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Indian Standard

METHODS OF TEST FOR CHEMICAL RESISTANT MORTARS

PART I SILICATE TYPE AND RESIN TYPE

(Third Reprint JANUARY 1998)

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 6 *May* 1968

Indian Standard

METHODS OF TEST FOR CHEMICAL RESISTANT MORTARS

PART I SILICATE TYPE AND RESIN TYPE

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AMENDMENT NO. 1 DECEMBER 1982

TO

IS:4456(Part I)-1967 METHODS OF TEST FOR CHEMICAL RESISTANT MORTARS

PART I SILICATE TYPE AND RESIN TYPE

Alterations

(*Page 13, clause 8.2.8, line 2*) - Substitute 'IS:4457-1982*' *for* 'IS:4457-1967*'.

(*Page 13, clause 8.3, line 2*) - Substitute '198.5 x 100 x 25 mm' *for* '198.5 x 100 x 35 mm'.

(*Page 13, foot-note with '*' mark*) - Substitute the following:

'*Specification for ceramic unglazed vitreous acid-resisting tiles (*first revision*)'.

Indian Standard

METHODS OF TEST FOR CHEMICAL RESISTANT MORTARS

PART I SILICATE TYPE AND RESIN TYPE

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 7 December 1967, after the draft finalized by the Non-cement Floor Coverings Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 The silicate type and resin type of chemical resistant mortars for use as a bonding material in construction will be covered in separate Indian Standards given below:

*Specification for chemical resistant mortars : Part I Silicate type

*Specification for chemical resistant mortars : Part II Resin type

0.2.1 This standard which covers the methods of test for the determination of various characteristics of these mortars is an essential adjunct to these specifications.

0.3 In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country. This has been met by referring to the publications given in Appendix A.

0.4 In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960†.

1. SCOPE

1.1 This standard covers the methods for carrying out the following tests on silicate type and resin type chemical resistant mortars:

Method of Test	*Clause Number*
a) Working time	3
b) Setting time	4

†Rules for rounding off numerical values (*revised*).

Method of Test	*Clause Number*
c) Tensile strength	5
d) Flexural strength	6
e) Compressive strength	7
f) Bond strength	8
g) Absorption and apparent porosity	9
h) Chemical resistance	10

2. TERMINOLOGY

2.1 For the purpose of this standard, the following definitions shall apply:

2.1.1 *Working Time* — The time interval in minutes from the start of mixing the powder filler and the liquid binder or resin at any specific temperature and in the absence of direct sun light, during which the mortar may be applied to a brick or tile surface without curling behind the trowel.

2.1.2 *Setting Time* — The time interval in minutes from the start of mixing the powder filler and the liquid binder or resin at any specific temperature, to that time when the vicat needle having a tip 1 mm square in section or 1·13 mm diameter fails to pierce the block in the vicat mould for about 5 mm, measured from the bottom of the mould.

3. WORKING TIME

3.1 Object — To determine the working time of silicate type and resin type chemical resistant mortars.

3.2 Apparatus

3.2.1 *Balance* — of capacity 1 kg, sensitive to 0·1 g.

3.2.2 *Mixing Pan* — A porcelain enamelled pan measuring approximately 400 mm × 250 mm × 50 mm deep.

3.2.3 *Spatula* — of stainless steel and about 25 mm wide.

3.2.4 *Trowel* — A masons' triangular trowel.

3.3 Conditioning — All materials used in this test shall be stored at 27° ± 2°C for at least 16 hours prior to use.

3.4 Preparation of Mortar

3.4.1 Prepare 1 kg of mortar using proportionate amounts of filler and liquid binder or resin, as recommended by the manufacturer. An appropriate amount of liquid binder or resin shall be poured into the mixing pan and the

filler shall be gradually added to the liquid binder or resin mixing thoroughly with the spatula or trowel. The mixing operation shall be continued for one minute to obtain a uniform mixture. The total mixing time shall not exceed 4 minutes.

3.4.2 The mortar shall be spread in a layer of uniform thickness covering the entire surface of the mixing pan.

3.5 Procedure — Remove approximately 15 g portions of the mortar at 5 min intervals and trowel on the horizontal surface of a clean dry brick or asbestos cement board. Consider the mortar workable if it stays in the applied position, without curling behind the trowel while spreading. Do not return the material used for tests to the mixing pan.

3.6 Report — Record the working time as the time in minutes from the start of mixing the filler and liquid binder or resin until the mortar ceases to be workable and fails to stay in the applied position while spreading.

4. SETTING TIME

4.1 Object — To determine the setting time of silicate type and resin type chemical resistant mortars.

4.2 Vicat Apparatus — The vicat apparatus as shown in Fig. 1 shall be employed.

4.3 Procedure

4.3.1 *Preparation of Test Block* — Prepare about 1 kg of mortar as given in **3.4.1.** Start a stopwatch at the instant when the filler is added to the liquid binder or resin. The temperature during gauging shall be 27° ± 2°C. Fill the vicat mould completely with the mortar and smooth the surface of the mortar making it level with the top of the mould. The mould shall rest on a non-porous plate. The mortar block thus prepared in the mould shall be used for testing. During the test the block shall be kept at a temperature of 27° ± 2°C and in an atmosphere of at least 90 percent relative humidity and away from draughts.

4.3.2 *Determination of Setting Time* — Place the test block confined in the mould and resting on the non-porous plate under the rod bearing the needle for determining the setting time. The needle shall be 1 mm square in section or 1·13 mm diameter and shall have a flat end. Lower the needle gently in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block. In the beginning, the needle will completely pierce the test block. Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block for about 5 mm measured from the bottom of the mould.

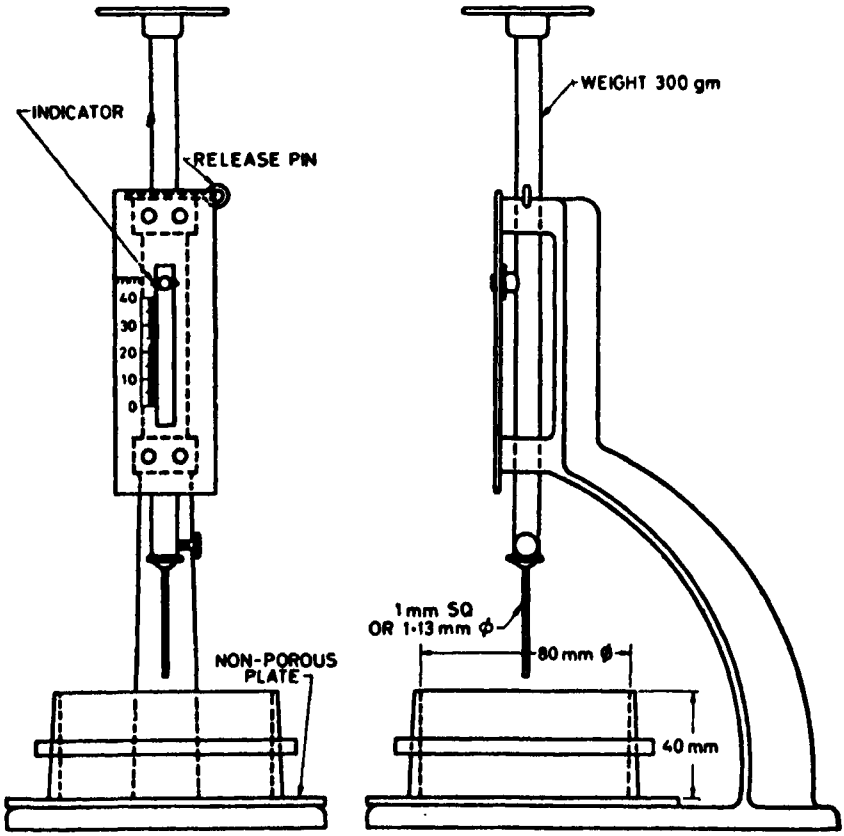


FIG. 1 VICAT APPARATUS

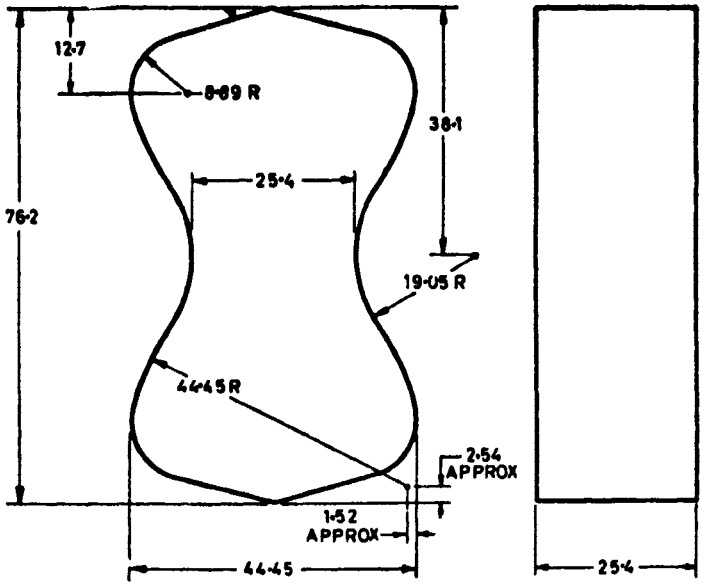
4.4 Report — Record the setting time as the period elapsing between the time when the filler is added to the liquid binder or resin and the time at which the needle fails to pierce the test block by about 5 mm.

5. TENSILE STRENGTH

5.1 Object — To determine the tensile strength of silicate type and resin type chemical resistant mortars.

5.2 Apparatus — In addition to those given in **3.2.1** to **3.2.4** the following shall also be provided.

5.2.1 *Moulds* — The moulds shall be capable of producing briquettes of the shape shown in Fig. 2.



All dimensions in millimetres.

FIG. 2 DIMENSIONS OF STANDARD BRIQUETTE

5.2.2 *Testing Machine* — The universal type testing machine in which load is applied at constant but adjustable rate.

5.3 Preparation of Mortar — The mortar shall be mixed in the proper proportion and in the manner specified by the manufacturer. At least 1·5 kg of silicate type of mortar shall be mixed from which six test specimens may be prepared assuming that the mortar density is not greater than 3. Larger quantity will be required if the mortar density exceeds 3.

5.3.1 At least 1 kg of resin type of mortar may be mixed from which six test specimens may be prepared assuming that the mortar density is not greater than 2. Larger quantity will be required if the mortar density exceeds 2.

5.4 Moulding Test Specimens — The moulds prior to filling shall be given a thin coat of suitable material, such as silicon grease to prevent sticking of the mortar to the metal of the mould. Various materials may be used provided they do not interfere with the setting of the mortar and do not materially change the dimensions of the mould. The moulds shall be filled with the mortar taking care to prevent entrapment of air which would cause void spaces, and the mortar shall be struck off evenly with a spatula.

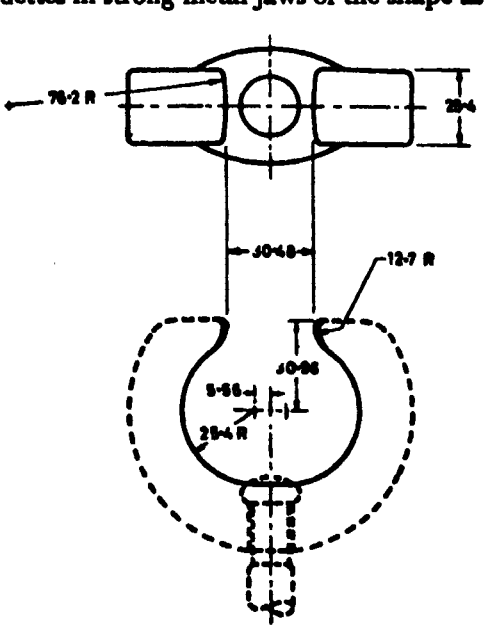
5.5 Conditioning of Test Specimens

5.5.1 The test specimens shall remain in their respective moulds for a period of 24 hours after moulding. For cashew nut shell liquid resin mortar the test specimen shall be kept in their respective moulds for a period of 48 hours after moulding.

5.5.2 *Silicate Type Mortar* — At the end of 48 to 60 h after the specimens have been prepared, completely immerse them in 20 percent by weight hydrochloric acid for a period of 60 minutes. Then remove the specimens from the acid and blot dry using a paper towel. Age the specimens for a period of 7 days in air at 27° ± 2°C supported in such a manner that air circulates on all sides. Protect the specimens from contact with water until tested.

5.5.3 *Resin Type Mortar* — Age the specimens for a period of 7 days in air at 27° ± 2°C.

5.6 Procedure — Test the briquettes for tensile strength after 7 days of the preparation of the mortar or at desired intervals. The age of the specimens shall be reported. At least six briquettes shall be tested at each period and the tensile strength shall be the average of six test results for that period. Hold the test briquettes in strong metal jaws of the shape as shown in Fig. 3.



All dimensions in millimetres.

FIG. 3 JAWS FOR HOLDING BRIQUETTES

Apply the load steadily and uniformly starting from zero and increasing at the rate of 7 kg/cm^2 of section in 12 seconds.

NOTE — In order to distribute the stress set up by the pressure of the jaws over as large a surface of the briquette as possible, it is recommended that rubber or greased paper shall be inserted between the sides of the briquette and the jaws of the machine.

5.7 Faulty Briquettes and Retests — Briquettes which upon removal from the moulds at the end of the first 24-hour period after gauging do not conform to the requirements for width at the waist line and thickness, or which are manifestly faulty, shall be rejected. If, after such rejection, the number of briquettes left over is insufficient for four tests at each specified period, fresh gauging shall be done.

5.8 Calculation and Report — In calculating the average value of test results at any period, strength values differing by more than 15 percent from the average shall be discarded. After discarding such values, if less than 4 strength values are left for determining the tensile strength, a retest shall be made.

6. FLEXURAL STRENGTH

6.1 Object — To determine the flexural strength of silicate type and resin type chemical resistant mortars.

6.2 Apparatus

6.2.1 *Balance* — of capacity 1 kg sensitive to 0·1 g.

6.2.2 *Specimen Moulds* — Moulds permitting the moulding of bars of dimension 25 × 25 × 250 mm.

6.3 Test Specimens

6.3.1 *Preparation of Mortar* — The mortar shall be mixed as specified in **3.4**. About 2 400 g of the mortar shall be mixed from which four bars shall be prepared.

6.3.2 *Moulding of Test Specimens* — The mould shall be lubricated by applying a thin film of mould release or lubricant.

6.3.2.1 The mould shall be filled with mortar taking care to eliminate air pockets by working the mortar with spatula or thin trowel. The top surface shall be levelled with the spatula and the excess mortar shall be striken off evenly.

6.3.3 *Conditioning of Test Specimens* — The test specimens shall remain in their respective moulds for a period of 24 h after moulding under the storage conditions given in **6.3.3.2**. For cashew nut shell liquid resin mortar the period shall be 48 h.

6.3.3.1 After removal from the mould the silicate type mortar test specimens shall be acid treated in accordance with the recommendations of the manufacturer and the method of acid treatment shall be recorded. If no specific method for acid treatment is specified by the manufacturer, the acid treatment prescribed below shall be perfomed 48 to 60 h after preparing the specimens:

a) Completely immerse the specimens in a 20 percent solution (by weight) of hydrochloric acid for a period of 60 min, and

b) Remove the specimens from the acid and blot dry using a paper towel.

6.3.3.2 The specimens shall be aged in such a manner that all sides are exposed to the air at a temperature of 27° ±2°C and a relative humidity of 65±5 percent until tested. All specimens shall be protected from contact with water until tested.

6.4 Procedure — The bar specimens shall be tested after 7 days of preparation of the mortar. If desired, the conditioning time may be extended to establish the age-strength relationship. Report the age of the specimens.

6.4.1 The test specimen shall be placed centrally on self-aligning bearers *A*, *B* and *C* as shown in Fig. 4. The bearers shall be of mild steel 40 mm in diameter and shall be in the same horizontal plane.

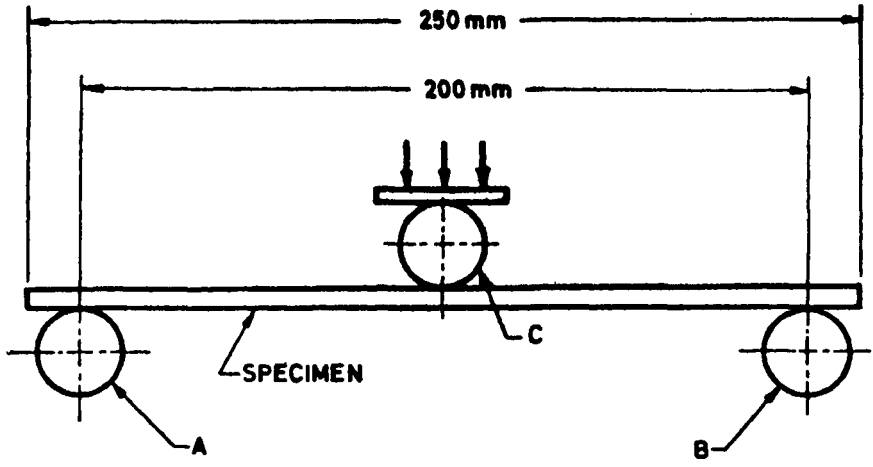


FIG. 4 ARRANGEMENT OF LOADING

6.4.2 The distance between the bearers *A* and *B* at the lines of contact with the specimen shall be 200 mm. The bearer *C* shall be midway between bearers *A* and *B* measured horizontally and rests upon the surface of the specimen.

6.4.3 The load shall be applied at a uniform rate of 42 kg/cm²/min through bearer *C*.

6.5 Calculation — Calculate the flexural strength in kg/cm² as follows:

$$\text{Flexural strength} = \frac{3\,Pl}{2\,bd^2}$$

where

P = load in kg at the time of breaking,

l = length of span in cm,

b = width of specimen in cm at point of break, and

d = depth of specimen in cm at point of break.

6.6 Report — The report shall include the following:

a) Type of mortar;

b) Mixing ratio;

c) Conditioning procedure;

d) Test conditions, such as temperature and humidity;

e) Age of test specimens in days; and

f) Individual and averaged results of flexural strength.

6.6.1 Defective specimens shall be eliminated and the average flexural strength shall be calculated on all the remaining test specimens made from the same sample and tested at the same age. If individual values differ by more than 15 percent from the average or if fewer than three values were used in deriving the average, the test shall be repeated in exactly the same manner.

7. COMPRESSIVE STRENGTH

7.1 Object — To determine the compressive strength of silicate type and resin type chemical resistant mortars.

7.2 Apparatus — In addition to those given in **3.2.1** to **3.2.4** the following shall be also provided.

7.2.1 *Moulds* — The moulds shall be made of hard metal not attacked by the mortar and shall be of the type capable of making three 50-mm cubes at one time. These shall be tight fitting and shall be separable into not more than two parts. The parts of the moulds when assembled shall be positively held together. The sides of the moulds shall be sufficiently rigid to prevent spreading or warping. The interior faces of the moulds shall be plane surfaces. The angle between adjacent interior faces and between interior faces and top and bottom planes of the mould shall

be 90 ± 0·5° measured at points slightly removed from the intersection of the faces.

7.2.2 *Compression Testing Machine*

7.3 Preparation of Mortar — The mortar shall be prepared as given at 3.4.

7.3.1 About 2 400 g of silicate type mortar may be mixed from which six 50-mm cube specimens shall be prepared assuming that the mortar density is not greater than 3.

7.3.2 About 1 600 g of resin type of mortar may be mixed from which six 50-mm cube specimens shall be prepared assuming that the mortar density is not greater than 2.

7.4 Moulding of Test Specimens — Prepare at least six 50-mm cube specimens. Prior to filling the moulds, give their inner surfaces a thin coat of suitable material, such as, silicon grease to prevent sticking of the mortar to the metal of the mould. The material used shall not interfere with the setting of the mortar. Fill the moulds with the mortar using the stainless steel spatula. Place approximately 30 g of the mortar in the mould and work down using a vertical stroke with the spatula to prevent trapping air in the specimen. When the moulds have been filled, strike off the excess mortar evenly with the top of the mould using an oscillating horizontal stroke of a straight edge.

7.5 Conditioning of Test Specimen — The test specimens shall remain in the respective moulds for a period of 24 h after moulding and for cashew nut shell liquid resin mortar the period shall be 48 h.

7.5.1 *Silicate Type of Mortar* — At the end of 48 to 60 h after the specimens have been prepared, completely immerse them in a 20 percent by weight hydrochloric acid for a period of 60 min. Remove the specimens from the acid and blot dry using a paper towel. Age the specimens for a period of 7 days in air at 27° ± 2°C supported in such a manner that air circulates on all sides. The specimens shall be protected from contact with water.

NOTE — Other aging periods at 27° ± 2°C are acceptable provided they are reported with the test data.

7.5.2 *Resin Type of Mortar* — Age the test specimens for a period of 28 days in air at 27° ± 2°C.

7.6 Procedure — Test six cubes for compressive strength at the end of the aging period. The compressive strength shall be the average of six cubes. The cubes shall be tested on their sides without any packing between the cube and the steel plattens of the testing machine. One of the plattens shall be carried on a base and shall be self-adjusting, and the load shall be steadily and uniformly applied, starting from zero at a rate of 350 kg/cm²/min.

NOTE — Cubes that are manifestly faulty shall not be considered. If any of the individual strength values of the specimen made from the same sample and tested at the same age differ by more than 15 percent from the average strength, or if fewer than four strength values were used in deriving the average strength, the test shall be repeated.

7.7 Report — The compressive strength shall be calculated from the crushing load and the average area over which the load is applied. Express the result in kg/cm^2.

8. BOND STRENGTH

8.1 Object — To determine the bond strength between chemical resistant mortars and the ceramic unglazed vitreous acid resisting tile.

8.2 Apparatus

8.2.1 *Balance* — of capacity 1 kg, sensitive to 0·1 g.

8.2.2 *Testing Machine* — universal type in which the load is applied hydraulically, or mechanically or electromechanically at a constant, but adjustable rate of cross head movement or loading. The weighing system may be of the pendulum lever, beam or hydraulic type.

8.2.3 *Mixing Pan*—porcelain enamelled pan measuring 250 × 400 × 50 mm.

8.2.4 *Trowel* — bricklayers' triangular trowel.

8.2.5 *Guide* — for marking tile.

8.2.6 *Special Test Head* — Consisting of two units of the type shown in Fig. 5.

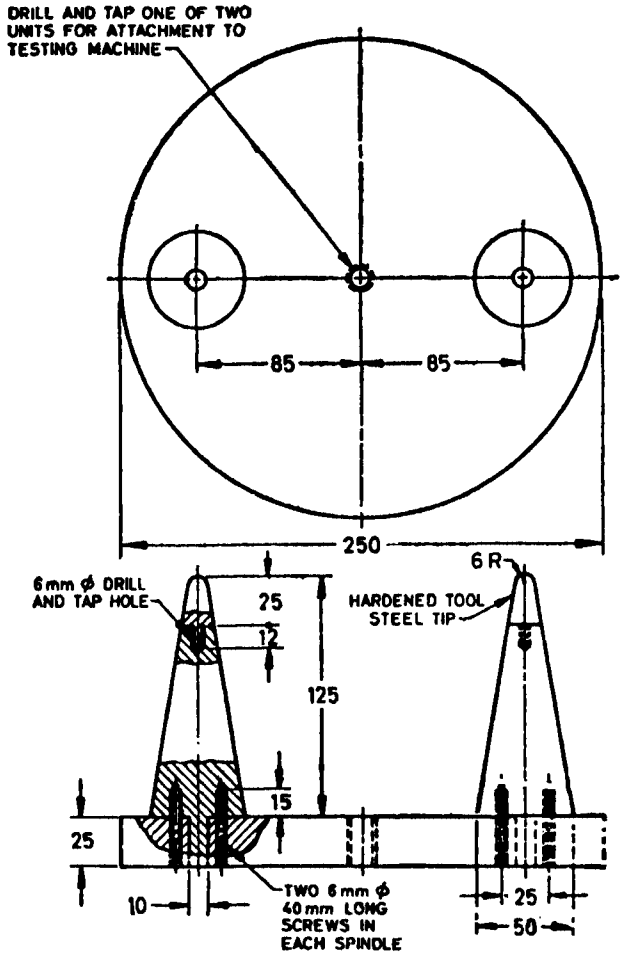
8.2.7 *Oven* — thermostatically controlled with interior of non-corroding material to maintain temperature between 105° and 110°C.

8.2.8 *Tile* — Ceramic unglazed vitreous acid resisting tile conforming to IS : 4457-1967*.

8.3 Conditioning the Tile — The tiles shall be cut to rectangular shape of dimension 198·5 × 100 × 35 mm. Dry the tiles at 105°C ±5°C for 24 h in the oven and allow to cool to 27° ± 2°C. The crossed tiles shall be at right angles to one another and centered one on the other when the specimen is assembled. At the same time, mark the contact points for the load test in the special test head.

8.4 Preparation of Mortar — Prepare about 1·5 kg of mortar mixing it in the proper proportions and in the manner recommended by the manufacturer.

*Specification for ceramic unglazed vitreous acid-resisting tiles.



All dimensions in millimetres.

FIG. 5 SPECIAL TEST HEAD

8.5 Preparation of Crossed Tile Test Specimen — With mortars designed for a trowel type application, apply the mortar over the area on the tile that is marked for the joint. The contact area of each tile shall be thoroughly applied with the mortar. The amount of mortar applied shall be 25 to 50 percent in excess of the required amount to ensure a full joint. Place one of the tiles, mortared side up, on a flat level surface. Then place two blocks on each side of the joint area of the bottom tile. The height of

the blocks shall be uniform and is dependent on the thickness of the mortar joint desired (*see* Note).

The blocks may be made of wood or rigid plastic. Place the second tile on top of the bottom tile in a criss-cross pattern (*see* Fig. 6) joining the mortared areas. Compress the top tile until its ends are firmly against the side blocks. At the same time, align the two tile mortar contacts as parallel surfaces. Strike off the excess mortar that has been squeezed from all sides of the joint. Remove the blocks, taking care not to disturb the joint area. Allow the mortar to set for a minimum of 24 h before handling the specimens.

NOTE — For example if a 5 mm thick joint is desired and the thickness of the tile is 35 mm, then the blocks should be 40 mm in height in order to provide the desired joint thickness.

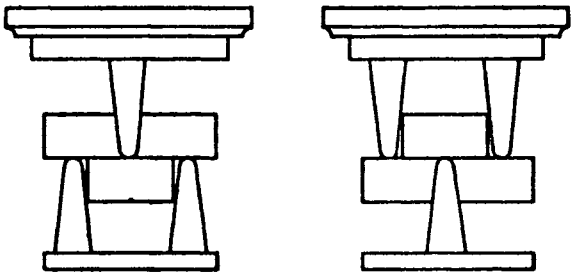


FIG. 6 CROSSED — TILE SPECIMEN MOUNTED ON SPECIAL HEAD

8.5.1 Extreme care shall be taken in handling the specimens. Lifting the unit by the top tile or stacking specimens one above the other shall be avoided.

8.6 Conditioning of the Test Specimens — Condition the specimens for 2 weeks at 27° ± 2°C.

8.7 Procedure — Mount the test specimen in the special test head as shown in Fig. 6. Place the specimen on the support points of the bottom head in such a manner that the specimen is balanced. The marked contact points on the bottom surface of the top tile shall match the support points of the bottom test head. Position the apparatus to match the contact points of the top head with the marked contact points on the top surface of the bottom tile.

8.7.1 Apply the load by setting the free cross head movement at the rate of 5 mm/min.

8.7.2 Inspect the joint after testing and note whether the failure was in the mortar or between the mortar and the tile, and the relative areas involved. This will indicate which is the greater, cohesion within the mortar or adhesion between the mortar and tile.

8.8 Calculation — Calculate the bond strength as follows:

$$B = \frac{W}{A}$$

where

B = bond strength in kg/cm^2,

W = load at failure in kg, and

A = area of joint in cm^2.

8.9 Report — The report shall include the following:

a) Type of mortar tested,

b) Identification of tile used,

c) Age of specimen at the time of test,

d) Number of specimens tested,

e) Type of failure by cohesion or adhesion, and

f) Average bond strength.

9. ABSORPTION AND APPARENT POROSITY

9.1 Object — To determine the absorption and apparent porosity of silicate type and resin type chemical resistant mortars.

9.2 Apparatus

9.2.1 *Balance* — of capacity of 100 g with a sensitivity of 0·5 mg.

9.2.2 *Specific Gravity Balance* — for determining the specific gravity of both liquids and solids with a sensitivity of 0·5 mg.

9.2.3 *Flask* — A glass flask carrying a reflex condenser and provided with interchangeable ground glass joints.

9.2.4 *Moulds* — Plastic tube of 25 mm diameter and 25 mm height having sufficient wall thickness to be rigid and retain dimensional stability during the moulding operation. A 6 mm thick flat plastic sheet shall be provided on which one open end of the mould may rest.

9.2.5 *Oven* — capable of maintaining a temperature of 105° ± 5°C.

9.3 Preparation of Mortars — Mix the mortar in the appropriate proportion specified by the manufacturer in a suitable flat bottom container made of non-corrodible metal or a porcelain enamelled pan using a trowel. Place the liquid in the mixing container, and approximately three-fourth of the powder and mix with the liquid by working with a trowel, turning the mass from bottom to top occasionally. When the mass is uniform add the remainder of the powder and continue the mixing in the same manner until the mortar is uniformly mixed. Record the time required for mixing.

9.4 Preparation of Test Specimen — Fill the mould with the mortar prepared as described in **9.3**. As the moulds are being filled, work a thin

narrow blade vertically through the mortar to permit the escape of the air which would cause void spaces. Level the top surface with the spatula and strike off the excess evenly.

9.5 Conditioning of the Test Specimens — Keep the specimens in the respective moulds for a period of 24 h for all types of mortars except for cashew nut shell liquid resin mortar which shall be kept in the moulds for a period of 48 h. Demould and place the specimens in an oven controlled at 105° to 110°C until they reach constant weight D. Consider the specimens as having reached constant weight when they do not lose more than 0·1 percent of thier original weight in 24 h at 105° to 110°C. Cool the specimens to 27° ± 2°C in a desiccator before weighing.

9.6 Number of Specimens — Six specimens shall be prepared.

9.7 Procedure — Place the weighed specimens in the flask. The flask shall have wire screen or glass beads at its bottom to prevent the specimen from coming in direct contact with the heated bottom of the flask. Add toluene for silicate type mortar and water for resin type mortars until the specimens are completely covered. Install the water cooled condenser and heat the flask by means of a hot plate or heating mantle. Boil the liquid for two hours. After boiling, cool the flask to 27° ± 2°C. The cooling may be accelerated by running cold water over the outer surface of the flask while swirling the flask.

9.7.1 Determine the suspended weight S of each test specimen while suspended in the liquid, to the nearest mg. If the weight of the suspension pan immersed in the liquid cannot be counter-balanced, subtract the tare weight with the suspension pan immersed in the liquid to the same depth as when the specimen is in place to obtain the net suspended weight S.

9.7.2 After determining the suspended weight, blot each specimen with a smooth cotton cloth to remove all liquid droplets from the surface and determine the saturated weight W. Excessive blotting shall be avoided as it will introduce error by withdrawing liquid from the pores of the specimen.

9.7.3 When testing silicate type mortars determine the specific gravity of toluene with the specific gravity balance at 27° ± 2°C.

9.8 Calculation — Calculate the volume of each test specimen in cubic cm as follows:

a) If the liquid is water $V = W - S$

b) If the liquid is toluene $V = \frac{W - S}{G}$

where

V = volume of the specimen in cm^3,
W = saturated weight of specimen in g,
S = suspended weight of specimen in g, and
G = specific gravity of toluene.

9.8.1 Calculate the apparent porosity which expresses as a percentage, the relationship of the volume of the open pores of the test specimen to its exterior volume as follows:

a) If the liquid is water $P = \frac{W - D}{V} \times 100$

b) If the liquid is toluene $P = \frac{W - D}{V \times G} \times 100$

where

P = apparent porosity,

W = saturated weight of specimen in g,

D = weight of specimens after conditioning to constant weight in g,

V = volume of the specimen in cm^3, and

G = specific gravity of toluene.

9.8.2 Calculate the absorption in percent as follows:

$$A = \frac{W - D}{D} \times 100$$

where

A = absorption in percent,

W = saturated weight of specimen in g, and

D = weight of specimens after conditioning to constant weight in g.

9.9 Report — Report the average values for the six specimens as follows:

a) Percentage of the apparent porosity, and

b) Percentage of water or toluene absorption.

9.10 Retest — If a single value deviates from the average value by more than 15 percent, this result shall be discarded and the average of the remaining specimens whose deviation does not exceed this limit shall be taken. Defective specimens shall be discarded. If after discarding the defective specimens and those whose value varies more than 15 percent from the average value, there remain less than four specimens, the test shall be repeated.

10. CHEMICAL RESISTANCE

10.1 Object — To evaluate the chemical resistance of silicate type and resin type chemical resistant mortars under anticipated service conditions. (This method is intended for use as a relatively rapid test in evaluating the chemical resistance).

10.1.1 The method provides for the determination of changes in the following properties of the test specimens and test reagents after exposure of the specimens to the reagent:

a) Weight of specimens,
b) Appearance of specimens,
c) Appearance of immersion mediums, and
d) Compressive strength of specimens.

10.2 Significance — The results obtained by this method should serve as a guide in, but not as the sole basis for selection of mortar for a particular application. No attempt has been made to incorporate into the method all the various factors which may enter into the serviceability of a mortar when subjected to chemical solutions or solvents.

10.3 Apparatus

10.3.1 *Balance* — of capacity 1 kg, sensitive to 0·1 g.

10.3.2 *Equipment for Mixing Mortar* — This may be a container of suitable size made of corrosion resistant metal or a porcelain pan and a spatula or trowel.

10.3.3 *Specimen Moulds — see* **9.2.4.**

10.3.4 *Containers*

a) Wide mouth glass jars of sufficient capacity, fitted with plastic or plastic lined metal screw caps for low temperature tests involving solutions or solvents of low volatility.
b) Erlenmeyer flasks of sufficient capacity each fitted with standard taper joints and reflux condenser attachment for use with volatile solutions or solvents.
c) Containers as described in **10.3.4**(a) and (b) having an inert coating on their inner surfaces or containers of a suitable inert material (such as polyethylene) for use with solutions which attack glass.

10.3.5 Constant temperature oven or liquid bath capable of maintaining temperature within a range of $\pm$ 2°C.

10.3.6 *Compression Testing Machine*

10.4 Reagents — The test reagents shall consist of reagents, solutions or products to which the mortars are to be exposed in service.

10.5 Test Specimens

10.5.1 The test specimens shall be cast right cylinders 25 $\pm$ 1 mm in diameter and 25 $\pm$ 1 mm in height with flat smooth faces normal to the axis of the cylinder prepared in moulds without using any release agent.

10.5.2 The number of specimens required is dependent upon the number of test solutions to be employed, the number of different temperatures at which testing is performed and the frequency of test intervals. The test specimens shall consist of sets of at least three cylinders for one solution at a single temperature and for each test interval. In addition, one set of at least three specimens shall be available for test immediately following the conditioning period, and other sets of at least three, equivalent to the number of test temperatures, for test after aging in air at the test temperature for the total test period. The total number of specimens required shall be calculated as follows:

$$N = 3\ (S \times T \times I) + 3T + 3$$

where

N = number of specimens,
S = number of solutions,
T = number of test temperatures, and
I = number of test intervals.

10.6 Preparation of Specimens — The method of preparation of specimens shall depend upon the type of mortar to be tested. They shall be prepared as described in **10.6.1** and **10.6.2**. If the faces of a specimen are not flat, smooth and normal to the cylinder axis, they may be sanded, ground or machined. Care shall be taken that the frictional heat developed during such operations does not damage the specimen.

10.6.1 *Resin Type Mortars* — Mix in the proper proportion and in the manner specified by the manufacturer. Place the mortar in the mould with a spatula taking care to ensure complete filling of the mould cavity without entrapment of the air. Scrap off excess mortar even with the face of the mould making the exposed surface as smooth and even as possible. Permit the mortar to remain in the mould at least for 48 h until it has set sufficiently to allow removal without danger of deformation or breakage.

10.6.2 *Silicate Type Mortars* — The mortar shall be prepared in the same manner as given in **10.6.1**. The mortar shall remain in the mould for 24 h after moulding.

10.7 Conditioning of Test Specimens

10.7.1 *Silicate Type Mortar* — Acid treat the specimens at the end of 48 to 60 h after the specimens have been prepared. Completely immerse the specimens in a 20 percent by weight solution of hydrochloric acid for a period of 60 min. Then remove the specimens from the acid and blot dry using a paper towel. Age the specimens for a period of 7 days in air at 27° ± 2°C and at a relative humidity not exceeding 90 percent.

10.7.2 *Resin Type Mortars* — Age the specimens for a period of 7 days in air at 27° ± 2°C.

10.8 Test Conditions — Test conditions, such as immersion medium, temperature, etc, shall simulate the anticipated service conditions as closely as possible.

10.9 Procedure

10.9.1 *Measurement of Specimen Diameters* — Immediately following the conditioning period, the diameter of all test specimens shall be measured to the nearest 0·01 mm using a micrometer. Two measurements at right angles to each other shall be taken and the average of the two values shall be reported as diameter.

10.9.2 *Exposure Weighing and Visual Inspection of Test Specimens* — Following the conditioning period, weigh all the specimens to the nearest 0·000 1 g on an analytical balance and record the values. Prior to immersion, record a brief description of the colour and surface appearance of the specimens and the colour and clarity of the test solution. Place the weighed specimens to be immersed in suitable containers resting on their curved sides, care being taken to prevent the cylinder faces from coming in contact with each other. The total number of specimens per container is not limited except by the ability of the container to hold the specimens, plus the requisite amount of test solution per specimen. However, the specimens shall always be an even number. Add approximately 150 ml of the test solution for each specimen, and place the closed container in a constant temperature oven adjusted to the required temperature or in a suitably adjusted liquid bath. Examine the specimens after 1, 7, 14, 28, 56 and 84 days of immersion to determine the nature of attack.

NOTE — Other inspection periods may also be employed and the test may be terminated prior to 84 days, if desired.

10.9.2.1 The specimen shall be cleaned by three quick rinses in running cold tap water and dried by blotting with a paper towel between each immersion. After the final blotting, the specimen shall be allowed to dry for half an hour resting on its curved surface. The specimen shall be weighed to the nearest milligram, and the compression test shall be conducted.

NOTE — If the specimens are to be forwarded to a testing laboratory for conducting the compression test, they may either be transported in the corroding environment, or each cleaned and dried sample placed in an individual air tight bag and so held until ready for weighing and testing. The elapsed time between the removal of the specimens from the corroding environment and the compressive tests should be uniform for all specimens.

10.9.2.2 Note any indication of surface attack on the specimen, any discolouration of the test solution, and the formation of any sediment.

10.9.3 *Compressive Strength Determination of Test Specimen* — Determine the compressive strength for one set of two specimens immediately following the conditioning period; for one set of two specimens after each inspection

period for each solution and each test temperature, and for one set of two specimens after aging in air for the total test period at each test temperature. Break the specimens following the weighing operation and record the maximum load. Place the specimen in the testing machine so that the plane faces of the cylinder are in contact with the surface of the compression tool or cage. Apply the load to the specimen at the rate of 40 kg/cm²/min.

10.9.4 *Changing of Immersion Medium* — Discard and replace the test solution with fresh material after each period. Solutions which are known to be unstable, such as aqueous sodium hypochlorite, shall be replaced as often as necessary in order to maintain original chemical composition and concentration.

10.10 Calculations

10.10.1 *Weight Change* — Calculate to the nearest 0·01 percent the percentage loss or gain in weight of the specimen during immersion for each examination period. Weight change, percent $= -\frac{(C - W)}{C} \times 100$

where

C = conditioned weight of specimen in g, and

W = weight of specimen after immersion in g.

NOTE — A result showing plus sign shall indicate a gain in weight and minus sign shall indicate a loss.

10.10.1.1 Construct a graph employing the average percentage of weight change of all specimens at a given examination period after immersion in a particular test solution at a given temperature, plotting the percentage of weight change as the ordinate and the test period, in days as the abscissa.

10.10.1.2 The absolute compressive strength in kg/cm² should be shown for the initial specimen and the final specimen. These values should be noted parenthetically near the plot point of each value.

10.10.2 *Change in Compressive Strength* — Calculate to the nearest 0·01 percent, the percentage decrease or increase in compressive strength of the specimen during immersion for each examination period. The cross sectional area of the specimen shall be based on the diameter as determined by the method given in **10.9.1.**

$$\text{Change in compressive strength, percent} = \frac{(S_1 - S_2)}{S_1} \times 100$$

where

S_1 = maximum load in kg per cross sectional area (cm²) of specimen after conditioning period, and

S_2 = maximum load, in kg per cross sectional area (cm^2) of specimen after test period.

NOTE — A result showing a plus sign will indicate a gain in compressive strength and a minus sign will indicate a loss.

10.10.2.1 Construct a graph employing the average percentage of change in compressive strength of the two specimens broken at a given examination period after immersion in a particular test solution at a given temperature, plotting the percentage of change in compressive strength as the ordinate and the test period, in days as abscissa.

10.11 Interpretation of Test Results

10.11.1 *Weight Change* — Because of the chemical nature of different types of mortars, the rate of weight change with time is of more significance than the actual value at any one time. A plot of the test results will indicate whether a particular mortar will approach constant weight in time or will continue to change in weight as the test progresses.

10.11.2 *Appearance of Specimen* — Visual inspection of the exposed specimen for surface cracks, loss of gloss, etching, pitting, softening, etc, is very important in cases where initial weight changes are high.

10.11.3 *Appearance of Immersion Medium* — Discolouration of the test solution and the formation of sediment are significant factors. An initial discolouration coupled with a high weight loss may indicate extraction of soluble components. Continuation of the test with fresh solution will indicate whether or not the attack is progressive.

10.11.4 *Change in Compressive Strength* — The same considerations hold true as given at **10.11.1** and, therefore, the rate of change in compressive strength is an important characteristic to be determined.

10.12 Report — The report shall include the following:

a) Type of mortar;
b) Mixing ratio;
c) Conditioning procedure;
d) Test conditions, such as immersion medium and temperature;
e) Colour and surface appearance of specimen before testing;
f) Total duration of test in days, and examination periods in days. For each examination period the data given in **10.12.1** are required;
g) Graph showing percent weight change plotted against test period; and
h) Graph showing percent change in compressive strength plotted against test period.

10.12.1 The following information shall be required:

a) Average percentage of weight change of specimens.

b) Appearance of specimens after immersion (surface cracks, loss of gloss, etching, pitting, softening, etc);

c) Appearance of immersion medium (discolouration, sediment, etc); and

d) Average percent change in compressive strength of specimens.

APPENDIX A

(*Clause* 0.3)

LIST OF PUBLICATIONS ISSUED BY AMERICAN SOCIETY FOR TESTING AND MATERIALS

C-414-65	Test for working and setting times of chemical-resistant silicate and silica mortars
C-308-64	Test for working and setting times of chemical-resistant resin mortars
C-307-61	Test for tensile strength of chemical-resistant resin mortars
C-453-60 T	Test for fluxural strength of chemically setting silicate-type chemical resistant mortars (tentative)
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C-579-65 T	Test for compressive strength of chemical-resistant mortars (tentative)
C-396-60	Test for compressive strength of chemically setting, silicate and silica chemical-resistant mortars
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