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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Testing of concrete —

Part 4:
Strength of hardened concrete

(Revision of ISO 4012:1978, ISO 4013:1978 and ISO 4108:1980)

Essais du béton —

Partie 4: Résistance du béton durci

ICS 91.100.30

In accordance with the provisions of Council Resolution 15/1993 this document is circulated in the English language only.

Conformément aux dispositions de la Résolution du Conseil 15/1993, ce document est distribué en version anglaise seulement.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

Pour accélérer la distribution, le présent document est distribué tel qu'il est parvenu du secrétariat du comité. Le travail de rédaction et de composition de texte sera effectué au Secrétariat central de l'ISO au stade de publication.

Contents

Foreword

This Standard Is one of a series of standards concerned with testing concrete.

The standards in the series are:

ISO 1920 part 1 - Testing Concrete: Sampling of fresh concrete.

ISO 1920 part 2 - Testing Concrete: Properties of fresh concrete.

ISO 1920 part 3 - Testing Concrete: Making and curing of test specimens.

ISO 1920 part 4 - Testing Concrete: Strength of hardened concrete.

ISO 1920 part 5 - Testing Concrete: Properties of hardened concrete other than strength.

ISO 1920 part 6 - Testing Concrete: Sampling, preparing and testing concrete cores.

ISO 1920 part 7 - Testing Concrete: Non-destructive tests of hardened concrete.

This series of Draft International Standards was prepared based on ISO standards and drafts and on the CEN Standards dealing with test methods of concrete.

This edition of DIS was amended as decided at the 2nd meeting of ISO/TC 71 SC 1 held in Sep. 2000 in Tokyo.

Testing of concrete —

Part 4:
Strength of hardened concrete

1 Scope

This standard specifies procedures for testing the strength of hardened concrete.

2 References

The following referenced documents are indispensable for the application 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 48, *Rubber, vulcanized or thermoplastic – Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 1920 *Part 3, Testing Concrete—Making and curing of test specimens*

ISO 3310-1, *Test Sieves*: T*echnical requirements and testing –Test sieves of metal wire cloth.*

EN 196 – 1:1994 - *Methods of testing cement— Part 1: Determination of strength*

EN 197 – 1 :2000, *Cement – Composition, specifications and conformity criteria for common cements*

EN 316 :1999, *Wood fiberboards - Definition, Classification and symbols*

EN 12390 – 4:2000, *Testing Hardened Concrete— Part 4: Compressive Strength -Specification for testing machines.*

3 Determination of compressive strength

3.1 Test specimens

3.1.1 Requirement

The test specimen shall meet the requirements of ISO 1920 part 3.

Damaged specimens shall not be tested.

Specimens which are badly honeycombed should not be tested.

Note In case the designated size (d) of the corss-section are outside the tolerances, the specimens may be used for testing by using the actual dimensions, see 3.4.

3.1.2 Adjustment of test specimens

Where the dimensions or shapes of test specimens do not comply with the requirements given in ISO /DIS 1920 part 3, because they exceed the respective tolerances, they shall be rejected or adjusted (if feasible) as follows:

- uneven surfaces may be levelled by grinding or by capping.

- the deviation of angles shall be corrected by cutting and/or grinding.

One of the methods given in Annex B shall be used to adjust the specimen.

Adjustment by grinding shall be the reference method

Specimens shall be tested in a compression testing machine complying with EN 12390-4.

The test machine shall be in calibration at the time of test. The calibration shall be carried out at least once per year, unless an accredited QA system requires a different calibration interval.

3.3 Procedure

3.3.1 Specimen preparation and positioning

Excess moisture shall be wiped from the surface of the specimen before placing in the testing machine.

All testing machine bearing surfaces shall be wiped clean and any loose grit or other extraneous material removed from the surfaces of the specimen that will be in contact with the platens.

No packing shall be used between the specimen and the platens and the spacing blocks if used.

Cube specimens shall be compressed perpendicularly to the direction of casting.

The specimen shall be centred on the lower platen to an accuracy of 1% of the designated size of cubic, or diameter of cylindrical specimens.

Where physical means of ensuring centring are provided on the testing machine, then these shall be deemed to satisfy the requirements for ensuring the accuracy of centring.

If auxiliary platens are used, the top auxiliary platen shall be aligned with the top of the specimen.

NOTE With two-column testing machines, cubic specimens should be placed with the trowelled surface facing a column.

3.3.2 Loading

The load shall be applied without shock and shall be increased continuously at a constant rate until no greater load can be sustained. The rate of load increase shall be not less than 0.2 MPa/sec and not greater than 1.0 MPa/sec.

When using manually controlled testing machines, any tendency for the selected rate of loading to decrease, as specimen failure is approached, shall be corrected by appropriate adjustment of the controls.

When using automatically controlled testing machines, the rate of loading, whilst testing concrete specimens in compression, shall be periodically checked to ensure that the rate is constant.

The maximum load indicated shall be recorded.

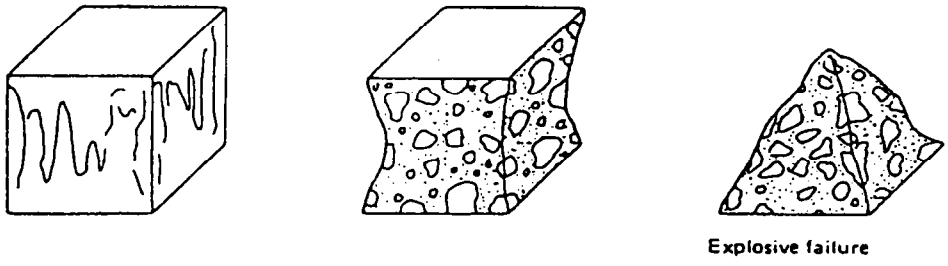
NOTE For specimens stored in water, the time permitted between taking out from water and beginning of loading should be half an hour maximum.

3.3.3 Assessment of type of failure

For cubic specimens, if the failure is satisfactory (see Figure 1), the fact shall be recorded. If the failure pattern is unsatisfactory, the fact shall be recorded and the type of failure shall also be recorded, together with the pattern number in Figure 2 closest to that observed.

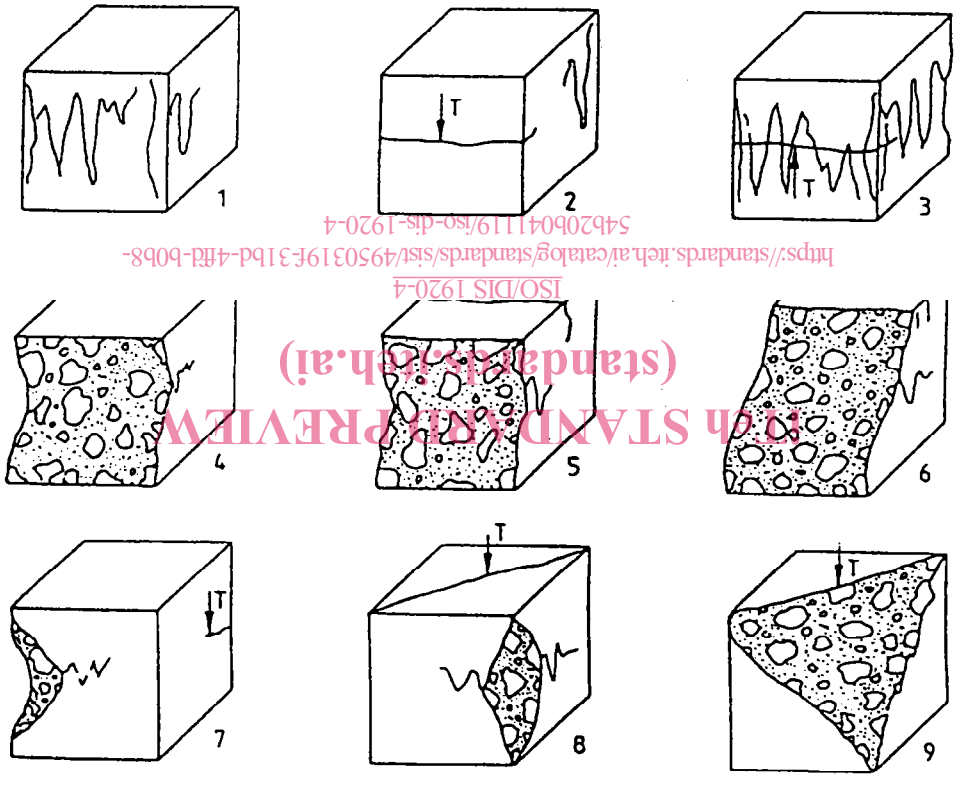
For cylindrical specimens, if the failure is satisfactory (see Figure 3), the fact shall be recorded. If the failure pattern is unsatisfactory, the fact shall be recorded and the type of failure shall also be recorded, together with the pattern letter in Figure 4 closest to that observed.

NOTE Unsatisfactory failures are usually caused by insufficient attention to the detailed procedures for making, capping and testing specimens. It is also possible for a machine fault to be the cause of an unsatisfactory failure.



NOTE All four exposed faces are cracked approximately equally, generally with little damage to faces in contact with the platens.

Figure 1 — Satisfactory failures of cube specimens



NOTE T = tensile crack

Figure 2 — Some unsatisfactory failures of cube specimens

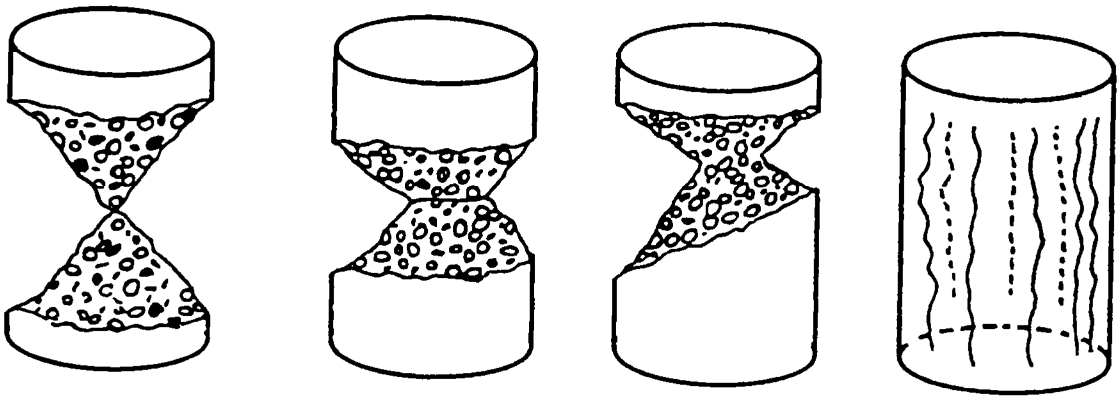


Figure 3 — Satisfactory failure of cylinder specimen

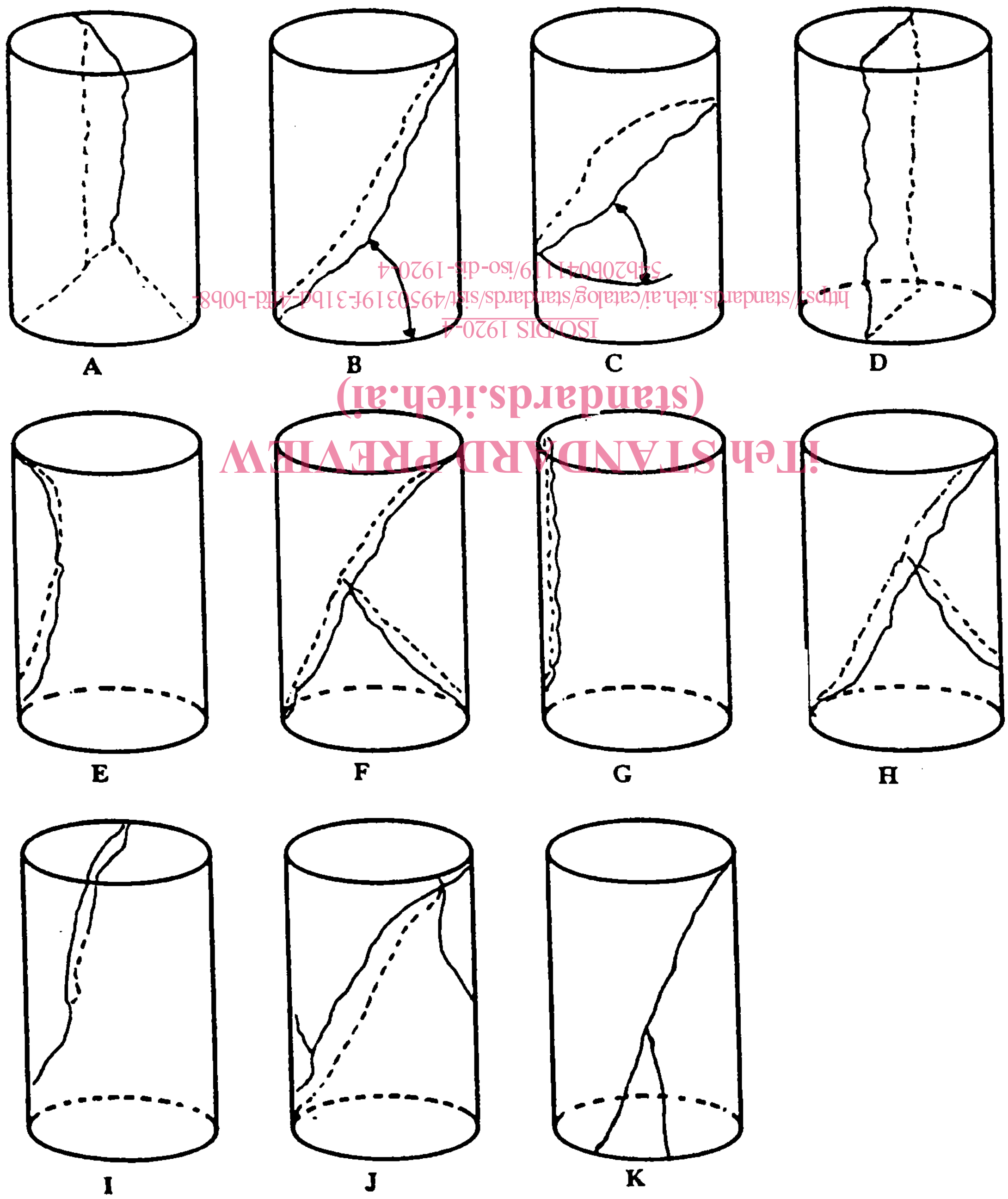


Figure 4 — Some unsatisfactory failures of cylinder specimens

3.4 Test results

The compressive strength is given by the equation:

$$f_c = \frac{F}{A_c}$$

where:

f_c is the compressive strength, in MPa

F is the maximum load, in N

A_c is the cross-sectional area of the specimen on which the compressive force acts, in mm^2

If the actual dimensions of the test specimen are within ± 0.5% of the designated size, the strength may be calculated on the basis of the designated size. If the actual dimensions are outside this tolerance, the strength calculation shall be based on the actual dimensions of the test specimen, determined in accordance with ISO 1920 part 3.

The compressive strength shall be expressed to the nearest 0.5 MPa.

3.5 Test report

In addition to the details required in clause 6, the test report shall include:

- method of adjustment
- compressive strength of specimen (to the nearest 0.5 MPa)
- type of failure (satisfactory or unsatisfactory, and if unsatisfactory the nearest type).

4 Determination of flexural strength

4.1 Test specimens

The test specimen shall be prisms.

Sawn specimens of nominal depth (d) of 100 mm or 150 mm with a square cross-section and overall length of between 4d and 5d may also be tested to this standard. The ratio of (d) to the maximum size of aggregate shall be not less than four.

The direction of casting shall be identified on the specimen

4.2 Apparatus

4.2.1 Testing machine,

The test shall be carried out using a testing machine complying with EN 12390–Part 4, clauses 4.2 and 4.3.

4.2.2 Force application,

The device for applying loads shall consist of two upper rollers and two lower rollers (see Figure 5) (This is the reference device.)

In the case where a centre-point load is used, the method of test shall be changed in accordance with Annex C.

All rollers shall be manufactured from steel and shall have a circular cross-section with a diameter between 20 mm and 40 mm; they shall be at least 10 mm longer than the width of the test specimen.

Each roller, except one of the lower ones, shall be capable of rotating around its axis and of being inclined in a plane normal to the longitudinal axis of the test specimen.

The distance, l , between the outer rollers (i.e. the span) shall be equal to 3d, where d is the width of the specimen. The distance between the inner rollers shall be equal to d. The inner rollers shall be equally spaced between the outer rollers as shown in Figure 5. All rollers shall be adjusted in their correct position with all distances having an accuracy of ± 2.0 mm.

4.3.1 Preparation and positioning of specimens

The specimen shall be examined and any abnormalities observed shall be reported.

For specimens stored in water, excess moisture should be wiped from the surface of the specimen before placing in the testing machine.

Specimens should not lose dampness before the test. For this, the time elapsed between its extraction from the humidity chamber or the water tank until the test wil be a maximum of 3 hours. During this time, the specimen will be maintained covered with wet burlap.

All testing machine bearing surfaces shall be wiped clean and any loose grit or other extraneous material removed from the surfaces of the specimen that will be in contact with the rollers.

The test specimen shall be placed in the machine, correctly centred with the longitudinal axis of the specimen at right angles to the longitudinal axis of the rollers.

The reference direction of loading is perpendicular to the direction of casting of the specimen.

NOTE The test result may be affected by the direction of loading with respect to the direction of casting.

4.3.2 Loading

The load shall not be applied until all loading and supporting rollers are resting evenly against the test specimen.

The load shall be applied without shock and shall be increased continuously at a constant rate until no greater load can be sustained. The rate of load increase shall be not less than 0.2 MPa/sec and not greater than 1.0 MPa/sec.

NOTE The required loading rate on the testing machine is given by the formula:

$$R = \frac{s \times d_1 \times d_2^{\,2}}{\ell}$$

where:

R is the required loading rate, in N/s

s is stress rate, in N/(mm^{2}s)

d_1, d_2 are the lateral dimensions of the specimen, in mm.

When using manually controlled testing machines, any tendency for the selected rate of loading to decrease, as specimen failure is approached, shall be corrected by appropriate adjustment of the controls.

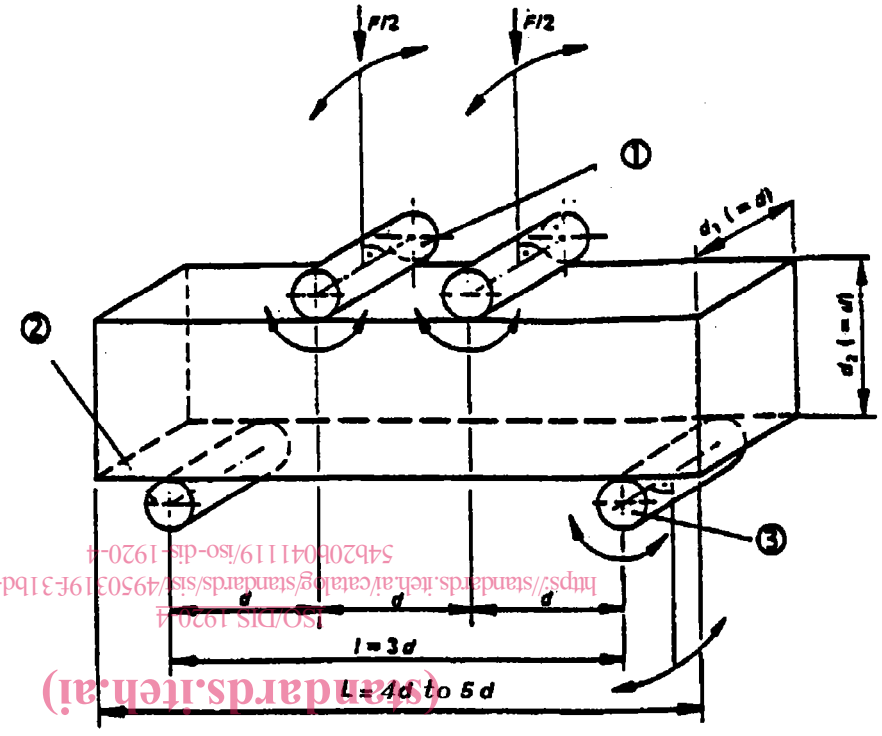
When using automatically controlled testing machines, the rate of loading shall be periodically checked to ensure that the rate is constant.

The maximum load indicated shall be recorded.

4.3.3 Assessment of type of fracture

The fractured specimen shall be examined and the appearance of the concrete and type of fracture

A fracture outside the loading rollers (see Figure 5) shall be reported.



Key

1 Loading roller (capable of rotation and of being inclined)
2 Supporting roller
3 Supporting roller (capable of rotation and of being inclined)

Figure 5— Arrangement of loading of test specimen (two-point loading)

4.4 Test results

The flexural strength is given by the equation:

$$f_{cf} = \frac{F \times \ell}{\quad}$$

where:

f_{cf} is the flexural strength, in N/mm^2 or MPa

F is the maximum load, in N

d_1, d_2 are the lateral dimensions of the specimen, in mm.

l is the spacing of the lower rollers, in mm.

The flexural strength shall be expressed to the nearest 0.1MPa.

4.5 Test report

In addition to the details required in clause 6, the test report shall include:

- method of loading: two point/centre point
- flexural strength of specimen (to the nearest 0.1MPa).

5 Determination of tensile splitting strength

5.1 Specimens

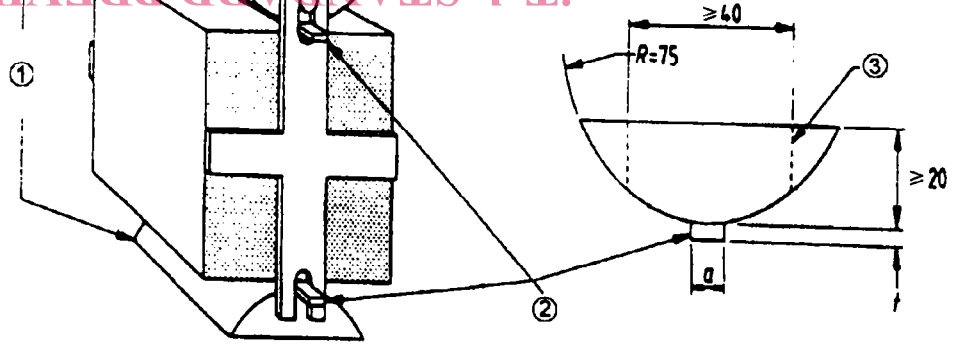
The specimens shall meet the requirements of clause 3.1.1 and 3.1.2

5.2 Apparatus

5.2.1 Testing machine,

The test shall be carried out using a machine complying with EN12390–Part 4, Clauses 4.2 and 4.3.

Curved steel loading pieces may be used in place of conventional plane platens, when tests are carried out on cubical or prismatic specimens (see Figure 6).



Key
1 Steel loading piece
2 Hardboard packing
3 Segment may be trimmed

Figure 6 — Curved loading piece

The machine shall be in calibration at the time of test.

5.2.2 Jig,

A jig may be used for positioning the specimen and the packing strips (optional). The jig shall not restrict the deformation of the specimen during the test.

A suitable jig for cylindrical specimens is shown in Figure 7.