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Test methods for natural fibre-reinforced plastic composite (NFC) deck boards

Méthodes d'essai pour les planches en composite bois-plastique (WPC)

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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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The committee responsible for this document is ISO/TC 61, *Plastics*, Subcommittee SC 11, *Products*.

Introduction

Natural fibre-reinforced composite (NFC) or wood-plastics composite (WPC) is made from one or more natural fibres or flours and a polymer or mixture of polymers. Natural fibres and flours come from different vegetable sources. Any kinds of polymers, virgin or recycled, can be used but currently the most common ones are poly(vinyl chloride), polypropylene, and polyethylene. For editorial reasons, in this International Standard, the term and abbreviation "natural fibre-reinforced composite" (NFC) is used instead of "wood-plastics composite" (WPC).

NFC materials can be considered neither as filled plastics nor as a special kind of wood material. They are to be considered as different materials having their own characteristics.

At present, the main application of NFC products is deck boards. NFC deck boards can be processed by different techniques, as extruding for profiles and pipes, compression moulding or injection moulding.

Recently, industrial interests have focused on NFC as a composite material partially derived from biomass.

However, as NFC's main constituents are hydrophilic natural fibres and hydrophobic polymer(s), problems such as cracking, bending, and strength reduction may occur in case of long-term use due to their different characteristics in the use environment related to e.g. moisture, UV resistance and thermal changes. However, due to the lack of standardized testing methods to evaluate the performance and durability of NFC, it is difficult to give the orientation for the product development and to protect the consumers' interest. Consequently International Standards are being established in order to encourage technology development in the NFC production field and to protect consumers from NFC products of low quality.

Test methods for natural fibre-reinforced plastic composite (NFC) deck boards

1 Scope

This International Standard provides test methods of natural fibre-reinforced composite (NFC) deck boards used in exterior applications. This International Standard will cover the preparation of specimen, test equipments, procedures of measurements and evaluation methods.

2 Normative references

The following referenced 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.

ISO 178, *Plastics — Determination of flexural properties*

ISO 179-1, *Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test*

ISO 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 868, *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 899-2, *Plastics — Determination of creep behaviour — Part 2: Flexural creep by three-point loading*

ISO 1183-1, *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pyknometer method and titration method*

ISO 1478, *Tapping screws thread*

ISO 4892-2, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps*

ISO 8124-3, *Safety of toys — Part 3: Migration of certain elements*

ISO 9239-1, *Reaction to fire tests for floorings — Part 1: Determination of the burning behaviour using a radiant heat source*

ISO 11359-2, *Plastics — Thermomechanical analysis (TMA) — Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*

ISO 11664-1, *Colorimetry — Part 1: CIE standard colorimetric observers*

ISO 11664-2, *Colorimetry — Part 2: CIE standard illuminants*

ISO 11664-4, *Colorimetry — Part 4: CIE 1976 L*a*b* Colour space*

ISO 12460-4, *Wood-based panels-Determination of formaldehyde release*

ISO 18314-1, *Analytical colorimetry — Part 1: Practical colour measurement (in preparation)*

EN 15534-1, *Composites made from cellulose-based materials and thermoplastics (usually called wood polymer composites (WPC) or natural fibre composites (NFC)) — Part 1: Test methods for characterization of compounds and products*

3 Terms and definitions

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

3.1
natural fibre composite
NFC
product made thereof being the result of the combination of one or several cellulosic materials with one or several thermoplastics

3.2
solid type board
board that have a totally filled cross section

Note 1 to entry: It can be fixed to the supports by using anchoring clips or screws.

3.3
structured type board
board that have hollow parts in the cross section

Note 1 to entry: It can be fixed to the supports by using anchoring clips or screws.

Note 2 to entry: It is available e.g. in hollow, honeycomb, and arch types.

4 Test specimens

Unless otherwise specified, test specimens having the actual thickness and width of the product shall be used for testing. Sampling may be agreed between the supplier and the applicant.

5 Conditioning

Unless otherwise specified in the relevant test method, the test specimens shall be conditioned during at least 72 h in the standard atmosphere 23/50 according to ISO 291 [(23 ± 2) °C, (50 ± 10) % RH].

6 Test method

6.1 Density

6.1.1 Test method

The density of NFC materials shall be determined according to ISO 1183-1 Method A (immersion method).

6.1.2 Test specimens

The density of NFC materials shall be measured using test specimens which the mass is at least 1,0 g.

6.1.3 Immersion liquid

Use freshly distilled or deionised water containing not more than 0,1 % of a wetting agent to help removing air bubbles. The liquid with which the test specimens come into contact during the measurement shall have no effect on the test specimens.

6.1.4 Procedure

Weigh the test specimen, to the nearest 0,1 mg, in air while suspended with a wire of maximum diameter 0,5 mm. Record the mass of the test specimen.

Immerse the test specimen into the immersion liquid. The temperature of the immersion liquid shall be (23 ± 2) °C. Remove any adhering air bubbles with a fine wire before weighing the mass of the test specimen in the liquid. Weigh the immersed test specimen to the nearest 0,1 mg.

Calculate the density ρ_S, in grams per cubic centimetre, of the test specimen at (23 ± 2) °C, using Formula (1):

$$\rho_S = \frac{\rho_w \times m_{S,A}}{m_{S,A} - m_{S,IL}} \quad (1)$$

where

ρ_w is the density of water at 23 °C (=0,998 2 g • cm^{-3});

$m_{S,A}$ is the mass, in grams, of the test specimen in air;

$m_{S,IL}$ is the mass, in grams, of the test specimen in the immersion liquid.

6.2 Maximum bending load

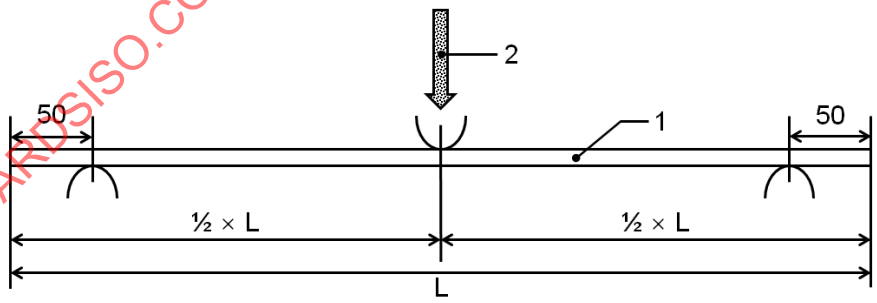
6.2.1 Test specimens

Use the width and thickness of the product as the width and thickness of the test specimen; and the length of the test specimen shall be 100 mm longer than the span length of the supports of the actual construction. If the span length of the supports is not specified, choose 600 mm as a length of specimen.

6.2.2 Test method

For the maximum bending load test, determine the radius of the pressing rod and the supports, and the testing speed in accordance with ISO 178, and then measure the maximum bending load by positioning the test specimen as shown in Figure 1. The side which is exposed upwards in construction shall be placed upwards for maximum bending load test. Perform the test using three specimens, and then obtain the mean value.

Dimensions in millimetres



Key

1 test specimen

2 applied load

L length of the test specimen

Figure 1 — Testing apparatus for the determination of the maximum bending load

6.3 Bending creep strain

6.3.1 Test specimens

The dimensions of the specimen for the bending creep strain test shall follow those of 6.2.1.

6.3.2 Test method

The testing apparatus as defined in 6.2 shall be used in the bending creep test. Increase the load to 850 N within 5 s in accordance with ISO 899-2, and, after maintaining this loaded state for 312 h, calculate the bending creep strain according to Formula (2) after durations of 168 h and 312 h at (23 ± 2) °C or durations of 48 h and 96 h at (50 ± 5) °C. The side which is exposed upwards in construction shall be placed upwards for bending creep strain test. Perform the test using three specimens, and then obtain the mean value.

$$\varepsilon_t = \frac{600 s_t \times h}{L^2} (\%) \tag{2}$$

where

ε_t is bending creep strain;

S_t is the central deformation between the supports at time (t), expressed in millimetres;

h is the thickness of the test specimen, expressed in millimetres;

L is the distance between the supports, expressed in millimetres.

6.4 Impact resistance

6.4.1 Test specimens

The dimensions of the impact resistance test shall follow those of 6.2.1.

6.4.2 Test method

If supports are used in the test position and fix the test specimen on the supports, drop a steel ball (weighing 1 042 ± 5 g and measuring 64 mm in diameter) from a height of 100 cm. In case of solid type, record the indents to an accuracy of 0,1 mm. And in case of structure type, record the cracks or indents to an accuracy of 0,1 mm.

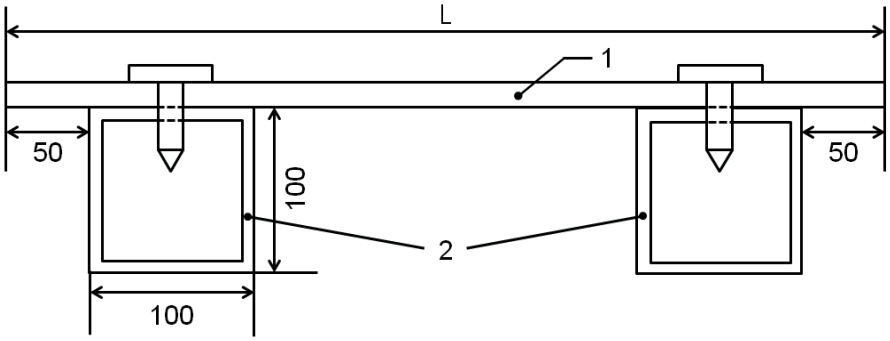
If no support is used in the construction, fix the specimen at a height of 10 cm or more from the bottom, as shown in Figure 2. Perform the tests in two kinds of conditions as described below and record the results.

The impact position can be decided by testing body and the client, but the weakest positions except edges are recommended.

For testing at the room temperature condition, maintain the test specimens at (23 ± 2) °C and (50 ± 10) % relative humidity for 3 d or more.

For testing at low temperature condition, maintain the test specimens at (–30 ± 2) °C for 24 h and immediately perform the test within 2 min.

Dimensions in millimetres



Key

1 test specimen

2 supports

Figure 2 — Impact resistant testing apparatus

6.5 Impact strength

6.5.1 Test specimens

Test specimens of type 1 according to ISO 179-1 shall be used. If a part of the product is used as the test specimen, the thickness may be up to 10,2 mm. Where, the test specimen shall have the side to be exposed outside after construction.

Table 1 — Impact strength test specimen

Dimensions in millimetres

Type	Length (l)	Width (b)	Thickness (h)	Distance between supports (L)
#1	80 ± 2	10,0 ± 0,2	4,0 ± 0,2	62 ± 0,5
NOTE The specimen dimensions (thickness, h, width, b, and length, l) are defined by h < ≤ b < l.				

6.5.2 Test method

The unnotched test specimens designated as ISO 179-1 shall be used. The impacting side shall be that is to be exposed after construction. The impact strength (a_{cu}), expressed in kJ/m^2, is calculated using 5 test specimens and Formula (3).

$$a_{CU} = \frac{E_c}{h \times b} \times 10^3 \quad (3)$$

where

E_c is the corrected absorption energy, expressed in Joule, caused by the rupture of a test specimen;

h is the thickness of the specimen, expressed in millimetres;

b is the width of the specimen, expressed in millimetres.

6.6 Distortion

6.6.1 Test specimens

The dimensions of distortion test specimens shall be specified in 6.2.1.

6.6.2 Test method

For the distortion test, maintain the test specimens at (23 ± 2) °C temperature and (85 ± 5) % relative humidity for 3 d, and at (23 ± 2) °C temperature and (35 ± 5) % relative humidity for 3 d.

Place the ruler in a diagonal line on the deck plate, while keeping the exposing side turned upwards. If the surface is concave, insert a measuring wedge in the position where the gap between the ruler and the specimen's surface is maximum. The measuring wedge shall be at a right angle with the ruler as shown in Figure 3. And, then obtain the size of the gap using the scale of the measuring wedge.

If the measuring surface is convex, insert the measuring wedge at both ends of test specimen so that the gaps between the ruler and the deck ends are almost the same, as shown in Figure 3. Measure the size of the gap and obtain the mean value. Obtain the mean value for the other diagonal line and select the larger one. Obtain the distortion value [W_a(%)] to the first decimal position using Formula (4).

$$W_a\left(\%\right) = \frac{h}{l} \times 100 \tag{4}$$

where

l is the diagonal line of the test specimen, expressed in millimetres;

h is the size of the gap as obtained from the scale of the wedge, expressed in millimetres.

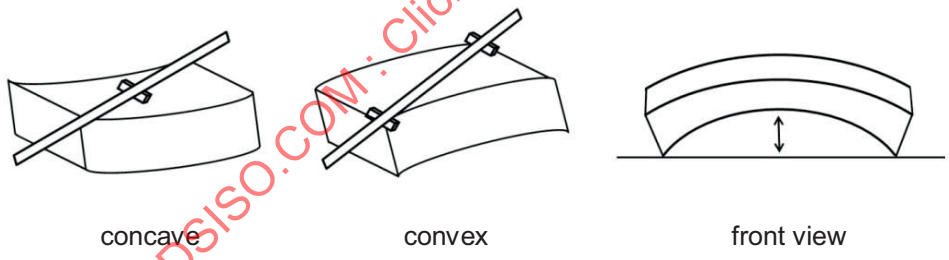


Figure 3 — Measuring distortion

If distortion of the lateral direction occur on the specimen, as shown at Figure 3, place the concave face of the test specimen to see the flat table, and measure the size of the maximum gap between the table and the test specimen to the nearest 0,1 mm.

After conditioning (Clause 5), initial distortion shall be also measured as above.

6.7 Screw holding strength

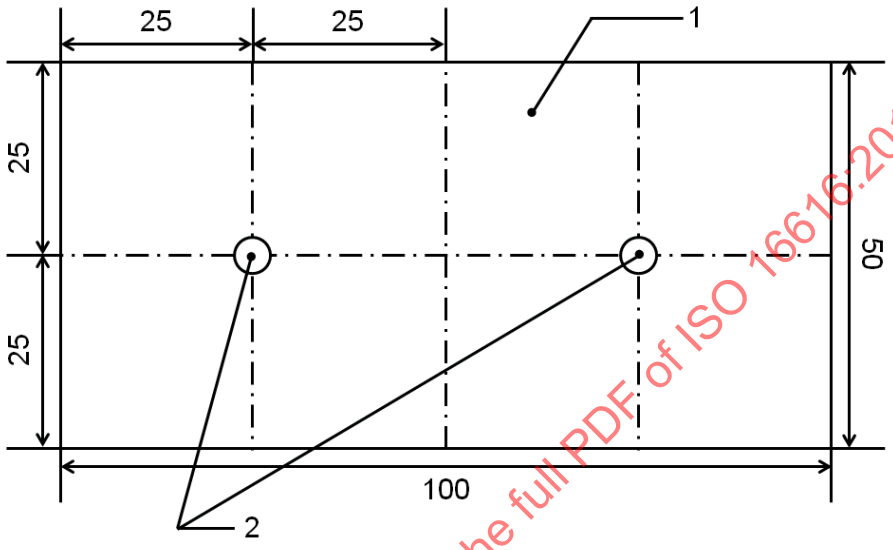
6.7.1 Test specimens

Prepare the test specimens for the screw holding strength test as shown in Figure 4.

6.7.2 Test method

For the screw holding strength test, use screws with a diameter of 4,2 mm and a length of 38 mm with a thread no. ST 4,2 according to ISO 1478. Insert them into test specimens vertically to a depth of 15 mm, as shown in Figure 4, and then pull the screws vertically. Measure each maximum load and obtain the mean value to serve as the screw holding strength. Where, the throwing load speed shall be (10 ± 1) mm/min. Also test may be conducted at the weakest point which is decided by testing body and client.

Dimensions in millimetres



Key

1 test specimen
2 drill bit

Figure 4 — Screw holding strength test

6.8 Skid resistance

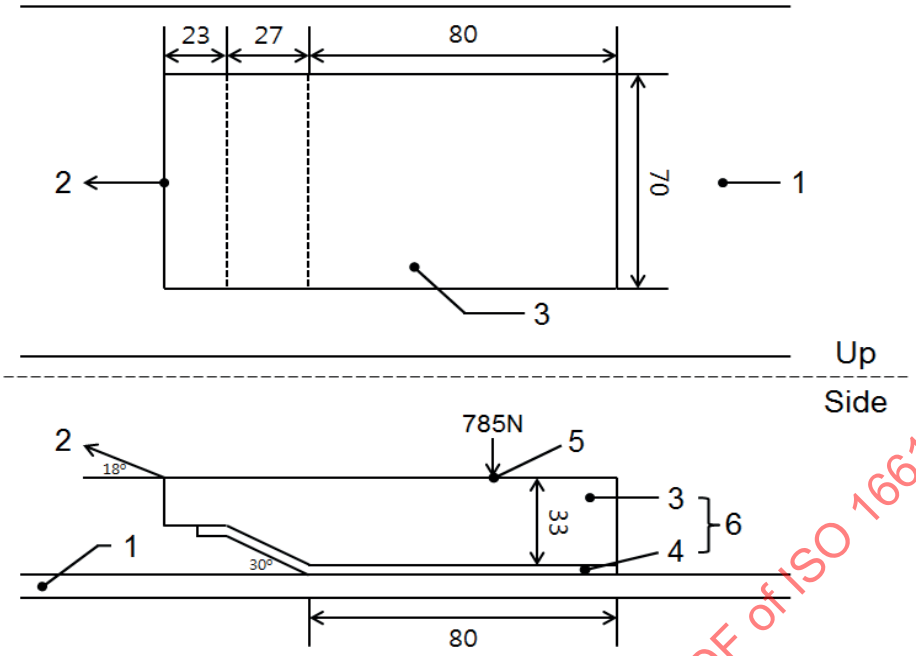
6.8.1 Test specimens

The dimensions of the test specimen for the skin resistance test shall be the same as those of the products in terms of width and thickness, while the length shall be not less than 300 mm. If the width of the product is no more than 100 mm, the width of the combined specimens shall not be less than 100 mm.

6.8.2 Test method

The skid resistance test apparatus is used. A rubber sheet with 75 approximately 80 of hardness (Shore A) in accordance with ISO 868 and 3 approximately 6 mm of thickness shall be used as the skid strip for the test, and the surface of the specimen shall be dry.

Dimensions in millimetres



Key

1 test specimen
2 tensile load
3 skid support plate
4 rubber plate
5 load point
6 skid strip

Figure 5 — Skid resistance testing apparatus

a) Attach the rubber sheet to the bottom of the steel support plate and place the skid strip in contact with the test specimen at the vertical load of 785 N. Pull the skid strip upwards at an angle of 18° and at a tensile load speed of 785 N/s, and measure the maximum tensile load. Calculate the skid resistance coefficient (CSR) using Formula (5) to 2 significant figures. Measure the CSRs at the extruded direction and at the right angles to the extruded direction, and the smaller CSR value shall be served as the skid resistance of the test specimen.

$$\mathrm{CSR} = \frac{P_{\max}}{W} \tag{5}$$

where

CSR is the skid resistance coefficient;

$P_{\max}$ is the maximum tensile load (N);

W is the vertical load (785 N).

b) Surface conditions of test specimen are chosen for the aim of test, and the testing materials are shown in the Table 2.

1) Clean and dry.

2) Wet at the amount of 200 g/m^2 of tap water.

3) Scatter the test powder 7 (Table 2) at the amount of 10 g/m^2.

4) Scatter the mixture of tap water, test powder 1, and test powder 7 (Table 2) in the proportion of 20:9:1 at the amount of 400 g/m^2.

5) Scatter the cooking oil at the amount of 40 g/m^2.

Table 2 — Skid resistance testing meterials

Classfication	Use material	Range of median diameter (weight basis) μm
1	Silica	185 approximately 200
2	Silica	27 approximately 31
3	Silica	6,6 approximately 8,6
4	Talcum	7,2 approximately 9,2
5	Fly ash	13 approximately 17
6	Usual portland cement	24 approximately 28
7	Loam	27 approximately 31

6.9 Water absorption

6.9.1 Test specimens

The thickness and width of the test specimens shall be those of the actual products from which they are prepared. The length shall be 100 mm.

6.9.2 Test method

After conditioning according to Clause 5, measure the test specimens using a balance with accuracy of 0,01 g or higher, and then measure and record the thickness, width and length of the central part of the test specimens using a calliper with accuracy of 0,1 mm or higher (Figure 6).

When measuring the thickness, width and length of the specimen, the contact span between the test specimen and calliper shall be more than 10 mm. For the measurement of thickness, the contact position shall not be less than 5 mm and not be more than 15 mm from the lengthwise-cut edge of the production direction as shown in Figure 7.

When measuring the weight and dimensions change with water absorption, choose one between the two methods described below.

a) Test method in accordance with EN 15534-1 for determining the moisture absorption in weight, thickness, width and length of test specimens. The weight, thickness, width and length of the test specimens are measured after a total moisture absorption in water at (23 ± 2) °C temperature for 28 d.

b) Immerse the test specimens in water at (100 ± 2) °C for 5 h, supporting the test specimens with suitable jigs to ensure that they do not touch the bottom of the vessel. After 5 h of submersion in boiling water, immediately immerse the test specimens in (23 ± 2) °C of water for 20 min, and then after complete removal of water from the surface of the test specimens, measure the changes in weight and dimensions.

$$\Delta W_e = \frac{W_{e2} - W_{e1}}{W_{e1}} \times 100 \quad (6)$$

where

ΔW_e is the change of weight owing to water absorption in percentage (%);

W_{e1} is the weight before immersion (g);

W_{e2} is the weight after immersion (g).

$$\Delta Th = \frac{Th_2 - Th_1}{Th_1} \times 100 \quad (7)$$

where

ΔTh is the change of thickness owing to water absorption in percentage (%);

Th_1 is the thickness before immersion (mm);

Th_2 is the thickness after immersion (mm).

$$\Delta W_i = \frac{W_{i2} - W_{i1}}{W_{i1}} \times 100 \quad (8)$$

where

ΔW_i is the change of width owing to water absorption in percentage (%);

W_{i1} is the width before immersion (mm);

W_{i2} is the width after immersion (mm).

$$\Delta Le = \frac{Le_2 - Le_1}{Le_1} \times 100 \quad (9)$$

where

ΔLe is the change of length owing to water absorption in percentage (%);

Le_1 is the length before immersion (mm);

Le_2 is the length after immersion (mm).

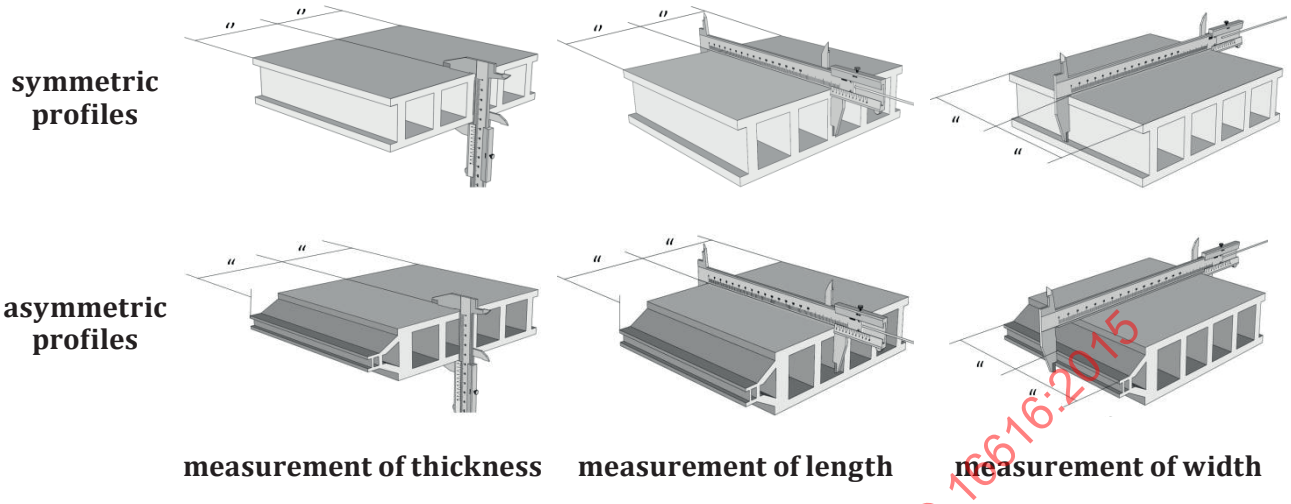


Figure 6 — Measuring points for the determination of swelling characteristics

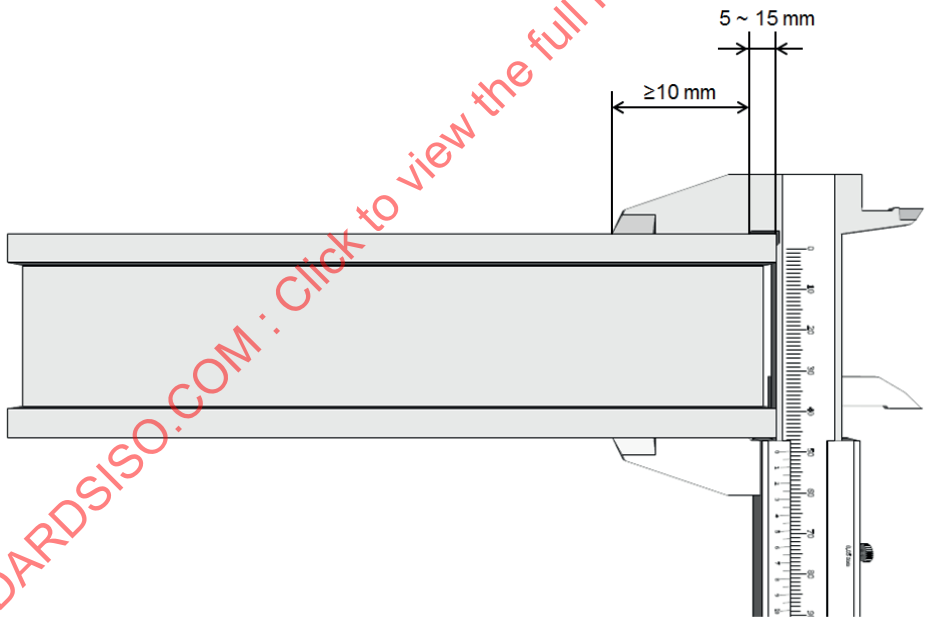


Figure 7 — Detail regarding measurement of thickness

6.10 Freeze and thaw test

6.10.1 Test specimens

The dimensions of the test specimens shall be defined in 6.2.1.