ABSTRACT

Ageing of bitumen within an asphalt structure has, for many years, been the source of contention; especially when one attempts to understand the nature and extent of that ageing. This presentation has looked at field experience, where a road construction has been monitored over a period of 20 years and tried to ascertain how "standard" penetration grade bitumen has aged in comparison to a cross linked polymer material (Styrelf® 13/80).
The paper highlights the very good performances in term of durability of the crosslinked polymer modified binder in comparison to the conventional binder.

Polymer modified binders started to be used significantly thirty years ago in order to improve the mechanical performance of asphalt, especially for wearing courses in Europe.
This development came in response to increased problems of rutting and cracking due to significant increases in heavy traffic on the motorway network.
A lot of laboratory studies have been conducted for the evaluation of polymer modified bitumen in comparison to conventional bitumen, but no field data were available.

In 1988, the National Roadway Service of the Canton of Valais in Switzerland constructed the superstructure and the pavement of the N9 motorway over a distance of 15 km. One stretch was made available for the execution of test sections in order to compare the behaviour of polymer and additive modified bituminous mixtures with that of pure bituminous mixtures. A large observation field with identical conditions was made available for the construction of 16 different comparative test sections, each 300 m long under the same construction site, traffic and climatic conditions, using the same construction procedures and equipment. For these sections, only the wearing course binders varied. Twelve modified and four pure asphalt cements, used as references, were selected for the construction of the wearing courses. The pavement was designed according to the Swiss standard SN 640322 of 1971 for a lifetime of 20 years, 1600 daily ESAL of more than 8 tons and a 5% annual traffic progression. Another section of 4 km of cross linked polymer modified binder was established with the same PMB. This board has been replaced in 2009 after 21 years of service.
This motorway is subjected to moderate traffic, but severe climatic conditions, especially in terms of temperature daily cycle.

Bitumen from these test sections (penetration grade and Cross linked polymer) have been analysed at periods through the life of the road and analysed using a series of laboratory tests. The results of these tests have also been compared with certain laboratory based simulative ageing protocols.
In the study, an intense campaign to monitor the surface condition and laboratory tests on materials was conducted on these boards. The comparative test sections included a reference pure bitumen 80/100 and a crosslinked styrene-butadiene copolymer modified bitumen Styrelf® 13/80. After 19 years, the Styrelf section was the only remaining surface not having suffered cracking. More analysis after 19 years was performed on a complementary road section abutting the test sections, and constructed with a similar PmB binder in 1988, but a slightly thicker wearing course.

The field binder samples were first extracted and recovered. This important step was carried out according to the Swiss standard SN 670 403a and EN 12697-3:2005 (14) at LAVOC. This laboratory had built up a huge experience on extraction and recovery of conventional and modified binders. Results at the initial state as well as those after up to 14 years of age were obtained for both binders. Additional data after 19 years is available for the PMB. RTFOT and PAV laboratory accelerated ageing was also performed for comparison to the field aging.

The pavement cores obtained by sawing the layers were heated in the microwave and then divided into 3500g portions. The cores were then extracted by toluene with double centrifugation to separate the binder from the aggregates according to SN 670 401a and EN 12697-3:2005 (16). It is based on recovery of a mass of residual asphalt between 120 and 150g. In the first evaporation phase run in a rotating evaporator, boiling toluene is evaporated maintaining the bath at a 145 ± 1°C temperature under a 40 to 50kPa pressure and a 65 ± 5rpm rotation speed. The residual solvent evaporation proceeds lowering the pressure down to 1.9 ± 0.1 kPa. These conditions are maintained for 20 min ± 30 seconds.

Several tests were utilised to assess the performance of the two materials after ageing in situ for periods of 0, 2, 4, 8, 14 and 19 years. These included Softening Point (EN 1427, Penetration (EN 1426), Dynamic viscosity at 130^{o}C, Elastic Recovery (EN 13398), Fraass Breaking Point and Bending Beam Rheometer (EN 14771).

The initial testing shows clearly the impact of the mixing, transport and laying, as the penetration hardens significantly and the Softening Point increases. Thereafter there is a marked difference in performance of penetration grade bitumen to Styrelf.

It is noticeable that after 8 years the Styrelf has reached a plateau whereas the penetration grade material continues to change. Indeed, the same picture is evident for Dynamic viscosity.

Regarding the low temperature characteristics, it is always difficult to be absolutely prescriptive, as the reproducibility of the test is often questionable, but figures exhibit the same trend, again indicating the reduced loss of performance over time by the cross linked PMB.

The BBR figures, both ISO stiffness figures and the m-value show the same trend,. Interestingly, there appears to be a strange anomaly in the low temperature characteristics, whereby after 8 years, the low temperature performance not only ceases to deteriorate in the PMB, but actually improves.

The positive conclusion from the low temperature and elastic recovery trends, suggests that there is not the same tendency towards increasing cracking potential with age as is evident with penetration grade bitumens.

It demonstrates the link between low in situ cracking, good performance of the asphalt and the measurements in the laboratory. The field ageing affected the plain asphalt much more than the polymer modified binder.

KEY WORDS: Field experience, ageing, long-term performance, polymer modified binder