CONCRETE, REPAIR MATERIALS AND PROTECTIVE COATING:
SHRINKAGE AND SWELLING

Key words: Test method, protective coating, concrete

1 SCOPE
The method describes a test for measuring the shrinkage or swelling of repair mortars during the hardening period and the subsequent desiccation period.

2 AREA OF APPLICATION
The method is a laboratory method in which the changes in length of a mortar prism are measured during a standard hardening period. The method was developed especially to be applied for the description of repair mortars. The maximum particle size of the material must not exceed 8 mm.

3 REFERENCES
Danish Standard 427 Portland Cement. 1st ed. May, 1973, paragraph 4.6.2.1
NT BUILD 197:
Concrete, fresh: Stiffening (Penetration resistance)
NT BUILD 295:

4 DEFINITIONS
Shrinkage: Shrinkage is a reduction in length of a test sample caused by desiccation.
Swelling: Swelling is an increase in length of a test sample caused by water absorption.

Stiffening: Stiffening is the age of the mortar at a penetration resistance of 3.5 MN/m², when the freshly cast mortar is stored at 20°C ± 2°C. (Refer to NT BUILD 197.)

5 SAMPLING
Three prisms (40 x 40 x 160 mm) for each test (shrinkage and swelling) are cast from the mixed mortar. Measuring pins are cast into the end faces of the prisms. (See figure of prism.)

The mortar is compacted in the moulds placed on a drop table until a smooth surface is obtained, normally after 60 strokes for 1 minute. The moulds are then carefully covered and stored according to the stiffening period of the mortar.

<table>
<thead>
<tr>
<th>Stiffening period</th>
<th>Period to be covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 2 hours</td>
<td>5 - 6 hours</td>
</tr>
<tr>
<td>2 - 5 hours</td>
<td>16 - 20 hours</td>
</tr>
<tr>
<td>over 5 hours</td>
<td>approx. 4 x period of setting</td>
</tr>
</tbody>
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The temperature of mortar and air are recorded.

6 TEST METHOD
6.1 Principle
Shrinkage: During the hardening and desiccation processes the mortar is exposed to longitudinal changes due to chemical shrinkage and desiccation shrinkage. In order to determine this change the length is measured during both the hardening and the desiccation period.

Swelling: Hardened mortar stored in a water bath will absorb water and increase its volume, i.e. swell. The longitudinal change during the water curing period is measured.
6.2 Apparatus
Water container, thermostatically controlled: 20 ºC ± 2ºC
Climatic chamber: 20 ºC ± 2 ºC, 65 % RH ± 5 % RH
Measuring pins of a rust resistant material
Moulds (40 x 40 x 160 mm)
Measuring bridge for 40 x 40 x 160 mm prisms (measuring accuracy 0.01 mm)
Sliding caliper (measuring accuracy 0.1 mm)
Frictionless substratum
Proctor needle or similar for determination of penetration resistance
Drop table
The figure below illustrates the principle of drop table.

6.3 Preparation of test sample
The preparation of test samples is described in paragraph 5, Sampling.

6.4 Procedure
6.4.1 Shrinkage
The prisms are demoulded at the end of the curing period and the length between the extreme ends of the measuring pins is measured by means of the sliding caliper. The length, \( l_1 \), is calculated by subtracting the total length of the measuring pins.

The length, \( l_0 \), of each of the prisms, as measured by the length comparator, is recorded.

The prisms are placed in a climatic chamber at 20 ºC ± 2 ºC, 65 % RH ± 5 % RH.

The length, \( l_n \), is measured by the length comparator, 1, 3 and 7 days after casting and then every 7th day until a total of 84 days.

The prisms are placed on a frictionless substratum to ensure freedom of movement during the storage period.

6.4.2 Swelling
The prisms are demoulded at the end of the curing period and stored according to the instructions of the manufacturer.

If no other arrangements have been made, the prisms are stored as follows:

6.4.2.1 Portland cement based mortars: 26 days in a water bath at 20 ºC ± 2 ºC
6.4.2.2 Polymer-Portland cement based mortars:
3 days in a water bath at 20 °C ± 2 °C
25 days in a climatic chamber at 20 °C ± 2 °C
65% RH ± 5% RH

After 28 days of hardening the length between the extreme ends of the measuring pins is measured by means of a sliding caliper and the length, \( l_i \), is calculated by subtracting the total length of the measuring pins.

The length, \( l_0 \), of each of the prisms, as measured by the length comparator, is recorded.

The prisms are placed in a water bath at 20 °C ± 2 °C

The length, \( l_n \), is measured by the length comparator 1, 3 and 7 days after the hardening period and then every 7th day until a total of 84 days.

\[
\Delta l_n = \frac{l_0 - l_n}{l_i} \times 100 \%
\]

where
- \( l_i \) = the length between the extreme ends minus the total length of the measuring pins
- \( l_0 \) = the length as measured by the length comparator at the start of the measuring period
- \( l_n \) = the length as measured by the length comparator at the end of the measuring period, \( n \) days
- \( \Delta l_n \) = the change in length in % at the end of the measuring period, \( n \) days, stated to 2 decimals

Shrinkage results in positive \( \Delta l_n \).
Swelling results in negative \( \Delta l_n \).

6.6 Test report

The test report shall include the following information:

a) Name and address of the testing laboratory
b) Date and identification number of the test report
c) Name and address of the organization or the person who ordered the test
d) Test method (number and title)
e) Any deviations from the test method
f) Identification of the material
g) Casting date
h) The temperatures of the mortar and the air and the period during which the moulds were covered
i) Hardening conditions
j) Date of the start of the test
k) Test result
l) Other information essential for an evaluation of the result
m) Evaluation of the result, if included in the order
n) Date and signature.