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फाइबर सीमेंट की सपाट चादरें — विशिष्टि

Indian Standard

FIBRE CEMENT FLAT SHEETS — SPECIFICATION

(Incorporating Amendment Nos. 1 & 2)

ICS 91.100.40

BUREAU OF INDIAN STANDARDS
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Price Group 7

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Cement Matrix Products Sectional Committee had been approved by the Civil Engineering Division Council.

This standard has been formulated to fulfill the need for a specification for non-asbestos fibre cement flat sheets.

In the formulation of this standard, due weightage has also been given to the international coordination among the standards and practices in different countries in addition to relating it to the practices in the field in this country. For this, assistance has been derived from the following:

ISO 8336 : 1993 Fibre-cement flat sheets. International Organization for Standardization.

ISO 390 : 1993 Products in fibre-reinforced cement — Sampling and inspection. International Organization for Standardization.

The composition of the technical committee responsible for formulation of this standard is given at Annex K.

This edition 1.2 incorporates Amendment No. 1 (May 2002) and Amendment No. 2 (June 2003). Side bar indicates modification of the text as the result of incorporation of the amendments.

For the purpose of deciding whether a particular requirement of this standard is compiled with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

FIBRE CEMENT FLAT SHEETS — SPECIFICATION

1 SCOPE

1.1 This standard covers the characteristics and establishes methods of control and test as well as acceptance conditions for fibre cement flat sheets.

It covers sheets intended for external applications such as cladding facades, curtain walls, soffits, etc, and sheets intended for internal use such as partitions, floors, ceilings, etc, with a wide range of properties appropriate to the type of application. These sheets may have either a smooth or textured surface.

1.2 This standard does not apply to the following products, most of which are covered under separate standards:

a) Asbestos cement flat sheets;

b) Asbestos cement building boards;

c) Gypsum plaster board;

d) Boards of cement reinforced with fibrous wood particles;

e) Fibre cement slates and siding shingles;

f) Silica-asbestos-cement flat sheets; and

g) Non-combustible fibre-reinforced boards of calcium silicate or cement for insulation and fire protection.

2 REFERENCES

The Indian Standards listed in Annex A contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

3 GENERAL COMPOSITION

Fibre cement flat sheets consist essentially of an inorganic hydraulic binder (*see* Note) or a calcium silicate binder formed by the chemical reaction of a siliceous material (includes ground silica, pulverized fuel ash and amorphous silica) and a calcareous material reinforced by organic fibres and/ or inorganic synthetic fibres. The inorganic hydraulic binder shall be either 33 grade ordinary Portland cement conforming to IS 269 or 43 grade ordinary Portland cement conforming to IS 8112 or 53 grade ordinary Portland cement conforming to IS 12269 or Portland Pozzolana cement (fly ash based) conforming to IS 1489 (Part 1) or Portland Pozzolana cement (calcined clay based) conforming to IS 1489 (Part 2) or rapid hardening Portland cement conforming to IS 8041 or Portland slag cement conforming to IS 455. Fly ash used shall be conforming to IS 3812. Process aids, fillers and pigments which are compatible with fibre reinforced cement may be added.

NOTE — In case of Portland pozzolana cement and Portland slag cement, addition of pozzolanic materials and slag shall not be permitted.

4 CLASSIFICATION

4.1 Flat sheets covered by this standard shall be of two types, namely, Type A and Type B.

a) *Type A*

Type A sheets are intended for external applications where they may be subjected to the direct action of sun, rain and/or snow. They may be supplied coated or uncoated. Type A sheets shall comply with the requirements of the type characteristics given in **6**.

b) *Type B*

Type B sheets are not subjected to the type tests and are intended for internal applications and external applications where they will not be subjected to the direct action of sun, rain and/or snow.

NOTE — If sheets of Type B are used in external applications where they are directly exposed to the weather but are protected (for example, coating or impregnation), the weather resistance of the product is determined by the quality of the protection. Specification of this protection and methods for control and test are outside the scope of this standard.

4.2 The sheets are further classified into five categories according to their modulus of rupture as given in Table 1.

4.3 The manufacturer shall declare the type and category of his product in his literature.

5 ACCEPTANCE CHARACTERISTICS

5.1 Dimensional and Geometrical Characteristics

5.1.1 *Nominal Length and Width*

Flat fibre cement sheets shall be available in nominal lengths up to 3 000 mm and nominal widths up to 1 220 mm. Sheets of greater

nominal lengths and widths may be supplied as agreed between the manufacturer and the supplier. The length and width shall be measured in accordance with the method given in Annex B.

NOTE — The nominal dimensions (width and length) may be increased by 20 to 30 mm (oversize sheets) for application where the sheet is required to be cut by the user.

5.1.2 *Thickness*

Flat fibre cement sheets shall be of thickness from 3 to 30 mm, the thickness shall be measured in accordance with the method given in Annex B.

NOTE — Thickness other than specified in **5.1.2** may be supplied by mutual agreement between the manufacturer and the purchaser.

5.1.3 *Tolerances on Dimensions*

Tolerances on nominal dimensions shall be as follows:

a) On length and width (indicated by d)

$d \leq 1\,000$ mm: ± 5 mm

1 000 mm < $d \leq 1600$ mm: ± 0.5 percent

$d > 1\,600$ mm: ± 8 mm

These tolerances do not apply to oversize sheets.

b) On thickness, e:

$e \leq 6$ mm: ± 0.6 mm

$e > 6$ mm: ± 10 percent

For sheets without texture on the exposed face, the maximum difference between extreme values of the thickness measurements within one sheet shall not exceed 15 percent of the maximum measured value.

NOTE — Tighter tolerances may be adopted by agreement between the manufacturer and the purchaser.

5.1.4 *Tolerances on Shape*

5.1.4.1 *Straightness of edges*

The tolerance on the straightness of edges shall be 3 mm/m for the relevant dimension (length or width) when measured in accordance with the method given in Annex B.

5.1.4.2 *Squareness of edges*

The tolerance on the squareness of sheets shall be 4 mm/m when measured in accordance with the method given in Annex B.

NOTE — Tighter tolerances may be adopted by agreement between the manufacturer and the purchaser.

5.2 Mechanical and Physical Characteristics

Where the product is supplied coated, the following mechanical and physical specifications shall apply to the coated (that is finished) product. When sampling is to be done from continuous production, testing of the base sheet prior to coating is acceptable when it can be shown that there is a correlation between the results of tests on sheets with and without coating.

5.2.1 *Bending Strength*

When tested in accordance with the method given in Annex C, the minimum modulus of rupture of the sheets, expressed in MPa, shall be as specified in Table 1. The modulus of rupture shall be the average of the values obtained from testing the samples in both directions.

Table 1 Minimum Modulus of Rupture

(*Clauses* 4.2, 5.2.1 *and* 6.1)

Category	Modulus of Rupture, *Min* (MPa)	
	Type A Sheet	Type B Sheet
(1)	(2)	(3)
1	—	4
2	—	7
3	7	10
4	13	16
5	18	22

Type A sheet strengths shall only be specified in the wet condition and the specimens shall be tested in the wet condition.

Type B sheet strengths shall only be specified in the equilibrium condition and the specimens shall be tested in the equilibrium condition. When sampling is to be done from continuous production, these sheets may be tested on dry or saturated specimens, provided a relationship can be established between the equilibrium values and the dry or saturated values.

NOTE — If the manufacturer includes product strengths in his literature, it should be clearly stated whether they are mean or minimum values.

5.2.2 *Apparent Density*

The manufacturer shall specify in his literature the minimum apparent density for each category of sheet when tested in accordance with the method given in Annex C; the density shall be not less than this value.

5.2.3 Any additional characteristics, which the manufacturer desires to specify, may be mutually agreed between the manufacturer and the purchaser, including their method of testing and the requirements.

6 TYPE CHARACTERISTICS

This clause applies to Type A sheets only. These tests shall be carried out on products as delivered. Where the tests are carried out on coated sheets, this shall be stated in the report.

6.1 Bending Strength

When tested in accordance with the method given in Annex D, in equilibrium and wet conditions, the average modulus of rupture of each individual piece of the finished products shall not be less than the values for the appropriate category specified in Table 1. In addition, the mean modulus of rupture under wet conditions shall be not less than 50 percent of the mean modulus of rupture under equilibrium conditions.

6.2 Water Impermeability

When tested in accordance with the method given in Annex E, traces of moisture may appear on the underside of the sheet, but in no instance shall there be formation of drops of water.

6.3 Frost Resistance

For sheets for frost resistant applications, the sheets when tested in accordance with the method given in Annex F, after 50 freeze-thaw cycles, the limit L_i of the average ratio $\bar{r}$ shall not be less than 0.75.

6.4 Warm Water

When sheets are tested in accordance with the method given in Annex G, the limit L_i of the average ratio $\bar{r}$ shall be greater than 0.75.

6.5 Soak-Dry

When sheets are tested in accordance with the method given in Annex H, the limit L_i of the average ratio $\bar{r}$ shall be greater than 0.75.

6.6 Heat-Rain

This test shall be carried out on the finished product. When sheets are tested in accordance with the method given in Annex J, any visible cracks, delamination or other defects in the sheets shall not be of a degree such as to affect their performance in use.

7 TESTS

7.1 Acceptance Tests

The objective of an acceptance test is to establish whether a batch of products conforms to a specification. The tests shall be performed on samples drawn either from continuous production or from a consignment (*see also* **8**). The acceptance tests shall be carried out at the manufacturer's works on sheets and test specimens cut from sheets as delivered.

The following acceptance tests shall be carried out:

a) Dimensional and geometrical characteristics (compulsory) (*see* Annex B),

b) Bending strength (compulsory) (*see* Annex C), and

c) Apparent density (compulsory) (*see* Annex C).

7.2 Type Tests

A type test is concerned with the approval of a new product and/or a fundamental change in formulation and/or method of manufacture, the effects of which cannot be predicted on the basis of former experience. The tests shall be performed on the as-delivered product. The test is required to demonstrate conformity of a generic product to a specification but is not required for each production batch. When type tests are carried out, the product shall also be subjected to the acceptance tests to ensure that it complies with the requirements of this standard.

The following type tests shall be carried out:

a) Bending strength (*see* Annex D),

b) Water impermeability (*see* Annex E),

c) Freeze-thaw (*see* Annex F),

d) Warm water (*see* Annex G),

e) Soak-dry (*see* Annex H), and

f) Heat-rain test (*see* Annex J).

Warm water, Freeze-Thaw and heat-rain test are optional tests as per the requirement of the purchaser.

8 SAMPLING AND ACCEPTANCE CRITERIA

8.1 Scale of Sampling

8.1.1 *Lot*

In any consignment all the sheets of the same type and category, of the same thickness and manufactured under similar conditions of production (that is manufactured from the same formulation on the same forming machine without prolonged or abnormal interruptions and having the same acceptance requirement for relevant test) shall be grouped together to constitute a lot.

8.1.2 The number of sheets to be selected at random from the lot shall be in accordance with Table 2.

8.2 Inspection by Variables

The inspection shall be carried out, on one sample, the size of which is given in col 2 of Table 2, as given in **8.2.1** to **8.2.7**.

8.2.1 Divide the readings in the order in which they have been recorded into groups of 5, except when the sample size is 7, in which case the group size is the same as the sample size.

8.2.2 For each group, compute the range R.

8.2.3 From the group ranges R compute the average range R.

8.2.4 Compute the sample mean $\overline{X}$ by dividing the sum of the measurements by the sample size.

8.2.5 Obtain from col 3 of Table 2 the coefficient k.

8.2.6 Compute the acceptability limit AL and determine the acceptability of the lot by means of Table 3.

8.2.7 The conformity of the lot to the requirement of this standard shall be obtained on the basis of the tests on the sheets selected from it.

Table 2 Sample Size and Acceptance Coefficient

(*Clauses* 8.1.2, 8.2 *and* 8.2.5)

Size of the Lot	Sample Size	Acceptance Coefficient
(1)	(2)	(3)
≤ 150	3	0.502
151 to 180	3	0.502
181 to 500	4	0.450
501 to 1 200	5	0.431
1 201 to 3 200	7	0.405
3 201 to 10 000	10	0.507

Table 3 Acceptance Criteria for Inspection by Variables

(*Clause* 8.2.6)

Limit Prescribed in Relevant Standard	*AL*	Acceptance, if	Rejection, if
(1)	(2)	(3)	(4)
Lower specified limit, L_i	$L_i+k\overline{R}$	$X \geq AL$	$X < AL$
Upper specified limit, L_u	$L_u-k\overline{R}$	$X \leq AL$	$X > AL$

9 INSPECTION AND MANUFACTURERS TEST CERTIFICATE

9.1 The purchaser or his representative shall have access at all reasonable times to the manufacturer's stock area for the purpose of inspecting the materials and products and selecting and testing the sheets, which shall be so conducted as not to interfere unnecessarily with the loading in the carriers.

9.2 The manufacturer shall, upon request, furnish the purchaser or his representative with the certificate that the finished product complies with the specification in all respects.

10 MARKING

Each sheet shall be indelibly stamped and marked by any suitable method with the following information:

a) Indication of source of manufacturer;

b) Date of manufacture;

c) Type and category of sheet;

d) Size and thickness of sheet; and

e) The words 'FROST RESISTANT' on the sheets suitable for frost resistant applications.

10.1 BIS Certification Marking

Each sheet may also be marked with the Standard Mark.

10.1.1 The use of Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the rules and regulations made thereunder. The details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained for the Bureau of Indian Standards.

11 SAFETY RULES

a) *Product Identification*

Sheets shall be marked with indelible characters to show that they do not contain asbestos.

b) *Information to Users*

The company should, through its distribution system, supply adequate information to the users concerning safety precautions to be taken during handling or machining of products and that excessive exposure to dust by cutting, drilling, sanding and turning or similar operations should be avoided by one or several of the following means:

1) using low speed power tools,

2) wetting the product,

3) using personal protective equipment (respirators), and

4) use of hand-tools.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
269 : 1989	Specification for ordinary Portland cement, 33 grade (*fourth revision*)
455 : 1989	Portland slag cement (*fourth revision*)
1489	Specification for Portland pozzolana cement:
(Part 1) : 1991	Fly ash based (*third revision*)
(Part 2) : 1991	Calcined clay based (*third revision*)
3812 : 1981	Specification for fly ash for use as pozzolana and admixture (*first revision*)
8041 : 1990	Specification for rapid hardening Portland cement (*second revision*)
8112 : 1989	Specification for 43 grade ordinary Portland cement (*first revision*)
12269 : 1987	Specification for 53 grade ordinary Portland cement

ANNEX B

[*Clauses* 5.1.1.1, 5.1.2, 5.1.4.1, 5.1.4.2 *and* 7.1 (a)]

METHOD FOR TESTING DIMENSIONS

B-1 APPARATUS

The apparatus shall include the following items:

a) Smooth, flat and rigid inspection surface of production quality and of dimensions appropriate to the dimensions of the sheets.

Two metal rules shall be fixed at right angles along adjacent edges of the inspection surface. The straightness of each metal rule shall be at least 0.3 mm/m and the right angle shall be accurate to at least 0.1 percent (less than 1 mm deviation from normal per metre of length) or 0.001 rad.

Alternatively, a portable square may be used. The same requirements for straightness and angularity shall apply.

b) Suitable metal rulers, capable of being read to 0.5 mm.

c) Dial gauge, reading at least to 0.05 mm, with flat parallel metal jaws, between 10 mm and 15 mm in diameter.

B-2 MEASUREMENT OF LENGTH AND WIDTH

For each dimension, carry out three measurements, that is, one in the middle and one at approximately 50 mm from either end. Avoid taking the measurement over a local deformation which could be considered as a visual defect. Smooth any rough areas. Take each reading to the nearest 0.5 mm. Report the individual results. Assess the results against the tolerances given in **5.1.3**.

B-3 MEASUREMENT OF THICKNESS

Carry out three measurements across the width at one end of the smooth or textured sheet (with the dial gauge) as indicated in Fig. 1. Take each reading to an accuracy of 0.05 mm. Report the individual results. Calculate the arithmetic mean and difference between extreme values. Assess the results against the tolerance given in **5.1.3**.

NOTE — If the face texture does not allow a sufficiently accurate measurement of the thickness, the thickness of face-textured products is determined from volume measurement by water displacement where the test piece has been saturated before measurement. The thickness is given by the formula:

$$e = \frac{V}{l\ b}$$

where

e is average thickness of the test piece in mm,

V is volume determined by water displacement in mm^3,

b is specimen width in mm, and

l is specimen length in mm.

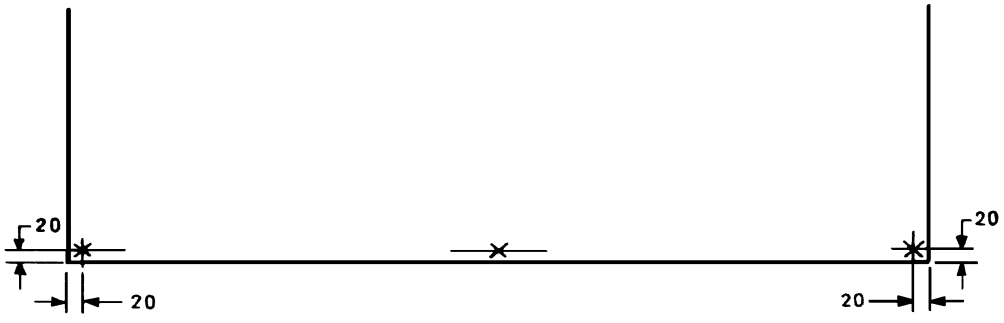
Alternative methods for determination of the average thickness of textured specimens may be used provided they can be proven, on average, to yield a thickness measurement within ±2 percent of that determined from volume measurement.

B-4 MEASUREMENT OF STRAIGHTNESS OF EDGES

Apply each edge to the relevant arm of the square. Measure to the nearest 0.5 mm by means of a steel rule, the greatest separation between the edge of the sheet and the arm of the square. Report the results. Assess each result against the tolerance given in **5.1.4.1**.

B-5 MEASUREMENT OF OUT OF SQUARENESS OF EDGES

Place each of the four corners of the sheet in succession between the arms of the square keeping the large side against the large arm and the other side in contact with small arm. In this position, measure the distance of the apex of the corner from the small arm of the square. Report each result. Assess the results against the tolerance given in **5.1.4.2**.



All dimensions in millimetres.

FIG. 1 MEASUREMENT OF THICKNESS

ANNEX C

(*Clauses* 5.2.1, 5.2.2, 7.1, D-2, D-3, F-1, F-3, G-2, G-3, G-4, H-1, H-2 *and* H-3)

METHOD OF TEST FOR BENDING STRENGTH AND APPARENT DENSITY

C-1 BENDING STRENGTH

C-1.1 Shapes and Dimensions of Test Pieces

The test specimens shall be two square specimens of 250 mm × 250 mm per sheet.

NOTE — For sheets of thickness in the range 9 mm <e≤20 mm, the test specimens may be either square or rectangular. For rectangular specimen the length should be test span +40 mm and width should be 100 mm minimum.

C-1.2 Cutting Specimens

The test specimens shall be cut from the same part of the sheet. One possible layout is shown in Fig. 2 (the distance of 200 mm is indicative). Other cutting layouts may be used provided that an equal number of specimens are cut perpendicular and parallel to the manufacturing direction.

C-1.3 Conditioning for Equilibrium Strength

Place the test specimens for 7 days in an ambient condition and in such a manner that all faces are adequately ventilated. Record the temperature and relative humidity.

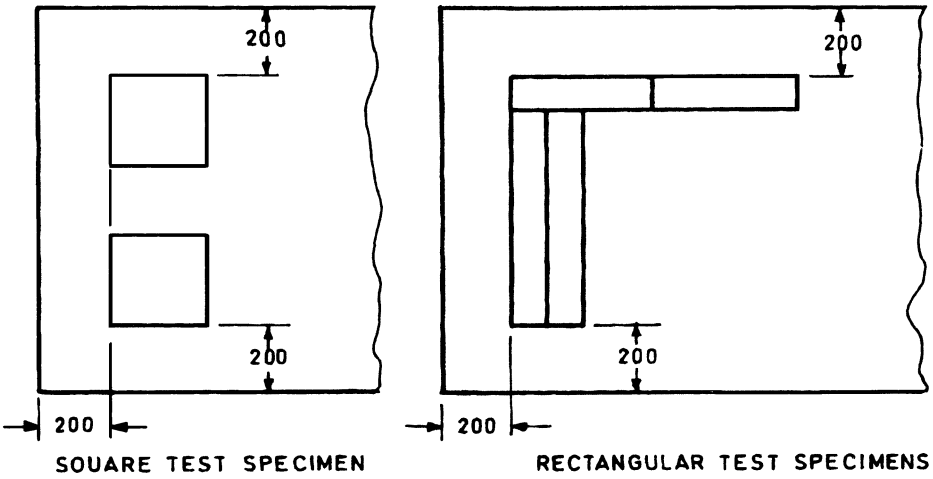
C-1.4 Conditioning for Wet Strength

Immerse the test specimens in water at ambient temperature for 24 h. The test specimens shall be tested immediately upon removal from the water.

C-1.5 Apparatus

The apparatus shall include the following items:

a) Bending test machine (*see* Fig. 3) with a constant rate of deflection when applying the load (where this facility is not available, a constant rate of loading is acceptable) and with an error of accuracy



All dimensions in millimetres.

FIG. 2 CUTTING OF TEST SPECIMENS

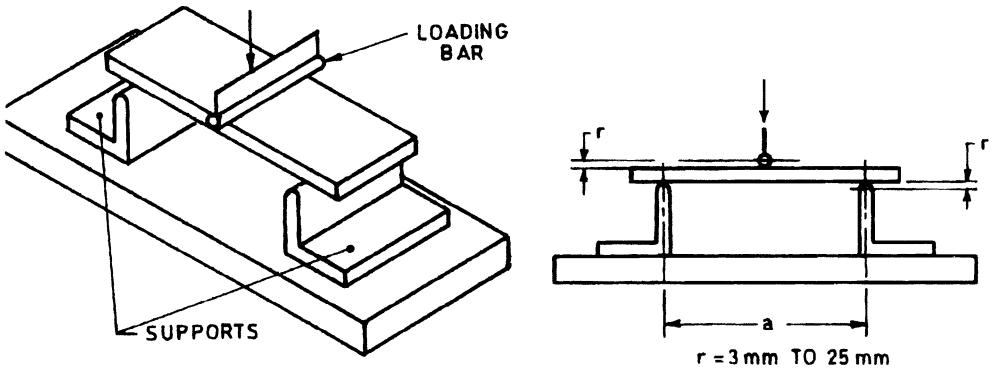


FIG. 3 BENDING TEST MACHINE LAYOUT

and an error of reproducibility equal to or less than 3 percent comprising:

1) two parallel supports, one rigid and one self aligning, the distance between the supports, a, being a function of the thickness of the test piece (*see* Table 4). The upper faces of the supports shall be rounded and shall have a radius r between 3 mm and 25 mm.
2) a loading bar identical to the two supports shall be situated above the specimen so that it is parallel to the supports and at an equal distance from each support.

Table 4 Distance Between Support Test Span

[*Clause* C-1.5 (a)]

Test Specimen	Distance Between Axes of Supports (Test Span), mm
(1)	(2)
Square	215
Rectangular	18*e*, *Min*

NOTES

1 For square specimens other distances between supports may be used provided compatibility can be demonstrated between results obtained with the different test spans and results obtained with the standard spans.

2 The distance between the axes of the supports may be reduced for narrow products, where full size specimens cannot be obtained, provided the distance is not less than 18*e* where *e* is thickness of the specimen, in mm.

b) A micrometer reading to at least 0.05 mm with flat parallel metal jaws between 10 mm and 15 mm in diameter.

C-1.6 Procedure

Arrange the test piece with the underside against the supports and load the test piece along its centreline by means of the loading bar. Load the specimen such that breakage occurs within 10 to 30s. A constant rate of deflection is preferred; where this facility is not available a regular rate of loading is acceptable.

Measure the thickness at two points for smooth specimens and four points for textural specimens along the section of breakage as indicated in Fig. 4.

For square specimens, re-assemble the broken pieces. Submit the re-assembled test specimens to a second bending test with the line of load application at right angles to that of the first test. Measure the thickness of the test piece at two points for smooth sheets or four points for textured sheets along the new section of breakage as indicated in Fig. 4.

Where rectangular test specimens are used, the strengths in the two directions are obtained by testing each of the appropriate specimens (*see* Fig. 4).

C-1.7 Expression and Interpretation of Results

The modulus of rupture, R_f, in MPa, is given by the formula

$$R_f = \frac{3Pl}{2be^2}$$

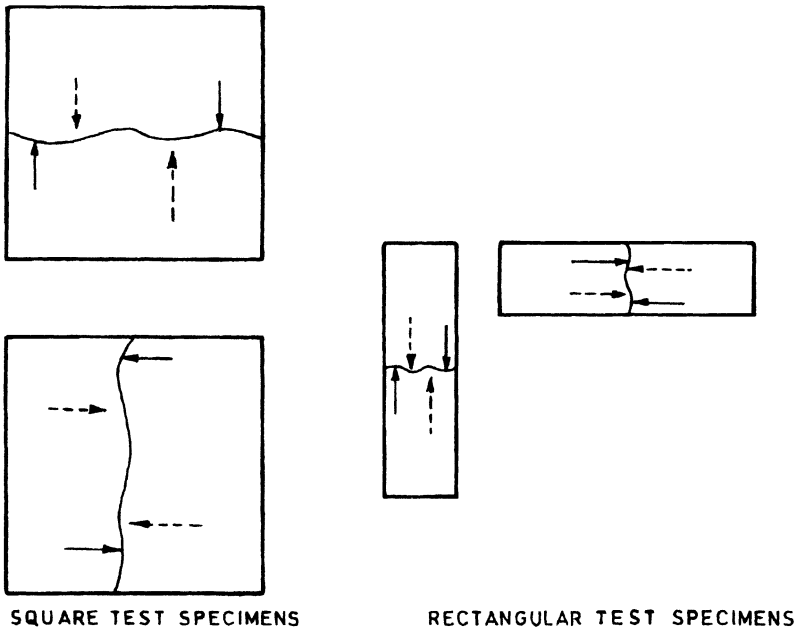


FIG. 4 MEASUREMENT OF THICKNESS OF SPECIMENS

where

P is the breaking load in N;

l is the distance between axes of supports in mm;

b is the width of the test piece, in mm; and

e is the average thickness of the test piece (arithmetic average of two measurements for smooth and four measurements for textured), in mm.

The modulus of rupture of the sheet shall be the arithmetic mean of the four values (two values in each direction). Assess the results against the requirement given in **5.2.1**.

C-2 MEASUREMENT OF APPARENT DENSITY

C-2.1 Preparation of Specimens

The test specimens shall be cut from sheets as delivered. The test piece should preferably be a piece of the sheet used for the bending test.

C-2.2 Apparatus

The apparatus shall include the following items:

a) Ventilated oven capable of achieving a temperature of 100 to 105°C with a full load of specimens; and

b) Weighing scale accurate to within 0.1 percent, and equipped to determine the immersed mass of the specimen as well as the non-immersed mass.

C-2.3 Procedure

Determine the volume by immersion in water or another method having an equivalent accuracy. In the case of immersion in water, the test piece shall be saturated in water beforehand. Determine the mass by drying out the test specimens in a ventilated oven maintained at 100 to 105°C for 24 ± 1h.

C-2.4 Expression and Interpretation of Results

The density 'ρ' in grams per cubic centimetres, is given by the formula:

$$\rho = \frac{m}{V}$$

where

m is the mass of the test specimen after drying, in g; and

V is the volume of the test specimen, in cm^3

Assess the results against the requirement given in **5.2.2**.

ANNEX D

(*Clauses* 6.1 *and* 7.2)

METHOD OF TEST FOR BENDING STRENGTH (TYPE TEST)

D-1 GENERAL

This test method is designed to assess the equilibrium modulus of rupture and wet modulus of rupture, and the ratio of these.

D-2 PREPARATION OF SPECIMENS

Twenty specimens shall be cut from at least five sheets. Sheets which have provided specimens for other type-tests may be used. Specimen dimensions shall be as required for the bending test in accordance with Annex C. The specimens shall be marked with the sheet number from which they were cut and separated into two identical groups of 10 specimens each, one for equilibrium strength testing and one for wet strength testing. In case of rectangular specimens care should be taken that each batch shall contain five specimens cut in one direction and five specimens cut in other direction. The test specimens shall be conditioned in accordance with the provisions of **C-1.3** and **C-1.4** as appropriate.

D-3 TEST EQUIPMENT AND PROCEDURE

The bending strength test shall be carried out in accordance with the provisions of **C-1**.

D-4 EXPRESSION AND INTERPRETATION OF RESULTS

The equilibrium modulus of rupture shall be the arithmetic mean of the test results obtained in the equilibrium condition. The wet modulus of rupture shall be the arithmetic mean of the test results obtained in the wet condition. Assess the results against the requirement given in **6.1**.

ANNEX E

(*Clause* 6.2)

METHOD OF TEST FOR WATER IMPERMEABILITY

E-1 PREPARATION OF SPECIMEN

Three test specimens shall be cut, that is, one from each of three sheets. Sheets used to provide specimens for other type-tests may be used or other sheets may be taken. Specimen dimensions shall be 600 mm × 500 mm minimum except for narrow products when the dimensions shall be 600 mm × the maximum possible width.

E-2 EQUIPMENT

A suitable frame, to be sealed on top of the specimen. The frame dimensions shall be 550 mm × 450 mm minimum. A narrow frame of the same length shall be used for narrow products.

E-3 SPECIMEN CONDITIONING

The specimens shall be kept in a controlled environment for at least 7 days at ambient temperature.

E-4 PROCEDURE

Place and seal the frame on top of the face of the specimen and fill with water to a height of 20 mm above the face of the sheet. Place the specimens at ambient condition and record the temperature and relative humidity. The duration of the test shall be 24 h.

E-5 EXPRESSION AND INTERPRETATION OF RESULTS

Examine the underface after 24 h and verify that it conforms to the requirement given in **6.2**.

ANNEX F

(*Clauses* 6.3 *and* 7.2)

METHOD FOR FREEZE-THAW TEST

F-1 PREPARATION OF SPECIMENS

Sample five sheets as delivered by the producer. Cut 10 sets of paired specimens to suit the bending test (*see* **C-1**). Each pair of specimens shall be cut from one sheet and given the same number for later comparison of results.

F-2 APPARATUS

The apparatus is the same as for the bending test. In addition, for this test, cooling units shall be used, which when filled completely with test pieces ensure a test piece temperature of –20°C, 2 h after starting freezing. The freezing chamber shall be equipped with an air circulation unit.

F-3 PROCEDURE

Submit one lot of 10 specimens to the bending test according to **C-1**, and at the same time submit other lot of 10 specimens to the following freeze-thaw test.

At the same time immerse the specimens in water at ambient temperature until the difference of mass between two consecutive weighings spaced 24 h apart is less than 0.5 percent.

Submit the specimens to 50 freeze-thaw cycles consisting of:

a) cooling in air to –20°C ± 2°C in not less than 1 h and not more than 2 h. The specimens shall then be held at –20 ±2°C for 1h (*see* Notes under **F-4**).

b) Thawing in water at ambient temperature for 2 h and not more than 3 h. Then freezing shall recommence.

The temperature and relative humidity shall be reported. Each freeze-thaw cycle will have a minimum cycle time of 4 h and a maximum of 6 h. The temperature specified above refers to the freezing cavity. At the end of this period, place the specimens in a laboratory atmosphere for 7 days.

Examine the specimens with the naked eye in order to detect possible cracks, delamination or other defects and record any observation.

After preliminary conditioning, carry out the wet bending test as specified in **C-1**.

F-4 EXPRESSION AND INTERPRETATION OF RESULTS

For each pair of specimens, i ($i = 1$ to 10), calculate the individual ratio r_i as follows:

$$r_i = \frac{R_{fi}}{R_{fci}}$$

where

R_{fi} is the modulus of rupture of the ith test specimen after 50 freeze-thaw cycles, and

R_{fci} is the modulus of rupture of the ith reference test specimen (from the first lot).

Calculate the average $\bar{r}$ and standard deviation, s, of the individual ratios r_i. Calculate the 95 percent lower confidence limit, L_i of the average ratio r as follows:

$$L_i = r - 0.58\, s$$

Assess the results against the requirement given in **6.3**.

NOTES

1 Freeze-thaw cycles may be controlled automatically or manually. Continuous automatic cycling is preferred.

Manual supervision of freeze-thaw cycles shall record completion of each cycle.

2 An interval between cycles (72 h *Max*) is permissible. During this interval specimens should be stored in ambient conditions.

3 During both freezing and thawing the specimens should be positioned to enable free circulation of the conducting medium (air or water) around each.

4 An alternative method in which the saturation of the specimen during cycling is ensured by sealing the saturated specimens in plastic bags may be used where suitable automatic equipment for the preferred method is not available.

ANNEX G

(*Clauses* 6.4 *and* 7.2)

METHOD FOR WARM WATER TEST

G-1 GENERAL

This test investigates the possible degradation of the products by keeping them in warm water for a protracted period. This test is a comparative one and is only significant for products as delivered.

G-2 PREPARATION OF SPECIMENS

Sample 10 sheets as delivered by the producer. Cut 10 sets of paired specimens to suit the bending test (*see* **C-1**). Each specimen pair shall be cut adjacent from one sheet and given the same number for later comparison of results.

G-3 APPARATUS

The apparatus shall include the following items:

a) Water bath capable of temperature control to 60 ± 5°C; and

b) Testing equipment for determination of bending strength as described in **C-1.5** (a).

G-4 PROCEDURE

Make two sets of 10 specimens each. Submit the first lot of 10 specimens to the wet bending test (*see* **C-1**). Immerse the 10 specimens of the second lot in water at 60 ± 5°C saturated with product of the same composition, for 56 ± 2 days. At the end of this period place the specimens in a laboratory atmosphere for 7 days. After preliminary conditioning, carry out the wet bending test as given in **C-1**.

G-5 EXPRESSION AND INTERPRETATION OF RESULTS

For each pair of specimens, i ($i = 1$ to 10), calculate the individual ratio:

$$r_i = \frac{R_{fi}}{R_{fci}}$$

where

R_{fi} is the modulus of rupture of the ith pair of specimens after immersion in warm water, and

R_{fci} is the modulus of rupture of the ith pair of reference specimens (from the first lot).

Calculate the average r, and standard deviation, s, of the individual ratios r_i. Calculate the 95 percent lower confidence limit, L_i of the average ratio r, as follows:

$$L_i = r - 0.58\ s$$

Assess the ratio against the requirement given in **6.4**.

ANNEX H

(*Clauses* 6.5 *and* 7.2)

METHOD FOR SOAK-DRY TEST

H-1 PREPARATION OF SPECIMENS

Sample 10 sheets as-delivered by the producer. Cut 10 sets of paired specimens to suit the bending test in **C-1**.

Each pair of specimens shall be cut adjacent from one sheet and given the same number for later comparison of results.

H-2 APPARATUS

The apparatus shall include the following items:

a) Ventilated oven capable of achieving a temperature of 60 ± 5°C and a relative humidity of less than or equal to 20 percent with a full load of specimens;

b) Bath filled with water at ambient conditions; and

c) Equipment for bending test as defined in **C-1**.

H-3 PROCEDURE

Divide the paired specimens to form two lots of 10 specimens each. After the conditioning procedure, submit the first lot of 10 specimens to the bending test as described in **C-1**.

At the same time submit the second lot to 25 soak-dry cycles consisting of:

a) immersion in water at ambient temperature for 18 h, and

b) drying in a ventilated oven of 60 ±5°C and relative humidity of less than 20 percent for 6 h.

If necessary, an interval up to 72 h between cycles is allowed. During this interval, specimens shall be stored in immersed conditions. After 25 cycles, place the specimens in a laboratory atmosphere for 7 days. At the end of this period, carry out the wet bending test as specified in **C-1**.

H-4 EXPRESSION AND INTERPRETATION OF RESULTS

For each pair of specimens, i ($i = 1$ to 10) calculate the individual ratio, r_i, as follows:

$$r_i = \frac{R_{fi}}{R_{fci}}$$

where

R_{fi} is the modulus of rupture of the ith specimen after the soak-dry cycling, and

R_{fci} is the modulus of rupture of the ith reference test specimen (from the first lot).

Calculate the average $\bar{r}$, and standard deviation, s, of the individual ratios, r_i. Calculate the 95 percent lower confidence limit, L_i of the average ratio $\bar{r}$ as follows:

$$L_i = \bar{r} - 0.58\, s$$

Assess the ratio against the requirement given in **6.6**.

ANNEX J

(*Clauses* 6.6 *and* 7.2)

METHOD FOR HEAT-RAIN TEST

J-1 GENERAL

This annex describes an optional test method to assess the performance of a cladding system composed of fibre cement sheets in a particular installation (sub-frame and fixings) under cyclic changes of heat and moisture. This test should be carried out on finished products.

J-2 PRINCIPLE

Sheets are fixed to a building frame in accordance with the recommended installation practices of the manufacturer. The system is then subjected to alternate wetting and heating cycles, following which any structural alteration is recorded.

J-3 SAMPLING

Sheets used for the test shall be drawn at random from the stock of finished products. The number of sheets required will depend upon the manufacturer's installation recommendations and on the sheet size under test.

J-4 APPARATUS

Test installations with the following facilities:

a) A sub-frame to which the sheets under test may be fixed vertically.

b) Water spray system which will provide complete wetting of one face.

c) Heating system to provide uniform radiant heat to give blackbody temperature across complete test frame surface of 60 ± 5°C and approximately uniform power output during the cycle.

d) A control system allowing the test conditions to alternate automatically as prescribed in the test procedure.

J-5 TEST PROCEDURE

Select a representative installation system. Assemble the system according to the manufacturer's recommendations. The construction should include provision for at least one sheet joint in its central region. The perimeter of the frame should allow standard sheet edge finishing. The frame dimensions shall give a minimum area of 3.5 m^2 and allow at least two sheets to be installed with normal orientation. If the area of each sheet is 1.8 m^2 or more, use two specimens. If the combined area of the sheets exceeds 5 m^2, the sheet length may be reduced to provide a test area of not more than 5 m^2. If the area of each sheet is less than 1.8 m^2, use sufficient number of sheets to cover an area of 3.5 m^2.

Fix the sample sheets to the test frame observing all the manufacturer's recommendations. The edge fixing distance should be a minimum allowed and the centre distance between fixings should be the maximum allowed. Include all weather-proofing and other attachments normally specified in the assembly. Where sheets are recommended to have overlapping joints, assemble the test frame accordingly.

Subject the assembled frame to the following test cycle:

a) Water spray: 2 h 50 min

b) pause: 10 min

c) radiant heat: 2 h 50 min

d) pause: 10 min

The sheets shall be submitted to 25 cycles.

Assess the product for visual defects against the requirement given in **6.6**.

J-6 OBSERVATIONS/REPORTING

On completion of the final test cycle, inspect the sheets for damage or structural alteration caused by the test.

ANNEX K

(*Foreword*)

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(*Continued on page* 14)

(*Continued from page* 13)

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