Road and Transportation Research Association

Working Group on Asphalt Pavements

FGSV

Test description for determining the deformation behaviour of bitumen and bituminous binders using a Dynamic Shear Rheometer (DSR) – Part 4: Binder Fast Characterisation Test (BTSV)

AL DSR-Prüfung (BTSV)

W 1

Edition 2017/Translation 2018

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Preliminary remark:

The ‘Test description for determining the deformation behaviour of bitumen and bituminous binders using a Dynamic Shear Rheometer (DSR), Part 4: Binder Fast Characterisation Test (BTSV) (AL DSR-Prüfung (BTSV)), Edition 2017’, was drafted by the Road and Transportation Research Association’s Subcommittee on Bitumen and Modified Bitumen and finalised by the Working Committee on Binders (chaired by Dr.-Ing. Tobias Hagner).

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1 Introduction

This test description is based on the test standard DIN EN 14770 ‘Bitumen and bituminous binders – Determination of complex shear modulus and phase angle – Dynamic Shear Rheometer (DSR)’.

2 General remarks

The test is carried out using a Dynamic Shear Rheometer (DSR) to evaluate performance of bituminous binders at elevated service temperatures. The temperature at which a bituminous binder demonstrates a defined complex shear modulus in stress controlled oscillation mode at a constant frequency and continuous increase of test temperature, and the respective phase angle are determined.

This test description covers the testing of paving grade bitumen and modified bitumen, as fresh binders, as well as binders after laboratory ageing (e.g. DIN EN 12607-1, DIN EN 14769), and binders that have been recovered from asphalt.

Tests conducted in accordance with this test description are not suitable for bituminous binders containing particles (e.g. fillers, rubber aggregate) larger than 250 µm.

Note: The results obtained using the Binder Fast Characterisation Test (BTSV) can also be approximated by interpolating the results of tests conducted according to the test description AL DSR (T-Sweep). When using this approach on aged bituminous binders or bituminous binders that have been recovered from asphalt, the linear viscoelastic range needs to be determined.

Note: The use of this European Standard can involve hazardous materials, operations and equipment. This European Standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this European Standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

3 Terms and definitions

For general definitions, see DIN EN 12597 ‘Bitumen and bituminous binders – Terminology’.

Complex shear modulus (G*): Ratio of peak stress and peak strain in harmonic sinusoidal oscillation.

Phase angle (δ): Phase difference between stress and strain in harmonic sinusoidal oscillation.

Deformation (γ): Maximum displacement of the moveable plate at the outer rim in relation to gap width, in per cent.

Linear viscoelastic range: range in which the complex shear modulus is independent of stress or strain.

Isochrone: Equation or curve on a graph representing the temperature-dependent behaviour of a material at a constant frequency.

Temperature rate: Continuous decrease or increase of the test temperature.

State of instationary temperature: Temperature gradient in the test specimen due to temperature rate.

4 Test principles

This test procedure is used to determine the temperature (T_{BTSV}), at which a bituminous binder demonstrates a complex shear modulus of 15 kPa when tested in a state of instationary temperature under defined stress in oscillation mode, and the respective phase angle (δ_{BTSV}).

The test must be carried out in stress controlled oscillation mode with a continuously increasing test temperature.

A parallel plate system with a plate diameter of 25 mm and a gap of 1 mm is used.

A shear stress of (500 ± 5) Pa is continuously applied to the test specimen at a frequency of 1,59 Hz. While the stress is being applied, the test temperature is continuously increased at a rate of (1,2 ± 0,05) K/min within a temperature range of 20 °C and 90 °C. The temperature range up to 30 °C is used to set the temperature rate and is not taken into account in the evaluation.

5 Test equipment

5.1 Dynamic Shear Rheometer (DSR)

A Dynamic Shear Rheometer that complies with DIN EN 14770 with parallel plates with a diameter of 25 mm and a temperature control system that allows temperature to be controlled accurately to within ± 0,1 °C over a minimum range of 20 °C to 90 °C for the duration of an entire test. In order to minimise temperature gradient between the plates, the temperature control system must include both plates.

Note: Test equipment featuring systems where the upper and lower plates have the same diameter facilitate the removal of excess material from the sample introduced.

5.2 Moulds for test specimens

Moulds that comply with AASHTO T 315, made of silicone or a similar material to which the test specimens do not adhere. The use of grease or similar products is not permitted.

5.3 Oven

Oven capable of being controlled at temperatures between 50 °C and 200 °C with an accuracy of ± 5 °C.

6 Preparation of the Dynamic Shear Rheometer (DSR)

Prepare the rheometer according to the manufacturer's instructions. Select the parallel plate system and the gap in accordance with this test description.

Note: The rheometer and the temperature control system should be checked, adjusted, and, if necessary, calibrated at regular intervals. It is recommended that test results are regularly compared by measuring a control substance and documenting the outcome on a mean value control card. For guidance on how to keep a mean value control card, see Annex B of the Test description for determining the deformation behaviour of bitumen and bituminous binders using a dynamic shear rheometer (DSR) – Part 1: Conducting the test with a temperature sweep (AL DSR-Prüfung (T-Sweep)).

Carefully prepare the rheometer by cleaning the plates with a suitable solvent and a soft cleaning cloth or paper.

7 Sample preparation

7.1 General remarks

ATTENTION! This test description covers the handling of equipment and bituminous binders at very high temperatures. When handling hot bituminous binders, always wear suitable protective gloves and goggles and avoid all contact with exposed skin.

Take samples in accordance with DIN EN 58 and prepare them in accordance with DIN EN 12594.

The heating times given in DIN EN 12594 should be considered maximum times before the taking of test samples. Homogenise the laboratory test sample before taking test samples.

To reheat the test place it, protected against air, in the oven, which is heated to a maximum of 180 °C. For polymer-modified bituminous binders and viscosity modified polymer-modified bituminous binders, heat the oven to a maximum of 180–200 °C; do not exceed 200 °C.

Test samples may only be reheated once.

Reheating times for test samples shall conform to following requirements

– 50 g to 100 g: max. 30 min;
– 100 g to 500 g: max. 60 min;
– 500 g to 1000 g: max. 120 min.

7.2 Preparation of test specimens

Homogenise the heated test sample by stirring with a suitable tool, e.g. a glass rod or a spatula.

Pour the test sample into the moulds, avoiding air bubbles.

Use a new test specimen for each BTSV measurement in the DSR.

Note: It is recommended that all test specimens are prepared at once.

Allow the test specimens to cool to ambient temperature in silicone moulds and let them rest, protected by a cover, for a minimum of 2 h before testing. Polymer-modified bituminous binders must rest for at least 12 h.

Note: If the type of binder involved is not known, allow the test sample to rest for at least 12 h.

The maximum resting time for all bituminous binders is 36 h.

To ensure demoulding with minimum deformation, the test specimens may be cooled for a maximum of 30 minutes to 5 °C to 10 °C. Demould and transfer the test specimen to the rheometer immediately after cooling.

Note: In order to avoid contamination of the test specimen surface by the skin, wear clean gloves to demould and place the test specimen in the DSR.

Note: After the cooling of the test specimen, water may condensate on the cold test specimen, thereby impairing the adhesion of the specimen and the plates.

8 Conducting the test

8.1 Placing the test specimen in the rheometer

In order to ensure adhesion of the test specimen to the plates, preheat the plates of the rheometer to (80 ± 10) °C. Keep this temperature constant for at least 10 minutes.

If heating is done in a water bath, ensure that the plates are dry before inserting the test specimen.

Place the test specimen in the heated system.

At the temperature described above, position the plates to a gap between 1,025 mm and 1,050 mm and keep them at the selected temperature for at least 5 minutes. If the test specimen does not fill the entire gap, stop the test.

Trim any excess material with a suitable tool that has been preheated to no more than 90 °C.

Position the plates to the testing gap of (1,00 ± 0,01) mm.

No more than 10 minutes should elapse between the insertion of the test specimen and reaching of a gap of (1,00 ± 0,01) mm.

8.2 Test conditions

Maintain a constant gap of (1,00 ± 0,01) mm throughout the full duration of the test.

Once the start temperature of 20 °C has been reached, allow (15 ± 1) min to reach temperature equilibrium.

Start the test at a temperature of (20 ± 0,1) °C and end it at the latest at a temperature of 90 °C. Within this temperature range, increase the test temperature continuously at a temperature rate of (1,2 ± 0,05) K/min.

Once the complex shear modulus falls below $G^* = 14$ kPa, end the test.

Note: It is possible to record reliable complex shear modulus values until $G^* = 1$ kPa is reached. This allows additional information for the qualitative evaluation of the bituminous binder to be gathered.

Throughout the duration of the test, keep the test specimen at a constant shear stress of (500 ± 5) Pa under oscillation at a frequency of f = 1,59 Hz in the parallel plate system.

8.3 Measurement

Throughout the test, record the values for the complex shear modulus, phase angle, and temperature every $t \leq 2,5$ s.

9 Expression of results

Using the measured data, determine the temperature (T_{BTSV}) at which the complex shear modulus equals (15 ± 0,05) kPa. Also determine the phase angle (δ_{BTSV}) at this temperature.

Note: If no measured data is available at G = (15 ± 0.05) kPa, calculate (T_{BTSV}) and (δ_{BTSV}) by interpolation of neighbouring data, whereby an exponential function must be used to calculate (T_{BTSV}) and a linear function to calculate (δ_{BTSV}) respectively.*

Two individual test results for the temperature (T_{BTSV}) can be considered valid as long as the difference is a ≤ 0,5 K. For (T_{BTSV}), calculate the arithmetic mean of two valid individual test results and round it to 0,1 °C. Express the respective phase angle (δ_{BTSV}) as an arithmetic mean, rounded to 0,1°.

If the temperature (T_{BTSV}) is determined to be below 30 °C, the test procedure described in this test description is not applicable.

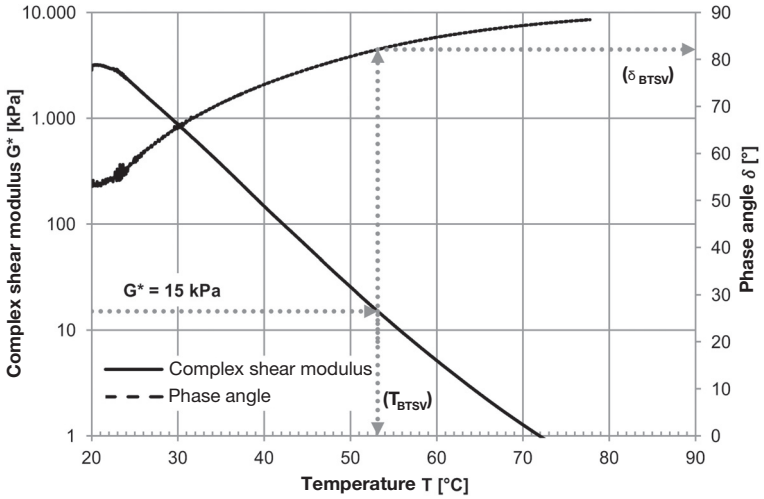

Fig. 1: Typical curves for the complex shear modulus and phase angle with continuously increasing test temperature

10 Precision

The precision of this test procedure has not yet been determined.

An estimation of its precision was derived from a comparative test involving six laboratories. The tests were conducted on three fresh bituminous binders (160/220, 25/55-55 A, and 40/100-65 A). The estimated precision is given in Table 1.

Table 1: Estimated precision of the procedure for determining (T_{BTSV})

Binder	Paving grade bitumens	Polymer-modified bitumens
Repeatability r [K]	0,5	1,0
Reproducibility R [K]	2,0	4,0

11 Test report

The test report shall contain the following information:

- type and grade of bituminous binder, including information on conditioning stage, as well as the full identification of the tested sample;
- date of the test;
- shear stress applied, to an accuracy of 1 Pa;
- temperature (T_{BTSV}), at which the complex shear modulus, G*, equals (15 ± 0.05) kPa , to an accuracy of 0,1 °C;
- phase angle (δ_{BTSV}) at temperature (T_{BTSV}), with an accuracy of 0,1°;
- any deviation from this test description and the reason for it.

Annex A: Technical standards and specifications

DIN	DIN EN 58	Bitumen and bituminous binders – Taking a bituminous binder sample	1)2)
	DIN EN 12594	Bitumen and bituminous binders – Preparation of test samples	1)2)
	DIN EN 12597	Bitumen and bituminous binders – Terminology	1)2)
	DIN EN 12607-1	Bitumen and bituminous binders – Determination of the resistance to hardening under influence of heat and air – Part 1: RTFOT method	1)2)
	DIN EN 14769	Bitumen and bituminous binders – Accelerated long-term aging with a pressure aging vessel (PAV)	1)2)
	DIN EN 14770	Bitumen and bituminous binders – Determination of complex shear modulus and phase angle – Dynamic Shear Rheometer (DSR)	1)2)
FGSV	AL DSR-Prüfung (T-Sweep)	Test description for determining the deformation behaviour of bitumen and bituminous binders using the Dynamic Shear Rheometer (DSR) – Part 1: Conducting the test with a temperature sweep (FGSV 722)	2)
AASHTO	AASHTO T 315	Standard Method of Test for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)	3)

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