Road and Transportation Research Association

Working Group on Aggregates, Unbound Pavements

FGSV

Technical testing regulations for aggregates in road construction

Part 5.4.4

Determining the polishing value of coarse aggregates using the Wehner/Schulze test method (PWS)

R 1

TP Gestein-StB

Edition 2020, Translation 2025

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Part 6.6.3

Determining the polishing value of coarse aggregates using the Wehner/Schulze test method (PWS)

Edition: 2020

1 Application

This part of TP Gestein-StB describes how to determine the polishing value of coarse aggregates ($PWS_{d/D}$) using the Wehner/Schulze test method (PWS). With regard to the required equipment, please refer to TP Asphalt-StB, Part 49.

The polishing value ($PWS_{d/D}$) determined using the Wehner/Schulze test method is an evaluation of the polishing resistance characteristics of coarse aggregates (test particle sizes 2/5.6 mm, 5.6/8 mm, 8/11 mm or 11/16 mm) to polishing.

Note:
Other test particle sizes must meet the following requirements:

- *Lower sieve sizes (d) at least 1.0 mm*
- *When using the upper sieve size up to and including 5.6 mm, the maximum ratio (D/d) should be 3.*
- *When using the upper sieve size up to and including 8 mm, the maximum ratio (D/d) should be 2.*
- *When using an upper sieve size above 8 mm, the maximum ratio (D/d) should be 1.5.*

2 Description of the method and measuring principle

The test device consists of a polishing unit and another unit for measuring the coefficient of friction.

The samples are subjected to a static load created by three rotating conical polishing rollers in the polishing unit while adding a water/quartz dust mix. Then three rubber test heads (measuring rubbers) rotating at 100 km/h are lowered onto the sample surface being sprayed with water in the coefficient of friction measuring unit and decelerated to a standstill.

The coefficient of friction is calculated from the ratio between the frictional force (activated horizontal force) and the contact force (vertical force) of the rubber test heads.

3 Test device

Refer to Section 3 of TP Asphalt-StB, Part 49

About Section 3.2.3 of TP Asphalt-StB, Part 49, Control plate:

Note: A textured glass plate (wire ornament glass 521 mm – 7 mm) can be used as the control plate for the low measuring range. For the glass control plate, the reference value μref (average value from at least 50 measurements on the glass control plate for the rubber test heads conditioned on coarse aggregates) is usually in the range of 0.100 to 0.135.

4 Other materials

Refer to Section 4 of TP Asphalt-StB, Part 49

Additionally required:

- Laboratory scales with an accuracy of 1 g
- Spirit level
- Paving grade bitumen 20/30 or harder
- Test sieves in accordance with the lower and upper sieve size of the test particle size classification
- Suitable casting mould made of heat-resistant material with the dimensions (d_i = (225 ± 5) mm, h_i = (21 ± 1) cm)
- Load weight of (15 ± 0.5) kg and a diameter that is no more than 5 mm smaller than the diameter of the casting mould.
- Vibrating table with a minimum frequency of 40 Hz
- Stirring rod
- Limestone filler.

5 Determination of the coefficient of friction

Refer to Section 5 of TP Asphalt-StB, Part 49

6 Sample preparation and production

6.1 Sample preparation

The aggregate sample must weigh at least 45 kg. This sample is reduced pursuant to DIN EN 932-2 to a laboratory sample of at least 14 kg, which then has to be dried at a temperature of (110 ± 5) °C until its weight is constant.

Note: A constant weight is achieved if the weight difference is no more than 0.05 wt. % after being weighed twice at least two hours apart.

The corresponding test particle size must be derived from the laboratory sample using the test sieves and then washed. This test sample is dried until its weight is constant.

Afterwards, unfavourably shaped particles must be removed from the test particles using sieves pursuant to DIN EN 933-3.

The test sample of the test particles prepared in this manner must then be stored in a dry, clean and resealable container.

6.2 Sample production

6.2.1 Asphalt mastic preparation

Approx. 8 kg of asphalt mastic[1] are deemed sufficient for producing a mastic sample. The asphalt mastic [(70 ± 1) wt. % filler, (30 ± 1) wt. % bitumen] must be composed as follows:

- 5,600 g of filler (limestone powder) must be heated to (225 ± 5) °C in a suitable container.
- Parallel to this, at least 2,400 g of bitumen must be heated to (225 ± 5) °C.
- The heated bitumen must be added to the heated filler and mixed accordingly.
- The asphalt mastic must be homogenised at (225 ± 5) °C for at least 10 minutes.

6.2.2 Mastic sample production

The casting mould, test particles and asphalt mastic must be heated up to (225 ± 5) °C. The following steps (a to e) for producing a mastic sample must be completed within five minutes:

a. The casting mould must be placed on the vibrating table.

b. Part of the pre-heated test particles should be poured into the casting mould until the mould is roughly one third full. The vibrating table must be put into operation.

c. The asphalt mastic must be carefully poured onto the test particles, thereby ensuring that all cavities can be filled slowly.

d. The asphalt mixture consisting of the test particles and the asphalt mastic must be homogenised using a stirring rod until air bubbles no longer appear.

Note: It is recommended to stir very carefully along the edge between the lateral face and the base of the casting mould.

e. The remaining, pre-heated test particles must be poured into the casting mould until the mould is roughly two thirds full, before proceeding in the same manner according to steps c and d.

Finally, the load weight must be placed in the casting mould on top of the asphalt mixture, which must be compacted for a further three minutes on the running vibrating table.

Note: Longer compaction times may be required for porous rock. In this case, it is recommended to place the filled casting mould in a drying cabinet at a minimum temperature of 200 °C for at least 10 minutes before repeating the vibrating process with a load weight.

Note: For test particles with $D \leq 4$ mm or porous rocks, it is recommended to premix the test particles with roughly 2 to 4 kg of asphalt mastic in a suitable laboratory mixer and then to prepare the sample accordingly.

Once completed, the casting mould with the sample must be stored for at least 12 hours to cool down to room temperature. The product removed from the mould is referred to as the mastic sample. The underside of the produced sample must be labelled.

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[1] A larger quantity of asphalt mastic may be required for porous rocks.

6.2.3 Test surface production

Two samples are generated from the mastic sample produced for the test. To do so, the mastic sample must be sawn in two places. The first saw-cut should be positioned 4.5 cm ± 0.5 cm from the underside of the produced sample (see Fig. 1). The cross sections with the resulting exposed aggregates are the areas to be tested (vertically hatched areas in Fig. 1) and are to be labelled as such on the lateral face. The second saw-cut should be positioned 4.5 cm ± 0.5 cm from the first saw-cut and is only used to adjust the height of the upper sample (dotted line in Fig. 1 and corresponding cut surfaces).

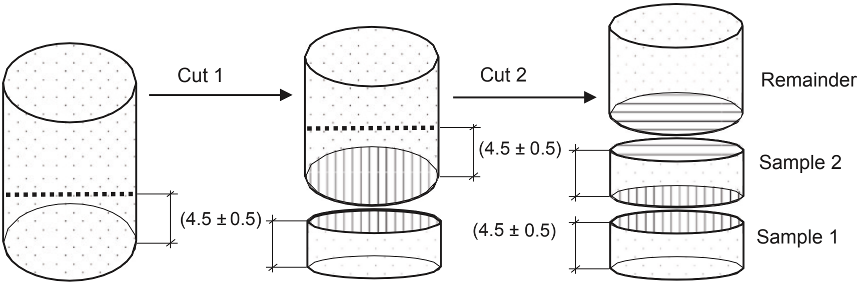

Figure 1: Cutting concept for mastic samples to prepare the test surfaces

The test surfaces (vertically hatched areas in Fig. 1) of the samples must be ground.

The samples must then be dabbed dry and stored at – (20 ± 3) °C for 12 to 24 hours before sandblasting.

The sample surface to be tested, pre-cooled to – (20 ± 3) °C (vertically hatched areas in Fig. 1), must be sandblasted. The mastic is removed from the sample surface to be tested, thereby exposing the coarse aggregates. It must be ensured that the sample surface is evenly sandblasted within (220 ± 10) seconds. After sandblasting, the samples must be cleaned thoroughly.

Note: A distance of (145 ± 15) mm between the nozzle and the sample surface has proven to be adequate. A different sandblasting time may be used in individual cases if the mastic is not removed sufficiently from the sample surface within the prescribed sandblasting time. In case of doubt, a suitable method should be employed to check the surface and the sandblasting time adjusted accordingly. However, the sandblasting times for the sample surfaces of one test series must always be the same.

The test surface produced in this manner must be tested within 72 hours in accordance with Section 7. The test samples must be stored at room temperature with the surface to be tested facing upwards on a flat, rigid surface until testing takes place.

7 Performance of the test

7.1 Test preparation

The polishing value is determined on at least two samples.

The polishing head with polishing rollers and the clamping device must be cleaned carefully, and any adhering quartz dust must be removed. Smooth running of the polishing rollers must be checked by hand.

The sample is fixed horizontally in the clamping device. The clamping device with the sample has to be mounted on the sample table.

The water/quartz dust mix can be contaminated through surface abrasion and the rubber coating of the polishing rollers. The mix must be checked before the test and replaced if necessary, but at the latest after
540,000 roller passes.

7.2 Polishing load

The polishing head of the polishing unit is lowered onto the surface of the sample. The water/quartz dust mix applicator must be activated. The temperature of the water/quartz dust mix must not exceed 25 °C and must be checked regularly during the polishing process.

Polishing is performed at a rotating speed of (500 ± 5) rpm.

The polishing process must be stopped after 90,000 roller passes, and the coefficient of friction is then measured in accordance with Section 7.3.

The polishing rollers and the sample must be cleaned thoroughly.

7.3 Measurement of the coefficient of friction

The surface being tested must be free of polish and any wear residues before performing the measurement.

The coefficient of friction is determined in accordance with Section 5 of TP Asphalt-StB, Part 49.

Before and after determining the coefficient of friction, a functional check of the unit for measuring the coefficient of friction must be performed with the rubber test head set used on the control plate. The coefficients of friction μ_{km1} (before determining the coefficient of friction) and μ_{km2} (after determining the coefficient of friction), which are measured for the control plate, must be determined.

The control values $\mu_{km1(i)}$ and $\mu_{km2(i)}$ for each sample i may deviate by no more than 10 %.

8 Calculations and statement of results

The coefficient of friction determined at 60 km/h is used as the coefficient of friction for each sample i. The result $\mu_{PWS(i)}$ of the individual sample must be rounded to three decimal places.

The polishing value of coarse aggregates using the Wehner/Schulze $PWS_{d/D}$ test method is the average value from two individual determinations $\mu_{PWS(i)}$, taking into account the applied roller passes.

If the difference between two individual values is greater than 0.020 after 90,000 roller passes, a third sample must be tested and the result determined with the compatible individual values.

$$PWS_{d/D} = \frac{\mu_{PWS(1)} + \mu_{PWS(2)}}{2}$$

The result $PWS_{d/D}$ must be rounded to two decimal places.

Note: It is recommended to prepare the third sample from one of the two test surfaces, if necessary. In this case, the tested surface must be wet ground to ensure that 0.5 cm to 1 cm is removed. Afterwards, the surface must be sandblasted in accordance with Section 6. Finally, the third test surface must be tested.

Note: The individual value furthest away from the arithmetic average value can be eliminated and the range of the remaining individual values checked. If the critical range is still exceeded, all the measured values need to be discarded and the test samples produced again.

9 Details in the test report

The test report must include a reference to this TP:

a) Name and address of the test laboratory

b) Number of the test report

c) Name of the client

d) Description and labelling of the sample, delivery and test particle size, date of receipt or production of the sample

e) Manufacturer of the polishing rollers and the rubber test heads, stating the serial number

f) Coefficients of friction determined on the control plate before and after the test

g) Labelling of the test method, and testing of the boundary conditions;

h) Date of the test

i) Changes compared with this TP (e.g. different rubber hardness)

j) Test result $PWS_{d/D}$ with details of the compatible individual values

k) Signature of the person responsible for the test report

l) Date of issue of the test report.

10 Precision

Precision data has not yet been determined for the method. With regard to the repeatability precision, the following can be estimated from research project FE no. 06.0098/2012/DGB.

	Standard deviation	**Precision**
Critical range for individual values	–	$d_a = 0.020$ [–]
Repeatability precision	$\sigma_r = 0.009$ [–]	$r = 0.024$ [–]
Comparative precision	–	–

Where:
d_a = critical range for two individual values
r = limit of precision under repeatability conditions pursuant to DIN ISO 5725: $r = 2.77 \cdot \sigma_r$
R = limit of precision under comparative conditions pursuant to DIN ISO 5725: $R = 2.77 \cdot \sigma_R$
σ_r = standard deviation from inter-laboratory tests determined under repeatability conditions pursuant to DIN ISO 5725
σ_R = standard deviation from inter-laboratory tests determined under comparative conditions pursuant to DIN ISO 5725

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