BS EN 1097-10:2014

BSI Standards Publication

# Tests for mechanical and physical properties of aggregates

## Part 10: Determination of water suction height

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**National foreword**

This British Standard is the UK implementation of EN 1097-10:2014. It supersedes BS EN 1097-10:2002 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/502, Aggregates.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2014

ISBN 978 0 580 80137 2
ICS 91.100.15

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2014.

**Amendments/corrigenda issued since publication**

| Date | Text affected |
|---|---|

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# EN 1097-10

May 2014

ICS 91.100.15

Supersedes EN 1097-10:2002

English Version

# Tests for mechanical and physical properties of aggregates - Part 10: Determination of water suction height

Essais pour déterminer les caractéristiques mécaniques et physiques des granulats - Partie 10: Hauteur de succion d'eau

Prüfverfahren für mechanische und physikalische Eigenschaften von Gesteinskörnungen - Teil 10: Bestimmung der Wassersaughöhe

This European Standard was approved by CEN on 24 February 2014.

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# Foreword

This document (EN 1097-10:2014) has been prepared by Technical Committee CEN/TC 154 “Aggregates”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2014 and conflicting national standards shall be withdrawn at the latest by October 2014.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 1097-10:2002.

This European Standard forms part of a series of tests for mechanical and physical properties of aggregates. Test methods for other properties of aggregates will be covered by parts of the following European Standards:

— EN 932, Tests for general properties of aggregates

— EN 933, Tests for geometrical properties of aggregates

— EN 1367, Tests for thermal and weathering properties of aggregates

— EN 1744, Tests for chemical properties of aggregates

— EN 13179, Tests for filler aggregate used in bituminous mixtures

The other parts of EN 1097 are:

— *Part 1: Determination of the resistance to wear (micro-Deval)*

— *Part 2: Methods for the determination of resistance to fragmentation*

— *Part 3: Determination of loose bulk density and voids*

— *Part 4: Determination of the voids of dry compacted filler*

— *Part 5: Determination of the water content by drying in a ventilated oven*

— *Part 6: Determination of particle density and water absorption*

— *Part 7: Determination of the particle density of filler — Pyknometer method*

— *Part 8: Determination of the polished stone value*

— *Part 9: Determination of the resistance to wear by abrasion from studded tyres — Nordic test*

— *Part 11: Determination of compressibility and confined compressive strength of lightweight aggregates*

The technical changes between this edition and the 2002 version are as follows:

a) 6.3 and 6.4, minimum size of vessel and moisture container have been reduced;

b) 6.13, tolerance on temperature stability has been broaden;

c) Clause 7, Table 2, minimum volume of test portion has been reduced;

d) 8.4, Figure 2 has been redrawn and clarified;

e) 8.2 to 8.4, units have been updated;

f) Definition of constant moisture content has been clarified and appended to 8.4.

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

# 1 Scope

This European Standard specifies the reference method, used for type testing and in case of dispute, for determining the water suction height of an aggregate in direct contact with a free water surface. For other purposes, in particular production control, other methods may be used, provided that an appropriate working relationship with the reference methods has been established.

NOTE Capillary water uptake in an aggregate layer under the ground floor may cause moisture problems in the building. If the layer is thicker than the water suction height of the aggregate used, the layer is considered as a capillary barrier.

# 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 932-2, *Tests for general properties of aggregates - Part 2: Methods for reducing laboratory samples*

EN 932-5, *Tests for general properties of aggregates - Part 5: Common equipment and calibration*

EN 1097-5, *Tests for mechanical and physical properties of aggregates - Part 5: Determination of the water content by drying in a ventilated oven*

# 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1**
**water suction height**
level to which the water raises in a layer of aggregate in direct contact with a free water surface

**3.2**
**maximal hygroscopic moisture content**
moisture content of aggregates in a sealed container just below 100 % relative humidity

**3.3**
**aggregate size**
designation of aggregate in terms of lower (*d*) and upper (*D*) sieve sizes

Note 1 to entry: This designation accepts the presence of some particles which will be retained on the upper sieve (oversize) and some which will pass the lower sieve (undersize).

**3.4**
**constant mass**
mass determined after successive weighings at least 1 h apart not differing by more than 0,1 %

Note 1 to entry: In many cases constant mass can be achieved after a test portion has been dried for a pre-determined period in a specified oven at (110 ± 5) °C. Test laboratories can determine the time required to achieve constant mass for specific types and sizes of sample dependent upon the drying capacity of the oven used.

**3.5**
**test portion**
sample used as a whole in a single test

# 4 Principle

A test portion of dry aggregate in a vertical tube is brought into direct contact with a free water surface, allowing the aggregate to take up water by suction. When equilibrium is reached, the water suction height is determined from the moisture content variation within the test portion.

NOTE 1 The water suction height may be affected by the relative humidity. For this reason, the hygroscopic moisture content is simultaneously determined and the largest effect is recorded as the water suction height.

NOTE 2 The water suction height may be affected by the compacted dry bulk density. For this reason, the compacted dry bulk density is determined and recorded.

# 5 Materials

## 5.1 Water, boiled and cooled before use

NOTE Fresh tap water and demineralized water are both suitable as long as they are free from any impurity.

## 5.2 Reagents

Saturated potassium sulfate solution, prepared by dissolving (12 ± 1) g of reagent grade potassium sulfate by stirring in (100 ± 1) g of demineralized water at (40 ± 1) °C. Allow the solution to cool to room temperature and store in a closed bottle.

NOTE The potassium sulfate solution is used to avoid condensation while determining the maximal hygroscopic moisture content (6.4), as water drops from the condensation may soak the test sample.

# 6 Apparatus

**6.1 All apparatus**, unless otherwise stated, shall conform to the general requirements of EN 932-5.

**6.2 Tube**, made of transparent material with a height of not less than 200 mm and a diameter as specified in Table 1.

NOTE Aggregates with a large value of water suction height may require a longer tube.

The lower end of the tube wall shall be fitted with at least four slots, ensuring free movement of water into the tube. An example of slot design is shown in Figure 1. The tube shall be glued in the centre of the vessel (6.3). Take care not to clog the slots. The width of the slots should be smaller than *d* to prevent particles to flow into the vessel.

**6.3 Vessel,** made of transparent material. The internal bottom area of the vessel shall be large enough to have a minimum distance of 50 mm between the edge of the vessel and the wall of the tube. The vessel is fitted with a needle made of non-corrosive material, to indicate a water level (10 ± 1) mm above the base of the vessel, as shown in Figure 1.

**6.4 Moisture container and close fitting lid**, made preferably of transparent material, with an internal bottom area as specified in Table 1 and an internal depth of at least 60 mm. The container is fitted with a heat insulated cover or placed inside the test cabinet (see 6.13).

NOTE Vessels and containers can be circular or rectangular.

**Table 1 — Minimum dimensions of tube and moisture container**

| **Upper aggregate size *D*** mm | **Minimum internal diameter of tube** [a] mm | **Minimum internal bottom area of moisture container** [b] $m^2$ |
|---|---|---|
| 8 | 125 | 0,04 |
| 10 | 125 | 0,04 |
| 16 | 140 | 0,04 |
| 20 | 140 | 0,05 |
| 32 | 170 | 0,08 |
| [a] See 6.2. | | |
| [b] See 6.4. | | |

**6.5 Glass basin**, flat bottom crystallising type of 150 ml nominal capacity, to contain the potassium sulfate solution (see 5.2).

**6.6 Balance**, with an accuracy of 0,1 g for masses of 100 g or more and an accuracy of 0,01 g for masses of less than 100 g.

**6.7 Plastic bag and rubber band**, size appropriate to the diameter of the tube.

**6.8 Wood stick (wooden dowel)**, with a diameter of approximately 0,25 X the diameter of the tube and a height of approximately 500 mm, for packing of the material in the tube.

**6.9 Plastic water bottle with spout,** for water supply and level adjustment.

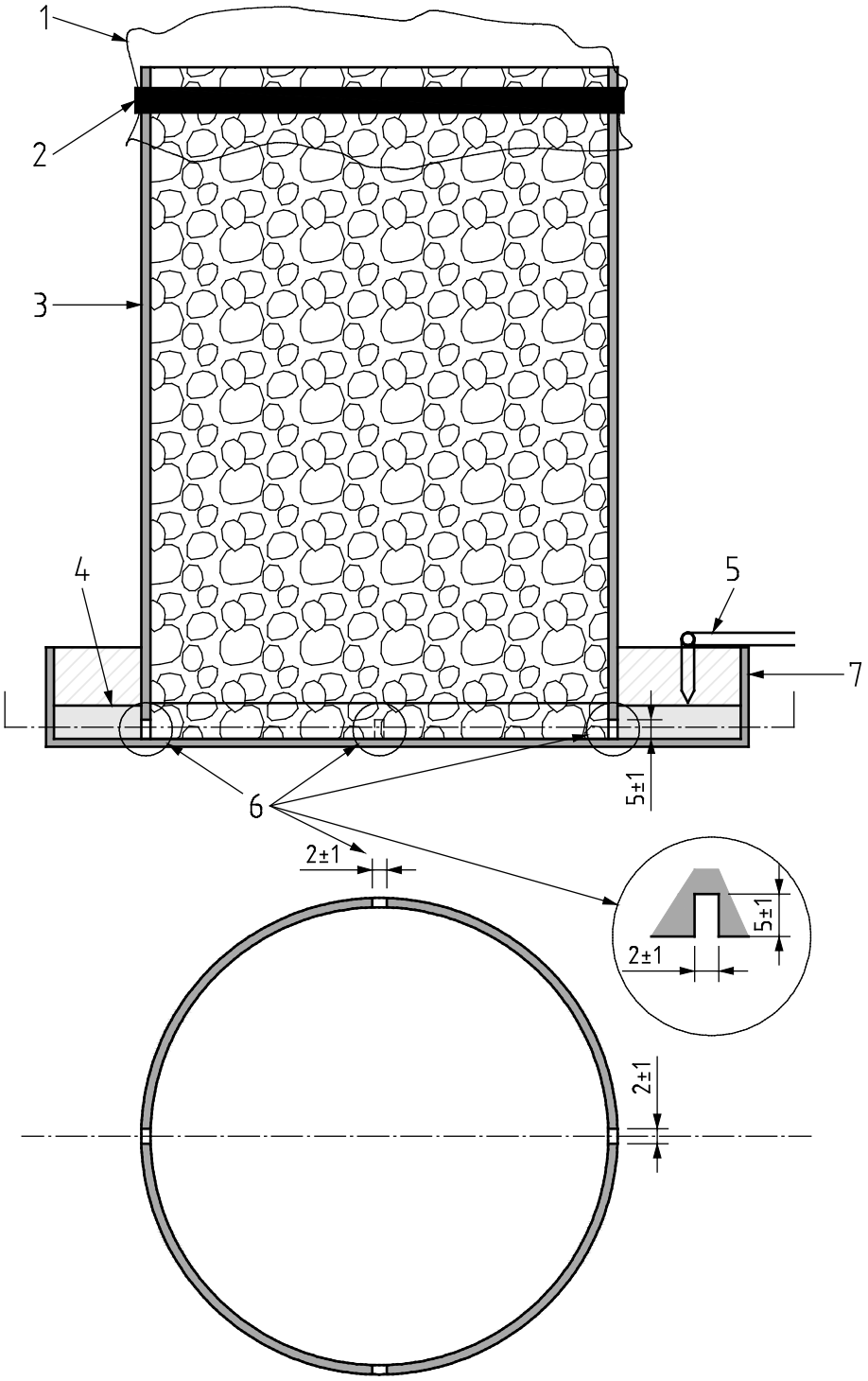
**6.10 Ventilated oven**, thermostatically controlled to maintain a temperature of (110 ± 5) °C.

**6.11 Steel straight edge**, for levelling the surface of the aggregate with the top of the tube.

**6.12 Adhesive tape**, to seal the moisture container.

**6.13 Test cabinet**, or similar controlled environment capable of maintaining a stable temperature (± 2,0 °C) between 20,0 °C and 25,0 °C.

Dimensions in millimetres




**Key**

| | | | | | |
|---|---|---|---|---|---|
| 1 | plastic bag | 4 | water surface | 7 | vessel |
| 2 | rubber band | 5 | level needle | | |
| 3 | tube | 6 | slots (design in mm) | | |

**Figure 1 — Tube and vessel for determination of water suction height**

# 7 Preparation of test portions

The laboratory sample shall be reduced in accordance with EN 932-2 to produce two test portions: one for determination of the maximal hygroscopic moisture content (8.2) and the other for determination of the compacted dry bulk density (8.3) and the water suction height (8.4). The volume of the test portions shall be as specified in Table 2.

Dry the two test portions in the ventilated oven at (110 ± 5) °C to constant mass as specified in EN 1097-5.

**Table 2 — Minimum volume of test portions**

| **Upper aggregate size *D*** mm | **Minimum volume in litres** | |
|---|---|---|
| | **Determination of maximal hygroscopic moisture content** [a] | **Determination of compacted dry bulk density and water suction height** [b] |
| 8 | 0,25 | 3,0 |
| 10 | 0,25 | 3,0 |
| 16 | 0,25 | 3,5 |
| 20 | 0,5 | 3,5 |
| 32 | 1,0 | 5,0 |
| [a] See 8.2. | | |
| [b] See 8.3 and 8.4. | | |

# 8 Test procedure

## 8.1 General

Carry out the tests in the test cabinet maintained at the selected stable temperature specified in 6.13.

To prevent condensation on the inner surface of the tube and container, shield the apparatus from cold walls, cold windows, direct sunlight and draughts.

## 8.2 Determination of maximal hygroscopic moisture content

Place the glass basin containing the prepared saturated potassium sulfate solution in the centre of the moisture container. Distribute the test portion evenly over the remaining area of the moisture container. Fit the cover and seal the cover to the container with adhesive tape.

At the same time as the determination of water suction height (8.4) is complete, remove the test portion from the moisture container and weigh it ($M_{hyg}$). Dry the test portion in the ventilated oven at (110 ± 5) °C to constant mass as specified in EN 1097-5 and weigh, $M_{hygd}$.

Calculate the maximal hygroscopic moisture content $w_{hyg}$, in percentage by dry mass, to one decimal place in accordance with the following formula:

$$w_{hyg} = \frac{M_{hyg} - M_{hygd}}{M_{hygd}} \times 100 \quad (1)$$

where

$M_{hyg}$ is the mass of the moist test portion, in kilograms;

$M_{hygd}$ is the mass of the dried test portion, in kilograms.

NOTE For routine quality control testing, the determination of the maximal hygroscopic moisture content can be omitted for materials with consistent hygroscopic characteristics.

### 8.3 Determination of compacted dry bulk density

Weigh the selected empty tube and the vessel, $M_1$.

Transfer the dry test portion to the tube in minimum four equally thick layers. Lightly compact each layer with 10 blows of the end of the wooden stick, each blow being given by allowing the stick to fall freely from a height of not more than 50 mm above the surface of the aggregate layer. Take care not to crush individual particles and distribute the blows evenly over the surface.

After filling and light compaction of the last aggregate layer, level the surface of the aggregate at the top of the tube with the straight edge and discard the excess material. Weigh the vessel with the tube and the test portion, $M_2$.

Calculate the compacted dry bulk density of the test portion, $\rho_{cb}$, in Mg/m³, in accordance with the following formula:

$$\rho_{cb} = \frac{M_2 - M_1}{V} \quad (2)$$

where

$M_1$ is the mass of vessel and empty tube, in kilograms;

$M_2$ is the mass of vessel, tube and test portion, in kilograms;

$V$ is the volume of tube, in litres

### 8.4 Determination of water suction height

Fix the plastic bag to the upper end of the tube with a rubber band and fill the vessel with demineralized water until the level needle breaks the water surface.

Wait (5,0 ± 0,5) min and add water until the level needle breaks the water surface again.

Weigh the vessel, tube, test portion and water and record the total mass as $M_{tot}$ (5 min).

The level of water shall not fluctuate by more than 3 mm during the test. Determine the total mass, $M_{tot}$ ($t$), after the following time periods, $t$: (24 ± 2) h, (48 ± 4) h, (72 ± 4) h and (168 ± 4) h and then at intervals of (7 ± 0,5) days. Prior to each weighing, adjust the level of water so that the needle breaks its surface.

NOTE A constant water level can be achieved by connecting the vessel to a larger tank with constant water level as long as the connection is removed before each weighing.

Calculate the absorbed capillary water per square metre of water suction area after time $t$ hours (or days), Wc($t$), in kilograms per square metre, in accordance with the following formula:

$$W_c(t) = \frac{M_{tot}(t) - M_{tot}(5\,\text{min})}{\pi\left(\frac{d_t}{2}\right)^2} \quad (3)$$

where

$M_{tot}$ (5 min) is the total mass after 5 min, in kilograms;

$M_{tot}(t)$ is the total mass, after $t$ hours/days, in kilograms;

$d_t$ is the tube inside diameter, in metres.

When the mass change over a period of 7 days is less than 0,2 kg/m² water suction area the test is complete.

When the test is complete, the test portion is removed from the tube in layers with a thickness (in millimetres) not less than the upper aggregate size $D$. The lowest layer starts above the free water level, i.e. the 10 mm of aggregates sucked in water is not measured.

Weigh and record the mass of the material in each layer i, $M_{3i}$. Dry the material in the ventilated oven at (110 ± 5) °C to constant mass as specified in EN 1097-5, weigh and record the mass, $M_{4i}$. Calculate the moisture content of each individual layer i, $w_i$, in percentage by dry mass, to one decimal place in accordance with the following formula:

$$w_i = \frac{M_{3i} - M_{4i}}{M_{4i}} \times 100 \quad (4)$$

where

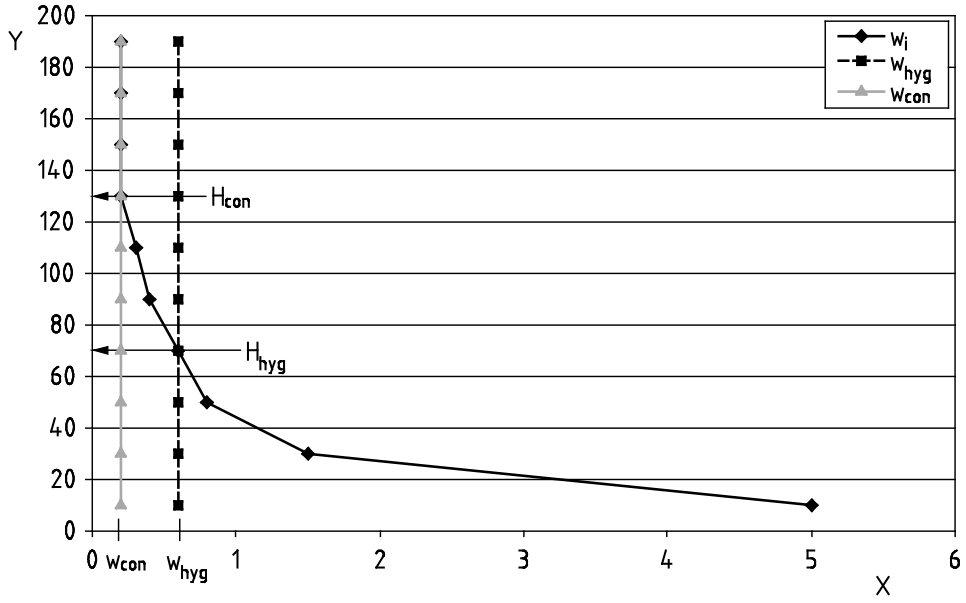
$M_{3i}$ is the mass of moist material in layer i, in kilograms;

$M_{4i}$ is the mass of dry material in layer i, in kilograms.

Plot the distance from the middle of layer i to the free water level, $H_i$, in mm, against the moisture content of layer i, $w_i$. Draw a curve through the plotted points (see example in Figure 2).

Determine the lowest height, $H_i$, where the moisture content, $w_i$, is below 0,5 % or where the difference in moisture content between two adjacent layers is less than 0,3 percentage units. The moisture content of this layer is designated $w_{con}$, and the distance from the middle of this layer to the free water level is designated $H_{con}$ (see Figure 2). Mark the point for $w_{con}$ on the horizontal axis and draw a vertical line as shown in Figure 2. $H_{con}$ is the point where the curve intersects this vertical line.

Mark the point for $w_{hyg}$ on the horizontal axis and draw a vertical line. Determine $H_{hyg}$ as the point where the curve intersects the vertical line (see Figure 2). If there is no clear intersection point (parallel lines) a difference between the moisture content in a layer ($w_i$) and hygroscopic moist ($w_{hyg}$) less than 0,3 percentage units is regarded as intersection. The value is given as the middle height of the layer intersected. The water suction height, $H_{cap}$, in millimetres, is defined as the larger of the two values $H_{hyg}$ and $H_{con}$ and should be expressed to the nearest whole number.




**Key**

X moisture content, w (%)

Y height above water surface, h (mm)

**Figure 2 — Example of diagram for determination of the water suction height**

# 9 Test report

## 9.1 Required data

The test report shall include the following information:

a) reference to this European Standard (EN 1097-10);

b) identification of the laboratory sample;

c) (maximal) hygroscopic moisture content, ($W_{hyg}$);

d) the moisture content of the individual layers of aggregate as a function of their distance above the free water surface, ($W_i$);

e) the water suction height, ($H_{cap}$);

f) date of test.

### 9.2 Optional data

The test report may include the following information:

a) name and location of the sample source;

b) name and location of the test laboratory;

c) absorbed and capillary risen water in the sample as a function of time ($W_{ct}$);

d) compacted dry bulk density of sample ($\rho_{cb}$);

e) petrographic description.

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