British Standard

BRITISH STANDARD

BS 598-110:1998

Incorporating Amendment No. 1

Sampling and examination of bituminous mixtures for roads and other paved areas —

Part 110: Methods of test for the determination of wheel-tracking rate and depth

ICS 75.140; 93.080.10

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/510, Road materials, to Subcommittee B/510/1, Coated macadam and hot asphalt, upon which the following bodies were represented:

British Civil Engineering Test Equipment Manufacturers' Association
County Surveyors' Society
Department of the Environment, Transport and the Regions (Highways Agency)
Institute of Asphalt Technology
Institute of Petroleum
Institution of Civil Engineers
Institution of Highways and Transportation
Mastic Asphalt Council Ltd.
Quarry Products Association
Refined Bitumen Association Ltd.
Road Surface Dressing Association
Scottish Office (Roads Directorate)
Society of Chemical Industry
Transport Research Laboratory
United Kingdom Accreditation Service

This British Standard, having been prepared under the direction of the Sector Committee for Building and Civil Engineering, was published under the authority of the Standards Committee and comes into effect on 15 November 1998

First published March 1996
Second edition November 1998

The following BSI references relate to the work on this standard:
Committee reference B/510/1
Draft for comment 97/102878 DC

ISBN 0 580 28210 4

Amendments issued since publication

Amd. No.	Date	Comments
10577	September 1999	Indicated by a sideline

Contents

Foreword

This part of BS 598 has been prepared by Subcommittee B/510/1. It supersedes BS 598-110:1996, which is withdrawn.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and competent people.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 9, and a back cover.

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1 Scope

1.1 This part of BS 598 specifies a method for determining the susceptibility of bituminous materials to plastic deformation at high road temperatures under pressures similar to those experienced on the road. The method applies to any bituminous wearing course material laid at a nominal thickness of up to 50 mm and is carried out on samples cored from laid and compacted material.

1.2 The test is usually carried out at a temperature of either 45 °C or 60 °C, but other test temperatures can be used.

NOTE 1 For research purposes, it may be necessary to determine the wheel-tracking rate of laboratory-prepared and compacted mixtures. However, this requires a carefully controlled and detailed procedure for specimen preparation and compaction, which is not included in this standard, but which, it is hoped, will be described in a future Draft for Development. Nevertheless, with the necessary changes, this method can be used for laboratory-prepared specimens.

NOTE 2 Precision data determined from experiments are given in annex A.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 598-100:1987, *Sampling and examination of bituminous mixtures for roads and other paved areas — Part 100: Methods for sampling for analysis.*

BS 598-104:1989, *Sampling and examination of bituminous mixtures for roads and other paved areas — Part 104: Methods of test for the determination of density and compaction.*

BS 903-A26, *Physical testing of rubber — Part A26: Method for determination of hardness (hardness between 10 IRHD and 100 IRHD).*

BS 903-A57, *Physical testing of rubber — Part A57: Determination of indentation hardness by means of pocket hardness meters.*

BS 958, *Specification for spirit levels for use in precision engineering.*

BS 1044-1, *Specification for gauge blanks — Part 1: Plug, ring and calliper gauges.*

BS 4372, *Specification for engineers' steel measuring rules.*

BS 5204-2, *Specification for straight-edges — Part 2: Steel or granite straight-edges of rectangular section.*

3 Terms and definitions

For the purposes of this part of BS 598, the definitions given in BS 598-100:1987 apply, together with the following.

3.1

wheel-track deformation

localized reduction in the thickness of a core caused by repeated passes of a loaded wheel

3.2

wheel-tracking rate

rate, in millimetres per hour, at which the wheel-track deformation increases with time under repeated passes of a loaded wheel over the last third of the test period

3.3

wheel-tracking depth

total wheel-track deformation, in millimetres, developed over the 45 min of the test

3.4

test surface

surface of the core on which the loaded wheel runs

3.5

test specimen

a single 200 mm diameter core

3.6

test result

mean wheel-tracking rate and wheel-tracking depth determined, for a particular material and location, from the testing of six test specimens

3.7

load cycle

two passes (outward and return) of the loaded wheel

4 Apparatus

NOTE Any tolerances stated are working tolerances rather than manufacturing tolerances, which would be expected to be tighter.

4.1 *Wheel-tracking apparatus*, consisting of a loaded wheel (see **4.2** and **4.3**) which bears on a test specimen held on a reciprocating table (see **4.4**). The table moves to and fro beneath the wheel (see **4.5**) and a device (see **4.7**) monitors the rate at which wheel-track deformation develops in the surface of the core. Vertical play in the loaded wheel bearings and in the lever arm pivot point shall each be less than 0.25 mm. The centreline of the loaded wheel shall lie at an angle no greater than 1° to the direction of motion of the moving table. A typical layout is shown in Figure 1.

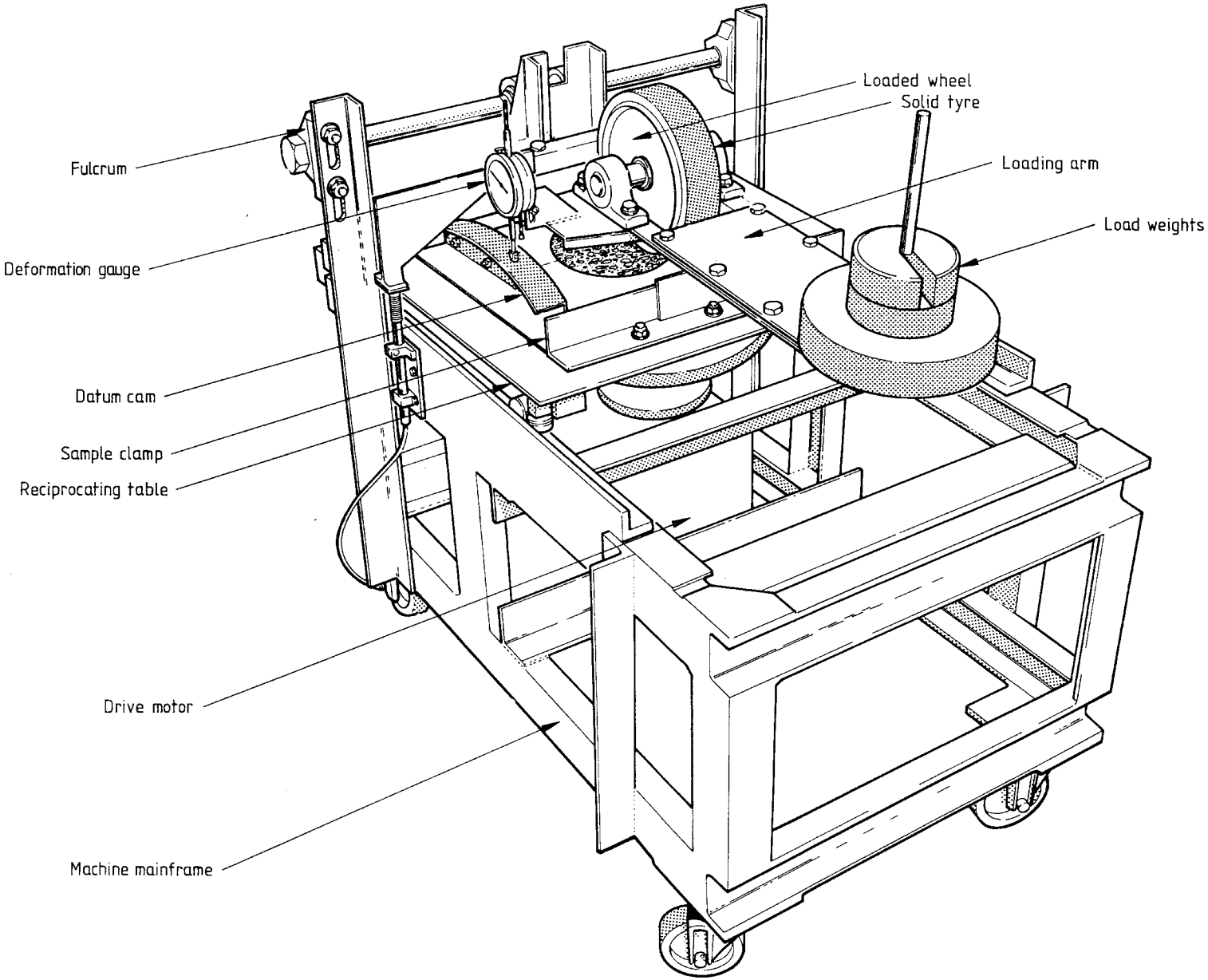

Figure 1 — Typical layout of wheel-tracking apparatus

4.2 *Tyre*, of outside diameter between 200 mm and 205 mm, fitted to the wheel. It shall be of rectangular section (50 ± 1) mm wide, treadless and 10 mm to 13 mm thick. The tyre shall be of solid rubber with a hardness number of (80 ± 5) IRHD units when tested in accordance with BS 903-A57.

NOTE In cases of dispute over rubber hardness, pieces can be cut from the tyre. In such instances testing should be in accordance with BS 903-A26.

4.3 *Weighted cantilever arm*, to apply a load to the wheel, under standard test conditions, of (520 ± 5) N, measured at the level of the top of the core and normal to the plane of the sample table.

4.4 *Reciprocating table*, constructed so as to enable a test specimen (see **3.5**) to be held firmly in place, with its upper surface horizontal, and with its centre positioned to ensure symmetrical tracking motion in each direction.

4.5 *Wheel-tracking machine*, constructed so as to enable the test specimen to be moved backwards and forwards under the loaded wheel in a fixed horizontal plane. The centre of the contact area of the tyre (**4.2**) shall describe simple harmonic motion with respect to the centre of the top surface of the test specimen, with a frequency of (21 ± 0.2) load cycles per minute and a total distance of travel of (230 ± 5) mm.

NOTE This form of motion is most readily achieved by a reciprocating drive from a cam, but alternative drive mechanisms are satisfactory as long as the motion conforms to **4.5**.

4.6 *Carriage and frame*, carrying marks that indicate the mid-point of traverse of the test specimen. Vertical movement at opposite corners of the carriage shall be less than 0.25 mm.

4.7 *Device to measure the vertical position of the loaded wheel*; either:

a) *automatic displacement measuring device connected to recording equipment*, set to measure the vertical position of the wheel when the centre point of the test specimen is within 10 mm of the centre point of the loaded area at the mid-point of traverse, the device having a range of not less than 20 mm and an accuracy of ±0.1 mm; or

b) *deformation gauge*, with a range of not less than 20 mm and an accuracy of ±0.1 mm.

NOTE The automatic displacement measuring device connected to recording equipment is preferred.

4.8 *Means for temperature control*, such that the temperature of the test specimen during testing is uniform and maintained constant at the specified test temperature ±1.0 °C.

NOTE One method of meeting this requirement is to locate the wheel-tracking apparatus within a constant-temperature room.

4.9 *Abrasive disc circular saw*, capable of cutting and trimming cores to the required dimensions.

NOTE A diamond-tipped saw blade is recommended.

4.10 *Steel rule*, conforming to BS 4372.

4.11 *Callipers*, conforming to BS 1044-1, capable of measuring the thickness of the core to an accuracy of ±1 mm.

4.12 *Clamping assembly*, for holding the test specimen firmly in place on the reciprocating table.

NOTE 1 A suitable clamping assembly consists of a flat steel baseplate on to which a core can be bedded in a holding medium and held in place by plywood clamping blocks that are located by steel dowel pins and bolted to the baseplate (see Figure 2). An alternative clamping assembly consists of a metal clamp of approximately 200 mm diameter.

NOTE 2 It is recommended that several pairs of clamping blocks to accommodate cores of different diameter, close to, but not exactly, 200 mm, be provided.

4.13 *Mounting table* (optional), for the purpose of levelling the surface of the test specimen and assembling the baseplate and clamping blocks around it.

NOTE A suitable mounting table is shown in Figure 2.

4.14 *Release agent*, for use with holding mediums such as polyester resin; e.g. liquid car polish.

4.15 *Cleansing solvent*, e.g. a mixture of 90 % acetone and 10 % kerosene (by volume), for cleaning the rubber tyre after use.

4.16 *Holding medium*, e.g. plaster of Paris or a polyester resin and hardener.

4.17 *Containers*, for mixing the holding medium.

4.18 *Thermometer* and/or *thermocouples*, of appropriate range, which are capable of measuring to an accuracy of ±0.2 °C, for determining the temperature of the test specimen during conditioning and testing.

4.19 *Sealing compound*, mastic or heat-transfer silicone.

4.20 *Thermometer*, capable of measuring to an accuracy of ±1 °C over a range which includes 5 °C to 30 °C, for determining the temperature of the test specimen during storage.

4.21 *Drill*, with a masonry bit suitable for drilling small holes in asphalt specimens.

4.22 *Spirit level*, at least 100 mm long, conforming to BS 958.

4.23 *Steel straight-edge*, at least 300 mm long, conforming to BS 5204-2.

4.24 *Hardboard* or *wooden packing strips*, approximately 290 mm long and 45 mm deep, of various thicknesses between 1 mm and 10 mm.

4.25 *Talc* or *French chalk*.

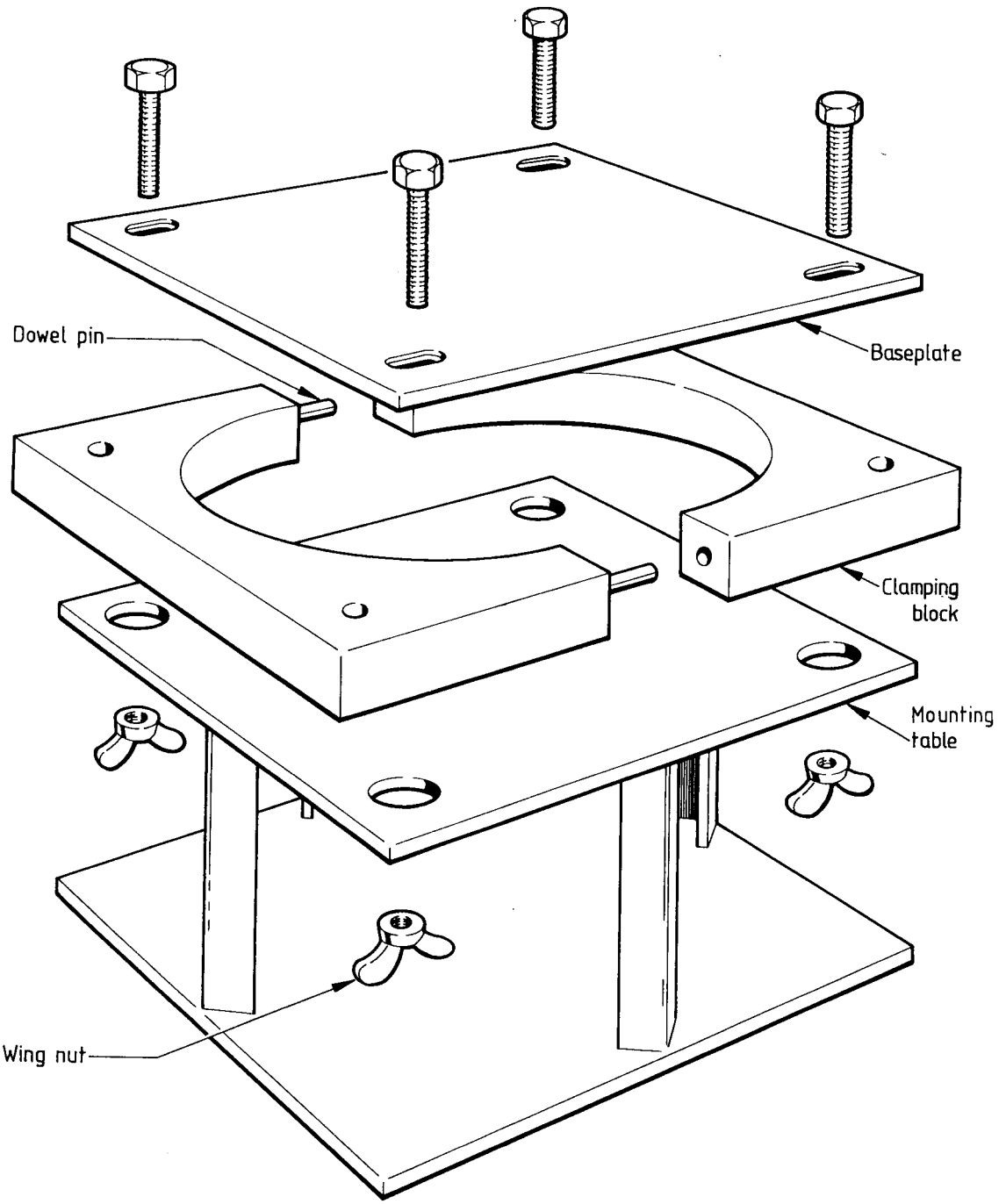

Figure 2 —Typical clamping assembly and mounting table

5 Sampling

5.1 Coring

The test specimens shall be cores of diameter 200 mm ± 5 mm and shall be taken in accordance with BS 598-100:1987, **7.2**. The thickness of the wearing course of the core shall not differ from the nominal thickness by more than 10 mm.

NOTE Six test specimens are needed to determine a wheel-tracking rate and a wheel-tracking depth in accordance with this standard.

5.2 Marking

Each specimen shall be marked to indicate the direction of traffic flow.

5.3 Storage

Cores shall be placed in storage at the laboratory within 48 h of extraction. If the storage period is less than 4 days, the storage temperature shall be within the range 0 °C to 25 °C. For storage beyond 4 days, the temperature shall be within the range 0 °C to 5 °C. Cores shall be transported and stored with one of their flat faces resting on a horizontal surface, and shall not be stacked. The storage temperatures and times, including those for any period when the cores are on site, shall be recorded.

6 Preparing the test specimen

6.1 Test surface

NOTE It is essential that the prepared test specimen has a flat test surface for the loaded wheel to run on, and a parallel flat surface to provide stable support underneath.

6.1.1 *Chipped rolled asphalt*

For chipped rolled asphalt, the test surface shall be the underside of the wearing course, after any lower layers have been trimmed from the core (see **6.2**).

NOTE It is impossible to provide a suitable flat test surface on the upper surface of a rolled asphalt core containing chippings.

6.1.2 *Other materials*

For any other material which is laid without an application of chippings, e.g. asphalt concrete, dense macadam, high stone-content rolled asphalt, the test surface shall be the upper surface.

6.2 Trimming

Trim cores to remove any unwanted road layers. Trim cores of chipped rolled asphalt using a circular saw to ensure that the resulting test surface is flat (see **6.1.1**).

When cores are trimmed, the thickness of the wearing course shall not be reduced by more than 5 mm. After trimming, measure the thickness in accordance with **6.5** and ensure that all cores conform to **6.6**.

NOTE It has been found experimentally that the thickness of a core does not have a significant effect on the wheel-tracking rate for wearing course materials traditionally used in the UK, provided that the thickness is about 35 mm to 55 mm. If thicker cores are used, the materials can exhibit some instability; if thinner cores are tested, the scope for wheel-track deformation is limited. A core which retains some of the lower layer will be more robust, and will not affect the test result if the wheel-tracking properties of the two materials are significantly different, and will give a value for the composite material if they have similar properties.

6.3 Density

Measure the density of the cores in accordance with BS 598-104:1989, clause **4,** except that any precoated chippings shall not be removed (**4.3.1**) and wax shall not be applied (**4.3.2**).

6.4 Temperature monitoring hole

Through the test surface of the core, drill one hole of diameter adequate to hold a thermometer or thermocouple (**4.18**), at 30 mm to 40 mm from the edge of the core, measured along the diameter at right angles to the direction of traffic flow, to a depth of half the core thickness.

6.5 Thickness

Measure the thickness of the core at four points at 90° intervals. Record the mean of these four measurements as the thickness of the core to ±1 mm.

6.6 Surface regularity

Place the straight-edge (**4.23**) horizontally along the line to be tracked across the core and check, using the steel rule (**4.10**), that any gap between the straight-edge and the test surface does not exceed 3 mm. Reject any core with a greater gap.

6.7 Mounting

6.7.1 Place the core with its test surface downwards on a smooth flat surface. Fit two clamping blocks face downwards around the core, oriented so that the wheel-tracking path can be aligned with the direction of the road traffic flow.

If the mounting table (**4.13**) is to be used, orient the core on the mounting table so that the wheel-tracking path aligns with the direction of the road traffic flow and the test surface is in contact with the table. Place the two clamping blocks face downwards on the table and bring them together around the core, with the dowel pins located.

6.7.2 Fill the space above and around the inverted core with freshly mixed holding medium so that it just overflows.

NOTE The holding medium should not be used to increase the overall thickness. If it is necessary to increase the thickness, use a disc of marine plywood or other non-compressible material.

6.7.3 If the mounting table is used, after adding the holding medium, slide the base plate on top and secure it to the clamping blocks using the four bolts and wing nuts.

Remove the mounted core from the mounting table once the holding medium has set.

6.7.4 When the holding medium has set, check that the core surface is level and that there is no deviation greater than 2 mm from the plane of the clamping block surfaces.

6.7.5 If the core is incorrectly aligned (see **6.7.4**), dismantle the assembly and repeat **6.7.1** to **6.7.4** until a satisfactory result is achieved.

6.7.6 Insert a thermometer or thermocouple (**4.18**) into the hole (**6.4**) so that the tip is at the centre of the core, and seal the hole using a suitable mastic compound or a silicone heat-transfer compound.

7 Test procedure

7.1 Conditioning

Condition the mounted test specimens for 4 h to 16 h at the specified test temperature, immediately prior to testing. Before testing begins, ensure that the specimen has attained the test temperature ±1.0 °C.

NOTE The test temperature is usually either 45 °C or 60 °C, but other temperatures can be specified.

7.2 Procedure for carrying out a single measurement

7.2.1 *General*

Ensure that there is no material adhering to the tyre of the wheel-tracking machine.

NOTE 1 A tyre with material adhering to it, or a damaged or worn tyre, can affect the result of a test.

Fix the test specimen, mounted in the clamping assembly and fitted with the thermometer or thermocouple (see **6.7.6**), rigidly to the reciprocating table of the wheel-tracking machine.

NOTE 2 If the surface of the test specimen is sticky, lightly dust it with talc or French chalk to minimize the amount of material picked-up on the tyre.

7.2.2 *Test temperature*

Throughout the test, maintain the test specimen at the specified test temperature ±1.0 °C, as measured by the thermometer or thermocouple.

NOTE It is recommended that the temperature be monitored at intervals of 1 min or less during the test.

7.2.3 *Measurement of deformation*

7.2.3.1 *General*

Monitor the development of wheel-track deformation with either an automatic displacement measuring device (see **7.2.3.2**) or a deformation gauge (see **7.2.3.3**).

Continue the test until the wheel-track deformation reaches a depth of 15 mm or for 45 min, whichever is the sooner.

If the test specimen is less than 30 mm thick, stop the test when the depth of wheel-track deformation reaches half the thickness of the specimen, rather than when it reaches 15 mm. In this case, adjust the calculations accordingly (see clause **8**).

7.2.3.2 *Measurement by automatic displacement measuring device*

Set the wheel-tracking machine at the end point of its traverse. When the test specimen is at the specified test temperature, set the machine in motion and take readings of the vertical displacement initially (r_0) and then after every 5 min ± 3 s, with the centre of the specimen located within 10 mm of the centre point of the loaded area, at the mid-point of traverse.

NOTE Measurements of the vertical displacement taken at intervals of 1 min or less will allow the development of the rut to be studied.

7.2.3.3 *Measurement by deformation gauge*

Set the centre of the test specimen within 10 mm of the centre point of the loaded area at the mid-point of traverse. Take an initial reading of the vertical position of the loaded wheel (r_0). Mark the wheel at the point it contacts the test specimen with a non-permanent mark. Remove the loaded wheel from the test specimen. When the test specimen is at the specified test temperature replace the wheel ensuring via the mark that the contact point is the same. Set the machine in motion and take readings of the vertical displacement every 5 min ± 3 s. Stop the machine in order to take each reading. Before restarting the machine, centre the test specimen, as for the initial reading, and allow it to return to the specified test temperature.

NOTE This method of measurement may give higher results if the machine is stopped for extended periods.

7.3 Procedure for carrying out a single test

Repeat **7.2** on the other five of the six test specimens.

8 Calculation and expression of results

8.1 Tracking rate of test specimen

For each test specimen, calculate the rate of increase of track depth T_R, in millimetres per hour (mm/h), from the following formulae, depending on the number of readings taken (including the initial reading) at 5 min intervals.

For at least eight readings:

$$T_R = 3.6\{r_n - r_{(n-3)}\} + 1.2\{r_{(n-1)} - r_{(n-2)}\}$$

For five to seven readings:

$$T_R = 6\{r_n - r_{(n-2)}\}$$

For three or four readings:

$$T_R = 12\{r_n - r_{(n-1)}\}$$

For one or two readings:

$$T_R = \frac{900}{t_{15}}$$

where

n is the total number of readings taken at 5 min intervals for up to 45 min, excluding the initial reading;

r_i is the vertical displacement measured at the ith reading, in millimetres (mm);

t_{15} is the time for the depth of wheel-track deformation to reach 15 mm, in minutes (min).

8.2 Wheel-tracking rate

8.2.1 If the difference between the highest and lowest values from the six test specimens exceeds both 1.5 mm/h and 1.1 times the mean value, then ignore the value with the greatest difference from the mean. If the difference is still greater than both 1.5 mm/h and 1.1 times the mean, then report the lack of uniformity.

8.2.2 Calculate the wheel-tracking rate of the material under test W_{TR}, in millimetres per hour (mm/h), from:

$$W_{TR} = 10.4 \times T_{Rm} \times \frac{w}{L}$$

where

T_{Rm} is the mean value of T_R (see **8.1**) for the six test specimens, in millimetres per hour (mm/h);

w is the width of the tyre applying the load, in millimetres (mm);

L is the load applied, in newtons (N).

NOTE The values of w and L should be as measured on the equipment used for the test rather than the nominal values.

8.2.3 Report the wheel-tracking rate to the nearest 0.1 mm/h. If a value of T_R has been ignored, report that value as an outlier.

8.3 Wheel-tracking depth

8.3.1 For each test specimen for which the depth of wheel-track deformation is less than 15 mm after 45 min, the wheel-tracking depth R, in millimetres (mm), is the change in vertical displacement from the initial value, r_0, to the ninth reading, r_9, in millimetres (mm).

8.3.2 For each test specimen for which the depth of wheel-track deformation reaches 15 mm before 45 min, calculate the wheel-tracking depth R, in millimetres (mm), from:

$$R = 15 \times \frac{45}{t_{15}}$$

where

t_{15} is the time for the depth of wheel-track deformation to reach 15 mm, in minutes (min).

8.3.3 The wheel-tracking depth for the material under test is the mean wheel-tracking depth for the six test specimens, reported to the nearest 0.1 mm.

9 Test Report

The test report shall include the following information for each test specimen:

a) date, time and place of sampling and sample identity number;

b) date, time and place of test;

c) density of the test specimen prior to testing;

d) storage temperatures, and times for which the specimen was stored at those temperatures;

e) specified test temperature;

f) mean thickness of test specimen;

g) the method of recording deflection, whether by auto displacement or deformation gauge;

h) the tracking rate of each test specimen (see **8.1**);

i) the mean wheel-tracking rate of each group of six test specimens, and the tracking rates of any individual specimens which were ignored in the determination of the mean (see **8.2**);

j) whether the difference between the highest and lowest tracking rates of the individual test specimens was greater than the limit stated in **8.2.1** (after excluding the value with the greatest difference from the mean);

k) the wheel-tracking depth of individual test specimens (see **8.3**);

l) the mean wheel-tracking depth of each group of six test specimens (see **8.3**);

m) any test conditions and operational details not included in this standard, and any anomalies likely to have affected the results;

n) whether or not a certificate of sampling is available;

o) name of the person taking technical responsibility for the test;

p) the number and date of this standard, i.e. BS 598-110:1998.

If a certificate of sampling is available [see **9**n)], a copy of the certificate shall be provided.

NOTE The test report may include the following optional information:

1) name of project;

2) name of supplier and source of material;

3) date of production of material;

4) specification of material.

Annex A (informative)

Precision

Precision values for wheel-tracking rate, in accordance with BS 5497-1, are given in Table A.1 for both laboratory-made and site test specimens.

The precision data were determined from standardization experiments conducted in the UK in accordance with BS 5497-1. The first experiment in 1992 involved 11 laboratories, using test specimens from site supplied by the organizing laboratory. The data from one laboratory was excluded from the analysis because of the number of outliers included. The second experiment in 1994 involved seven laboratories, using laboratory-made samples supplied by the organizing laboratory.

The precision data from the first experiment were determined for the method given in DD 184:1990. The precision data from the second experiment were determined for the modified method described in this standard.

Table A.1 — Precision values for wheel-tracking rate

Test specimens	Test result level [a]	Repeatability conditions, r	Reproducibility conditions, R
	mm/h	mm/h	mm/h
Laboratory-made	2.6	0.6	1.2
From site	2.2	0.8	1.4
	8.1	3.1	5.9
	13.5	4.0	5.7

[a] Mean of all the test determinations from all the participating laboratories.

Bibliography

Standards publications

BS 5497-1, *Precision of test methods — Part 1: Guide for the determination of repeatability and reproducibility for a standard test by inter-laboratory tests.*

DD 184:1990, *Method for the determination of the wheel-tracking rate of cores of bituminous wearing courses.*

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