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**Test methods for fibre-reinforced  
cementitious composites — Load-  
displacement curve using notched  
specimen**

*Méthodes d'essai des composites à base de ciment renforcés par des  
fibres — Courbe de déplacement de charge utilisant un échantillon  
entaillé*

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# Contents

	Page
Foreword .....	iv
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
<b>4 Symbols</b> .....	<b>2</b>
<b>5 Test specimen</b> .....	<b>2</b>
5.1 Geometry .....	2
5.2 Fabrication of specimen .....	2
5.3 Loading of specimen .....	3
<b>6 Test equipment</b> .....	<b>3</b>
6.1 Testing machine .....	3
6.2 Loading apparatus .....	3
6.3 Measuring device for load .....	4
6.4 Measuring device for CMOD .....	4
6.5 Measuring device for LPD .....	5
<b>7 Test procedure</b> .....	<b>5</b>
<b>8 Calculations</b> .....	<b>6</b>
<b>9 Test report</b> .....	<b>6</b>
<b>Annex A (informative) Method of estimating tension softening curve</b> .....	<b>7</b>
<b>Bibliography</b> .....	<b>10</b>

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

The committee responsible for this document is ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 6, *Non-traditional reinforcing materials for concrete structures*.

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# Test methods for fibre-reinforced cementitious composites — Load-displacement curve using notched specimen

## 1 Scope

This document specifies the test method for the load-displacement curves of fibre-reinforced cementitious composites (FRCC) by three-point loading of notched prisms. The main purpose of this test is to evaluate the tension softening curve of FRCC.

NOTE 1 Both crack mouth opening displacement (CMOD) and load point displacement (LPD) are specified as the displacement in load-displacement curves, but measurement of both might not be necessary. Either can be selected depending on the purpose of measurement.

NOTE 2 Three-point bending test using notched specimen generally provides higher results than those observed in four-point bending test, in which the fracture occurs at the weakest point of the specimen.

## 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.

ISO 1920-3:2004, *Testing of concrete — Part 3: Making and curing test specimens*

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## 3 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

#### **fibre-reinforced cementitious composite**

#### **FRCC**

concrete or mortar containing short discrete fibres that are distributed in matrix

Note 1 to entry: Fibres include chemical fibres (metallic fibres, inorganic fibres, synthetic fibres, and so on) and natural fibres.

### 3.2

#### **ligament**

area above the notch subject to fracture

### 3.3

#### **notch**

cut for the initiation of fracture

4 Symbols

Symbol	Unit	Description	Reference
$a_0$	mm	depth of notch	5.1
$b$	mm	width of ligament	5.1
$D$	mm	depth of cross section of specimen	5.1
$h$	mm	height of ligament	5.1
$L$	mm	overall length of specimen	5.1
$n_0$	mm	width of notch	5.1
$S$	mm	loading span	5.1

5 Test specimen

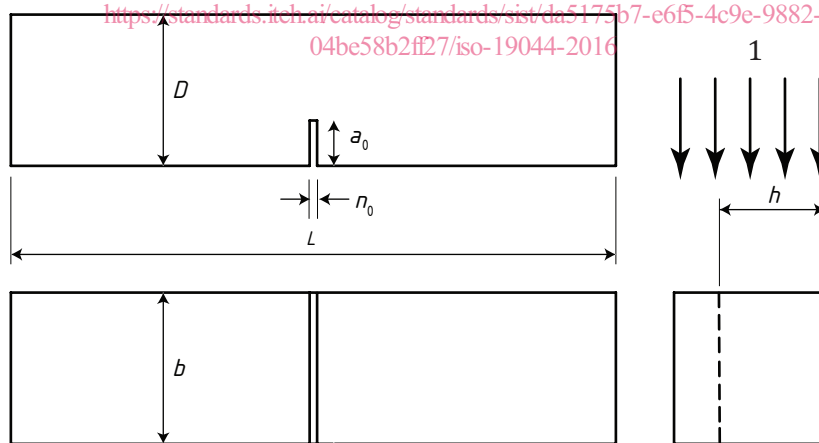
5.1 Geometry

Specimens shall be prisms of square cross section with a notch at the mid-length as shown in [Figure 1](#).

- a) The cross sectional size of the specimen shall be fixed with two types for the ease of operating as follows: 150 mm × 150 mm and 100 mm × 100 mm. The side length of the cross section of the specimen shall be equal to or larger than three times the fibre length.

The specimens with different dimensions provide different test results even if the same FRCC is used. These test results should not be compared.

- b) The overall length of the specimen ( $L$ ) shall not be less than 3,5  $D$ .
- c) The notch depth ( $a_0$ ) and notch width ( $n_0$ ) shall be 0,3  $D$  and not more than 5 mm, respectively.



Key

- 1 direction of casting

Figure 1 — Specimen

5.2 Fabrication of specimen

- a) The maximum aggregate size shall not be larger than 1/4 of the side length of the cross section of the specimen.
- b) Moulds specified in ISO 1920-3:2004, 5.2.1 shall be used.

- c) FRCC shall be placed in one placing sequence without joints. In case of flowable FRCC, pouring toward the axial direction from the one side of the mould is recommended. The internal vibrator and compacting rod/bar shall not be used.
- d) The notch shall be cut using a concrete saw when the FRCC has developed sufficient strength.  
The notch should be cut in one side that faced the side of the mould. The casting surface becomes vertical one for loading. It is not necessary to cut the edges of the notch to specific forms, as the edge shape scarcely affects the test results.
- e) The number of specimens shall be not less than six. The tolerances of specimens are  $\pm 0,5$  % for a side of section.
- f) The mass of each specimen shall be measured to the nearest 0,05 kg.

### 5.3 Loading of specimen

- a) Specimens shall be subjected to testing in a condition immediately after completion of the specified curing procedure.
- b) The direction of loading shall be perpendicular to the direction of casting of the specimen.
- c) The loading span ( $S$ ) shall be  $3 D$ . The tolerance of the loading span is  $\pm 2$  %.

## 6 Test equipment

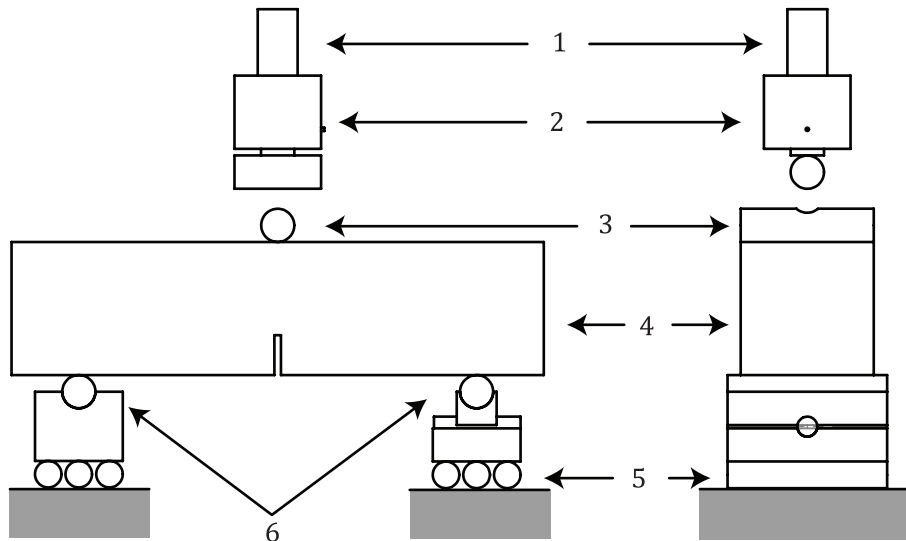
### 6.1 Testing machine

A testing machine capable of operating in a controlled manner, i.e. producing a constant rate of displacement (CMOD or LPD), and with sufficient stiffness shall be used.

### 6.2 Loading apparatus

In order to eliminate torsional action on the specimen, the loading block and one of the supports shall be rotatable around their axes in the direction of the specimen axis. Both supports shall be hinged with rollers in order to avoid any restraint on the deformation until the specimen completely ruptures.

Both supports should be movable, as the horizontal movement of the specimen is restrained at the loading block. Inserting multiple rods under both supports as shown in [Figure 2](#) is a simple and effective solution for a movable mechanism. In order to ensure the absence of horizontal restraint, it is advisable to press the specimen lightly by hand before applying any load to confirm smooth movement of the specimen in the horizontal direction.



**Key**

- 1 machine head
- 2 load cell
- 3 round bar
- 4 specimen
- 5 roller
- 6 round bar  $\phi = 20 \text{ mm} - 30 \text{ mm}$

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**Figure 2 — Loading apparatus**

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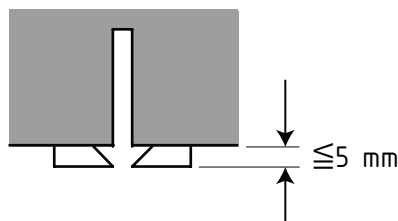
**6.3 Measuring device for load**

The load shall be measured using a load cell with an accuracy of 1 % of the estimated peak load or better. The load cell shall be fixed to the testing machine.

**6.4 Measuring device for CMOD**

The CMOD shall be measured using a clip gauge with an accuracy of 1/500 mm or better. If clip gauges cannot be directly attached to the notch, knife-edges are used. The thickness of the knife-edges to which the clip gauge is attached shall be not more than 5 mm (Figure 3). If the knife-edges are used, measuring position of CMOD shall be indicated in the test report. Also, if the inverse analysis is conducted, the measuring position should be considered.

Knife-edges, which should be made of metal, should be attached as shown in Figure 3 using an adhesive to ensure bond with the specimen. When wet testing is to be conducted with knife-edges attached to the specimen with an adhesive, the surfaces receiving the knife-edges have to be temporarily dried at the time of adhering. In this case, it is advisable that the portions other than the surfaces receiving the knife-edges be covered with a wet cloth or immersed in water to avoid drying.

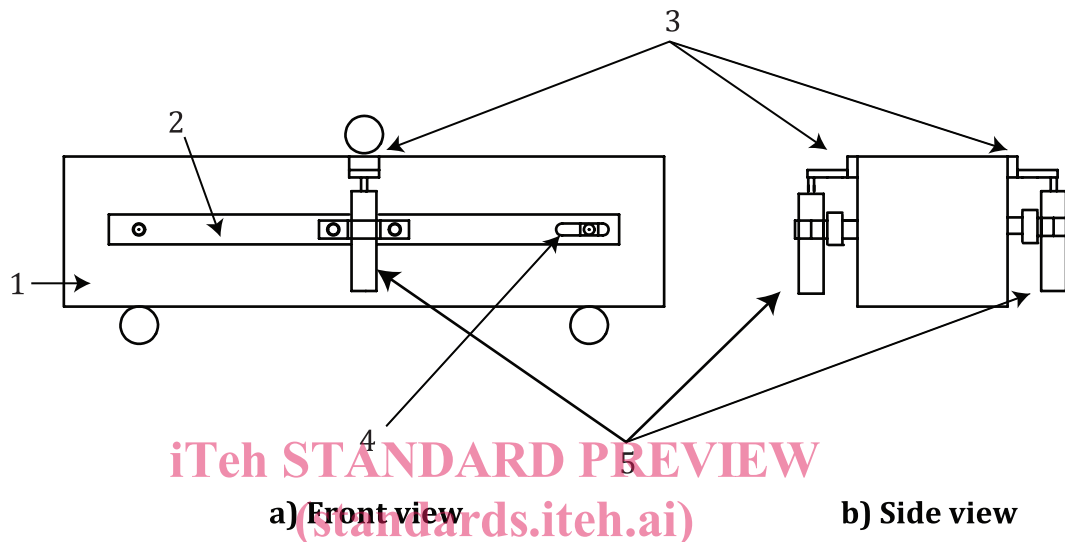


**Figure 3 — Knife-edges**



## 6.5 Measuring device for LPD

The LPD shall be measured using displacement transducers as shown in Figure 4. The transducers shall have an accuracy of 1/500 mm or better. Holder frames, made of aluminium or steel bars, shall be used in order to eliminate the rigid-body displacement of the specimen and its deformation due to crushing at the loading and support points. The loose hole shall be made at the one support of the holder frames in order to avoid the restraint on the axial deformation of the specimen. The measuring points shall be, as a rule, on both sides of the specimen directly below the loading point using angles. However, if it is difficult to fix displacement transducers at such points, measurement at the shoulders of the notch near the bottom centre is permitted.



### Key

- 1 specimen
- 2 holder frame
- 3 angle
- 4 loose hole
- 5 displacement transducer

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**Figure 4 — Measuring system of LPD**

## 7 Test procedure

- a) Set the specimen on the loading apparatus so that the notch shall be located on the bottom.
- b) Load the specimen continuously and without shock.
- c) The CMOD (or LPD) shall be increased at a constant rate of 0,05 mm/min. After the CMOD (or LPD) reach 0,1 mm, the rate may be increased to a constant rate of 0,2 mm/min.

Though it is desirable to keep the loading rate constant from the beginning through the end of testing, it can be increased within the range of not substantially affecting the load-displacement curve, to shorten the testing time, after the post-cracking reductions in the load have settled. The method of such a change in the loading rate shall be reported.

- d) Measure the load and CMOD and/or LPD continuously from the beginning through the end of testing. The intervals between readings by a digital measuring device shall be short enough to permit 20 or more readings before the peak load is reached. Testing shall be continued until the