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Classical (empirical) Bitumen Testing Methods in Austria

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***Abstract*— *Binder (bitumen) properties are often standardised based on known empirical tests. In the European standards these are: needle penetration test, Fraass breaking point, softening point ring and ball, elastic recovery of modified bitumen and ductility. The informative value of empirical tests regarding the suitability of the binder is limited, as is well known. These test methods are simple, inexpensive and quick methods to describe bitumen. Since these test methods do not make any statement about the actual material parameters, such as stiffness or phase angle, and are not used as in reality, these empirical methods must be viewed critically today.*

***Keywords*— *Bitumen; ductility; elastic recovery; Fraass; penetration; point ring and ball.*

I. Classical (empirical) bitumen testing methods in Austria

Needle penetration test to European standard EN 1426, 2015

The penetration test (Fig.1, Fig.2) is carried out as follows: during needle penetration, a standardised needle is loaded with a weight for a certain time at a specified temperature and the penetration depth of the needle is determined in 1/10 mm. The numerical values in the designation of a bitumen (for example bitumen 50/70, 70/100, 160/220) is the range of penetration depths of the needle for bitumen. For example, bitumen 50/70 has a penetration at +25 °C of between (50 -70) x10^{-1} mm.

The test is standardised and takes place at +25 °C, with the needle penetrating at 100 grams in a load interval of 5 seconds. The test is carried out three times, whereby the points of contact of the needles must be approx. 1 cm apart - result = hardness measurement. The lower the penetration depth, the harder the bitumen [1].

Figure 1: left: Apparatus for conducting the penetration test for bitumen, right: 100 g needle [2]

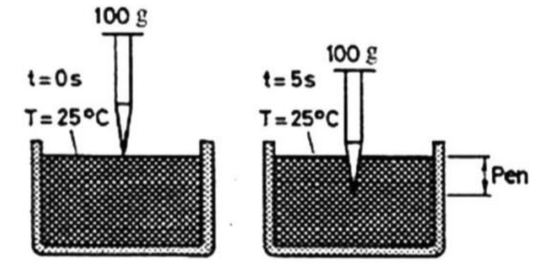

Figure 2: Penetration test sketch [3]

Determination of the Fraass breaking point to European standard EN 12593, 2015

The second test important for determining the bitumen properties is the determination of the Fraass breaking point according to European standard EN 12593, 2015. The break point automat is shown on the left in Fig.3. This is the temperature at which a film of bitumen, which has been melted or pressed onto a test sheet, breaks when the test sheet is cooled down and deflects as prescribed (Fig.3-right). The test is carried out in a standardised breaking point device. The Fraass breaking point is the arithmetic mean of two tests. The results must not be more than 3 °C apart. If the two are more than 3 °C apart, a third value must be determined. The arithmetic mean is then determined from the two values closest to each other [1].

Figure 3: left: Breaking point machine, right: Bending device [2]

According to Fraass, the breaking point is therefore the temperature in degrees Celsius at which a bituminous binder film of specified uniform thicknesses ruptures under specified load conditions (Fig.4).

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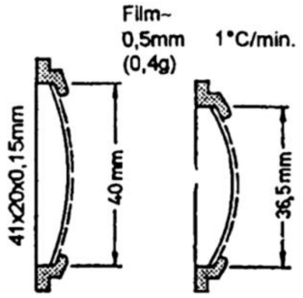

Figure 4: Breaking point sketch [3]

Determination of the softening point - Ring and Ball method to European standard EN 1427, 2015

To determine this value, a steel ball weighing 3.5 g is placed on a layer of bitumen placed between two rings (Fig.5, Fig.6). In the course of the test, the binder is evenly heated 2 x 3 g. When the sample has bent downwards by 25.4 ± 0.2 millimetres, the corresponding temperature is determined. The Ring & Ball softening point can be used to test bitumen that have their softening point between +25 °C and +160 °C. This test is carried out twice. The lower the softening point, the softer the bitumen.

Figure 5: left: Ring and ball machine, top right: Bitumen bag, bottom right: Measuring rings [2]

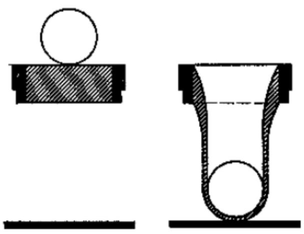

Figure 6: Ring and ball test – sketch [3]

Determination of the elastic recovery of modified bitumen to European standard EN 13398, 2018

The sample (2 x 20 g = 40 g for two moulds) is stretched to 20 cm in a water bath at +25 °C (Fig.7, Fig.8), the thread is cut off and the length is measured after 30 min. The ratio between the stretched length and the length between the half threads in [%] is given as elastic recovery.

While the elastic recovery of road bitumen is only 13%, the PmB at 92% almost returns to its original state (Fig.9).

Figure 7: Elastic recovery [2]

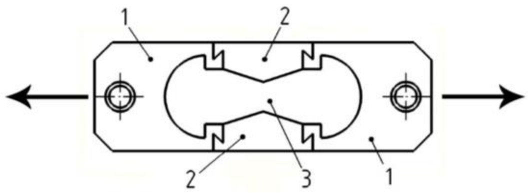

Figure 8: Test mould for determining of the elastic recovery and ductility: 1. head part; 2. side part; 3. recess for pouring in the bitumen [3]

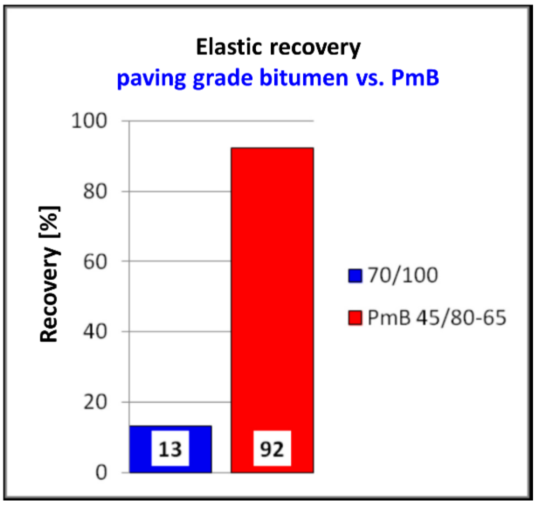

Figure 9: Difference between road bitumen (paving grade bitumen) B 70/100 and PmB 45/80-65 [2]

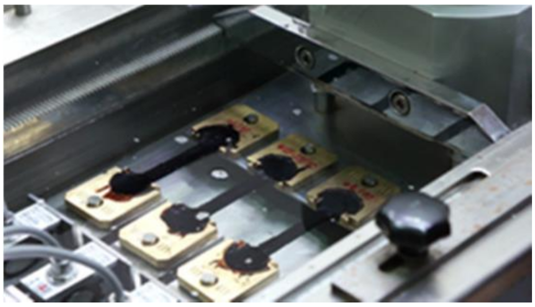

Figure 10: Ductilometer for the ductility test [1]

Determination of ductility to German standard DIN 52013, 2007

The ductility test is similar to the elastic recovery test with the difference that the bitumen is pulled out until it cracks. The sample with an initial cross-sectional area of 100 mm² is pulled at +5 °C and at a speed of 50 mm/min until it breaks. In contrast to the elastic recovery, the water bath is tempered at +5 °C. The force required to pull out the sample is recorded with the ductilometer during the pulling process (Fig.10).

Interpretation of the results of bitumen tests

As with the comparative bitumen tests and also with the GVO (Germ. "*Gebrauchsverhaltensorientiert*" - performance-based) tests on the asphalt mix, clear advantages can be shown with regard to the use of modified bitumen grades (PmB) with regard to an increase in the permissible standard load changes and the structural life.

The only disadvantage of PmB compared to conventional road bitumen is that the polymers (thermoplastic or plastomeric) only increase the viscosity (hence the stiffness of the bitumen), which can have a negative effect on the cracking behaviour at low temperatures.

When the asphalt was paved by hand with a PmB as a binder (Fig.11), the asphalt sections also regularly complained to the author as site manager of numerous construction sites that the PmB asphalt was extremely difficult to lay by hand because it behaved like chewing gum when pulled with an asphalt puller (Fig.11). To cheer people up, I then bought a snack for the asphalt section.

Figure 11: Manual laying of the asphalt with PmB bitumen on a construction site belonging to the author [K. Hrapović, 2006]

The advantages of polymer modified bitumen (Fig.12) over conventional road bitumen (Fig.13) from available studies and practical experience gained by the author over decades are more than clear and indicate that PmB is definitely preferred as a binder for the asphalt mix of roundabouts as traffic areas with special loads:

- The PmB bitumen have a significantly higher softening point after ring and ball than conventional road bitumen with the same penetration.
- Due to the higher softening point while the breaking point remains the same, there is a greater plasticity range. The PmBs thus reach softening points of +70 °C and more, while at the same time being far superior to conventional road bitumen in the low temperature regime.
- Thanks to their higher softening temperature and elastic properties, PmB have good resistance to deformation.
- Thanks to the addition of polymers and additives, PmB has been shown to age more slowly than conventional road bitumen.

It is therefore more than clear that Polymer Modified Bitumen (PmB) has far better properties than conventional road bitumen and is therefore recommended for asphalting roundabouts as traffic areas subject to particular stress.


Figure 12: Polymer modified bitumen (PmB) [4]
Figure 13: Conventional road bitumen [5]

II. Conclusion

Although only about five percent of the mass of our asphalt roads consists of bitumen (the rest is rock), the mechanical properties of asphalt are decisively influenced by the bituminous binder. Bitumens are low-volatile, dark-coloured mixtures of many substances, which, in addition to hydrocarbons and hydrocarbon derivatives, can also contain sulphur, oxygen and nitrogen. Bitumen is resistant to the effects of most inorganic acids, salts, aggressive waters, carbonic acid and alkalis. Road bitumen is produced by distillation and, if necessary, subsequent oxidation. Three test methods have been defined for the classification of bitumen types, which form the essential basis for the classification of bitumen types according to EN 12591: Needle Penetration according to EN 1426, Softening Point Ring and Ball according to EN 1427 and Fraass Breaking Point according to EN 12593. Bitumens are named according to the range of needle penetration. These three test methods, especially EP RuK and needle penetration, are the authoritative determination methods and relevant for the daily handling of road bitumen. In addition, there are a number of further classic test methods such as elastic recovery of modified bitumen according to EN 13398 and ductility according to German standard DIN 5201.

In the conventional bitumen testing scheme, the bitumen samples are examined by means of various tests (e.g. penetration, softening point with ring and ball, breaking point according to Fraass), which do not give any direct physical parameters of the bitumen or the asphalt produced with it for certain damage cases (e.g. cracks, rut formation). A conclusion from these test values to the actual behaviour of the bitumen in the asphalt road is only possible through practical experience and estimation. Since conventional bitumen testing methods do not provide information on the actual material parameters such as stiffness or phase angle and the bitumen is not stressed as in reality (type of load, climatic conditions, etc.), empirical (conventional) tests must be viewed critically.

In addition to the classical (empirical) methods, the following methods, so-called performance based requirements (Germ. GVO = *gebrauchsverhaltensorientiert*) methods, are used in Austria for testing bitumen in accordance with EU standards. These GVO methods are much more practice-oriented and they give the statement about the material parameters such as stiffness, phase angle, etc.

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