the middle and in the boundary region of the APJ reached about 3mm after 6000 passes. No irregularities of the surface of the APJ were observed.
- With a rut depth of 1mm after 6000 passes, the porous asphalt ZOAB surfacing was harder than the APJ. Nevertheless, there was no spalling of the edge of the adjacent pavement surfacing during the test.

APJ A18-2, Silent Joint 500:

- As for Thorma Joint at the APJ A18-1, no irregularities were observed on the loaded surface of the Silent Joint 500.
- The rut depth of the APJ A18-2 reached about 5mm and was therefore significantly higher than that of the APJ A18-1. This could be due to the difference in binder for both APJs. The enterprise which built both APJs confirmed that the used binders were different and the binder for the APJ A18-1 should be harder than that of the APJ A18-2.
- Rut depth of the porous asphalt ZOAB of the APJ A18-1 and of the APJ A18-2 was the same.

5.2 Bridge A58 Daesdonc

- Both APJs with Silent Joint 500 had a similar behaviour. After 6000 passes approx. 3mm rut depth were found.
- No irregularities on the test track surface of both APJs could be observed.
- The rut depth of the porous asphalt ZOAB without Densith at the APJ A58-2 was approx. 1mm after 6000 passes like on the bridge A18 Bielheimerbeek. However, the ZOAB with Densith at A58-1 was very hard. After 6000 passes the rut depth was only half of the porous asphalt ZOAB without Densith.

5.3 General conclusions

- Under the applied test conditions as well as under the climatic conditions during the tests no negative influences of the metal parts (e.g. L-sections, springs etc.) of the Silent Joint 500 concerning unevenness of the loaded APJ surface could be observed.
- The rut depth of both APJs with Silent Joint 500 on the bridge A58 Daesdonc was smaller than that of the bridge A18 Bielheimerbeek. The reason could be due to the sort of the binder, to the aggregates/binder ratio or to the interaction between aggregates and binder. The rut depth on the Daesdonc Bridge of ca. 3mm after 6000 passes is similar to what we have seen in Switzerland in the lab as well in the field. The rut depth of 5mm for Silent Joint 500 on the Bielheimerbeek Bridge is relatively large, but according to our experiences this value is still acceptable. Thus, the rutting behaviour of the investigated APJs can be considered as normal. One important difference to the situation in Switzerland is the very intense traffic on the motorway A58. Therefore a long-term observation of the investigated APJs would provide useful information on the performance of Silent Joint 500 under intense traffic loads. This long-term observation could be done in the similar way as the Swiss research project report no 579 "*Polymer-modified asphaltic plug joints; Installation and long-term performance*".

- Rutting behaviour of the porous asphalt ZOAB on both examined bridges was the same but smaller than of the APJ. The porous asphalt ZOAB with Densith at the APJ A58-1 was the hardest. Despite its hardness, no break of the edge of the adjacent pavement surfacing occurred during the tests. Nevertheless it is recommended to observe and to assess the state of the porous asphalt ZOAB with or without Densith within the adjacent pavement surfacing during the enterprise.
- Under the applied test conditions as well as under the climatic conditions during the tests no negative influences of the metal parts (e.g. L-sections, springs etc.) of the Silent Joint 500 concerning unevenness of the loaded APJ surface could be observed.

6 Appendix: Diagrams of the measurements and photos documentation

6.1 Bridge A18 Bielheimerbeek

6.1.1 Asphaltic plug joint A18-1

APJ A18-1, profile 3 (on wearing course, about 7cm from the adjacent pavement surfacing):

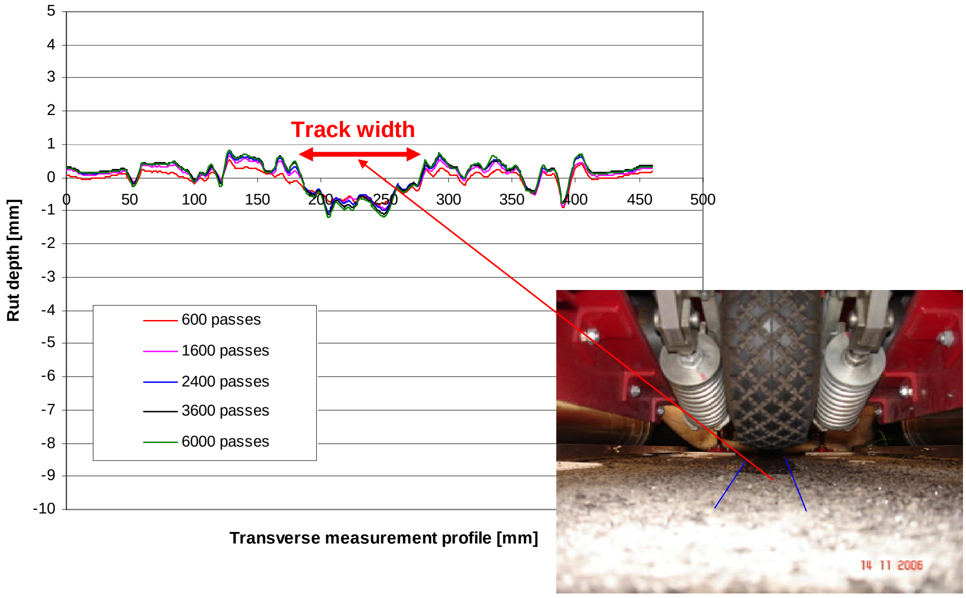

Figure 6.1.1: Diagram of rut depth measurements of the APJ A18-1 on profile 3 (on wearing course, about 7cm from the adjacent pavement surfacing)

APJ A18-1, profile 2 (on the APJ, about 7cm from the adjacent pavement surfacing):

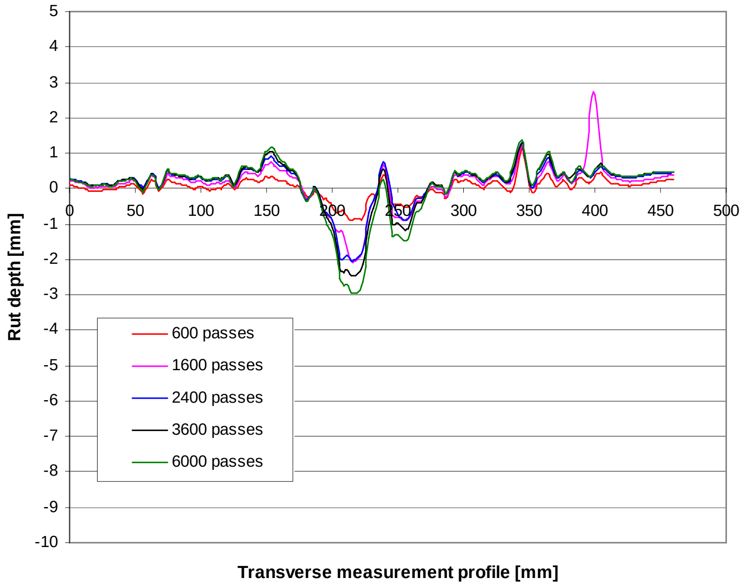

Figure 6.1.2: Diagram of rut depth measurements of the APJ A18-1 on profile 2 (on the APJ, about 7cm from the adjacent pavement surfacing)

APJ A18-1, profile 1 (on the middle of the APJ):

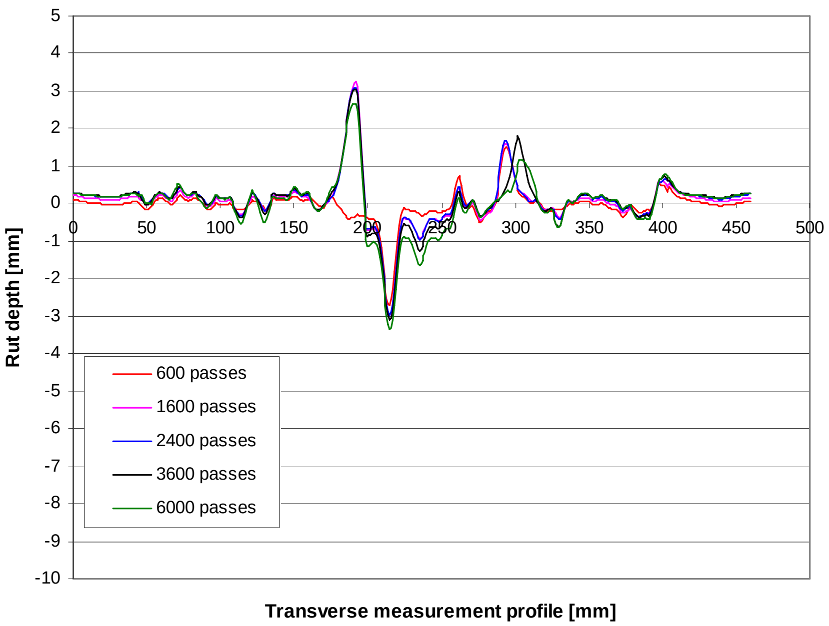

Figure 6.1.3: Diagram of rut depth measurements of the APJ A18-1 on profile 1 (in the middle of the APJ)

APJ A18-1, diagram of the temperature measurement:

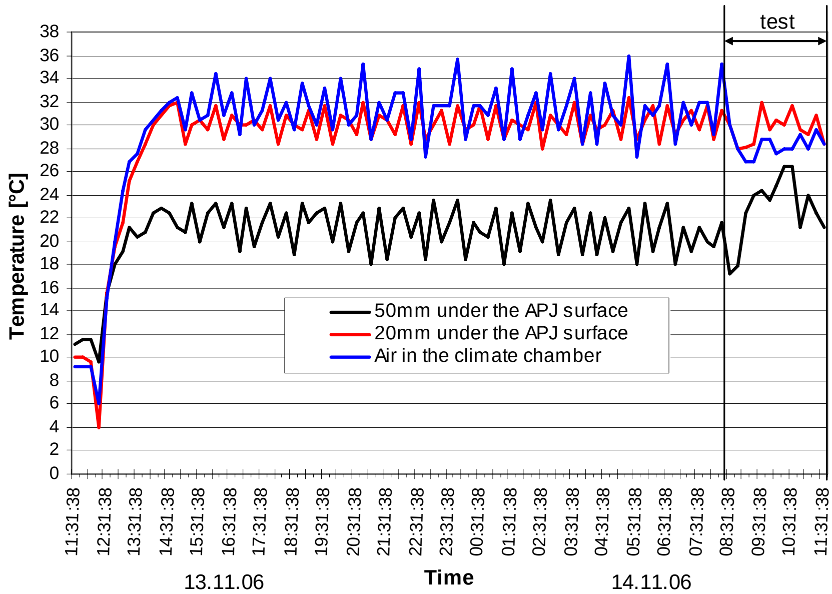

Figure 6.1.4: Diagram of the temperature measurement during the heating and the test of the APJ A18-2

6.1.2 Asphaltic plug joint A18-2

APJ A18-2, profile 3 (on wearing course, about 7cm from the adjacent pavement surfacing):

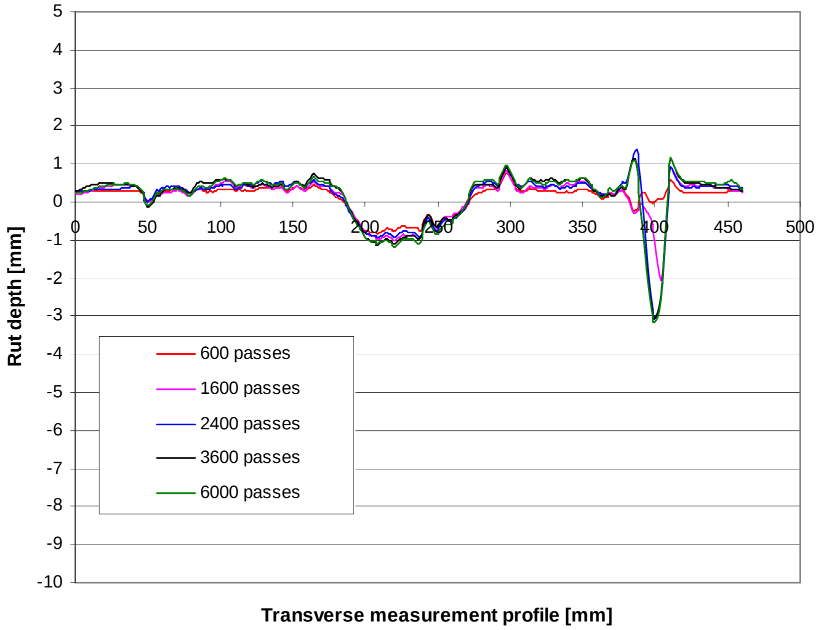

Figure 6.1.5: Diagram of rut depth measurements of the APJ A18-2 on profile 3 (on wearing course, about 7cm from the adjacent pavement surfacing)

APJ A18-2, profile 2 (on the APJ, about 7cm from the adjacent pavement surfacing):

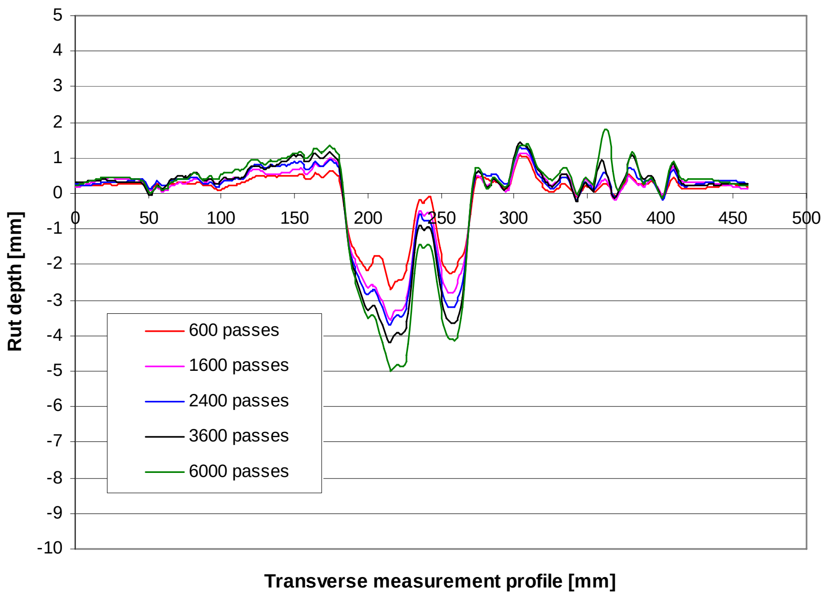

Figure 6.1.6 Diagram of rut depth measurements of the APJ A18-2 on profile 2 (on the APJ, about 7cm from the adjacent pavement surfacing)

APJ A18-2, profile 1 (on the middle of the APJ):

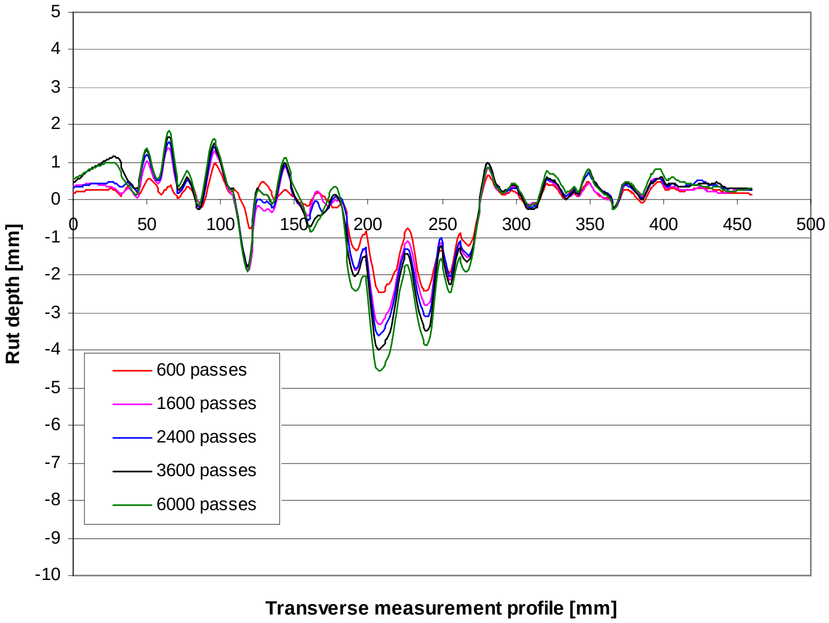

Figure 6.1.7: Diagram of rut depth measurements of the APJ A18-2 on profile 1 (in the middle of the APJ)

APJ A18-2, diagram of the temperature measurement:

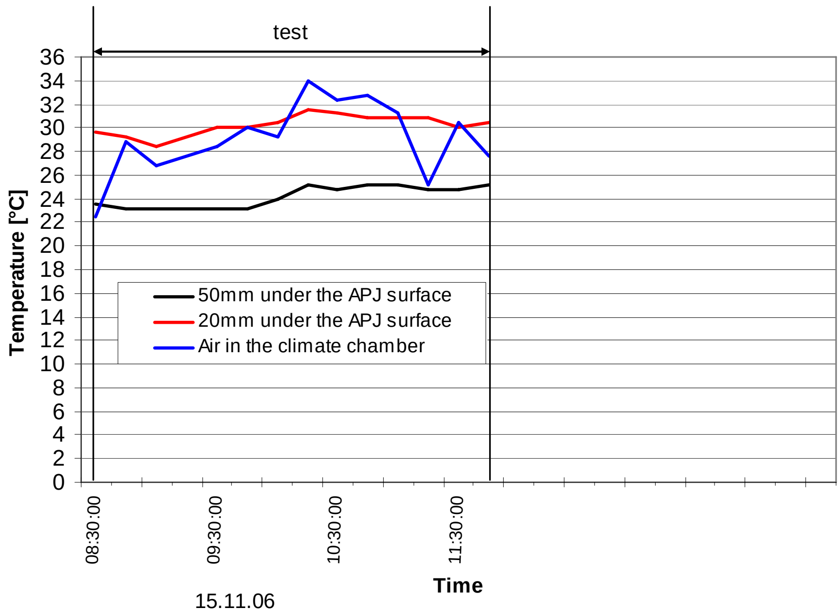

Figure 6.1.8: Diagram of the temperature measurement during the test of the APJ A18-2

6.2 Bridge A58 Daesdonc

6.2.1 Asphaltic plug joint A58-1

APJ A58-1, profile 3 (on wearing course, about 5cm from the adjacent pavement surfacing):

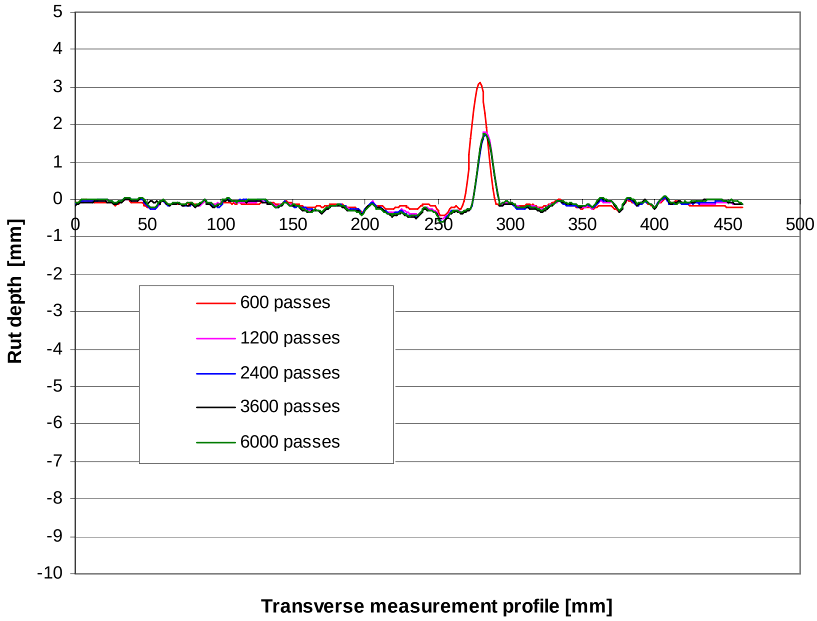

Figure 6.2.1: Diagram of rut depth measurements of the APJ A58-1 on profile 3 (on wearing course, about 5cm from the adjacent pavement surfacing)

APJ A58-1, profile 2 (on APJ, about 5cm from the adjacent pavement surfacing):

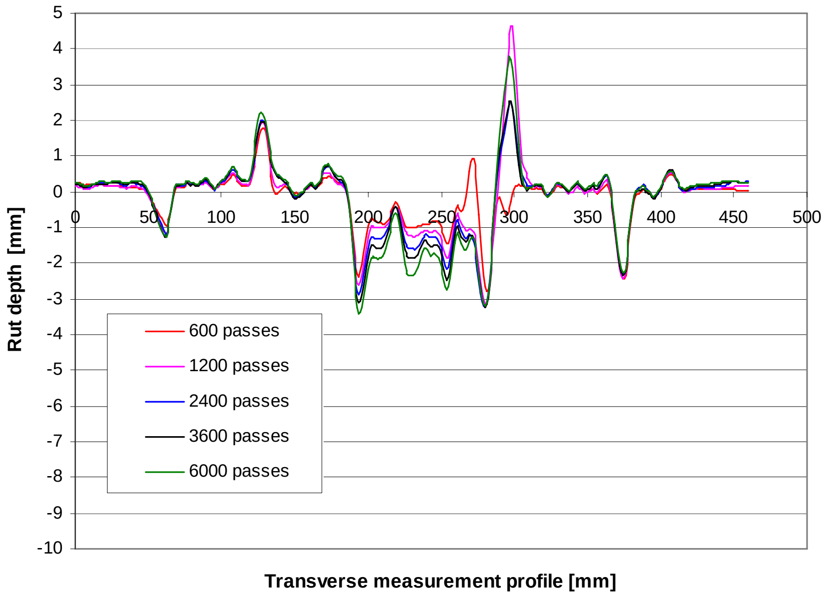

Figure 6.2.2 Diagram of rut depth measurements of the APJ A58-1 on profile 2 (on the APJ, about 5cm from the adjacent pavement surfacing)

APJ A58-1, profile 1 (in the middle of the APJ):

Figure 6.2.3: Diagram of rut depth measurements of the APJ A58-1 on profile 1 (in the middle of the APJ)

APJ A58-1, diagram of the temperature measurement:

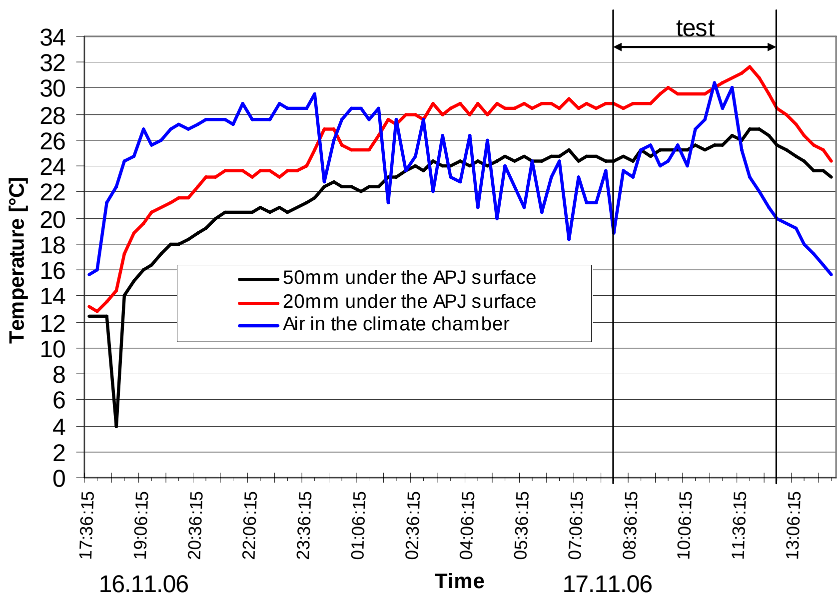

Figure 6.2.4: Diagram of the temperature measurement during the test of the APJ A58-1

6.2.2 Asphaltic plug joint A58-2

APJ A58-2, profile 3 (on wearing course, about 5cm from the adjacent pavement surfacing):

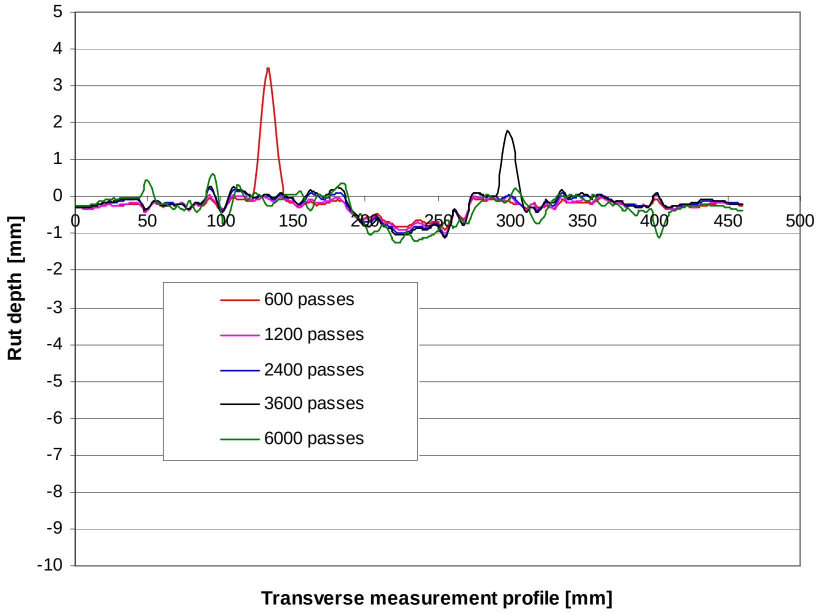

Figure 6.2.5: Diagram of rut depth measurements of the APJ A58-2 on profile 3 (on wearing course, about 5cm from the adjacent pavement surfacing)

APJ A58-2, profile 2 (on APJ, about 5cm from the adjacent pavement surfacing):

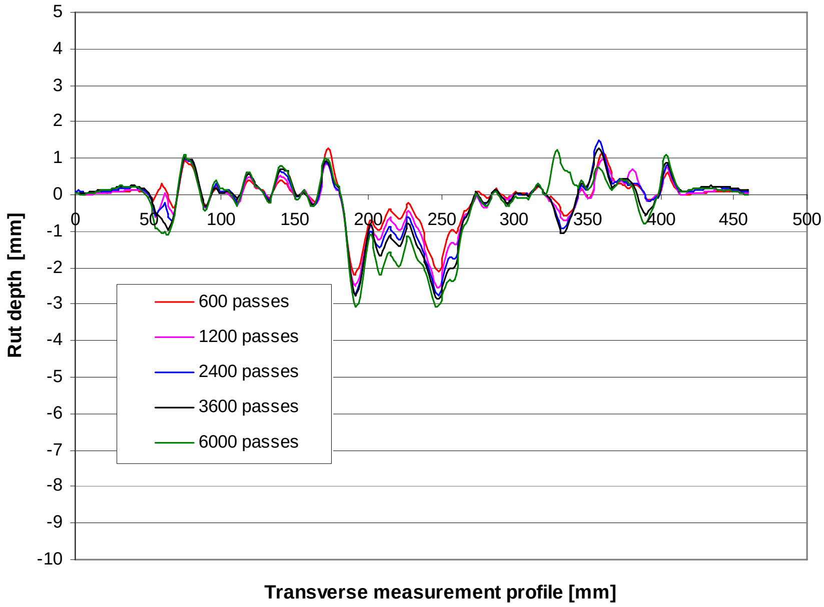

Figure 6.2.6 Diagram of rut depth measurements of the APJ A58-2 on profile 2 (on the APJ, about 5cm from the adjacent pavement surfacing)

APJ A58-2, profile 1 (in the middle of the APJ):

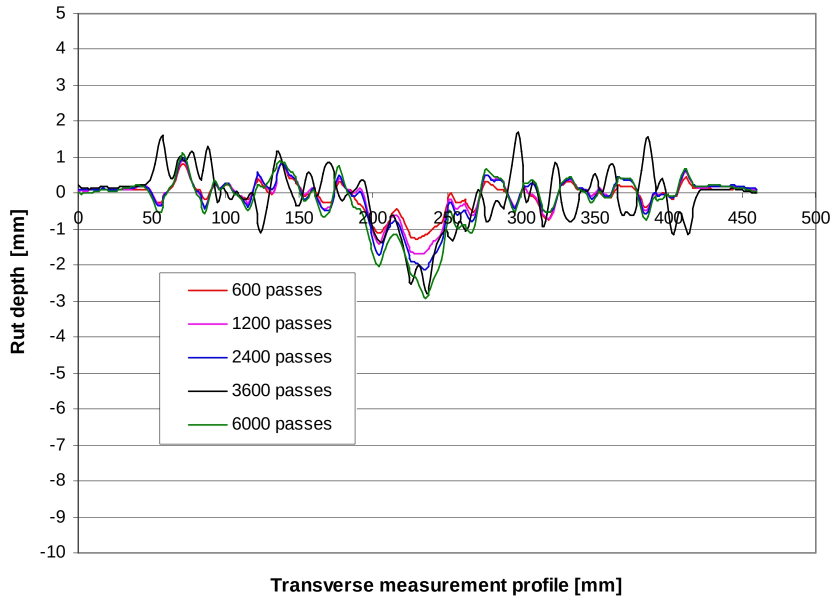

Figure 6.2.7: Diagram of rut depth measurements of the APJ A58-2 on profile 1 (in the middle of the APJ)

APJ A58-2, diagram of the temperature measurement:

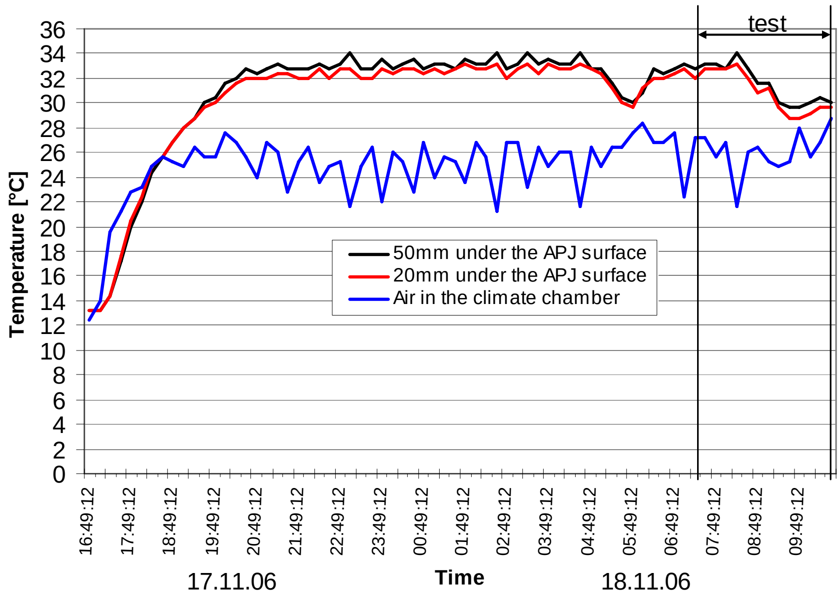

Figure 6.2.8: Diagram of the temperature measurement during the test of the APJ A58-2

6.3 Photos documentation

APJ A18-1 and APJ A18-2 on the bridge Bielheimerbeek:

Figure 6.3.1: Bridge Bielheimerbeek from the side

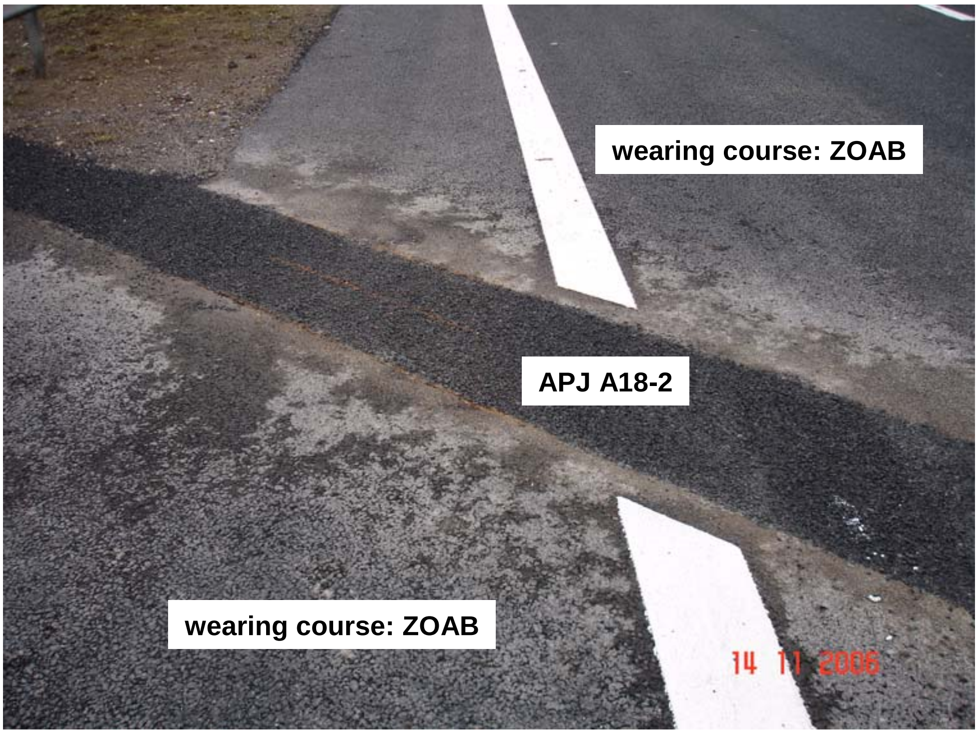

Figure 6.3.2: Appearance of surface dressing of the APJ A18-2

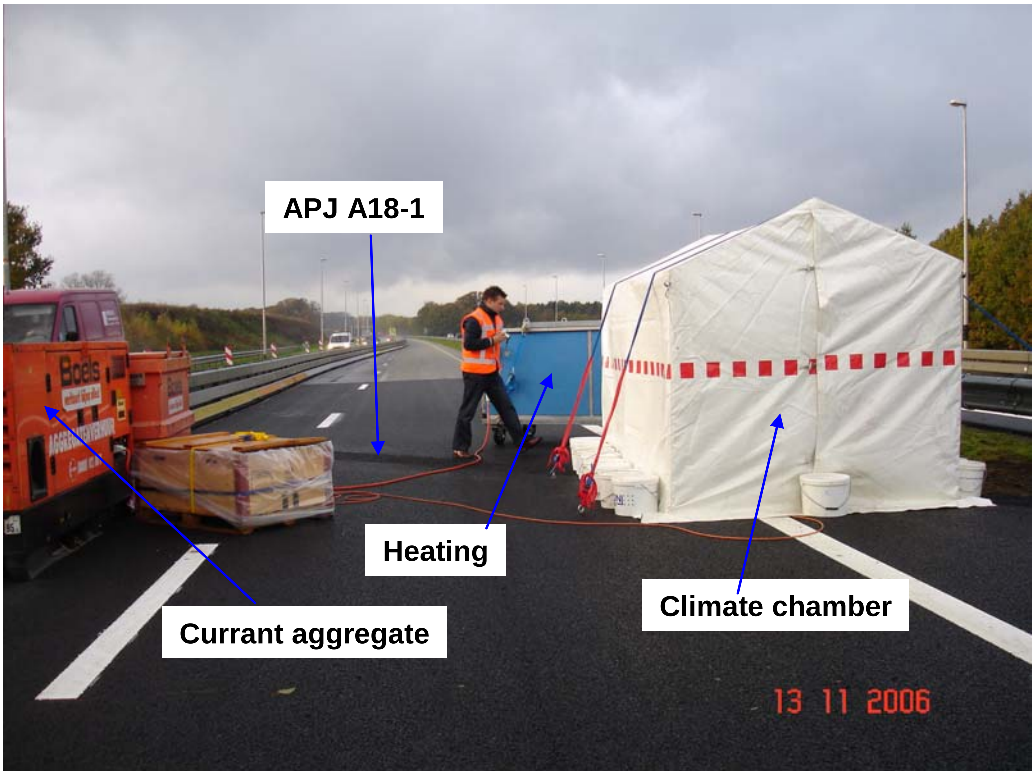

Figure 6.3.3: Test devices on the bridge Bielheimerbeek

Figure 6.3.4: Device installation for testing the APJ A18-2

APJ A58-1 and APJ A58-2 on the bridge Daesdonc:

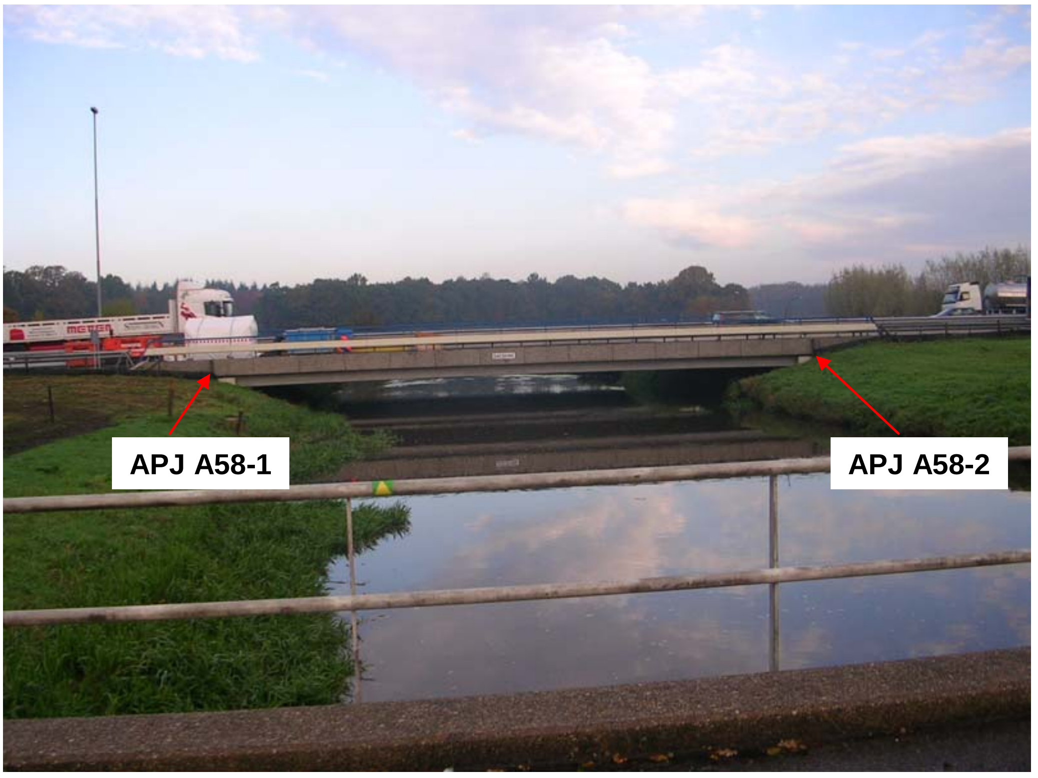

Figure 6.3.5: Bridge Daesdonc from the side

Figure 6.3.6: Test field on the bridge Daesdonc

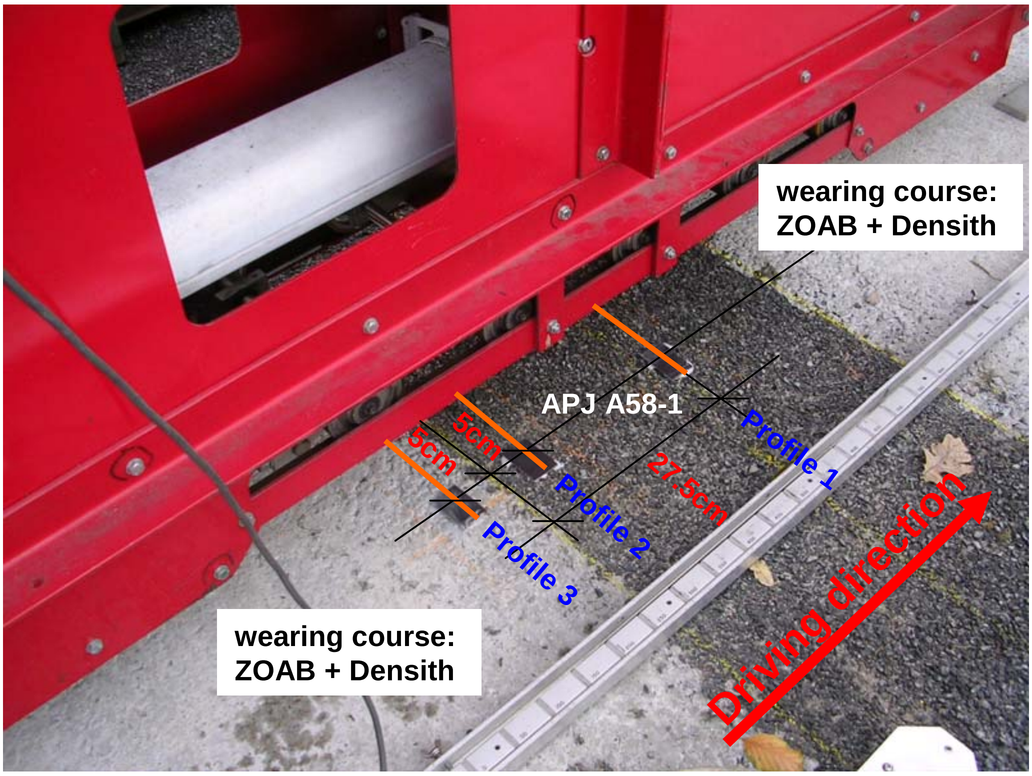

Figure 6.3.7: Test profiles of the APJ A58-1

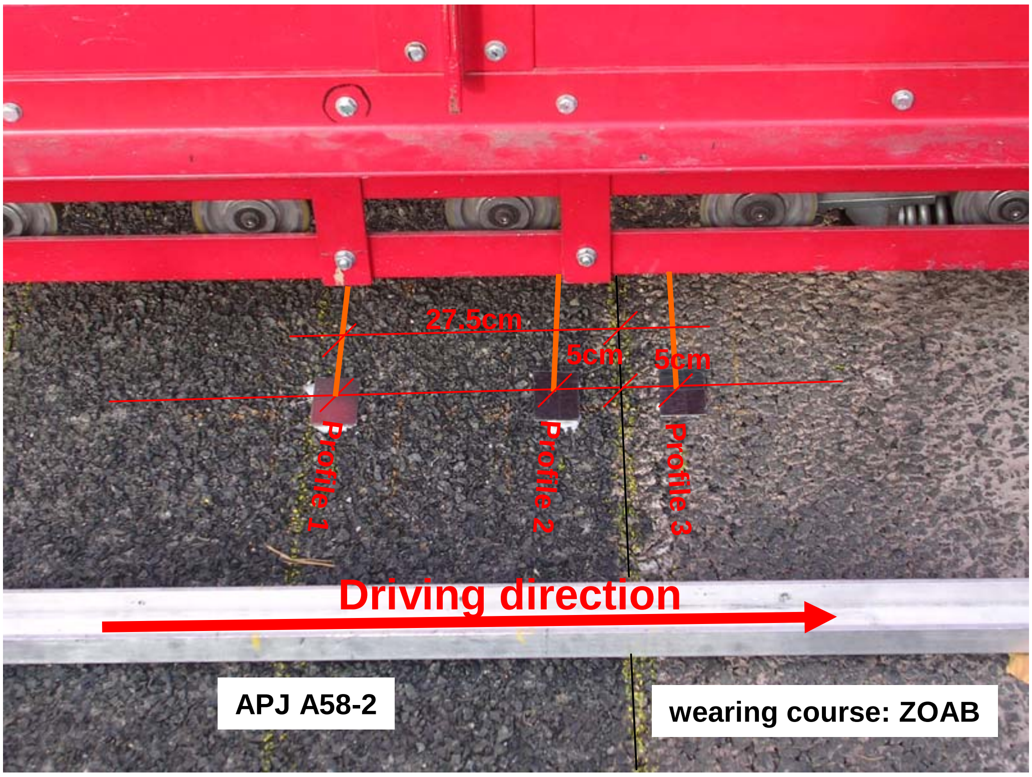

Figure 6.3.8: Test profiles of the APJ A58-2

Figure 6.3.9: Viewing, inspection and discussion during testing the APJ A58-1 on Friday, November 17th 2006

Figure 6.3.10: Viewing, inspection and discussion during testing the APJ A58-1 on Friday, November 17th 2006