

Testing aggregates —

Part 124: Method for determination of frost-heave

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Foreword

This Part of BS 812, prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee, forms part of a general revision that is being made of the 1975 edition of BS 812. As each of the tests or collection of related tests, is prepared, it is intended to issue it as a separate Part of BS 812.

This Part contains the test procedure for the determination of the frost-heave of aggregates which have been compacted at a pre-determined moisture content and density. The test was not included in previous editions of BS 812 but has now been included because there is a need for a test to identify frost-susceptible aggregates which could otherwise be used in an unbound form in road bases and sub-bases at depths likely to experience frost penetration during the life of the road. The procedure for preparing the test specimens and determining the frost-heave of an aggregate is substantially the same as that given in TRRL Supplementary Report 829. However, the consideration of the circumstances in which a material of a given frost-heave may be used in practice, which is discussed at length in SR 829, is not dealt with here because it is outside the scope of BS 812. Guidance on the interpretation of the results should therefore be sought from the specifying authority.

It is intended that other British Standards should call up BS 812 test methods as the basis for compliance. Nevertheless, it is *not* intended that all aggregates will be subjected regularly to all the listed tests. Other British Standards will call up only the relevant test methods.

Some of the tests in other Parts of BS 812 are of limited application, and advice on the use of simple tests is given, for example, when they can be used for a preliminary sorting of aggregates to see whether more expensive testing is justified.

Reference should be made to BS 812-101 for general guidance on testing aggregates, precision of test methods and variance arising from sampling errors.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 22, 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 Part of BS 812 describes a method for determining the frost-heave of an aggregate compacted into cylindrical specimens at a pre-determined moisture content and density.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 812 the definitions in BS 812-101 and BS 812-102 apply.

3 Principle

Cylindrical specimens of aggregate compacted at a predetermined moisture content and density are placed in a self-refrigerated unit (SRU). This unit is designed so that the upper surfaces of the specimens are subjected to freezing air at $-17\text{ }^{\circ}\text{C}$ whilst their lower ends are allowed access to water maintained at $+4\text{ }^{\circ}\text{C}$. This temperature gradient created through the specimens causes water to be drawn into the freezing zone and may lead to the formation of ice lenses. These lead to an increase in height of the specimens which is measured at intervals over a period of 96 hours. The maximum increase in height recorded is defined as the frost-heave of the aggregate.

4 Sampling

4.1 The sample used for the test (the laboratory sample) shall be taken in accordance with clause 5 of BS 812-102:1984. Reduce the sample by the procedures described in clause 6 of BS 812-102:1984 to produce the following test portions (see note).

- A minimum of 36 kg, for the preparation of the frost-heave test specimens.
- A minimum mass as given in Table 1 for the determination of the accompanying particle-size distribution.
- A minimum mass of 50 kg, for the determination of the moisture content and dry density at which to prepare the frost-heave test specimens.

NOTE In many instances additional test portions will be required for use in other preliminary tests that are often specified e.g. plasticity of the fines fraction, ten percent fines value etc.

4.2 Dry each test portion at a temperature of $105 \pm 5\text{ }^{\circ}\text{C}$ prior to testing.

NOTE If there is any reason to suspect that oven-drying changes the properties of the material it should be air-dried and its air-dry moisture content determined as described in clause 7 of BS 812-2:1975. It is essential that the amount of water in the material be allowed for when calculating the amounts of the material and water required to prepare the portions for test.

Table 1 — Minimum mass of test portion for sieve analysis

Nominal size of material	Minimum mass of test portion
mm	kg
63	50
50	35
40	15
28	5
20	2
14	1
10	0.5
6	0.2
5	0.2
3	0.2
<3	0.1

5 Apparatus

NOTE Except where otherwise specified, the tolerances on dimensions given to two places of decimals is $\pm 0.1\text{ mm}$, to one decimal place $\pm 0.5\text{ mm}$ and to the nearest whole number $\pm 1\text{ mm}$.

5.1 *Particle size apparatus.* The apparatus for determining the particle size distribution shall be as described in clause 5 of BS 812-103:1985.

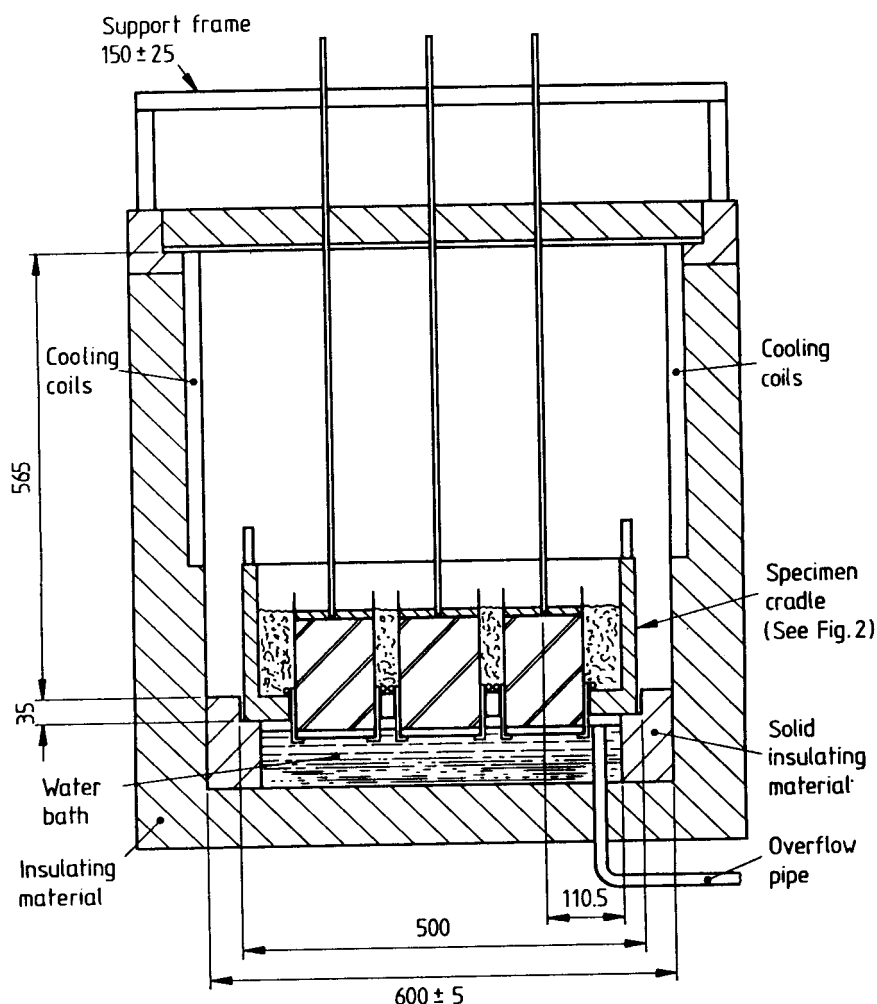
5.2 *Dry density and moisture content relation apparatus.* The apparatus for determining the dry density/moisture content relation shall be either as described in BS 5835-1 or in Test 14 of BS 1377:1975 (see note to 8.2.1).

5.3 *A self-refrigerated unit (SRU)*

5.3.1 *General description.* The frost-heave test SRU shall be a self-contained unit comprising a test chamber and associated refrigeration and control equipment. For convenience of use, none of the major dimensions shall exceed 2 m, the unit shall be fitted with castors, and adjustable legs shall be provided so that the equipment can be levelled.

5.3.2 *The test chamber*

5.3.2.1 The principal features and dimensions, all of which shall be maintained, of the test chamber are shown in Figure 1 and Figure 2. It shall consist of a chilled tank with smooth stainless-steel sides, into the floor of which is let a stainless-steel water-bath. The sides of the water-bath shall be connected to the sides of the tank by a thermally insulating medium which does not absorb water. A wooden cradle capable of holding nine test specimens shall locate centrally over the water-bath. The cooling system applied to the tank sides shall be above the specimen cradle.



All dimensions are in millimetres.

Figure 1 — Main features and dimensions of test chamber

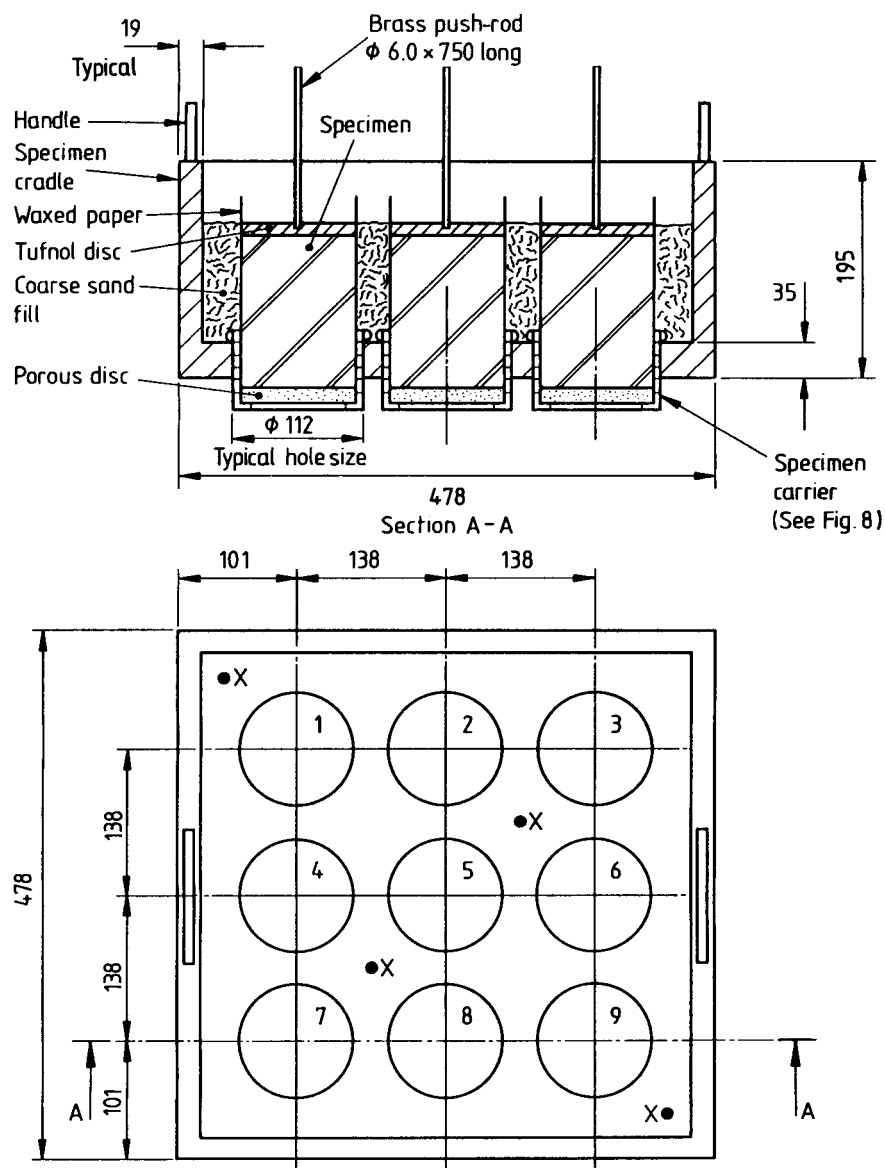
5.3.2.2 The test chamber shall be provided with a hinged lid having a stainless-steel lower surface. The lid shall have nine holes at the same centres as the holes in the specimen cradle to allow push-rods (see 5.3.4.1) to be located. These holes shall be not less than 10 mm and not more than 15 mm in diameter. The water-bath shall be provided with an overflow tube (see 5.3.3.1) and shall also be fitted with a separate drain-cock. An interior light shall be fitted to the underside of the lid.

5.3.3 The refrigeration and control equipment

5.3.3.1 A means of maintaining the water in the water-bath at a constant level between 8 mm and 11 mm from the underside of the specimen cradle (i.e. as close as possible to the tops of the porous discs). The principle of a suitable device is illustrated in Figure 3 (see note).

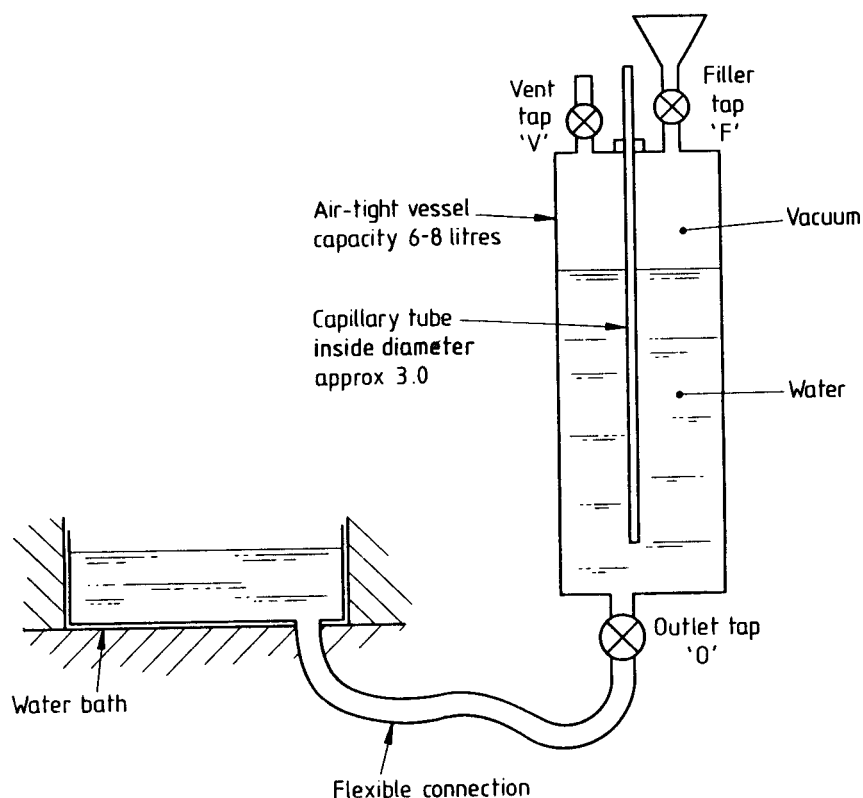
NOTE The device shown in Figure 3 has been found to be a simple and convenient method of maintaining a constant level of water in the apparatus but it is permissible for other means of keeping the water level constant to be used if preferred.

5.3.3.2 A device for gently circulating the water in the water-bath to maintain an even temperature distribution (see 7.2.1).



All dimensions are in millimetres.
Material: Plywood (Marine quality) Waterproof finish
X indicates the positions of four thermocouples in the air

Figure 2 — Specimen cradle showing specimen position numbers



Dimension is in millimetres.

Figure 3 — Principle of a constant level device to control water supply to frost-heave specimens

5.3.3.3 An air cooling system, to provide a means of cooling the sides of the tank above the specimen cradle such that the operating temperatures for the air defined in clause 7 can be achieved and maintained. The system shall be capable of reducing the air temperature at the centre of the tank to -20 ± 2 °C with the normal arrangement of specimens (Figure 2) in place (see 7.2.2). It shall be possible to achieve these temperatures between 4 h and 14 h from the time the system is switched on. The system shall be capable of operating at ambient temperatures of 15 °C to 25 °C.

5.3.3.4 A water-cooling system, to provide a means of cooling the water in the water-bath such that the operating temperatures for the water defined in clause 7 can be achieved and maintained. It shall be possible to achieve these temperatures between 4 h and 14 h from the time the system is switched on. The system shall be capable of operating at ambient temperatures of 15 °C to 25 °C.

NOTE It is not essential to have a separate cooling system for the water-bath. A system utilizing heat-loss through the specimens and additional cooling from the system cooling the air above the specimen cradle, together with a heater mat to limit the minimum temperature, is acceptable provided that the operating temperature requirements are met.

5.3.3.5 Temperature indicators. At least five thermocouples complying with the requirements of BS 4937-5 in the water-bath and five in the air (see note 1) above the specimen cradle together with a compatible electronic thermometer with a resolution of at least 0.1 °C.

A selector switch shall be provided to allow thermocouples to be tested in quick succession (see note 2).

NOTE 1 One of these five thermocouples will eventually be attached to the Tufnol disc covering the specimen in position 5 (see 10.1.2).

NOTE 2 If the electronic thermometer is mounted integrally within the console of the cabinet, it is essential that care be taken to prevent interference from electrical/magnetic components in the cabinet.

5.3.3.6 *A rigid detachable metal datum frame*, to support the push-rods (Figure 1) which can be positively located above the lid of the test chamber having horizontal bars with holes 6.5 mm diameter at the same centres as the holes in the specimen cradle and the test chamber lid. The upper surface of the datum frame shall be not less than 125 mm and not more than 175 mm above the top of the lid.

5.3.4 *Additional equipment for use with the SRU*

5.3.4.1 *Nine brass rods*, 750 mm long and 6.0 mm in diameter. These are illustrated in their positions during the test in Figure 1.

5.3.4.2 *A supply of clean and dry single-sized silica sand* from either the 5 mm to 2.36 mm or the 2.36 mm to 1.18 mm fractions.

NOTE About 30 kg is sufficient for one SRU.

5.3.4.3 *A steel rule* complying with the requirements of BS 4035 or other suitable means of measuring the displacement of the push-rods above the datum frame, readable and accurate to 0.5 mm.

5.3.4.4 *A two-pen chart recorder*, to record continuously the air and water temperatures during the test. It is recommended that the recorder be built into the SRU, although it is not essential that it should be, provided that access is provided for the sensors.

5.3.4.5 *A supply of surgery wool* or similar absorbent material.

5.3.4.6 *Waxed paper sheets*, approximately 350 mm × 200 mm in size and suitable adhesive tape. The thickness of the tape should be between 0.1 mm and 0.25 mm and that of the waxed paper between 0.2 mm and 0.4 mm.

5.3.4.7 *Discs*, at least nine, 95.0 mm in diameter, 5.0 mm thick with a central recess 10.0 mm diameter and 2.0 mm deep in one side.

NOTE Suitable discs (Carp Brand) can be obtained from Tufnol Limited, P.O. Box 376, Perry Barr, Birmingham, B42 2TB or 3 James Watt Place, College Milton North, East Kilbride, Scotland.

5.3.4.8 *Porous ceramic discs*, at least nine, 13.0 mm thick and 101.6 mm in diameter of maximum pore size 110 µm.

NOTE Grade P5 discs supplied by Fairey Industrial Ceramics Ltd., Fillybrooks, Stone, Staffs, are suitable.

5.3.4.9 *Copper specimen carriers*, at least nine, as shown in Figure 4.

5.4 *Balances* of suitable capacity readable to 0.1 % of the mass of the test portion. They shall be regularly calibrated according to the requirements of BS 5781.

NOTE In general two balances will be enough; one of 50 kg capacity accurate to 25 g and one of 5 kg capacity accurate to 5 g.

5.5 *Tared glass flask*, at least one of each of the following capacities:

250 mL, 500 mL, 1 000 mL.

5.6 *A mechanical mixer*, with a capacity of at least 20 kg. The mixer shall not cause any significant degradation of the particles.

5.7 *Containers*, at least nine, which can be made airtight, capable of holding 15 kg samples of mixed material.

5.8 *A steel mould and end-plugs* as shown in Figure 5.

5.9 *A hand-held steel tamper*, weighing 1 100 g to 1 200 g. A suitable design is shown in Figure 6.

5.10 *An electric vibrating hammer*, having a power consumption not less than 600 W and operating at a frequency between 25 Hz and 45 Hz. The hammer shall be checked at regular intervals using the procedure given in note 2 to Test 14 of BS 1377:1975.

NOTE The power consumption and frequency requirements are given as a guide to the type of hammer required.

5.11 *A steel tamper for the vibrating hammer* with a circular foot of 100 mm diameter. A suitable design is shown in Figure 7, the shank is a force-fit into the disc.

5.12 *A depth gauge*, capable of reading depths up to 250 mm, readable and accurate to 1 mm.

5.13 *A jacking device* or other suitable means of ejecting the compacted specimen from the mould, e.g. a compression testing machine with suitable means of extension extruders, as illustrated in Figure 8, Figure 9 and Figure 10.

5.14 *Thermometers*, complying with the requirements of BS 593.

5.15 *A ventilated oven* thermostatically controlled to maintain a temperature of 105 ± 5 °C.

6 Setting up of the self-refrigerated unit

NOTE The following operations should be carried out before the test specimens are prepared.

6.1 If necessary, adjust the SRU so that it is level and ensure that the test chamber, including the water-bath and constant-level device are clean, dry and at room temperature.

6.2 Check that the coarse sand for filling the space around the test specimens is clean, dry and at room temperature, and if necessary wash, re-sieve to the correct grading, and dry.

NOTE Because the sand can become contaminated with use it should periodically be washed and re-sieved to maintain the correct grading.