Eurobitume Position on Characteristics and Test Methods for Future Specifications for Bituminous Binders for Paving

Table of Contents

Eurobitume, June 2024, info@eurobitume.eu ISBN: 978-2-39068-055-0 D/2024/7512/188

1. Introduction

Eurobitume has considered options for the development of performance-related specifications for bitumen and bituminous binders for paving applications for a significant period of time. A first position paper on the subject was published in 2002[1]. Since the original publication, further work has been undertaken to develop the outcomes. One of the key elements in the development of these options were two data collection exercises, which were carried out in 2009 and 2020. One of the outcomes of the 2009 data collection was the need for more appropriate test methods to assess the performance of complex binders. The 2020 data collection exercise considered global research, practical application developments and potential changes to European product and test standards.

In the field of standardisation, CEN Technical Committee 336, Working Group 1, Task Group 14 was established in 2022 to investigate possibilities for future specifications for bitumen and bituminous binders. Task Group 14 was established following the decision not to proceed with the formal vote on revised EN 14023 (Framework Specification for Polymer Modified Bitumens).

Eurobitume established Task Force Specifications in 2017, with the aim of delivering the following goals:

- Consider options for revision of EN 14023[2].
- Consider next steps for revision of EN 12591[3] (paving grade bitumens) or other product standards, when relevant.
- Develop clear positions for Eurobitume members to be adopted within CEN/TC 336 national mirror committees.
- Consider possible specification criteria for bitumens with reduced application temperature.
- Provide technical support to Eurobitume local representations when relevant.

These goals are aligned with TG 14's aim of defining characteristics and test methods for a performance-based specification framework.

Both TG 14 and Eurobitume´s TF Specifications have focussed their work on complying with the Construction Products Regulation (CPR)[4] and specifically the performance of the bituminous binder in the construction works.

TF Specifications has identified several binder characteristics that can be linked to the performance of the construction works and should be included in future specifications. The Task Force has also considered the most critical ageing state for each characteristic.

The binder characteristics are discussed in the sections below.

2. Critical Ageing States

For the purposes of this document, the accepted method for short-term ageing is the rolling thin-film oven test (RTFOT) as described in EN 12607-1[5]. The accepted method for long-term ageing of bituminous binders is the combination of ageing induced by in the rolling thin-film oven test EN 12607-1 followed by the pressure ageing vessel (PAV) as described in EN 14769. It should be noted that different combinations of time and temperature are possible in EN 14769[6], which may produce different degrees of ageing. This document does not make any particular recommendation regarding the choice of conditions.

3. Permanent Deformation

Figure 1: Example of permanent deformation

Permanent deformation, also known as rutting, is a phenomenon observed in asphalt pavements and is usually associated with heavy and low-frequency loading, at elevated service temperature. Under these conditions, bituminous binders tend to behave in a predominantly viscous fashion. Consequently, permanent deformation of an asphalt pavement can be assumed to be related to flow and deformation of the bituminous binder. It is generally accepted that permanent deformation of an asphalt pavement can occur relatively early in its service life, therefore when considering the characteristics of bituminous binders to indicate permanent deformation, the binder should be assessed after short-term ageing.

There is currently insufficient data on in-service surface temperatures of asphalt pavements throughout Europe to allow the establishment of regional temperature zones, therefore it is recommended that a series of discrete temperatures are used to assess permanent deformation of bituminous binders. Having considered the views of its members, Eurobitume's TF Specifications recommends discrete temperatures in the range 40 – 80 °C are appropriate for the assessment of permanent deformation.

The Multiple Stress Creep Recovery Test (MSCRT) as described in EN 16659[7] is recommended as appropriate for assessing the contribution of a bituminous binder to resistance to permanent deformation in an asphalt pavement. The parameters of non-recoverable creep compliance (J_{nr}) and percent recovery (%R) are believed to be good indicators of the ability of a bituminous binder to resist deformation and exhibit an elastic response. EN 16659[7] states that bituminous binders should be tested at two stress levels: 0,1 and 3,2 kPa. However, it is generally accepted that the lower stress level does not effectively discriminate performance levels. Therefore, it is recommended that the properties of non-recoverable creep compliance and percent recovery are only determined at 3,2 kPa stress level.

Figure 2: Dynamic Shear Rheometer

Permanent Deformation

Method	MSCRT (EN 16659)
Ageing state	Short-term aged (EN 12607-1)
Parameters	J_{nr}, %R
Stress	3,2 kPa
Temperature	40 – 80 °C

4. Thermally-Induced Cracking

Thermally-induced cracking is a phenomenon observed in asphalt pavements and is usually associated with brittleness of the binder at low service temperature. As bituminous binders cool, their rheological properties tend to move from predominantly viscous to elastic behaviour. Therefore, thermally-induced cracking in an asphalt pavement is related to the low service temperature behaviour of bituminous binders. In contrast to permanent deformation, thermally-induced cracking in asphalt mixtures tends to appear after a significant period of service. It is therefore appropriate that, when considering test methods to indicate the thermally-induced cracking potential in a bituminous binder, the binder is assessed in its long-term aged state.

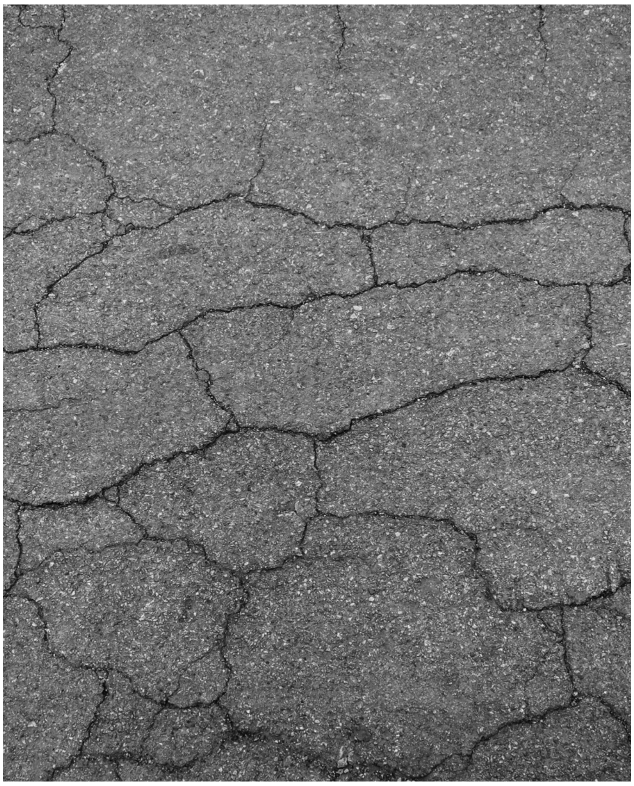

Figure 3: Example of thermally-induced cracking

As noted above, there is insufficient data on in-service temperatures of asphalt pavements to establish regional climatic zones in Europe. It is therefore accepted that definitions of low service temperature may vary from country to country.

Figure 4: Preparation of BBR test specimen

The Bending Beam Rheometer Test (BBR) as described in EN 14771[8] is recommended as appropriate to determine the contribution of a bituminous binder to the resistance of an asphalt pavement to thermally-induced cracking. The critical stiffness parameter of a bituminous binder is defined as the temperature at which a binder achieves a stiffness of S = 300 MPa in the bending beam rheometer. This critical stiffness parameter is believed to be a good indicator of the low service temperature of a bituminous binder and therefore the ability of an asphalt pavement to resist thermally induced cracking. EN 14771 also describes other parameters that can be used to describe the low service temperature, such as the m-value (rate of change of stiffness with time). However, these other parameters are not deemed to be as effective as the critical stiffness temperature.

Thermally Induced Cracking

Method	BBR (EN 14771)
Ageing state	Long-term aged (EN 12607-1 and EN 14769)
Parameters	T (S = 300 MPa)
Temperature	< 0 °C

5. Ravelling Resistance

Ravelling is defined as the loss of aggregate from an asphalt pavement and is related to both the adhesion and cohesion of the bituminous binder. As adhesion depends on contributions from both binder and aggregate, it cannot be considered in a specification for bituminous binders. Therefore, this document will only consider the cohesion of a bituminous binder as an indicator of its ability to contribute to the ravelling resistance of an asphalt pavement.

Figure 5: Example of ravelling

The cohesion of a bituminous binder may be determined using three standard methods: Force Ductility (EN 13589)[9], Tensile Test (EN 13587)[10] and Pendulum Test (EN 13588)[11]. The latter method is only suitable for the determination of the cohesion of binders used in surface dressing applications. Force Ductility as described in EN 13589 is the most widely accepted method for the determination of cohesion of bituminous binders and is recommended as the preferred method of assessing its contribution to the ravelling resistance of an asphalt pavement. Eurobitume's TF Specifications, however, recommends that modifications to the method are necessary to gain a better understanding of the total cohesion. In the current approach, only the area of the curve corresponding to elongation between 200 and 400 mm is converted into a cohesion value. Task Force Specifications recommends that the total area under the force-elongation curve is used to determine the cohesion and that the elongation to break should be reported.

Ravelling of an asphalt pavement tends to occur later in its service life, therefore it is appropriate that the cohesion of a bituminous binder is assessed in the long-term aged state.

Ravelling Resistance

Method	Force Ductility (EN 13589)
Ageing state	Long-term aged (EN 12607-1 and EN 14769)
Parameters	Total cohesion energy, J/cm² Elongation to break, cm
Temperature	10 – 30 °C

EN 14023 (Framework Specification for Polymer Modified Bitumens) specifies cohesion classes based on temperature and cohesion energy. The current temperature classes are at 5 °C intervals from 0 to 25 °C, with cohesion energy ranging from 0,5 to 3,0 J/cm². Eurobitume's Task Force Specifications recommends that total cohesion should be determined at temperatures in the range 10 – 30 °C.

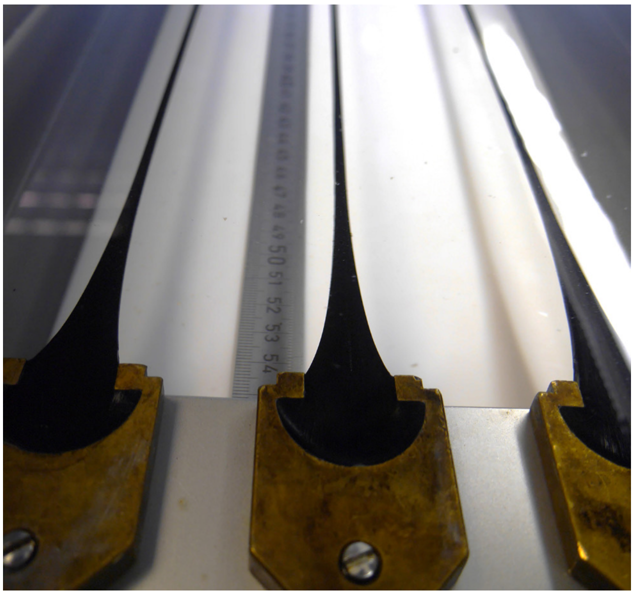

Figure 6: Force ductility test specimen

5.1 Ravelling Resistance for Surface Dressing Applications

As mentioned above, EN 13588 is specifically referenced as being suitable to determine the cohesion of bituminous binders used in surface dressing applications. It is therefore logical that it should be used as an indicator of the ravelling resistance of surface dressing applications.

EN 13808[12] (Framework Specification for Cationic Bituminous Emulsions) specifies that the maximum cohesion of a bituminous binder is reported at two stages selected from: residual binder after distillation (EN 1431)[13], recovered binder (EN 13074-1)[14], stabilised binder (EN 13074-2)[15] or aged binder (EN 13074-1, followed by EN 13074-2 and EN 14769). Eurobitume supports this approach.

Figure 7: Pendulum cohesion apparatus

Ravelling Resistance (Surface Dressing)

Method	Pendulum Cohesion (EN 13588)
Ageing state	Residual, recovered, stabilised, aged
Parameters	Maximum cohesion energy, J/cm^2
Temperature	10 – 60 °C

6. Fatigue-Induced Cracking

Fatigue-induced cracking is defined as the cracking which occurs in an asphalt pavement as the result of repeated loading at the surface and tensile failure (or loss of stiffness) in the base layers. Fatigue-induced cracking tends to appear towards the end of pavement life, therefore it would be appropriate to base any test method for it’s prediction on long-term aged binder. It is important to separate fatigue-induced cracking from thermal cracking, therefore Eurobitume recommends that the appropriate temperature range for any test method is between 10 – 30 °C.

Over the years, a number of studies have attempted to establish a correlation between the properties of bituminous binders and the fatigue performance of asphalt pavements. Two significant literature reviews have been published by the Federation of European Highway Research Laboratories (FEHRL) in 2006[16] and the Conference of European Directors of Roads (CEDR) in 2013[17] respectively. Both studies concluded that no single binder parameter could be correlated to asphalt fatigue. The CEDR study did, however, conclude that the output from the linear amplitude sweep (LAS)[18] test correlated reasonably well with the fatigue performance of asphalt mixture produced with unmodified binders. However, there was no correlation established for polymer-modified binders.

Parameters proposed as indicators for fatigue-induced cracking include the linear amplitude sweep (LAS), critical strain value[19] and viscous-elastic transition temperature (VETT)[20]. Eurobitume does not, however, believe that any of these parameters can be used for all binders and therefore does not support their inclusion in future specifications at this stage.

Fatigue-Induced Cracking	
Method	No method supported
Ageing state	Long-term aged
Parameters	No parameter supported
Temperature	10 – 30 °C

7. Stiffness

The stiffness of an asphalt pavement can be related to other aspects of performance, for example permanent deformation. Stiffer asphalt mixtures tend to be more resistant to permanent deformation than softer ones. Resistance to point-loading (or indentation) is also related to the stiffness of an asphalt mix. The CEDR (Conference of European Directors of Roads) report concluded that there was a good correlation between the stiffness of a binder, as determined in the DSR rheometer[21] and the stiffness of an asphalt mix, determined using, for example, EN 12697-26[22].

It can be argued that the stiffness of a bituminous binder, and therefore of an asphalt mixture, is relevant at all temperatures and at all ageing states. Therefore, Eurobitume recommends that stiffness is assessed at all relevant temperatures in the territory of use and at all ageing states. However, Eurobitume does not currently have a formal position on the appropriate test method. Most members have expressed a preference for equi-stiffness temperature (T (G* = 15 kPa) and T (G* = 5 MPa)) to be reported. This is effectively aligned with proposals developed during the unsuccessful attempt to revise EN 14023 and EN 12591.

Stiffness	
Method	Complex modulus and phase angle in DSR (EN 14770)
Ageing state	All
Parameters	Equi-stiffness temperature or rutting parameter
Temperature	0 – 70 °C

However, some members have expressed a preference to use the North-American rutting parameter G*/sinδ as defined in the AASHTO performance-grading system[23,24] as this also takes into account the degree of elasticity of the binder.

8. Temperature Susceptibility

The temperature susceptibility of a bituminous binder can be determined using a variety of empirical and performance-related techniques. Typically, the determination involves calculating (or estimating) the difference between the upper and lower service temperatures. One empirical method for the determination of temperature susceptibility is given in EN 14023 and is termed the “plasticity range”. This is the difference between the Softening Point Ring and Ball (EN 1427)[25] and the Fraass Breaking Point (EN 12593)[26]. The AASHTO specifications define temperature susceptibility using the rutting and fatigue parameters and creep stiffness. The upper service temperature is defined by minimum stiffnesses at particular temperatures as measured using the DSR, while low service temperature is defined by a maximum stiffness value from BBR measurements. Eurobitume members believe that temperature susceptibility is applicable to all ageing states of bituminous binders.

As reported above with stiffness, the majority of Eurobitume members have expressed a preference for temperature susceptibility to be determined using equi-stiffness temperatures (T (G* = 15 kPa) and T (G* = 5 MPa)). However, some members have expressed a preference for the phase angle (δ) to be incorporated.

Temperature Susceptibility

Method	Complex modulus and phase angle in DSR (EN 14770)
Ageing state	All
Parameters	Equi-stiffness temperature (in combination with phase angle (δ))
Temperature	Not applicable

9. Durability

The durability of a bituminous binder is effectively related to its resistance to ageing, but can also be interpreted in terms of the timespan that ensures a proper performance of the binder. It can be determined using a number of empirical and performance-related test methods. For example, for paving bitumens used in surfacing applications, the time taken for the needle penetration (EN 1426)[27] to fall to less than 15 1/10 mm can be used as an indicator of durability[28].

Eurobitume members believe that durability is assessed by a number of parameters and test methods described above and does not, therefore, recommend the establishment of a unique method for durability.

10. Conclusions

Eurobitume's Task Force Specifications has considered options for test methods which our members believe could be included in future specifications in Europe. It is recommended that test methods should be related to performance characteristics which relate to, or are indicative of, the performance of the binder in the construction works. Key test methods and binder characteristics have been identified that relate to the most critical areas of asphalt performance: permanent deformation, cracking, ravelling resistance and stiffness.

In some cases, for example ravelling resistance, modifications to existing test methods are recommended to ensure that more relevant information is obtained.

In addition to identifying the key test methods and characteristics, Task Force Specifications has identified the critical ageing state for the binder.

This position paper reflects Eurobitume's position on suitable test methods and binder characteristics for potential inclusion in future specifications in Europe.

11. References

1. *Eurobitume Position on Future Specification System for Bituminous Paving Binders, Eurobitume, 2002, ISBN 2-930160-06-3*
2. *EN 14023: Bitumen and bituminous binders — Specification framework for polymer modified bitumens*
3. *EN 12591: Bitumen and bituminous binders — Specifications for paving grade bitumens*
4. *Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC*
5. *EN 12607-1: Bitumen and bituminous binders — Determination of the resistance to hardening under influence of heat and air — Part 1: RTFOT method*
6. *EN 14769: Bitumen and bituminous binders - Accelerated long-term ageing conditioning by a Pressure Ageing Vessel (PAV)*
7. *EN 16659: Bitumen and bituminous binders — Multiple Stress Creep and Recovery Test (MSCRT)*
8. *EN 14771: Bitumen and bituminous binders — Determination of the flexural creep stiffness — Bending Beam Rheometer (BBR)*
9. *EN 13589: Bitumen and bituminous binders — Determination of the tensile properties of modified bitumen by the force ductility method*
10. *EN 13587: Bitumen and bituminous binders — Determination of the tensile properties of bituminous binders by the tensile test method*
11. *EN 13588: Bitumen and bituminous binders — Determination of cohesion of bituminous binders with pendulum test*
12. *EN 13808: Bitumen and bituminous binders — Framework for specifying cationic bituminous emulsions*
13. *EN 1431: Bitumen and bituminous binders — Determination of residual binder and oil distillate from bitumen emulsions by distillation*
14. *EN 13074-1: Bitumen and bituminous binders — Recovery of binder from bituminous emulsion or cut-back or fluxed bituminous binders — Part 1: Recovery by evaporation*
15. *EN 13074-1: Bitumen and bituminous binders — Recovery of binder from bituminous emulsion or cut-back or fluxed bituminous binders — Part 2: Stabilisation after recovery by evaporation*
16. *BitVal - Analysis of Available Data for Validation of Bitumen Tests, Forum of European National Highway Research Laboratories, 2006*
17. *Functional Durability-related Bitumen Specification (FunDBitS). Correlations between bitumen and asphalt properties. Fatigue life. Conference of European Directors of Roads, 2013*
18. *Standard Method of Test for Estimating Fatigue Resistance of Asphalt Binders Using the Linear Amplitude Sweep, AASHTO T391-20, 2021*
19. *Relation between the fatigue behavior of asphalt binders and bituminous mixtures. Péréz-Jiménez, F., Reyes-Ortiz, O. J., Miró Recasens, R. and Hernández Noguera, J. E&E2008*

20. *Viscous to Elastic Transition Temperature of Bitumen and the In Situ Performance of Bituminous and Asphaltic Materials. Widyatmoko, I., Heslop, M. W. and Eliott, R. C. Journal of the Institute of Asphalt Technology, Asphalt Professional No 14, 3–7*
21. *EN 14770: Bitumen and bituminous binders — Determination of complex shear modulus and phase angle — Dynamic Shear Rheometer (DSR)*
22. *EN 12697-26: Bituminous mixtures — Test methods – Part 26: Stiffness*
23. *Standard Specification for Performance-Graded Asphalt Binder, AASHTO M-320*
24. *Standard Specification for Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test, AASHTO M-332*
25. *EN 1427: Bitumen and bituminous binders — Determination of the softening point — Ring and Ball method*
26. *EN 12593: Bitumen and bituminous binders — Determination of the Fraass breaking point*
27. *EN 1426: Bitumen and bituminous binders — Determination of needle penetration*
28. *The Shell Bitumen Handbook (6th Edition). 2015, p.518-519*

Credits on figures with Eurobitume, if not stated otherwise below:

(1) Mr. J. Farrington; (2) Controls S.p.A. (DSR:Rheotest); (3) and (5) NAPA; (7) Vialab