Change in Bitumen Quality during the working stations

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ABSTRACT

The change of bitumen quality was investigated for 21 sites and three layers. Therefore samples were examined at the stage of delivery, after mixing in the lab, after production in the asphalt plant and after laying. The bitumen are discribed with the conventionel test methods (Softening Point, Penetration), with tests in the Dynamic Shear Rheometer (temperature sweep for phase angle and stiffness, Multiple Stress Creep an Recovery Test), with Bending Beam Rheometer and Force Ductility. The study included conventionel bitumen (EN 12591) and modified bitumen (PmB based on EN 14023) and with waxes modified bitumen. In some asphalt mixtures reclaimed asphalt was used. The results show the influence of the reclaimed asphalt on the bitumen quality and they show too that the different asphalts (AC, SMA, MA) stress the bitumen not constant. The bitumen used in asphalt for binder-courses was stressed much more than bitumen in other asphalt mixtures. The effect of higher modified bitumen seams to be adapted to normal modified bitumen after asphalt production and laying.

Keywords: Ageing, Creep, Modified Binders, Performance testing, Polymers

1. INTRODUCTION

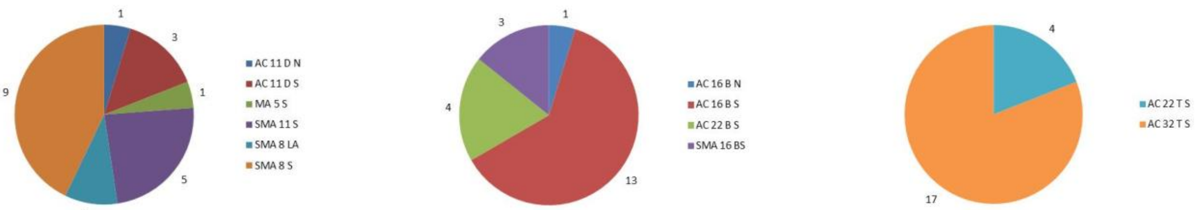
Within the research programme „Representative Determination of Performance-relevant Asphalt Properties that Provide the Basis for new Conditions of Contract“ [1], sponsored by Bundesanstalt für Straßenwesen, BASt 21, test-sections all over Germany have been accompanied. The test-sections are part of the road network (motorways, A and B roads). In all test-sections new base courses, binder courses and surface courses were laid. Tests were performed at the four phases of delivery (AL), after mixing in the laboratory (EP), after asphalt production in the asphalt plant (MW) and after laying (BK). The definitions of the four phases are the following:

Phase AL:	Analyses in the as-supplied state; samples taken at the refinery
Phase EP:	Analyses related to the asphalt mixture design with „reconstruction“ of the initial testing; samples are taken in the laboratory
Phase MW:	Analyses of asphalt mixtures produced at the asphalt mixing plant; samples are taken at the asphalt mixing plant or on site
Phase BK:	Analyses of cores taken at places where the corresponding asphalt mixtures are laid?; samples (cores) taken on site

In this paper, results regarding the bitumen quality are reported. Through comparison of the results in the different stages conclusions may be drawn for the contracts concerning different bitumen qualities. The material change (conventional and rheological properties of bitumen and polymermodified bitumen) during the supply chain of bitumen and asphalt is examined.

2. TEST-SECTIONS

Twenty-one test sections, examining three asphalt-mixtures containing bitumen or polymermodified bitumen (PmB) each, were performed (Total N = 63). The asphalt mixtures used in the different layers are given in figure 1. For all base courses and most of the binder courses reclaimed asphalt was used.Hence, the resulting bitumen quality is given in tables and figures of this paper. Figure 2 shows the bitumen used in the different layers.



surface course binder course base course

Figure 1: asphalts used in the test-sections

The most prevalent asphalt in the surface course is stone mastix (asphalt), more specifically stone mastix asphalt with a maximum size of 8mm. Only four asphalt concretes and one mastix asphalt were used. The main binder course was AC 16 B S, three binder courses were conceptioned like stone mastix asphalts. For the base courses, the majority was AC 32 T S.

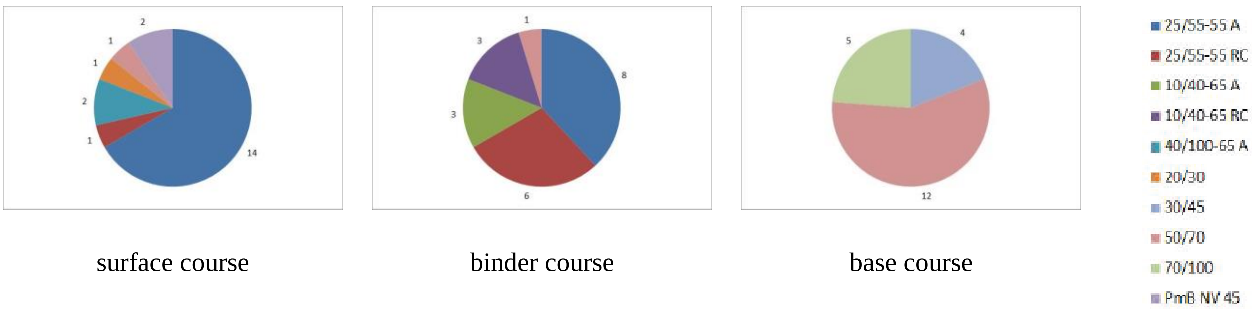


Figure 2: Bitumen used in the different asphalt-mixtures of the test-sections

Just one asphalt concrete and one mastix asphalt were produced with standard bitumen, the rest of the asphalt mixtures for surface courses polymermodified bitumen was used. Amongst asphalt for binder courses only one mixture was produced with standard bitumen, the other 20 mixtures were made with polymermodified bitumen. For the base courses only standard bitumen was used.

Figure 1 shows that stone mastix asphalt is the main asphalt mixture in the test-sections, additionally Figure 2 shows that polymermodified bitumen is used in many surface courses and most of the binder courses.

3. INVESTIGATION PROGRAMME

Table 1 illustrates all tests, carried out on bitumen in the different phases. As conventional tests, the softening point ring and ball, the penetration and – for polymermodified bitumen – the elastic recovery were examined in all phases. For the bitumen of the base courses only conventional tests were performed since no useful comparison was expected within the phases due to the usage of reclaimed asphalt.. The DSR-Tests were made in the AL-, MW- and BK-phase for asphalt-mixtures of surface and binder courses. BBR-tests and force ductility were not determined in the phase BK, because there were not enough cores to recover the necessary amount of binder for the tests.

Table 1: Investigation programme on the bitumen quality

	Phase											
	AL			EP			MW			BK		
	surface	binder	base	surface	binder	base	surface	binder	base	surface	binder	base
	course			course			course			course		
Conventional tests												
DSR-tests (temperature sweep, MSCR)												
BBR-tests												
Force ductility												

The following test procedures were used:

Softening Point R&B	EN 1427 [2],
Needle Penetration	EN 1426 [3],
Elastic Recovery	EN 13398 [4],
DSR – Temp. Sweep	EN 14770 [5], AL DSR-Prüfung (T-Sweep) [6],
DSR – MSCRT	AL MSCR-Prüfung (DSR) [7],
BBR	EN 14771 [8],
Force Ductility	EN 13589 [9], EN 13703 [10].

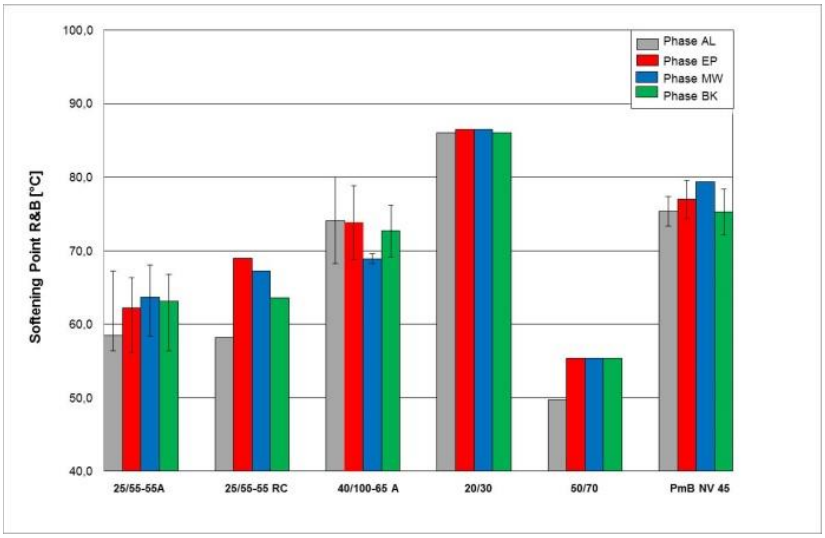
4. DISCUSSION

For conventional tests all results of the research project are shown, for the rheological tests only the results of the PmB 25/55-55 A are discussed because it is the most important bitumen in the research programme. The figures of the conventional tests provide mean values for each bitumen. Additionally, variances for the different samples of one bitumen are given.

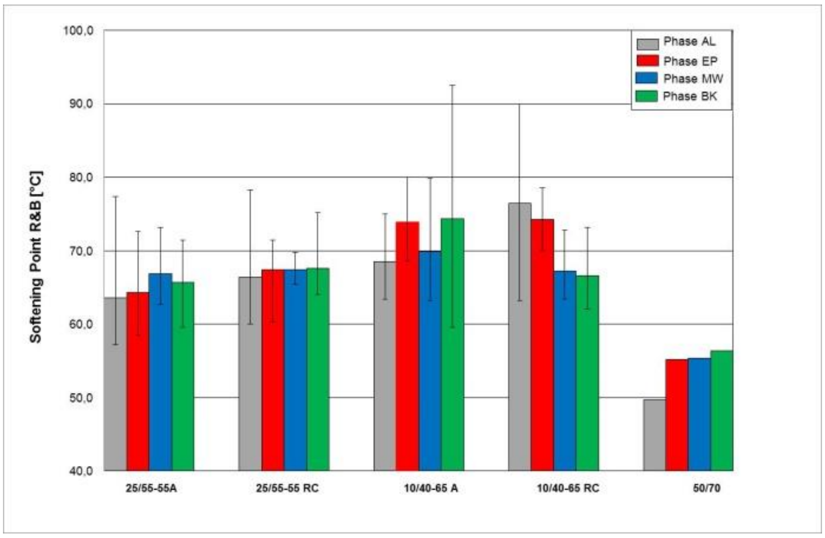
The conventional bitumen properties (Softening Point Ring and Ball, Needle Penetration and Elastic Recovery) were examined for all surface-courses, binder-courses and base-courses in the phases AL, EP, MW and BK. The Elastic Recovery was carried out only for polymermodified bitumen.

For the Softening Point Ring and Ball [3] (Figure 3) only two abnormalities were observed. Lower values for recovered bitumen were observed for RC-bitumen 10/40-55 within binder-courses in the phases MW and BK compared to phase AL. Significantly higher values of the softening point were observed in EP-, MW- and BK-phase compared with the AL-phase, due to the use of reclaimed asphalt in the base-course. However, within the EP-, MW- and BK-phase no significant differences were found. Lower variances in bitumen of surface-courses and binder-courses were observed in

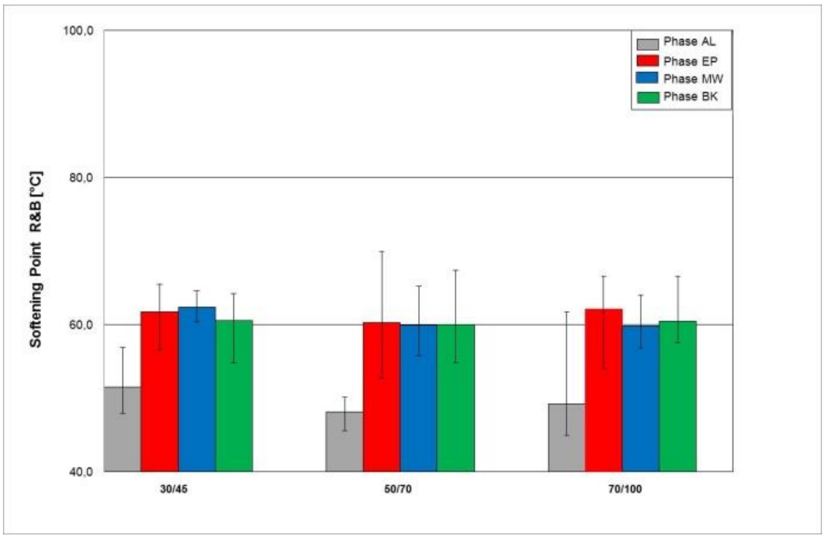
EP-, MW- and BK-phase compared to the delivery state (AL-phase). Obviously a certain leveling of the refinery related characteristics takes place.



surface course

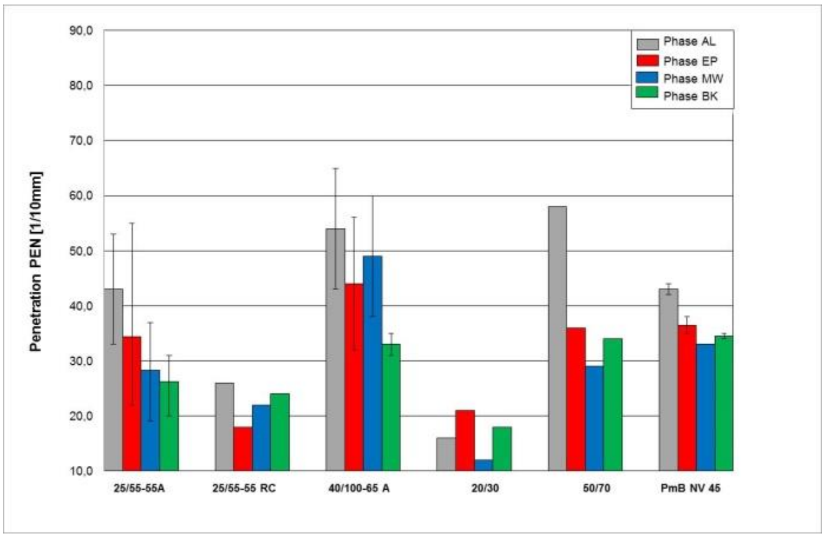


binder course

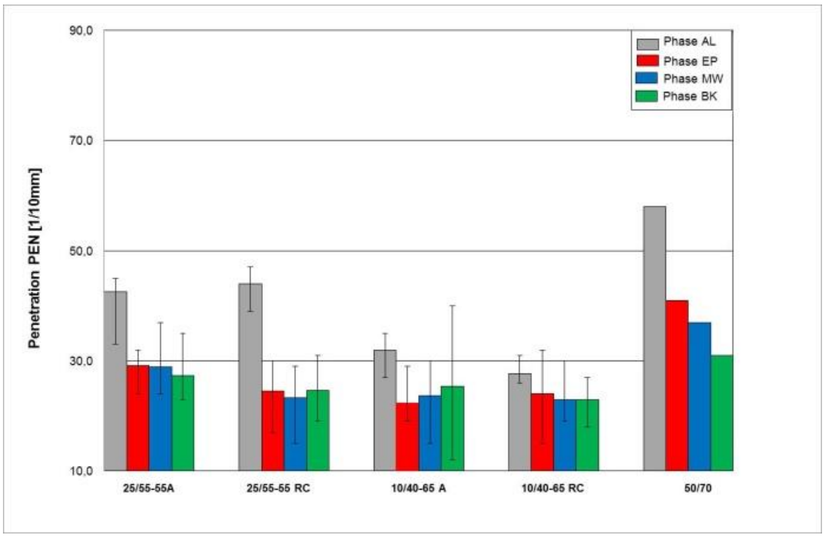


base course

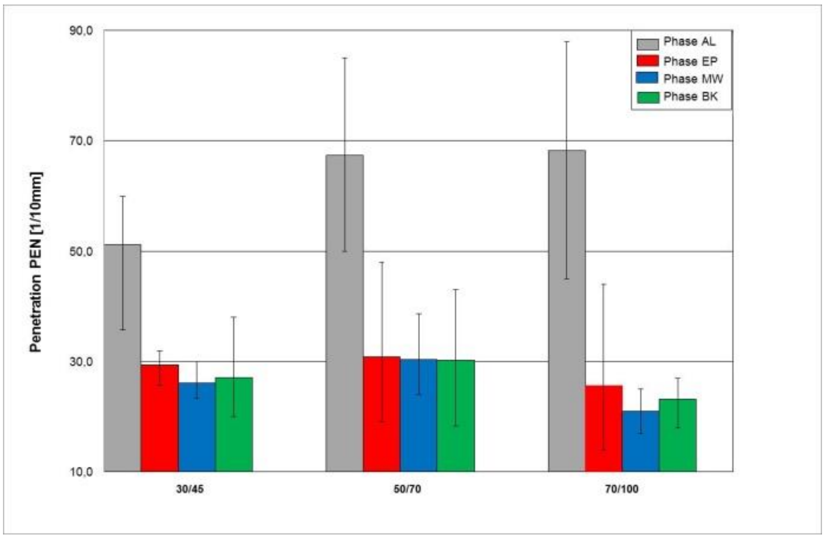
Figure 3: Softening point Ring and Ball



surface course



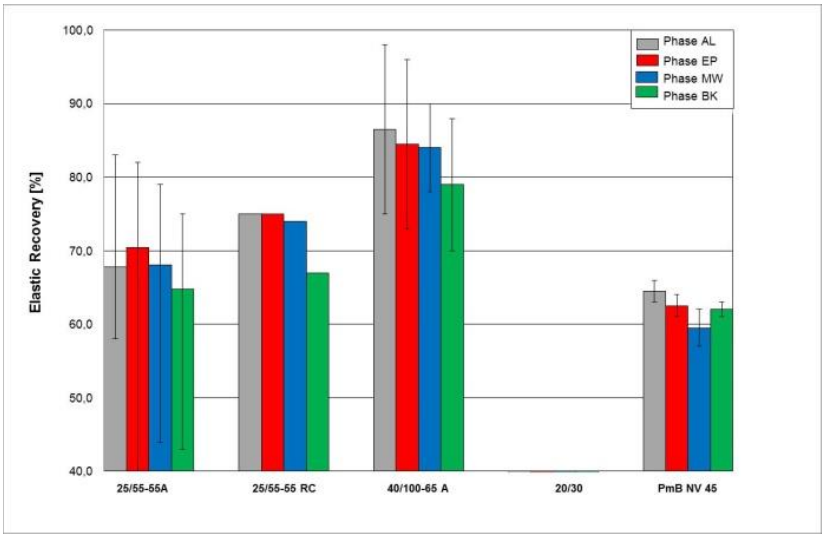
binder course



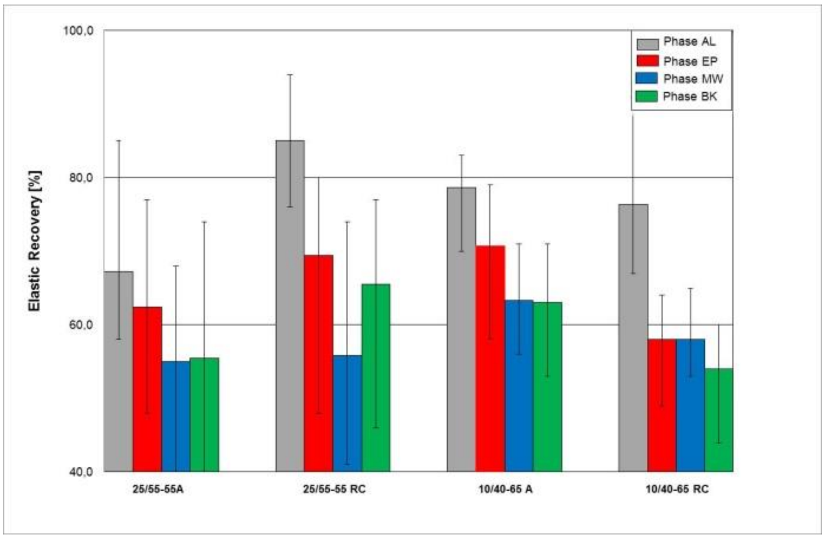
base course

Figure 4: Needle Penetration

The influence of reclaimed asphalt on base courses is demonstrated by Needle Penetration [3] (Figure 4). Furthermore, the differences between AL-, and remaining phases become more apparent with this characteristic value. In contrast to the Softening Points, the variances are higher for the EP-, MW- and BK-phase in comparison to the AL-phase. In the surface courses there is a greater difference between the EP-, MW- and BK-phase than for the binder courses. It seems that the production of asphalt mixtures for binder courses stress the bitumen more than in the production of surface courses.



surface course



binder course

Figure 5: Elastic Recovery

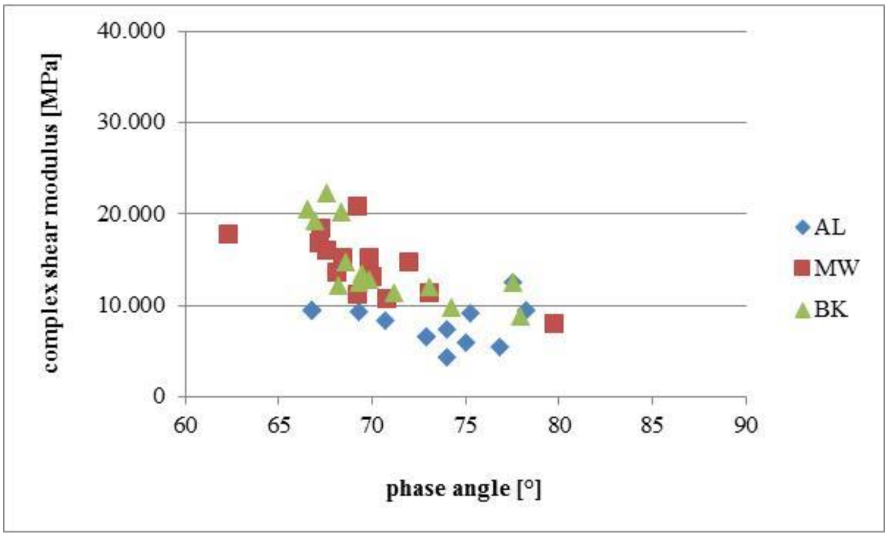
Looking at the Elastic Recovery [4] (Figure 5) comparable conclusions can be drawn. Again it appears that the production of asphalt mixtures for binder courses stress the bitumen more than the production of surface courses. Additionally you can see for this characteristic that the production of asphalt mixtures in the laboratory is less stressing for the bitumen than the production in the asphalt plant. The variations are comparable, with no significant differences observed.

In summary for the conventional binder properties it is to note, that the results of the investigated test-sections and phases lead to typical values. Special attention should be paid to the binder courses, because an enormous change in the quality of the bitumen during processing can be recognized in this mixture.

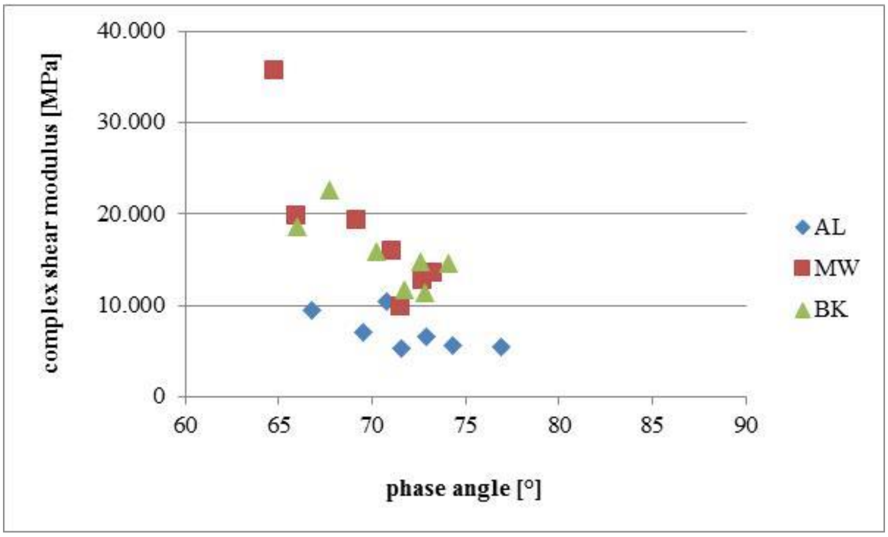
The studies with the Dynamic Shear Rheometer were made for all asphalt mixtures of surface courses and binder courses in the AL-, MW- and BK-phase. EN 14770 [5]. They served as base for the tests with temperature-sweep and an additional German test description [6] for the MSCRT [7] was used.

Instead of of temperature sweep results, Black Diagrams (Figure 6) at 60 °C are reported. As expected from the conventional tests, the stiffness in the phases MW and BK is higher than in phase AL. The stiffness in phase AL does not differ between surface and binder courses. The phase angles range between 65 and 80 ° independent of the phase. Again, the bitumen from binder course shows higher stiffness for phase MW and BK than from surface course.

The variance is at, for these tests, relatively low level, which corresponds also to the applicability of the test procedure. Looking at the detailed results it is striking that there are no differences in the quality of the polymermodified bitumen and the respective polymer modified bitumen associated RC in the phases MW and BK. One can get the impression that the positive quality in phase AL may be lost during processing.

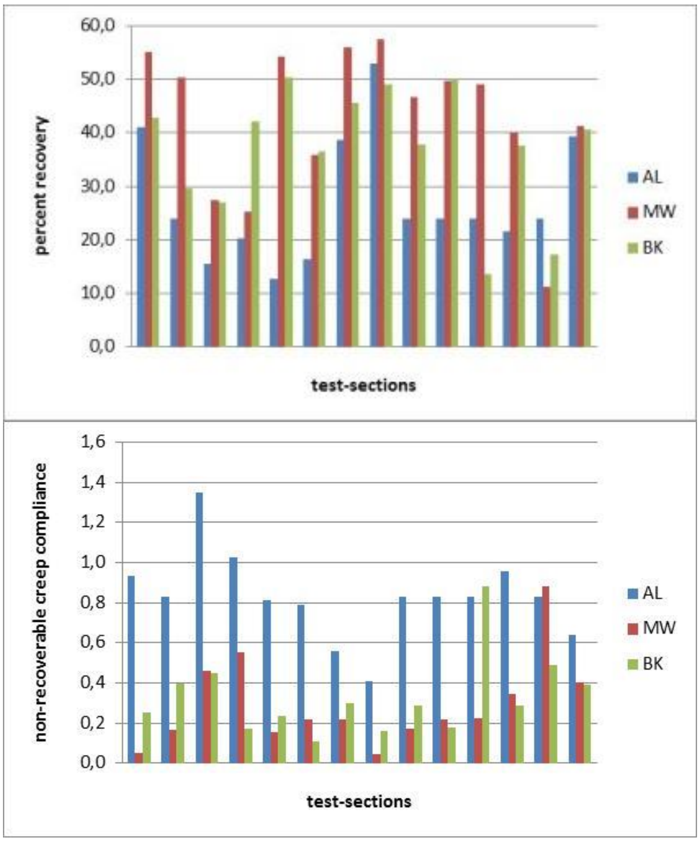


surface course

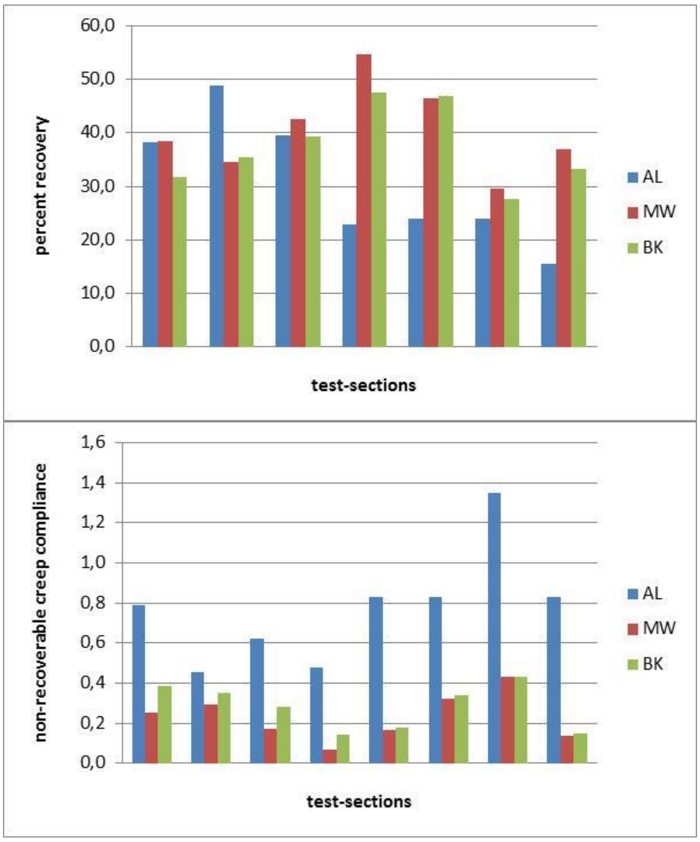


binder course

Figure 6: Black Diagramm of polymermodified bitumen 25/55-55 A



surface course

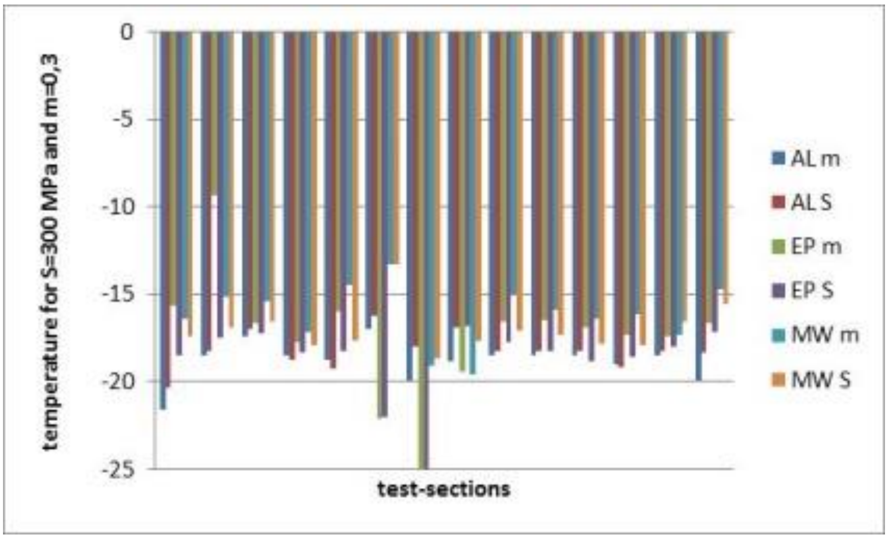


binder course

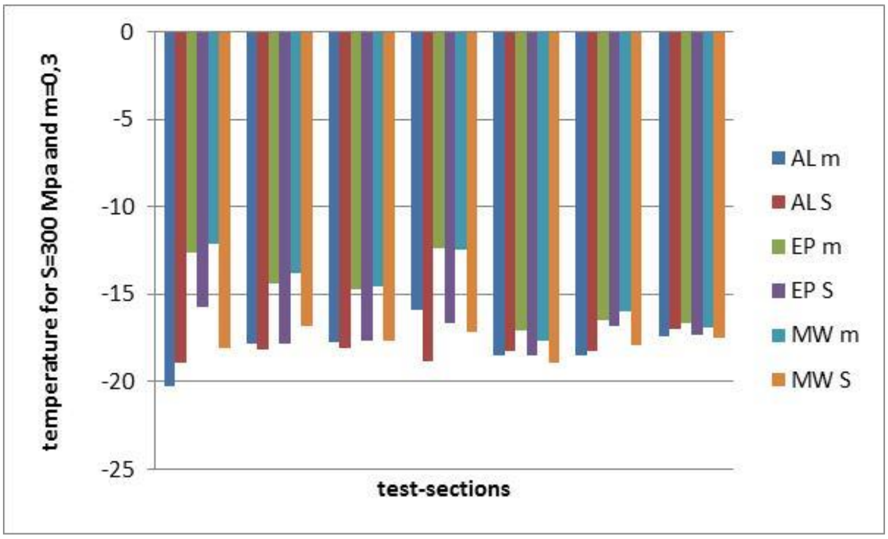
Figure 7: MSCRT results of polymermodified bitumen 25/55-55 A

The MSCR-Tests were conducted with three stress-levels (0,1 kPa, 1,6 kPa, 3,2 kPa) at a temperature of 60 °C. The following figures (Figure 9?) show the results with 1,6 kPa. The percentage of recovery is between 12 and 53 % in the phase AL. This difference can just be caused by the refinery. In phase MW the difference is nearly the same and in phase BK it is narrower. Almost in all test-sections the recovery in phase MW and BK is higher than in phase AL. The non-recoverable creep compliance is between 0,4 and 1,4 for phase AL and reduced to 0,1 to 0,8 for phase MW and BK.

Looking at the detailed results it is striking that in terms of percentage recovery, in the respective polymer modified binders associated RC binders found no differences in the sub-parameters in the phases MW and BK. Again one can get the impression that the positive quality in phase AL may be reduced by the processing. The determined variances are at a relatively large. The non-recoverable portion is at levels below 1% for all of the polymer modified binders. The bitumen has values more than 3%, especially in the delivered state.



surface course

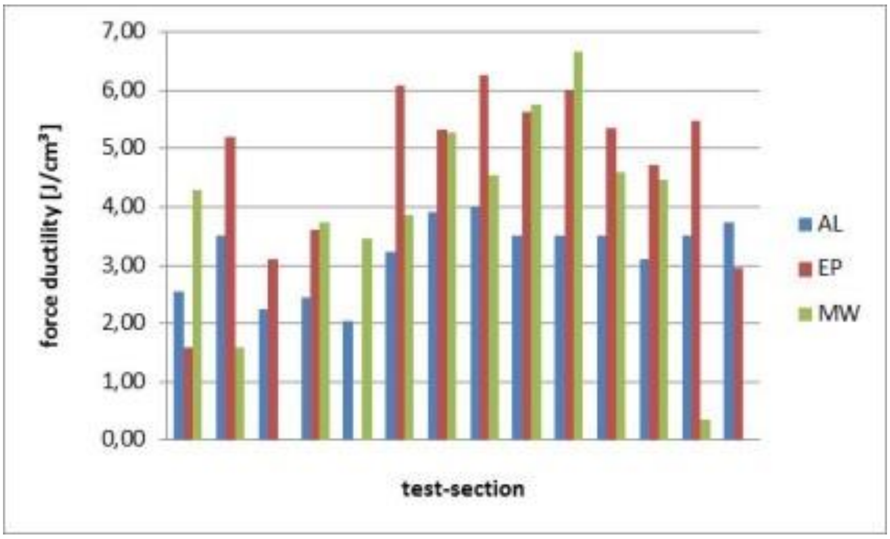


binder course

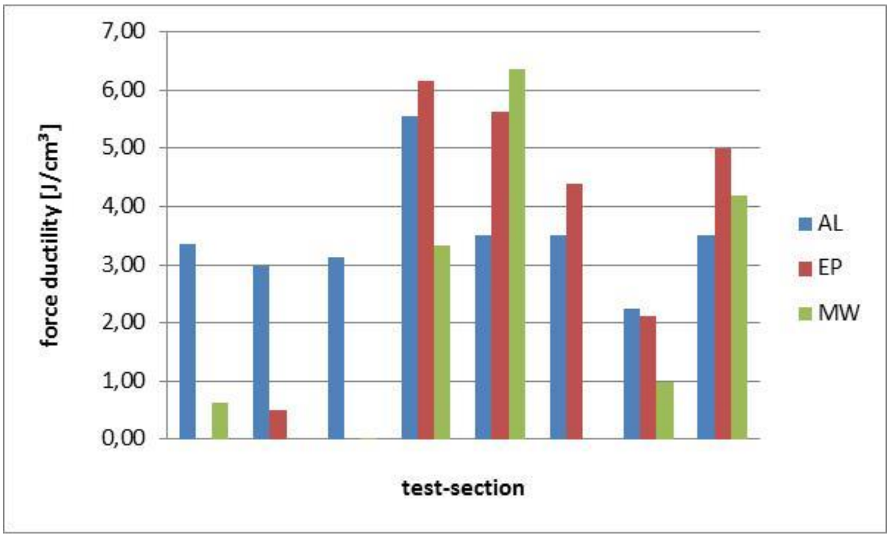
Figure 8: BBR results of polymermodified bitumen 25/55-55 A

The results of the BBR tests are given in figure 8. Each of the three phases is represented by two bars (for temperature with m=0,3 respectively S=300). It seems that the lower temperature always is reached for the criteria S – especially for phase MW and BK. For phase AL the temperature is between -17 and -22°C. for the phases MW and BK it is higher – in the range of -10 to -17°C. There is no difference between the courses and the phases.

The Force Ductility [8, 9] in phase AL is between 2,0 and 5,5 J/cm³, for the phases MW and BK between 0 and 6,6 J/cm³. Overall, results are significantly different, without observed trends. Large variances are observed.



surface course



binder course

Figure 9: Force Ductility of polymermodified bitumen 25/55-55 A

5. SUMMERY

The change of bitumen quality was investigated for 21 sites and three layers. Therefore, samples were examined at the stage of delivery (phase AL), after mixing in the lab (phase EP), after production in the asphalt plant (phase MW) and after laying (phase BK). The bitumen are described with the conventional test methods (Softening Point, Penetration, elastic Recovery), with tests in the Dynamic Shear Rheometer (temperature sweep for phase angle and stiffness, Multiple Stress Creep and Recovery Test), with Bending Beam Rheometer and Force Ductility. The study included standard bitumen (EN 12591), polymermmodified bitumen (PmB based on EN 14023), as well as wax-modified bitumen. In all asphalt mixtures for base course and most of the asphalt mixtures for binder course reclaimed asphalt was used.

For standard bitumen the supply chain can be recognized from the different stages with the conventional tests. There are no annormalities. The softening point for polymermodified bitumen show that this test doesn't fit to this bitumen, further conclusions may be drawn by needle penetration. Regarding elastic recovery it is evident that the value for revered bitumen from binder course is much lower than from surface course. It thereforet seems as if the asphalt production has great influence on the quality. In addition there is an influence from reclaimed asphalt even by using higher modified bitumen (suffix RC).

The Black Diagramm for bitumen, recovered from surface and binder course (in majority polymermodified bitumen), shows much higher complex shear moduli, two to four times higher than on delivery stage. This criterion fits much better to polymermodified bitumen than the softening point Ring and Ball. The effect of higher modified bitumen seems to be equal to normal modified bitumen after asphalt production and laying.

The tests point out that there should be more consideration of rheological tests especially for asphalt recovered bitumen.

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