British Standard

BRITISH STANDARD

BS 598-111: 1995

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

Part 111: Method for determination of resistance to permanent deformation of bituminous mixtures subject to unconfined uniaxial loading

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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 Aggregate Construction Materials Industries
British Civil Engineering Test Equipment Manufacturers' Association
County Surveyors' Society
Department of Transport (Highways Agency)
Department of Transport (Transport Research Laboratory)
Institute of Asphalt Technology
Institute of Petroleum
Institution of Civil Engineers
Institution of Highways and Transportation
Mastic Asphalt Producers' Association
Refined Bitumen Association Ltd.
Sand and Gravel Association Limited
Scottish Office (Building Directorate)
Society of Chemical Industry
Coopted members

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Foreword

This British Standard has been prepared by Subcommittee B/510/1. It supersedes DD 185:1990 which is withdrawn. DD 185:1990 described a simple static load compression test used at low strain.

This British Standard describes a simple static load compression test that can be readily performed by a control laboratory to give a measure of the deformation resistance of the material.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced 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 4, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard describes a method for determining the resistance to permanent deformation of bituminous mixtures at temperatures and loads similar to those experienced by these materials in roads. The method is applicable to samples of wearing course, basecourse and roadbase.

The method can be used to rank bituminous mixtures on the basis of resistance to permanent deformation, as a guide to relative performance in the pavement and also to obtain data for estimating potential deformation in the vehicle wheelpaths.

2 References

2.1 Normative references

This British Standard incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on the inside back cover. Subsequent amendments to, or revisions of, any of these publications apply to this British Standard only when incorporated in it by updating or revision.

2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this British Standard, the definitions given in BS 598-100 apply.

4 Apparatus

4.1 *Loading frame,* as shown in Figure 1.

NOTE 1 Provision should be made for maintaining a constant test and storage temperature environment for both the loading frame and samples awaiting test.
NOTE 2 The loading frame and samples may be kept within a controlled environment room or a suitable cabinet.

4.2 *Gloves and absorbent tissues,* for preparing and handling specimens.

4.3 *Thermometer or thermocouple,* of appropriate range and accurate and capable of being read to ± 0.5 °C, for determining the temperature of the test specimen or the storage and test environment.

4.4 *Stop clock, watch or other timing device,* accurate to 0.1 % over the time intervals between strain measurements.

4.5 *Steel rule,* conforming to BS 4372, with 1 mm graduations.

4.6 *Straightedge,* conforming to BS 5204-2.

4.7 *External callipers,* capable of measuring to ± 1 mm.

4.8 *Glass or steel plate,* with the upper surface not deviating from flatness by more than 0.03 mm over the width, a surface texture not exceeding 3.2 μm roughness average when determined in accordance with BS 1134-1 and a Rockwell (scale B) hardness value of at least 95 when tested in accordance with BS 891.

NOTE Indentations on the plate face resulting from the hardness test are acceptable. Capping plates conforming to BS 1881-120 are suitable.

4.9 *Dial gauge or recording equipment and data-acquisition system,* to measure load platen displacements, with a range of 10 mm and accurate to 0.1 % over the range.

4.10 *Jig,* to hold a cylinder or prismoidal test specimen during sample preparation.

4.11 *Saw,* capable of cutting and trimming specimens to the required dimensions.

NOTE A diamond-tipped saw blade is recommended. A grinding and polishing wheel has also been found to be of assistance in end-preparation.

4.12 *Silicone grease and graphite powder or flakes,* to provide a low-friction interface between the specimen and the load platens to prevent variations in the apparent specimen stiffness due to end restraint.

4.13 *Two load platens,* of stainless steel. Each platen shall have, for cylindrical specimens, a diameter at least 10 % to 15 % greater than the specimen diameter and, for prismoidal specimens, dimensions at least 10 % to 15 % greater than the relevant specimen plan dimension.

The loading surfaces shall be ground and polished with a flatness tolerance of not more than 0.03 mm over the platen width and shall be free from abrasions and scratches.

The bottom platen shall be securely fixed to the loading frame and the top platen shall be connected to the loading system via a spherical seating.

The mass of the top platen shall be such that a constant stress of 2 kPa ± 10 % is applied to the specimen.

Specimens of different lengths shall be accommodated by adjusting the position of either platen. The distance between the platens shall be adjustable over a suitable range.

NOTE Check the finish of the platens annually or whenever damage, e.g. scratches or surface corrosion, is evident. Clean the loading surface of the platens and inspect for minor damage before each test to ensure smoothness and to reduce the chance of abrasion or other damage. Remove minor blemishes by rubbing the platens with P600 grit silicon carbide paper.

4.14 *Loading system,* incorporating a pneumatic or other suitable load generator (see Figure 1) by means of which a load can be applied vertically to the axis of the test specimen via the load platens.

The applied load shall be measured to ± 2 % using a load cell calibrated in accordance with BS 1610-1, for a grade 2.0 machine.

NOTE For load applications to apply a stress of up to 100 kPa, the capacity of the system should be at least 2.0 kN. For load applications to apply a stress of up to 200 kPa stress, the capacity of the system should be at least 4.0 kN. For higher load ranges, the capacity of the system should be proportionally increased.

4.15 *Load,* capable of applying an axial stress of 100 kPa ± 2 kPa vertically to the specimen for the duration of the test.

NOTE The recommended stress application for the static load deformation test is 100 kPa ± 2 kPa. This should be suitable for most applications, however, other stress levels may be used.

4.16 *Deformation measurement system,* capable of measuring the static axial deformation of the test specimen resulting from the axial load pulse.

NOTE The deformation is determined and recorded at specified intervals by measuring the change in distance between the load platens, using the dial gauge or one or more electrical displacement transducers with a range equal to or greater than 10 mm and an accuracy of 0.1 % over the range. The axial strain is calculated and recorded at the same interval.

4.17 *Constant-temperature enclosure,* consisting of a cabinet or suitable room with forced air circulation, in which the test specimens can be conditioned and in which the test can be performed.

NOTE 1 It is easier to keep a constant temperature throughout the test specimen if the test equipment is placed in the constant-temperature enclosure.

NOTE 2 The enclosure should be large enough to house at least two test specimens and the test equipment.

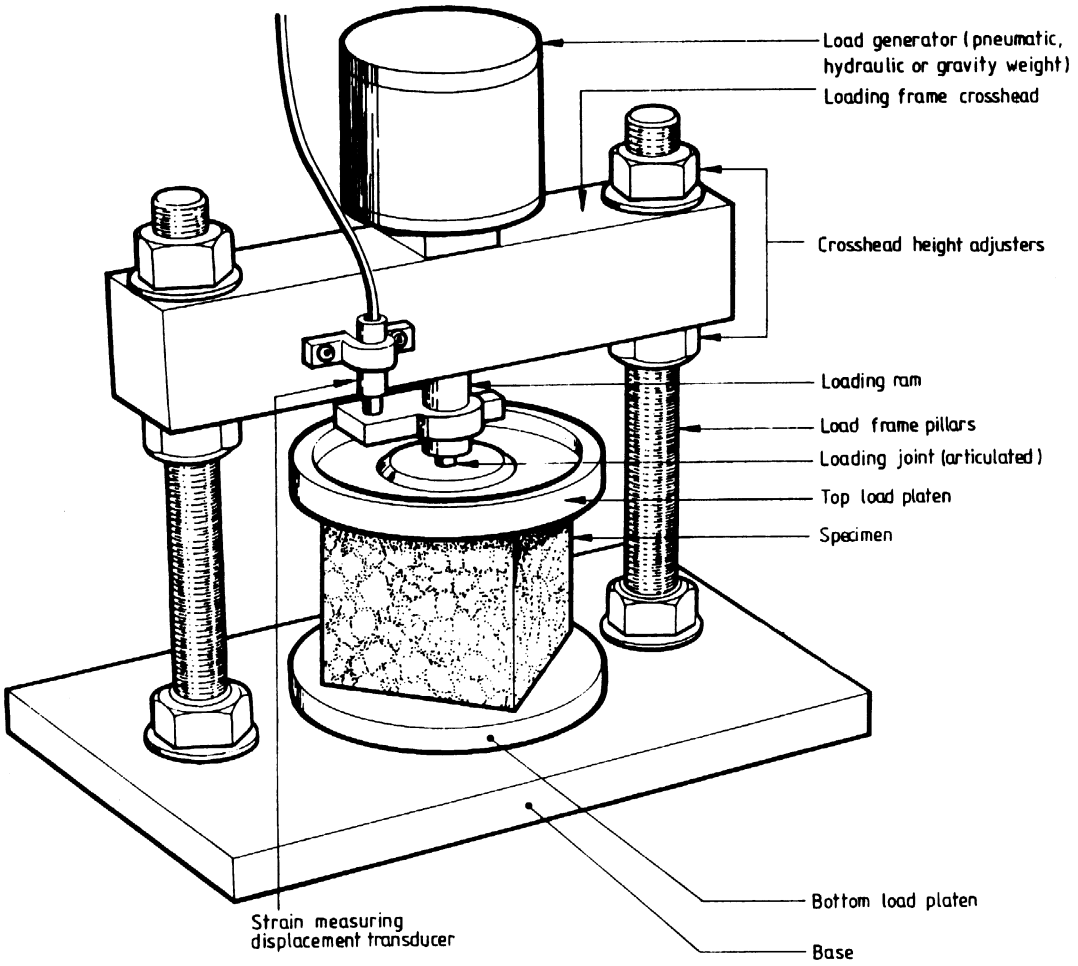

Figure 1 — Test equipment for the determination of static load stiffness modulus

5 Test specimens

5.1 Preparation

Using the saw, trim the cores or samples of material submitted for test to form test specimens of a nominal right cylinder or prism. Remove precoated chippings by trimming the surface flush. Clamp the sample in the jig and saw into slices with thicknesses in the range 40 mm to 100 mm, each slice constituting a test specimen. Ensure that the cut surfaces are planar and smooth.

No test specimen shall contain an interface between pavement layers and the interface between pavement layers shall not form an upper or lower surface of a test specimen.

NOTE 1 The preferred shape for test specimens is cylindrical, with a diameter of 100 mm ± 5 mm, 150 mm ± 5 mm or 200 mm ± 5 mm. Alternatively, rectangular prisms with dimensions similar to those stated for cylinders may be used.

Measure the thickness of each test specimen as follows. Place the specimen on the glass plate or the steel plate. Place the straightedge across a diameter and use the steel rule to measure the distance from the straightedge to the plate, to the nearest millimetre, at both sides of the specimen. Repeat these measurements at two further diameters spaced evenly around the test specimen (i.e. the three diameters being approximately 60° apart). If the difference between the smallest and the largest of the six thickness measurements is more than 2 % of the nominal diameter of the specimen, do not use the specimen.

Using the external callipers, make and record three measurements of the diameter of cylindrical specimens or the plan dimensions of prismoidal specimens. Make the measurements evenly around the circumference of the specimen.

Coat the ends of the specimen with a thin layer of silicone grease and cover this with graphite flakes or powder.

NOTE 2 Test samples can be cored from a compacted pavement layer or from laboratory-compacted slabs, or may be prepared in suitable laboratory moulds.

NOTE 3 It is recommended that test specimens with a diameter of at least 145 mm are used for mixtures with a nominal maximum aggregate size equal to or greater than 20 mm and that the specimen thickness should be as close to the layer thickness as possible, but not exceed 100 mm.

NOTE 4 Specimens can be prepared in the laboratory by compacting materials into cylindrical moulds. It cannot be inferred that this method of preparation will give results identical to or analogous to those obtained from specimens cut from a compacted pavement layer.

NOTE 5 The silicone grease should be spread evenly and thinly over the ends of the specimen. Remove surplus grease with a cloth or absorbent tissue to leave a surface with a "damp" appearance. Sprinkle graphite flakes evenly over the surface and then polish with a soft cloth to leave a shiny surface. Disposable gloves should be worn during this part of the preparation procedure to ensure that friction at the platen-to-specimen interface is minimized.

5.2 Storage conditions

If necessary, store test specimens in a dry atmosphere (65 % relative humidity at a temperature of 20 °C ± 5 °C). Record the storage temperature to an accuracy of ± 2 °C. Ensure that specimens are stored flat, face down, on a horizontal surface, and are not stacked.

NOTE Stiffness modulus values increase with time while temperature affects the rate of increase. If specimens are stored for more than a short period before testing, it is recommended that this be at 5 °C or less. While it is not yet possible to specify an absolute period of time, a maximum storage period of 4 days, before using the lower recommended temperature, is suggested.

5.3 Conditioning and testing temperature

Remove the test specimen from storage and keep it at the test temperature ± 0.5 °C (see note 1) or until measurements indicate that it has attained the test temperature (see note 2). Alternatively, store the test specimens at the test temperature overnight, then move the specimen into the constant-temperature enclosure (**4.17**) and conduct the test. Record the test temperature to an accuracy of ± 0.5 °C.

NOTE 1 The recommended test temperature is 30 °C ± 0.5 °C, however, other test temperatures may be used. At higher test temperatures, some mixtures may exhibit excessive deformation leading to collapse.

NOTE 2 It is convenient to measure temperatures within the constant-temperature enclosure by placing thermocouples on the surface and in the centre of a dummy specimen and recording the temperatures, testing taking place when uniform conditions are achieved. The dummy specimen should have dimensions and composition similar to those of the test specimen.

NOTE 3 A period of 4 h should be allowed for a specimen stored at a temperature other than that recommended to attain 30 °C ± 0.5 °C in the constant temperature test enclosure. If the specimen has been stored within 1 °C of the test temperature, then 1 h should be allowed for the specimen to attain 30 °C ± 0.5 °C in the constant temperature test enclosure.

NOTE 4 Specimens may be stored, conditioned and tested within the same enclosure where this suits the operational requirements of the laboratory.

6 Test procedure

6.1 Static load deformation test

6.1.1 *Test conditions*

The test load and conditions shall be as given in **4.15** and **5.3**.

NOTE A temperature of 30 °C ± 0.5 °C, an axial stress of 100 kPa ± 2 kPa and a loading time of 3 600 s ± 100 s, or until failure (if sooner), are recommended. Other combinations of temperature, load and time may be used to suit the application under consideration.

6.1.2 *Mounting the test specimen*

Wipe the load platens clean and inspect them to check they are not damaged. After bringing the test specimen to the recommended test temperature, place it centrally in position on the bottom platen.

Place the top load platen centrally on the top of the test specimen and place the assembly centrally beneath the load generator. Set up the transducers or dial gauges and preload the specimen with a conditioning load equivalent to a stress of 10 kPa ± 1 kPa for 600 s ± 6 s.

Record and report any axial deformation of the specimen after application of the conditioning load.

6.1.3 *Measuring procedure*

Increase the load smoothly from the conditioning load to the specified load over a period of not more than 3 s. Measure the axial deformation of the specimen as the test progresses from the displacement readings on the dial gauge or the output of the electrical displacement transducers.

NOTE The test is considered to have commenced from the time the conditioning load starts to increase to the recommended load.

To define the relationship between axial deformation and time, take readings at 10, 40, 100, 400, 1 000, 2 000, 3 000 and 3 600 s after completion of the test, or at other suitable time increments.

If, during the period of loading, the loading surfaces of the platens become more than 5° out of parallel, abandon the test, noting this reason on the test report.

7 Calculations and plotting graphs

7.1 Axial strain

Calculate the axial strain ϵ_s of the test specimen from the measured deformation using the equation:

$$\epsilon_{s,\,(t,\,T)} = \Delta h / h_0$$

where

$\epsilon_{s,\,(t,\,T)}$ is the axial strain caused to the specimen during loading time t (in s) at temperature T (in °C);

h_0 is the original distance between specimen loading surfaces;

Δh is the axial deformation (change in distance between specimen loading surfaces).

7.2 Static load stiffness modulus of the mixture

Calculate the static stiffness modulus of the mixture S_m (in kPa) using the following equation:

$$S_{m,\,(t,\,T)} = \sigma / \epsilon_{s,\,(t,\,T)}$$

where

$S_{m,\,(t,\,T)}$ is the static load stiffness modulus of the mixture at loading time t (in s) and loading temperature T (in °C);

σ is the applied stress (in kPa).

7.3 Plotting graphs

For static load deformation tests, prepare logarithmic-scale graphs showing the relationship between axial strain and test duration, in seconds. Submit the graphs with the test report.

8 Test report

The test report shall include the following information:

a) date of laying the material or age of the test specimen at the time of test, place of sampling and specimen identification;

b) test equipment used;

c) mean specimen diameter, or cross-sectional dimensions, and thickness and composition, if known;

d) date, time and place of test;

e) storage and test temperature and the axial loading regime under which the test was conducted;

f) static stiffness modulus and axial strain at completion of the test, graphs and printouts;

g) name of person performing the test;

h) the number and date of this British Standard;

i) whether or not a certificate of sampling is available.

If available, a copy of the certificate of sampling shall be provided.

If an estimate of permanent axial deformation of a pavement is to be made or if information on stiffness is required, the following additional information is required and shall be included in the test report:

1) recovered bitumen penetration at 25 °C and 40 °C determined in accordance with BS 2000-49;

2) ring and ball softening point of recovered bitumen determined in accordance with BS 2000-58.

NOTE The following additional information may be included:

i) name of the project;

ii) name of supplier and source of material;

iii) date of production of material;

iv) specification of material.

List of references

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 598, *Sampling and examination of bituminous mixtures for roads and other paved areas.*

BS 598-100:1987, *Methods for sampling for analysis.*

BS 891:1989, *Methods for hardness test (Rockwell method) and for verification of hardness testing machines (Rockwell method).*

BS 1134, *Assessment of surface texture.*

BS 1134-1:1988, *Methods and instrumentation.*

BS 1610, *Materials testing machines and force verification equipment.*

BS 1610-1:1992, *Specification for the grading of the forces applied by materials testing machines when used in the compression mode.*

BS 2000, *Methods of test for petroleum and its products.*

BS 2000-49:1993, *Determination of needle penetration of bituminous material.*

BS 2000-58:1983, *Determination of softening point of bitumen. Ring and ball method.*

BS 4372:1968, *Specification for engineers' steel measuring rules.*

BS 5204, *Specification for straightedges.*

BS 5204-2:1977, *Steel or granite straightedges of rectangular section.*

Informative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 1881, *Testing concrete.*

BS 1881-120:1983, *Method for determination of the compressive strength of concrete cores.*

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W4 4AL