



# SLOVENSKI STANDARD

## SIST-TS CEN/TS 12390-9:2017

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**Preskušanje strjenega betona - 9. del: Odpornost proti zmrzovanju/tajanju s soljo za tajanje - Luščenje**

Testing hardened concrete - Part 9: Freeze-thaw resistance with de-icing salts - Scaling

Prüfung von Festbeton - Teil 9: Frost- und Frost-Tausalz-Widerstand - Abwitterung

Essais sur béton durci - Partie 9: Résistance au gel-dégel-dégel en présence de sels de déverglaçage (écaillage)

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**ICS:**

91.100.30      Beton in betonski izdelki      Concrete and concrete products

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TECHNICAL SPECIFICATION  
SPÉCIFICATION TECHNIQUE  
TECHNISCHE SPEZIFIKATION

# CEN/TS 12390-9

December 2016

ICS 91.100.30

Supersedes CEN/TS 12390-9:2006

English Version

## Testing hardened concrete - Part 9: Freeze-thaw resistance with de-icing salts - Scaling

Essais sur béton durci - Partie 9: Résistance au gel  
dégel-dégel en présence de sels de déverglaçage  
(écaillage)

Prüfung von Festbeton - Teil 9: Frost- und Frost-  
Tausalz-Widerstand - Abwitterung

This Technical Specification (CEN/TS) was approved by CEN on 25 April 2016 for provisional application.

The period of validity of this CEN/TS is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the CEN/TS can be converted into a European Standard.

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EUROPEAN COMMITTEE FOR STANDARDIZATION  
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**CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels**

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## European foreword

This document (CEN/TS 12390-9:2016) has been prepared by Technical Committee CEN/TC 51 “Cement and building limes”, the secretariat of which is held by NBN.

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 CEN/TS 12390-9:2006.

The following technical modifications have been made in this new edition:

- In Clause 2, the normative references have been updated;
- In Clauses 5, 6 and 7,(for all test methods), a prescription measuring the CO<sub>2</sub> content of the air in the storage room has been introduced;
- In Annex A, the alternative applications have been strictly specified;
- In Annex B, a technical specification has been introduced;
- In the Bibliography, the references have been updated.

EN 12390, *Testing hardened concrete*, is currently composed with the following parts:

- *Part 1: Shape, dimensions and other requirements for 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 9: Freeze-thaw resistance — Scaling — Complementary element [Technical Specification];*
- *Part 10: Determination of the relative carbonation resistance of concrete [Technical Specification];*
- *Part 11: Determination of the chloride resistance of concrete, unidirectional diffusion;*
- *Part 13: Determination of secant modulus of elasticity in compression.*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: 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.

## Introduction

Concrete structures exposed to the effects of freezing and thawing need to be durable to have an adequate resistance to this action and, in cases such as road construction, to freezing and thawing in the presence of de-icing agents. It is desirable, especially in the case of new constituents or new concrete compositions, to test for such properties. This also applies to concrete mixes, concrete products, precast concrete, concrete members or concrete *in situ*.

There are two types of concrete deterioration when a freeze–thaw attack occurs, scaling and internal structural damage. Test methods on internal structural damage are described in the CEN Technical Report CEN/TR 15177, *Testing the freeze-thaw resistance of concrete — Internal structural damage*.

Many different test methods have been developed. No single test method can completely reproduce the conditions in the field in all individual cases. Nevertheless, any method should at least correlate to the practical situation and give consistent results. Such a test method may not be suitable for deciding whether the resistance is adequate in a specific instance but will provide data of the resistance of the concrete to freeze–thaw-attack and freeze–thaw-attack in the presence of de-icing agents.

If the concrete has inadequate resistance then the freeze–thaw attack can lead to two different types of damage, namely to scaling (surface weathering) and to internal structural damage. This part of this standard covers only testing for scaling resistance.

This Technical Specification has one reference method and two alternative methods. For routine testing either the reference method or one of the two alternative methods may be used with the agreement of the parties involved. In case of doubt, and if there is no such agreement, the reference method is used.

The testing methods may be used for comparative testing or for assessment against fixed acceptance criteria. The application of limiting values will require the establishment of the correlation between laboratory results and field experience. Due to the nature of the freeze–thaw action, such correlation would have to be established in accordance with local conditions, reflected in the national application documents.

## 1 Scope

This Technical Specification describes the testing of the freeze–thaw scaling resistance of concrete both with water and with sodium chloride solution. It can be used either to compare new constituents or new concrete compositions against a constituent or a concrete composition that is known to give adequate performance in the local environment or to assess the test results against some absolute numerical values based on local experiences.

Extrapolation of test results to assess different concretes, i.e. new constituents or new concrete compositions, requires an expert evaluation.

**NOTE** In some cases the test methods may not be suitable for testing special concretes e.g. high strength concrete or permeable concrete. In these cases the result needs to be treated with caution. Also, the testing methods included in this document may not identify aggregates that are subject to occasional ‘pop-outs’.

There is no established correlation between the results obtained by the three test methods. All tests will clearly identify poor and good behaviour, but they differ in their assessment of marginal behaviour. The application of different acceptance limits for test results enables assessment for different degrees of exposure severity. In case of justified modifications of the test parameters, precautions might apply. Some alternative applications are described in Annex A.

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

[SIST-TS CEN/TS 12390-9:2017](#)

ISO 5725 (all parts), *Accuracy (trueness and precision) of measurement methods and results*

[686431ab5cce/sist-ts-cen-ts-12390-9-2017](#)

## 3 Terms and definitions

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

### 3.1

#### **freeze-thaw resistance**

resistance against alternating freezing and thawing in the presence of water alone

### 3.2

#### **freeze-thaw resistance with de-icing salt**

resistance against alternating freezing and thawing in the presence of de-icing salt

### 3.3

#### **scaling**

loss of material at the testing surface of concrete due to freeze-thaw attack

### 3.4

#### **internal structural damage**

cracks inside concrete which cannot be seen on the surface, but which lead to an alteration of concrete properties, e. g. reduction of the dynamic modulus of elasticity

## 4 Making of test specimens

Except where details are specified in Clauses 5, 6 and 7 (e.g. the curing) prepare the test specimens in accordance with EN 12390-2. Concrete that requires vibrating for compaction is compacted on a vibrating table. The pre-storage conditions concerning temperature and moisture are documented.

The maximum aggregate size  $D_{\text{upper}}$  is restricted to one third of the mould length.  $D_{\text{upper}}$  is the upper permitted value of  $D$  for the coarsest fraction of aggregates in the concrete.

## 5 Slab test (reference method)

### 5.1 Principle

Slab specimens, sawn from concrete test specimens (Figure 1), are subjected to freeze–thaw attack in presence of a 3 mm deep layer of de-ionized water or 3 % sodium chloride (NaCl) solution. The freeze–thaw resistance is evaluated by the measurement of mass scaled from the testing surface after 56 freeze–thaw cycles.

### 5.2 Equipment

**5.2.1 Equipment for making 150 mm concrete cubes** according to EN 12390-2.

**5.2.2 Climate controlled room or chamber** with a temperature of  $(20 \pm 2)$  °C, a relative humidity of  $(65 \pm 5)$  % and an evaporation rate from a free water surface of  $(45 \pm 15)$  g/(m<sup>2</sup> h)<sup>1)</sup>.

Normally this evaporation rate is obtained with a wind velocity  $\leq 0,1$  m/s. The evaporation rate is measured from a bowl with a depth of approximately 40 mm and a cross section area of  $(225 \pm 25)$  cm<sup>2</sup>. The bowl is filled up with water to  $(10 \pm 1)$  mm from the brim.

The CO<sub>2</sub> content level shall be measured, recorded and kept at a daily average in the range of (300 – 1 000) ppmv to allow for carbonation<sup>2)</sup>.

**5.2.3 Diamond saw for concrete cutting.**

**5.2.4 Rubber sheet**,  $(3 \pm 0,5)$  mm thick which is resistant to the salt solution used and elastic down to a temperature of  $-27$  °C, or any alternative moisture retaining lining arrangement.

**5.2.5 Adhesive for gluing the rubber sheet to the concrete specimen.**

The adhesive is resistant to the environment in question.

NOTE Contact adhesive has proved to be suitable.

**5.2.6 Expanded Polystyrene cellular plastic**,  $(20 \pm 1)$  mm thick with a density of  $(18 \pm 2)$  kg/m<sup>3</sup> or alternative thermal insulation with at least a heat conductivity of 0,036 W/(m·K).

**5.2.7 Polyethylene sheet**, 0,1 mm to 0,2 mm thick.

**5.2.8 Freezing medium**, consisting either of 97 % by mass of tap water and 3 % by mass of NaCl (for test with de-icing salt) or of de-ionized water only (for test without de-icing salt).

1) Increased rate of surface evaporation and carbonation influences the microstructure. Different types of concrete will be affected in different ways and to a different extent, having impact on moisture exchange and ranking of the performance.

2) Under ambient (indoor/outdoor) and normal working conditions, adequate CO<sub>2</sub> level will automatically be maintained. For smaller, separate rooms or cabinets, the CO<sub>2</sub> level may drop significantly, and the level needs to be re-established by introducing fresh air or by other means adding of CO<sub>2</sub>.



**5.2.9 Freezing chamber** with temperature and time controlled refrigerating and heating system with a capacity such that the time-temperature curve presented in Figure 4 can be obtained in specimen, regardless of its position in the chamber.

The freezer has a good air circulation. The open-mesh shelves in the freezer are level. No deviation from the horizontal plane shall exceed 3 mm per metre in any direction.

**5.2.10 Thermocouples, or an equivalent temperature measuring device**, for measuring the temperature in the freezing medium on the test surface (see Figure 3) with an accuracy within  $\pm 0,5$  K.

**5.2.11 Vessel for collecting scaled material.**

The vessel is suitable for use at temperatures up to 120 °C without mass loss and is resistant to attack by sodium chloride.

**5.2.12 Suitable paper filter for collecting scaled material**, optional.

**5.2.13 Synthetic brush**, resembling a cloth brush, with semi- soft polyamide (nylon) hairs (see specification in Annex B).

**5.2.14 Spray bottle**, containing tap water for washing off scaled material.

**5.2.15 Drying cabinet**, controlled at a temperature of  $(110 \pm 10)$  °C.

**5.2.16 Balance**, with accuracy within  $\pm 0,05$  g

**5.2.17 Vernier callipers**, with accuracy within  $\pm 0,1$  mm

**5.2.18 CO<sub>2</sub> measurement apparatus.**

**5.3 Preparation of test specimens**

The test requires four specimens, one from each of four cubes.

During the first day after casting the cubes are stored in the moulds and protected against drying by use of a polyethylene sheet. The air temperature is  $(20 \pm 2)$  °C.

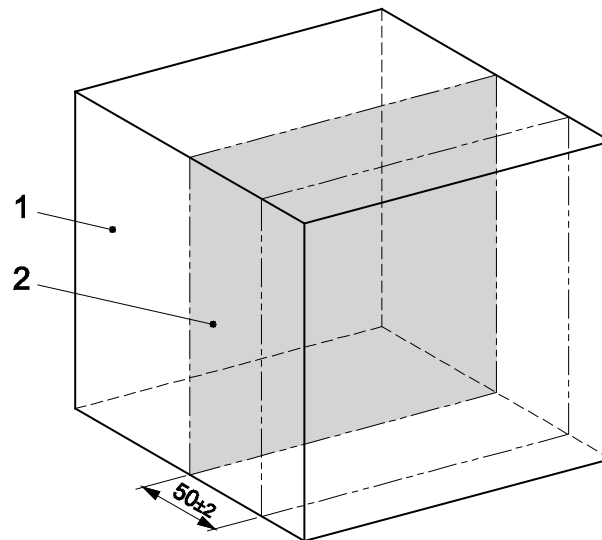
After  $(24 \pm 2)$  h, the cubes are removed from the moulds and placed in a bath with tap water having a temperature of  $(20 \pm 2)$  °C.

When the cubes are 7 d old, they are removed from the water bath and placed in the climate chamber (5.2.2), where they are stored until the freeze–thaw testing starts.

At  $(21 \pm 1)$  d <sup>3)</sup>  $(50 \pm 2)$  mm thick specimen is sawn from each cube perpendicular to the top surface so that the saw cut for the test surface is located in the centre of the cube, see Figure 1. The variation in thickness within a specimen shall not exceed 2 mm.

3) If for any reason (e.g. difficulties in delivery of samples, ...), the cutting date is not strictly 21 d, it is vital to strictly keep the following step for pre-conditioning in the seven days and the re-saturation in the consecutive three days. As a consequence, the final age of the sample may vary accordingly.

Dimensions in millimetres

**Key**

- 1 top surface at casting
- 2 test surface

**Figure 1 — Location of test specimen and test surface in sawn cube**

Directly after sawing, wash the specimen in tap water and wipe off the excess water with a moist sponge. Measure all dimensions of the specimen to an accuracy of  $\pm 0,5$  mm by using vernier callipers (5.2.17). Without delay, return it to the climate chamber ensuring that the test surface is vertical with a space between the specimens of at least 50 mm.

When the concrete is  $(25 \pm 1) d^4)$  old, rubber sheet, or any alternative moisture retaining lining arrangement, is glued to all surfaces of the specimen except the test surface (the bottom surface rubber does not necessarily need to be glued, see 5.5)<sup>5)</sup>. Place a string of glue or silicone rubber around the test surface in the joint between the concrete and the rubber. The edge of the rubber sheet reaches  $(20 \pm 1)$  mm above the test surface. After fixing the rubber sheet the specimen shall be returned to the climate chamber.

NOTE 1 The adhesive is normally spread on the concrete surfaces as well as on the rubber surfaces. The manner of gluing the rubber sheet illustrated in Figure 2 has been proved suitable.

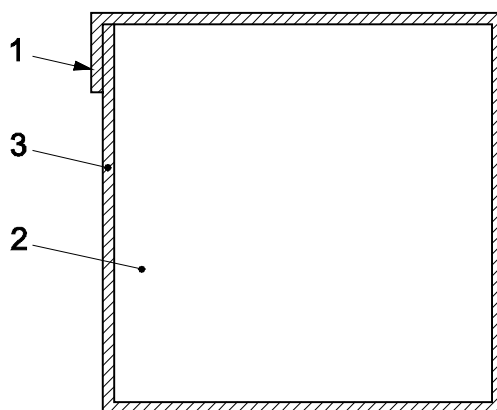
When the concrete is 28 d old, pour a layer about 3 mm deep of de-ionized water at a temperature of  $(20 \pm 2)$  °C on the top surface. This re-saturation continues for  $(72 \pm 2)$  h at  $(20 \pm 2)$  °C during which time the liquid layer shall be maintained at about 3 mm.

NOTE 2 For a specimen with the test area of 150 mm x 150 mm, 67 ml de-ionized water gives an approximately 3 mm thick layer.

During the freeze-thaw cycling, all surfaces of the specimen except the test surface are thermally insulated with  $(20 \pm 1)$  mm thick polystyrene cellular plastic (5.2.6) according to the test set-up in Figure 3. Another material or thickness providing equivalent thermal insulation can be used instead.

4) If for any reason (e.g. difficulties in delivery of samples, ...), the cutting date is not strictly 21 d, it is vital to strictly keep the following step for pre-conditioning in the seven days and the re-saturation in the consecutive three days. As a consequence, the final age of the sample may vary accordingly.

5) The objective of the glued rubber sheet is to ensure one-dimensional moisture exchange of the specimen prior to and during the freeze-thaw exposure.

**Key**

(top view)

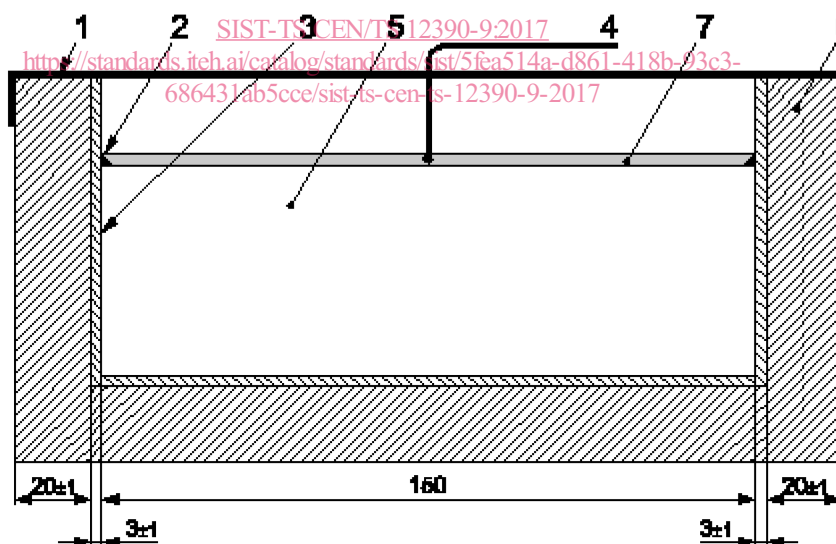
- 1 overlap
- 2 test surface
- 3 rubber sheet

**Figure 2 — Sealing the test specimen**

Start the test when the specimens are 31 d old, including 3 d of re-saturation. Not earlier than 15 min before the specimens are placed in the freezing chamber (5.2.9), replace the de-ionized water on the test surface with 3 mm of the freezing medium (5.2.8), at a temperature of  $(20 \pm 2) ^\circ\text{C}$ .

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Dimensions in millimetres

**Key**

(side view)

- 1 polyethylene sheet
- 2 glue string
- 3 rubber sheet
- 4 temperature measuring device in contact with the test surface
- 5 specimen
- 6 thermal insulation
- 7 freezing medium

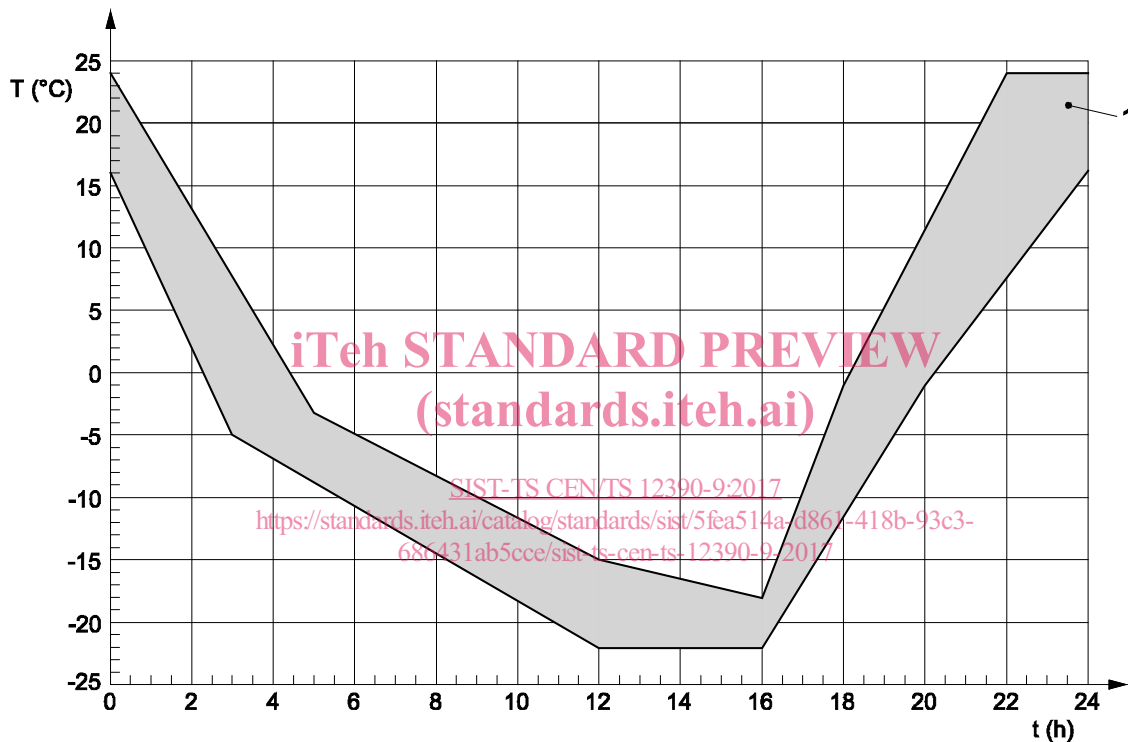
**Figure 3 — The test set-up used for the freeze-thaw test**

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The freezing medium is prevented from evaporating by applying a nearly flat, horizontal polyethylene sheet (5.2.7) as shown in Figure 3. The polyethylene sheet remains flat throughout the test so that the distance between the sheet and the surface of the freezing medium is at least 15 mm.

#### 5.4 Test procedure

To begin the test, place the specimens in the freezing chamber at the cycle phase time ( $0 \pm 30$ ) min according to Figure 4. After the specimens have been placed in the freezing chamber, subject them to repeated cycles of freezing and thawing. Monitor the temperature continuously in the freezing medium at the centre of the test surface for at least one specimen in the freezing chamber. During the test, the temperature in the freezing medium shall fall within the shaded area shown in Figure 4. The temperature shall exceed  $0\text{ }^{\circ}\text{C}$  during each cycle for at least 7 h but not more than 9 h. The air temperature in the freezer shall never fall below  $-27\text{ }^{\circ}\text{C}$ .



#### Key

- 1 temperature range at the centre of the test surface

**Figure 4 — Time (t) -temperature (T) cycle in the freezing medium at the centre of the test surface**

The points specifying the shaded area in Figure 4 are given in Table 1 below: