SLOVENSKI STANDARD
SIST EN 12390-14:2018

01-oktober-2018

Preskušanje strjenega betona - 14. del: Semiadiabatska metoda za ugotavljanje toplote, ki se sprosti med procesom strjevanja betona

Testing hardened concrete - Part 14: Semi-adiabatic method for the determination of heat released by concrete during its hardening process

Prüfung von Festbeton -Teil 14: Teiladiabatisches Verfahren zur Bestimmung der Wärme, die während des Erhärtungsprozesses von Beton freigesetzt wird

Essai pour béton durci - Partie 14: Méthode semi-adiabatique de détermination de la chaleur dégagée par le béton au cours son processus de durcissement

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (EN 12390-14:2018) has been prepared by Technical Committee CEN/TC 104 “Concrete and related products”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by February 2019, and conflicting national standards shall be withdrawn at the latest by February 2019.

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

This standard is one of a series on testing concrete.

EN 12390, *Testing hardened concrete*, consists of the following parts:

— *Part 1: Shape, dimensions and other requirements of specimens and moulds*

— *Part 2: Making and curing specimens for strength tests*

— *Part 3: Compressive strength of test specimens*

— *Part 4: Compressive strength - Specification for testing machines*

— *Part 5: Flexural strength of test specimens*

— *Part 6: Tensile splitting strength of test specimens*

— *Part 7: Density of hardened concrete*

— *Part 8: Depth of penetration of water under pressure*

— *Part 10: Determination of the carbonation resistance of concrete at atmospheric levels of carbon dioxide*

— *Part 11: Testing hardened concrete. Determination of the chloride resistance of concrete, unidirectional diffusion*

— *Part 13: Determination of secant modulus of elasticity*

— *Part 14: Semi-adiabatic method for the determination of heat released by concrete during its hardening process*

— *Part 15: Adiabatic method for the determination of heat released by concrete during its hardening process*

— *Part 16: Determination of shrinkage of concrete (in preparation)*

— *Part 17: Determination of creep of concrete in compression (in preparation)*

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, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This document specifies the procedure for the determination of heat released by concrete during its hardening process in semi-adiabatic conditions in a laboratory. Annex B specifies the procedure when the test is performed on site. The test is suitable for specimens having a declared value of *D* of the coarsest fraction of aggregates actually used in the concrete (D_{max}) not greater than 32 mm.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12350-1, *Testing fresh concrete - Part 1: Sampling*

EN 12390-2, *Testing hardened concrete - Part 2: Making and curing specimens for strength tests*

3 Terms, definitions, symbols, units and scripts

3.1 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

• IEC Electropedia: available at http://www.electropedia.org/

• ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1

semi-adiabatic calorimeter
equipment containing a calorimetric cell where the maximum heat losses are limited

3.1.2
calorimeter coefficient of heat loss
(α)
proportionality factor between heat losses and the difference of temperature between inside and outside of the calorimeter; the coefficient of heat loss is a linear function of this difference of temperature

3.1.3
semi-adiabatic heat release
(q)
heat released by unit mass of concrete during its hydration in semi-adiabatic conditions as a function of time

3.1.4
calorimeter cell
element containing the test sample in its mould or control specimen and having an external insulated enclosure with a sealable removable cover

3.2 Symbols, units and scripts

For the purposes of this document, the symbols and units in Table 1 apply.

Table 1 — Symbols, units and explanation

Symbol	Units	Explanation
C_{cal}	J/K	heat capacity of the calorimeter
C_{con}	J/K	total heat capacity of the concrete specimen alone
C_{mould}	J/K	total heat capacity of the mould with probe tube and mould cover
C_{tot}	J/K	total heat capacity
α	J/(h·K)	coefficient of heat loss of calorimeter
$\theta(t)$	K	difference in temperature between the concrete specimen and the control specimen at time t
$q(t)$	J/kg	heat release by unit mass of concrete at time t
$T_{ext,0}$	°C	initial ambient temperature in the conditioned testing room
$T_{ext}(t)$	°C	ambient temperature in the conditioned testing room at time t
$T_{con,0}$	°C	initial temperature of fresh concrete
$T_{con}(t)$	°C	temperature of the concrete specimen at time t
$T_{cal}(t)$	°C	temperature of the calorimeter cell at time t
$T_{ctl}(t)$	°C	temperature of the control specimen at time t
t	h	time elapsed since start of test t_0
t_0	—	initial time of test (first contact of water with cement)
Δt	min	time interval between two measures of temperature
c_c	J/(kg·K)	specific heat of cement
c_{ad}	J/(kg·K)	specific heat of additions
c_{ag}	J/(kg·K)	specific heat of dry aggregate
c_w	J/(kg·K)	average specific heat of water in hardening concrete
m_{con}	kg	mass of concrete sample
m_c	kg	nominal mass of cement in the mix design per cubic metre
m_{ad}	kg	nominal mass of additions in the mix design per cubic metre
m_{ag}	kg	nominal mass of dry aggregate in the mix design per cubic metre
m_w	kg	nominal mass of total water in the mix design per cubic metre
m_{mould}	kg	sum of the masses of empty mould, probe tube and mould cover
u, du	-	mathematical integration variable
$\Delta Q(t_n)$	J	calculated heat loss between measurements numbers n-1 and n
R^2	—	regression coefficient
C_T	J/K	total heat capacity of the system equipment containing calibration sample, a reference sample or the calibration medium
a, b	—	calibration coefficients

4 Principle

The test determines the quantity of heat released over time of a concrete specimen placed into a semi-adiabatic calorimeter designed for concrete.

The quantity of heat produced, expressed in joules per kilogram of concrete, is determined at regular intervals from just after casting of the specimen.

The test is carried out using two calorimeters which have been constructed to minimize the heat loss from the concrete sample to the surrounding environment and have similar heat loss coefficients and heat capacities.

A sample of fresh concrete is placed in a mould which is then introduced into the calorimeter and the internal temperature of the hardening concrete is measured. At any given time, the heat released by hydration equals the heat accumulated into both calorimeter and specimen plus the cumulative heat that has dissipated to the outside since the initial time.

The test is suitable for concrete containing all types of cement referred to in EN 206, with the exception of quick-setting cements.

5 Apparatus

5.1 Thermometers

To measure the temperature of the fresh concrete specimen (T_{con}) and the temperature of the control specimen (T_{ctl}) with a maximum permissible error of 0,3 K in the working range of the test of (10-100) °C.

5.2 Balance

To measure the mass of the concrete to a maximum permissible error of 0,1 %.

5.3 Temperature monitoring and control system

A digital multimeter, used to measure both the calibration cylinder resistance and test voltages having a maximum permissible error of 0,1 % in the operating range (0-200) V.

Stabilized power supply, with voltage adjustable between 2 and 200 V minimum; stability as a function of load: $\Delta V/V \leq 2 \cdot 10^{-4}$; and stability as a function of the mains voltage $\Delta V/V \leq 10^{-4}$.

One calibration cylinder (see A.1.1), containing an aluminium specimen with an identical shape to the test specimen and an electrical resistance of 2 500 ohms minimum with a resistivity having a low temperature coefficient of resistance e.g. constantan or manganin wire. The resistance connection wires are designed with a maximum cross-section of 0,05 mm² to avoid heat leaks.

Another calorimeter used as a reference calorimeter, equipped with an inert specimen of an identical design to the calibration cylinder, yet without an electrical resistance.

5.4 Semi-adiabatic calorimeter

To perform the test, two calorimeters having heat loss coefficients (α) at 20 °C and heat capacities (C_{cal}) to within 15 % of each other are required [3]. One contains the control specimen, the other the test specimen.

Each calorimeter typically consists of a calorimetric cell with a removable insulated cover and an external enclosure made with a high heat conductivity material, e.g. steel or other suitable material. The calorimeter cell is surrounded by an external insulating layer encased in a rigid caisson.

A cubic or cylindrical mould (with cover) made of steel with a wall thickness of approximately 0,1 to 0,2 mm or cardboard or similar material with a wall thickness of approximately 1,9 mm having a volume of at least 5 l.

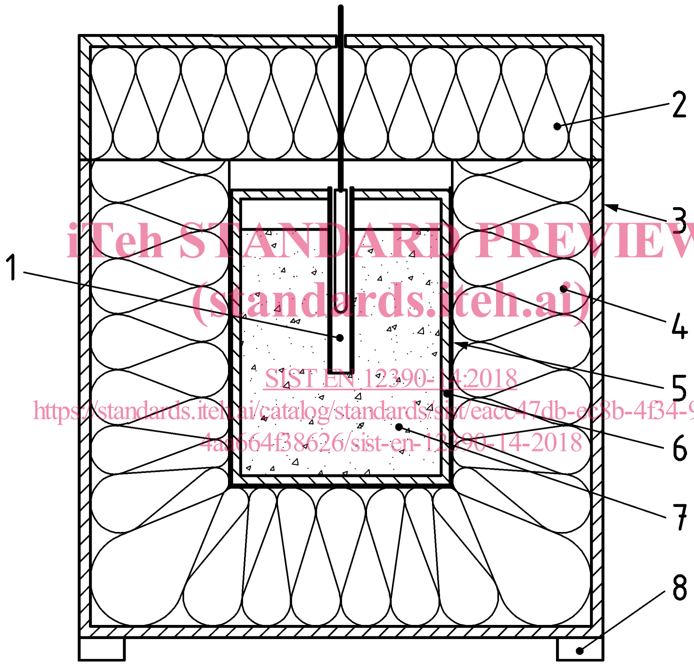
The mould cover shall allow the positioning of a probe tube made from a high heat conductivity material not readily attacked by cement paste in the centre of the sample to house a thermometer.

The tube is filled with diathermal fluid in order to provide the best possible heat contact between the thermometer and the concrete sample.

The apparatus shall be supported in a way to ensure that the temperature of the base is determined by the ambient air.

A schematic example is shown in Figure 1.

The calorimeters shall be calibrated according to the procedure specified in A.1 or alternatively A.2 every 4 years or any time the calorimeter has been modified or refurbished. The coefficient of heat loss of the calorimeter shall be less than 400 J/(K·h) for a difference of temperature of 20 K.



Key

Equipment items:

1 Probe tube for thermometer in diathermal fluid

2 Cover (with similar thermal insulation as 4)

3 External caisson

4 Thermal insulation

5 Calorimetric cell

6 Sample mould, with cover

7 Sample under test or control sample

8 Base

Figure 1 — Schematic arrangement of the semi-adiabatic calorimeter

5.5 Control specimen

A control specimen (thermally inert) cast using the same procedure as the test specimen and having a heat capacity similar to the test specimen within 15 % is required.

NOTE Concrete specimens of similar density are assumed to have similar heat capacity.

Concrete specimen of at least three months old is assumed to be thermally inert. Special attention should be taken for hydraulic binders with slow heat release.

6 Procedure

The test shall be carried out in a conditioned room with a temperature of (20 ± 2) °C.

The open calorimeters, control specimen and constituent materials shall be stored in the conditioned room for at least 24 h. Sufficient materials are required to produce a concrete volume of at least 20 l.

A control specimen is placed inside a calorimeter located in the conditioned room.

Prepare the amounts of components to produce the required volume of concrete, on the basis of the nominal mix design (one cubic metre). Their temperature shall be controlled to ensure that they are at room temperature before mixing begins.

The total mass (m_{mould}) of the empty mould, probe tube and mould cover shall be measured.

Without any delay after mixing, a portion of fresh concrete is sampled according to EN 12350-1 and cast into the mould according to EN 12390-2.

The initial time of test (t_0), the initial temperature of the fresh concrete ($T_{con,0}$) and, at t_0 (time $t = 0$), the temperature of the control specimen ($T_{ctl}(0)$) and the ambient temperature ($T_{ext}(0)$) shall be recorded.

NOTE 1 The initial time of the test (t_0) is considered to be the time at which the water is added to the cement and aggregate.

When the mould is nearly full, the probe tube is inserted. Concrete is added and compacted until the mould is fully filled. The mould cover is positioned and sealed in order to minimize evaporation and condensation inside the calorimeter.

The mass of the concrete sample in its mould (with probe tube and cover) shall be measured and the mass of the concrete sample (m_{con}) determined by the difference with mass m_{mould} and recorded.

The fresh concrete sample (in its mould) shall be introduced into the calorimeter cell, the thermometer positioned inside the probe tube, which is then filled with diathermal fluid, the calorimeter closed and the test and recording of temperatures started immediately.

The opening on the calorimeter cap, which serves to route the connection wires, shall be hermetically sealed so as to prevent convection currents between the calorimeter interior and the ambient environment.

If two or more specimens are tested in two or more calorimeters they shall be separated by at least 100 mm.

The time interval between the initial time (t_0) and the starting of the test on closure of the test calorimeter shall be short as possible (preferably less than 0,5 h) and shall be recorded.

During the test the temperatures of the concrete sample ($T_{con}(t)$) and of the control specimen ($T_{ctl}(t)$) and the ambient temperature in the conditioned testing room (T_{ext} (t)) shall be recorded at intervals Δt not exceeding 5 min.

The duration of the test shall be at least 72 h and may be continued at least until the measured temperature change of the concrete (T_{con}) over 24 h is not greater than 1 °C.