Indian Standard

CODE OF PRACTICE FOR PREPARATION AND USE OF MASONRY MORTARS

(*First Revision*)

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Indian Standard

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(First Revision)

0. F O R E W O R D

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 27 February 1981, after the draft finalized by the Building Construction Practices Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Choice of masonry mortar is governed by several considerations, such as type of masonry, situation of use, degree of exposure to weather, strength requirements, besides special considerations like fire resistance, insulation, rate of setting and hardening, etc. The ingredients for mortar have also a wide variety. Cementitious ingredients may be cement or lime or combinations of these and with or without addition of pozzolanas, plasticizers, etc. The aggregates may be sand, burnt-clay aggregate or cinder. As many of these ingredients have a wide variation in characteristics, the proportions in which they are to be mixed depend largely on practical experience with local materials. However, with the development of standard specifications to govern the quality of cement, lime, sand and other pozzolanic materials, it is possible to apply some of the basic principles for selection and use of masonry mortars, which have accrued as a result of research work in this field in the country and abroad. This standard is intended to provide such guidance regarding properties and use of masonry mortars.

0.3 This standard, published in 1965, was intended to bring out a long felt uniformity in the variety of practices being followed by various organizations in the country in the preparation of cement mortars, cement lime mortars and their use is masonry works. A separate standard, namely IS : 1625, was published in 1962 and revised in 1971 covering information regarding properties and preparation of lime mortars and their use in masonry works. The Sectional Committee responsible for the preparation of this standard, while taking up this revision, felt that the requirements for both cement mortars and lime mortars should be

brought together in one standard. Thus, this revision is prepared incorporating the provision of IS : 1625-1971* and to incorporate improvements found necessary in the light of the usage of the standard, and the suggestions made by various organizations implementing it. IS : 1625-1971* will be withdrawn with the printing of this revision.

0.3.1 In this revision, number of changes have been incorporated. The most significant being the gradation of masonry mortars only in terms of. their minimum compressive strength (at the age of 28 days), since proportioning of mortars by loose volume would not allow adjustment to take care of variations in the quality of the ingredients (*see* Table 1). However, volumetric proportioning (by loose volume) being the only practice being followed in the country, mortars in terms of different nominal mix proportions and which would give the range of above compressive strengths (at the age of 28 days) have also been included in this revision as a guidance to the users. The technical committee responsible for the preparation of this revision feels that where facilities for determining the actual mix proportion corresponding to the specified grade are not available, the nominal mixes as specified in this revision may be used. The committee in this respect recognises the existence of additional mixes other than what has been included in this revision, which might provide greater flexibility of choice to the users. But it is felt that inclusion of all possible combinations might not only burden the code but also might not be needed for the construction of great majority of masonry. The committee also appreciates the necessity of reflecting the expected increase in strength of lime based mortars after 28 days, which is otherwise the basis of gradation of masonry mortars, and feels the necessity of including a provision for taking advantage of this expected increased strength. But in the absence of definite technical data, the concept of substantial growth in strength of lime based mortars after 28 days is being excluded from the present version. Investigations are in progress and the information will be added in the standard as and when available. Further, the method of mixing the ingredients for various types of mortars has been dealt in detail in this revision and the method of determining the compressive strength of mortars has been modified. Only SI units have been used in this revision.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied 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†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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*Code of practice for preparation of lime mortar for use in buildings (*first revision*)
†Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard covers the preparation of masonry mortars and their use in masonry works.

NOTE — Use of mud mortars, gypsum mortars and bituminous mortars is not covered in this standard.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions in addition to those given in IS : 6508-1972* and IS : 4305-1967† shall apply.

2.1 Mortar — Mortar is a homogeneous mixture, produced by intimately mixing cementitious materials, water and inert materials, such as sand, to the required consistency for use in building together with masonry units.

2.2 Lime Mortar — A mortar containing lime and sand.

2.3 Composite Mortar — A mortar containing cement and lime in addition to other ingredients.

2.4 Grade of Masonry Mortar — The 'grade' of a masonry mortar will be defined by its compressive strength in N/mm^2 at the age of 28 days, as determined by the standard procedure detailed in Appendix A.

2.5 Consistency — The working consistency of a mortar or plastering mix as judged by the worker from its behaviour during application. Its assessment includes characteristics, such as initial fluidity, water retentivity, etc.

2.6 Hardening — The physio-chemical changes observed in a mortar due to the effect of one or more of the following phenomena:

a) Absorption of carbon dioxide,

b) Recrystallization, and

c) Chemical reaction.

2.7 Setting — The physical and chemical changes observed in a mortar mainly due to the hydration of hydraulic constituents of the mortar or due to the interaction of some of the constituents or a combination of both the types of reactions.

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*Glossary of terms relating to building lime.

†Glossary of terms relating to pozzolana.

2.8 Water Retentivity — The ability of mortars to retain water against suction and evaporation in general. It is indirectly a measure of the workability of mortars. It is measured by the flow of mortar when tested on a standard flow table before and after application of a specified suction (*see* Appendix C).

2.9 Workability — That property of freshly mixed mortar which determines the ease and homogeneity with which it can be mixed, placed, compacted and finished. It is the amount of energy to overcome friction and cause full consolidation.

3. NECESSARY INFORMATION

3.1 Proper selection of mortars for various uses depends upon the following factors:

a) Type of masonry, namely brick work, stone work, concrete block work, etc, and strength of individual masonry unit;

b) Situation of use of the masonry, namely, whether in foundation, superstructure, etc. Conditions of surrounding soil in the case of foundation work;

c) Load which the masonry will have to bear;

d) Conditions of exposure to weather or soil conditions in the case of masonry buried below ground level;

e) Type and grading of fine aggregates to be used in the mortar, namely, whether sand, burnt-clay aggregate or cinder aggregate;

f) In the case of hydraulic structures weathering conditions under water contact and under water head action; and

g) In case of use in storage of acidic or alkaline substances like fertilizers.

4. MATERIALS

4.1 Cement — Cement used in the preparation of masonry mortar shall conform to either IS : 269-1976* or 455-1976† or IS : 1489-1976‡ or

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*Specification for ordinary and low heat Portland cement (*third revision*).

†Specification for Portland slag cement (*third revision*).

‡Specification for Portland-pozzolana cement (*second revision*).

IS : 3466-1967* or IS : 8041-1978† or IS : 8043-1978‡ and IS : 8112-1976§.

4.2 Fine Aggregate

4.2.1 *Sand* — shall conform to IS : 2116-1980‖.

4.2.2 Burnt-clay, fly ash and cinder aggregate shall conform to IS : 3182-1975¶, IS : 3812 (Part III)-1966** and IS : 2686-1977††.

4.3 Lime — shall conform to IS : 712-1973‡‡.

4.3.1 Hydraulic and semihydraulic limes corresponding to class A, B and E of IS : 712-1973‡‡ are eminently suitable for use in masonry mortars, whereas fat limes corresponding to class C and D will require mixing of burnt clay pozzolana or other pozzolanic materials. Class C and D limes may also be used with addition of cement and pozzolanic materials.

4.3.2 Class A lime of IS : 712-1973‡‡ shall be supplied as hydrated lime alone. Class B, C, D and E lime as specified in IS : 712-1973‡‡ shall be supplied both as quick lime and hydrated lime. Quick lime shall never be used for structural purpose. It must be slacked first. Slaking at site of work shall be done in accordance with IS : 1635-1975§§.

NOTE — The quality and characteristics of lime are considerably influenced by the method of slaking in addition to the chemical composition. Also, inadequately slaked particles of lime will continue to hydrate after the lime is used in the mortar and consequently lead to defects, such as popping, blowing, crack development, etc.

4.4 Lime Pozzolana Mixture — shall conform to IS : 4098-1967‖‖.

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*Specification for masonry cement (*first revision*).
†Specification for rapid hardening Portland cement (*first revision*).
‡Specification for hydrophobic Portland cement (*first revision*).
§Specification for high strength ordinary Portland cement.
‖Specification for sand for masonry mortars (*first revision*).
¶Specification for broken brick (burnt clay) fine aggregate for use in lime mortar (*first revision*).
**Specification for fly ash: Part III For use as fine aggregate for mortar and concrete.
††Specification for cinder aggregates for use in lime concrete (*first revision*).
‡‡Specification for building limes (*second revision*).
§§Code of practice for field slacking of building lime and preparation of putty (*first revision*).
‖‖Specification for lime-pozzolana mixture.

4.5 Pozzolana

4.5.1 *Burnt Clay Pozzolana* — shall conform to IS: 1344-1968*.

4.5.2 *Fly Ash* — shall conform to IS : 3812 (Part I)-1966†.

4.6 Water — Water used for making masonry mortars shall be clean and free from injurious quantities of deleterious materials. Potable water is generally considered satisfactory for use in masonry mortar. For further requirements regarding limits of deleterious materials permitted reference may be made to IS : 456-1978‡.

4.7 Storage of Materials — Storage of materials shall be in accordance with IS : 4082-1977§.

5. DESIGN CONSIDERATIONS

5.1 Durability

5.1.1 The durability of masonry mortars depends upon the following factors:

   a) Volumetric changes during the process of setting, hardening, and later due to temperature variations or due to moisture movements in the surroundings, and the extent to which the mortar will internally accommodate the stresses induced by these volumetric changes before yielding;

   b) The nature and distribution of the resulting cracks, whether as fine cracks well-distributed throughout or large localized cracks;

   c) The extent to which the bond between the mortar and the masonry units is ruptured by volumetric changes and structural movements resulting not only in reduction in strength of masonry but also in provision of channels of seepage for water and other solution into the masonry which would further the process of deterioration; and

   d) Resistance to chemical attack in aggressive environment.

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*Specification for burnt clay pozzolana (*first revision*).

†Specification for fly ash: Part I For use as pozzolana.

‡Code of practice for plain and reinforced concrete (*third revision*).

§Recommendations on stacking and storage of construction materials at site (*first revision*).

5.1.2 All mortars are likely to deteriorate to a greater or lesser extent under prolonged exposure to the environment. The rate of deterioration depends not only upon the composition of the mortar, but also upon thorough, uniform and intimate mixing and the workmanship in laying the masonry.

5.1.3 *Effect of Volume Change*

5.1.3.1 In the early stages, when mortar is green, temperature fluctuations and variations in moisture content cause volume changes that are detrimental to a masonry mortar in course of time. Generally, the effect of temperature fluctuations is negligible compared to that of moisture variation. If there is excessive volume change due to alternate wetting and drying, the bond between the mortar and the masonry is liable to be destroyed, causing cracks to appear in the hard set mortar.

5.1.3.2 Since lime mortars undergo only negligible volume change after setting and initial shrinkage and the hardening of the mortar is also a slow process, the mortar is able to retain its bond with the masonry unit and be free from cracks.

5.1.3.3 Lime mortars are also able to take normal movements in masonry mortar caused by volume changes by virtue of internal accommodation; in this process it will undergo elastic or creep deformations and may recover fully or partly. The extensibility of masonry mortar, which indicates its capacity for internal accommodation, ranges from 2 to 3×10^{-4}. This is generally larger than the volume change (maximum shrinkage) that normally occurs in lime mortars on hardening. Because of the accommodation of the mortar, the stresses that develop due to various deformations, such as expansion, contraction and deflection, will get distributed in the mortar and their intensities will be low.

5.1.4 *Resistance to Sulphate Attack* — The sources of sulphate giving rise to this trouble will be:

   a) in exceptional circumstances, sulphate derived from the brick constituting the masonry unit;

   b) sulphate contained in the sand or fine aggregate used in the mortar where sulphate content in these has to be allowed high from economic consideration; and

   c) sulphate from soil in the case of masonry in contact with soil.

5.1.4.1 The cement in the mortar will undergo expansive reaction in the presence of sulphate, which will lead to cracks in the mortar. Where serious sulphate attack is expected, Portland slag cement, or

Portland pozzolana cement may preferably be used instead of ordinary Portland cement. Other general precautions to be taken against sulphate attack in masonry design as well as workmanship are covered in IS : 2212-1962*.

5.2 Hardening of Mortar — A masonry mortar should harden at such a rate that it causes no delay in the progress of work, but at the same time it is able to retain its plastic properties for a sufficient interval till the initial shrinkage of the mortor is complete. This will minimize the danger of cracks and opening of joints in masonry. The rate of hardening of lime mortars is slower than that of cement mortars, but is satisfactory for most of the normal building works, except where high strength is required.

5.3 Strength Development

5.3.1 Strength development is an important requirement before masonry is loaded to the full extent, and the rate of construction should synchronize with the development of the strength on masonry, particularly in the case of masonry with weak mortars. Extra time shall be allowed for hardening of mortar when the atmospheric temperature during construction is very low (minimum 5°C in 24 h). The period will have to be increased by 100 percent for the time during which the temperature remains below 5°C and by 50 percent for the time when temperature is between 5 and 10°C.

5.3.2 The strength of lime mortars is dependent on the class of lime (*see* IS : 712-1973†) and other constituents used in the mortar (*see* Table 1). Incorporation of cement and/or pozzolana in lime mortar mixes made with Class B and Class E lime will increase the strength and rate of hardening of the mortars without appreciably reducing workability.

5.4 Quantity of Water — The quantity of water to be added to the mortar shall be such that the working consistency (*see* **2.1**) is obtained. Excess water shall be avoided.

6. GRADE OF MORTAR

6.1 Masonry mortars shall preferably be specified by the grade in terms of their minimum compressive strength as given in Table 1. Masonry mortars in terms of mix proportion which gives the range of compressive strength (at the age of 28 days) values are also given in Table 1 for guidance.

> NOTE — The compressive strength of mortar shall be determined in accordance with the procedure given in Appendix A.

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*Code of practice for brickwork.

†Specification for building limes (*second revision*).

TABLE 1 GRADE OF MASONRY MORTARS

(*Clauses* 0.3.1, 5.3.2 *and* 6.1)

Sl No.	Grade	Mortar Mix (by Loose Volume)					Compressive Strength at 28 Days
		Cement	Lime	Pozzolana	Lime Pozzolana Mixture	Sand	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) N/mm²
1	MM 0·5	0	1 B or E	0	0	3	0·5 to 0·7
2		0	0	0	1 (LP-7)	1·25	
3		0	1 C or D	1	0	2	
4	MM 0·7	0	0	0	1 (LP-20)	1·5	0·7 to 1·5
5		0	0	0	1 (LP-40)	2·25	
6		1	3 C or D	0	0	12	
7		1	0	0	0	8	
8		1	0	0·4*	0	10	
9	MM 1·5	0	0	0	1 (LP-20)	1·25	1·5 to 2
10		0	0	0	1 (LP-40)	2	
11		1	0	0	0	7	
12		1	0	0·4*	0	8·75	
13		0	1A	0	0	3	
14	MM 2	0	1A	0	0	2	2 to 3
15		0	1C or D	3*	0	0	
16		1	2C or D	0	0	9	
17		0	0	0	1 (LP-20)	1	
18		0	0	0	1 (LP-40)	1·75	

(*Continued*)

TABLE 1   GRADE OF MASONRY MORTARS — *Contd*

Sl No.	Grade	Mortar Mix (by Loose Volume)					Compressive Strength at 28 Days
		Cement	Lime ·	Pozzolana	Lime Pozzolana Mixture	Sand	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) N/mm²
19	MM 3	0	1 C or D	2*	0	· 0	⎫
20		1	1 C or D	0	0·	0	⎪
21		1	0	0	0	6	⎪
22		0	1A	0	0	1	⎪
23		1†	0	0·21*	0	4·2	⎬ 3 to 5
24		0	0	0	1 (LP-40)	1·5	⎪
25		1	0	0·4*	0	7·5	⎪
26	MM 3	1	0	0	2 (LP-20)	12	⎭
27	MM 5	1	0 to ¼ B, C, D or E	0	0	4	⎫
28		1	0	0	0	5	⎪
29		0	0	0	1 (LP-40)	1	⎬ 5 to 7·5
30		1	0	0·4	0	6·25	⎪
31		1	0	0·4	0	5	⎭
32	MM 7·5	1	¼ C or D	0	0	3	⎫
33		1	½ C or D	0	0	4·5	⎪
34		1	0	0	0	4	⎪
35		1†	0	0·2*	0	2·1	⎬ 7·5 and above
36		1	0	0	0	3	⎪
37		1	0	0·4	0	3·75	⎪
38	MM 7·5	1	0	0	1 (LP-20)	8	⎭

NOTE 1 — A, B, C, D and E denote the classses of limes to be used [*see* IS : 712-1973 Specification for building lime (*revised*)].

NOTE 2 — The strength values of lime mortars given in the table are after wet grinding of the mortar ingredients.

NOTE 3 — The compressive strength shall be determined in accordance with the procedure given in Appendix A.

*Pozzolana of minimum lime reactivity of 4 N/mm².

†This ratio by volume correspondes approximately to cement pozzolana ratio of 0·8 : 0·2 by weight. In this case, only ordinary Portland cement is to be used [*see* IS : 269-1976 Specification for ordinary rapid hardening and low heat Portland cement (*third revision*)].

7. CRITERIA FOR SELECTION OF MASONRY MORTARS

7.1 The selection of masonry mortars from durability considerations will have to cover both the loading and exposure conditions of the masonry. The requirements for masonry mortar shall generally be as specified in **7.1.1** to **7.1.6** (*see also* Table 1).

7.1.1 In the case of masonry exposed frequently to rains and where there is further protection by way of plastering or rendering or other finishes, the grade of mortar shall not be less than MM 0·7 but shall preferably be of grade MM 2. Where no protection is provided, the grade of mortar for external walls shall not be less than MM 2.

7.1.2 In the case of load bearing internal walls, the grade of mortar shall preferably be MM 0·7 or more for high durability but in no case less than MM 0·5.

7.1.3 In the case of masonry in foundations laid below damp-proof course, the grades of morter for use in masonry shall be as specified below:

a) Where soil has little moisture, masonry mortar of grade not less than MM 0·7 shall be used;

b) Where soil is very damp, masonry mortar of grade preferably MM 2 or more shall be used. But in no case shall the grade of mortar be less than MM 0·7; and

c) Where soil is saturated with water, masonry mortar of grade MM 3 shall be used but in no case shall the grade of mortar be less than MM 2.

7.1.4 For masonry in buildings subject to vibration of machinery, the grade of mortar shall not be less than MM 3.

7.1.5 For parapets, where the height is greater than thrice the thickness, the grade of masonry mortar used shall not be less than MM 3. In the case of low parapets, the grade of mortar shall be the same as used in the wall masonry below.

7.1.6 The grade of mortar for bedding joints in masonry with large concrete blocks shall not be less than MM 3.

8. PREPARATION OF MASONRY MORTARS

8.1 Proportioning — Cement shall be proportioned only by full bags. Hydrated lime, pozzolana and, aggregates shall be measured by volume using gauge boxes of suitable capacity.

8.1.1 The quantities of some of the ingredients for measurement may also be taken on the basis of the unit weight. The unit weight of some of the materials in loosely placed condition are given in Table 2 for conversion from weight to volume.

TABLE 2 UNIT WEIGHT OF MATERIALS IN LOOSELY PLACED CONDITION

Sʟ No.	Material	Unit Weight g/m^3
(1)	(2)	(3)
i)	Sand (dry)	Variable (*see* Note)
ii)	Lime-pozzolana mixture	700 to 840
iii)	Pozzolana:	
	a) Burnt-clay pozzolana	775 to 945
	b) Fly ash	570 to 600
iv)	Dry hydrated lime	630 to 770

Note 1 — Loosely placed condition is achieved by pouring or filling the material in the container loosely, that is, without giving any jerk to the container.

Note 2 — The unit weight of dry and loose sand shall be found by actual field measurement.

8.2 Preparation of Cement Mortar — Mixing shall be done preferably in a mechanical mixer. If done by hand, the operation shall be carried out on a clean watertight platform. Cement and sand shall be mixed dry in the required proportions to obtain a uniform colour. The required quantity of water shall then be added and the mortar mixed to produce a workable consistency. In the case of mechanical mixing, the mortar shall be mixed for at least three minutes after addition of water; in the case of hand mixing, the mortar shall be hold back and forth for 5 to 10 minutes with addition of water.

8.2.1 Generally, only as much quantity of cement mortar as would be sufficient for 30 minutes, work shall be mixed at a time.

8.3 Preparation of Lime Mortar

8.3.1 *Slaking of Lime* — If lime is supplied in the form of quick lime, it shall be slaked and run into putty, if necessary, in accordance with IS : 1635-1975*.

8.3.2 *Mixing of Lime Mortars*

8.3.2.1 Putty and sand in the specified proportions shall be mixed with or without addition of water on a dry waterproof platform or in a mixer. The mix shall then be fed into a mortar mill with the required addition of water. The mortar shall be raked continuously during grinding, particularly in the angular edges of the mortar mill. Water may be added during grinding as required, but care shall be taken not to add more water than to bring the material to the working consistency. The mixing shall be done till every particle of the aggregate is coated uniformly with the cementitious material.

NOTE — Grinding of lime mortars shall be done, if necessary.

8.3.2.2 Dry hydrated lime and sand in specified proportions shall be mixed dry first and shall then be fed into a mortar mill with required additions of water. The mixing shall be done in accordance with **8.3.2.1**.

NOTE — When factory made dry hydrated lime conforming to IS : 712-1973† is used, grinding of the lime and sand in the mortar mill is not necessary.

8.3.3 Generally, only as much quantity of lime mortar (except made with Class A lime) as would be sufficient for day's work shall be mixed at a time. If eminently hydraulic lime (Class A) is present as an ingredient, the mortar shall be used within 4 hours after grinding.

8.4 Preparation of Composite Mortar

8.4.1 Where coarse sand is used, the lime putty and sand in the required proportions shall, after preliminary mixing on a watertight platform, with necessary addition of water, be ground in a mortar mill taking care to rake up continuously the mortar particularly at the corners, and also adding water as and when required during grinding. This mix shall then be transferred to a mechanical mixer to which the required quantity of cement is added and the content mixed for at least three minutes.

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*Code of practice for field slaking of building lime and preparation of putty (*first revision*).

†Specificatinn for building limes (*second revision*).

8.4.2 Where fine sand is used, the mixing operations shall be done in the same manner as in **8.4.1**, except that grinding may be omitted for the preliminary mixing of lime putty and sand.

NOTE — When factory made dry hydrated lime conforming to IS : 712-1973* is used, grinding of lime and sand in the mortar mill is not necessary.

8.4.3 If the mixture of lime putty and sand is not used immediately for mixing with cement, it shall be kept protected from drying out till the time of use.

8.4.4 When adding water in the mortar during mixing operations, it shall be ensured that it is added only to the extent necessary for obtaining working consistency for the mortar and not more.

8.4.5 Where pozzolana is used in the mortar, the pozzolana shall first be mixed with the lime in the specified proportions and ground in a mortar mill with the addition of required quantity of water. Sand shall then be added to the mix and mixing and grinding repeated till every aggregate particle gets coated uniformly with the cementitious material. Mixing after addition of cement shall be done in the same manner as described in **8.4.1** in a mechanical mixer.

8.4.6 Generally, only as much quantity of composite mortar as would be sufficient for 4 hours, work shall be mixed at a time.

8.5 Preparation of Mortars Using Lime-Pozzolana Mixtures — Mortars using lime-pozzolana mixtures shall be prepared in the same manner as described in **8.2**.

8.5.1 Mortars with lime-pozzolana mixture of type LP 20 and LP 40 as binder shall be used within 4 hours from the time of mixing of the mortar, whereas mortars which have hydraulic lime (Class B) or fatlime (Class C) and pozzolana or lime-pozzolana mixture of type LP 7 as ingredients, but do not have either Portland cement or eminently hydraulic lime (Class A) shall be used within 12 to 24 hours from the time of mixing of the mortar.

8.6 Retempering of Mortars

8.6.1 In the case of mortar using cement, the mortar that has stiffened because of evaporation of water from the mortar may be re-tempered by adding water as frequently as needed to restore the requirements of consistency. But this re-tempering shall be permitted only within 60 minutes from the time of addition of cement.

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*Specification for building limes (*second revision*).

9. CONSISTENCY OF MASONRY MORTARS

9.1 The working consistency of the mortar is usually judged by the worker during application. The water should be enough to maintain the fluidity of the mortar during application, but at the same time it shall not be excessive leading to segregation of aggregates from the cementitious material. The quantity of water needed for maintaining consistency or fluidity will also depend upon the masonry to which the mortar is used; for example, thinner joints will require greater fluidity; bed joints subject to heavy pressure may require stiffer mortar. Also, the mortar should be able to hold the water against suction by the masonry unit, particularly in the case of burnt clay and concrete products.

9.1.1 The consistency of mortars shall be measured in accordance with the procedure given in Appendix B and the following values of depth of penetration are recommended.

For laying walls with solid bricks	90 to 130 mm
For laying perforated bricks	70 to 80 mm
For filling cavities	130 to 150 mm

9.2 Water Retentivity — Measurement of water retentivity may be necessary only in the case where mortar is to be used with masonry unit which has got high suction characteristics. Water retentivity shall be determined as described in Appendix C and the flow after suction in the test shall not be less than 70 percent of the flow before suction.

10. SAMPLING OF FRESHLY MIXED MASONRY MORTARS

10.1 Apparatus — The following apparatus is required:

a) According to the method being used, either a metal receptacle of not less than 1 litre capacity or a scoop; and

b) Airtight containers.

10.2 Procedure — Samples shall be obtained by taking uniformly distributed increments (preferably from material in motion, provided this can be carried out in safety), and mixed to form a thoroughly combined bulk sample. The number of increments and the size of bulk sample necessary will depend upon the quality of the material and its variability and the accuracy of the test results required.

10.2.1 *Batch Mixes* — The mortar shall be sampled at the discharge point of a batch from the mixer. Not less than three increments shall be taken at about the times when one-quarter, one-half and three-quarters of the batch have been discharged. The increments shall be

taken by passing the dry, clean, metal receptacle across the stream of mortar in such a manner as to collect a thoroughly representative sample of mortar.

10.2.2 *Hand Mixes* — The mortar shall be turned over with clean, dry shovel and samples taken by means of the scoop at regular spacings throughout the mass.

10.2.3 *Heaps* — In the case of heaps, the increments shall be taken from material well below the surface in at least twelve different places in the mass, distributed in a regular manner, so as to ensure, when mixed, a thoroughly representative combined sample.

10.2.4 *Reduction of Bulk Sample* — The increments or sub-samples taken in accordance with any of the methods described above shall immediately be combined and thoroughly mixed and reduced to a sample of not less than 10 kg and placed in one or more airtight containers.

NOTE — If consistency test is to be made on a sample, arrangements shall be made to carry out the tests at the point of sampling.

10.3 Particulars of Sample — The following particulars shall be recorded and the sample container marked accordingly:

a) The date,
b) Place and method of sampling, and
c) The date of preparation and the quantity of the batch or consignment.

APPENDIX A

(*Clauses* 2.4, 6.1, and *Table* 1)

DETERMINATION OF COMPRESSIVE STRENGTH OF MASONRY MORTAR

A-1. OBJECT

A-1.1 To determine the compressive strength of the masonry mortars.

A-2. APPARATUS

A-2.1 Scales — The scales used in weighing materials for mortar mixes shall conform to the following requirements:

On scales in use, the permissible variation at a load of 2 000 g shall be ± 2·0 g. The permissible variation on new scales shall be one-half of this value. The sensibility reciprocal shall be not greater than twice the permissible variation.

A-2.2 Specimen and Moulds — The test specimens shall be cubes of size 50 mm and shall conform to the requirements given in **A-2.2.1**.

A-2.2.1 *Cube Moulds* — The moulds for the 50 mm cube specimen shall be metal not attacked by cement, cement-pozzolana mixture or lime-pozzolana mixture and there shall be sufficient strength and stiffness to prevent spreading and warping. The moulds shall be rigidly constructed in such a manner as to facilitate the removal of the moulded specimen without damage. The moulds shall be machined so that when assembled ready for use, the dimensions and internal faces shall be accurate to the following limits:

The height of the mould and the distance between the opposite faces shall be 50 ± 0.1 mm. The angle between adjacent interior faces and between interior faces and top and bottom planes of the mould shall be 90 ± 0.5 degrees. The interior faces of the moulds shall be plane surfaces with a permissible variation of 0.03 mm. Each mould shall be provided with a base plate having a plane surface machined to a tolerance 0.10 mm and made of non-absorbent, non-corridible and non-reactive material. The base plate shall be of such dimensions as to support the mould during the filling without leakage.

The parts of the mould when assembled shall be positively held together, and suitable methods of ensuring this, both during the filling and on subsequent removal of the filled mould, shall be provided in order to prevent the moulded specimen from damage.

A-2.3 Mixing Apparatus — The mixing apparatus shall conform to the requirements specified in **A-2.3.1** and **A-2.3.2**.

A-2.3.1 *Mixer* — The mixer shall be an electrically driven mechanical mixer which shall consist essentially of the following:

a) A stainless steel mixing bowl with a nominal capacity of 5 litres of the shape and dimensions as shown in Fig. 1 and provided with means by which it can be securely fixed to the mixing frame during mixing, and

b) A mixer blade of the form and dimensions shown in Fig. 2 revolving about its axis as it is driven in a planetary movement around the bowl by an electric motor.

A-2.3.1.1 The two directions of rotation shall be opposite. The speed of rotation during mixing shall be as follows:
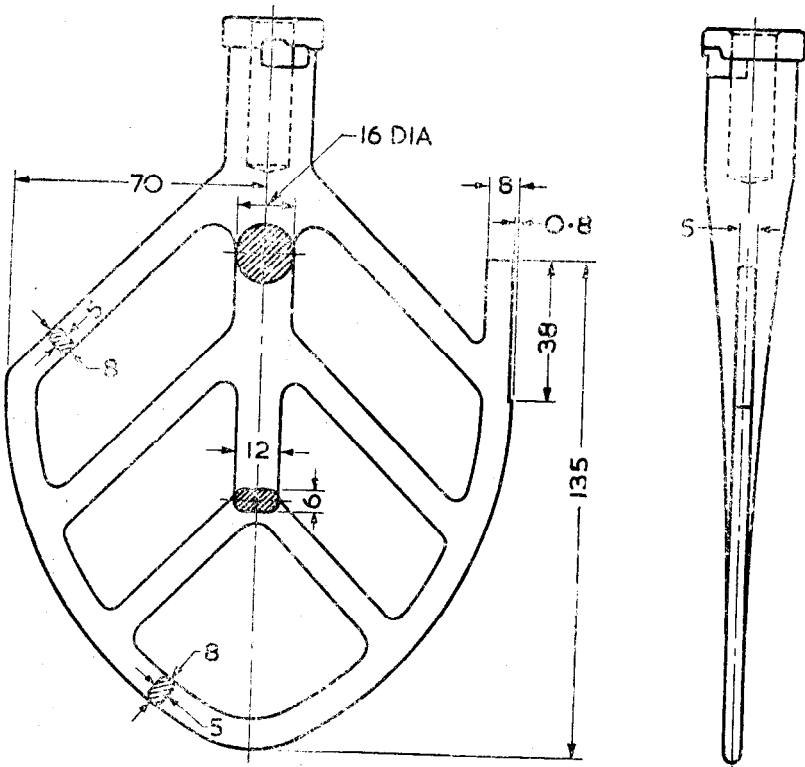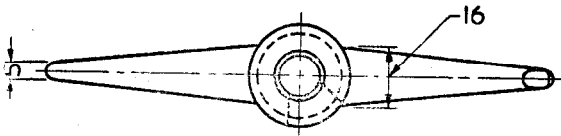
a) Blade revolving about its own axis 140 ± 5 rev/min

b) Planetary movement 62 ± 5 rev/min

Note — The above bowl and blade shall be used when the mass of the solid material including putty is between 3 and 4.5 kg.

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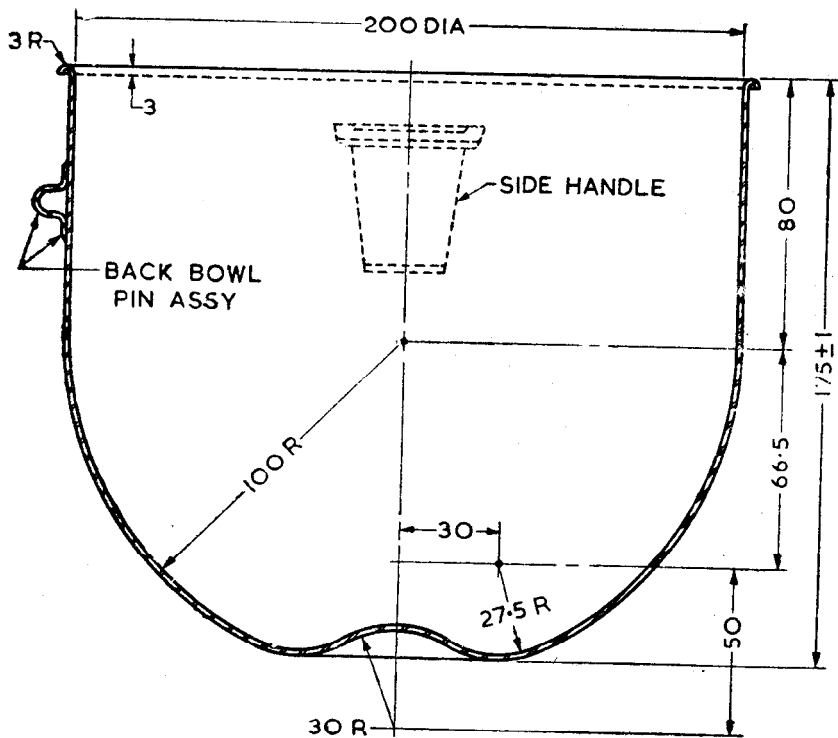
All dimensions in millimetres.

FIG. 1   MIXING BOWL

All dimensions in millimetres.

Fig. 2 Paddle

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A-2.3.2 A plastic scraper.

A-2.4 Tamping Rod — A metal bar 25 mm square and 200 mm long.

A-2.5 Trowel — This shall have a steel blade 100 to 150 mm in length with straight edges.

A-2.6 Flow Table — The flow table shall be as given in IS: 5512-1969*.

A-3. PREPARATION OF MOULDS

A-3.1 The interior faces of the specimen moulds shall be thinly covered with mineral oil or light cup grease. After the moulds are assembled, excessive oil or grease shall be removed from the interior faces and the top and bottom surfaces of each mould. Moulds shall then be set on plane, non-absorbent non-corrodible and non-reactive base plates that have been thinly coated with mineral oil, petrolatum, or light cup grease.

A-4. PREPARATION OF MORTAR

A-4.1 The mortar shall be of the materials and proportions intended for use in the construction mixed to give a flow of 110 to 115. The mixing procedure for sample made in the laboratory shall be as given in **A-4.2.1**.

A-4.1.1 *Trial Mixing* — Trial mortars shall be made with specified proportion of dry ingredients and adding different percentages of water until the specified flow is obtained. Each trial shall be made with fresh mortars. The mixing shall be done mechanically as described in **A-4.1.1.1** to **A-4.1.1.5**.

A-4.1.1.1 The mixing of the ingredients shall be carried out at a temperature of $27 \pm 2°C$ and all ingredients before mixing shall be brought to the same temperature.

A-4.1.1.2 The dry ingredients shall then be placed in the mixing bowl and mixed for 30 seconds. Over the next 30 seconds, while mixing, water shall be poured at a uniform rate into the bowl and the mixing shall be continued for 60 seconds.

A-4.1.1.3 The mixer shall then be stopped and the paddle and sides of the bowl shall be cleaned down in about 15 seconds with the plastic scraper. The bowl shall be covered with a damp cloth and the mortar be allowed to stand for a period of 10 minutes.

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*Specification for flow table for use in tests of hydraulic cements and pozzolanic materials.

A-4.1.1.4 The mortar shall then be remixed for 60 seconds.

A-4.1.1.5 When using lime putty, the procedure shall be as described above, except that the sand and lime putty shall be premixed by hand or in the mixer until the lime appears to be uniformly distributed.

A-4.2 Remixing of Mortars in the Laboratory — Samples of mortar received in the laboratory for testing shall be examined for any leakage or evaporation and segregation or bleeding of the liquid. The whole of the sample, with any liquid which has separated or has condensed inside the container, shall be transferred as completely as possible to an impermeable working surface and remixed, using a trowel, until it appears homogeneous.

A-4.2.1 The top of the flow table shall be carefully wiped clean, dried and the flow mould shall be placed at the centre. A layer of mortar about 25 mm in thickness and mixed in accordance with **A-4.1.1** shall be placed in the mould and tamped 20 times with the tamping rod. The tamping pressure shall be just sufficient to ensure uniform filling of the mould. The mould shall then be filled to overflow with mortar and tamped, as specified for the first layer. The mortar shall be cut off plane and level with the top of the mould by drawing the straight edge of a trowel (held perpendicular to the mould) with a sawing motion across the top of the mould. The top of the table shall be wiped clean and dried, taking care to remove any water from around the edge of the flow mould. The mould shall then be lifted away from the mortar and the flow table shall be immediately dropped through a height of 12·5 mm, 25 times in 15 seconds. The flow is the resulting increase in average base diameter of the mortar mass, measured on at least four diameters at approximately equispaced intervals expressed as a percentage of the original base diameter.

A-5. TEST SPECIMENS

A-5.1 Cubes — The mould as prepared under **A-3.1** shall be filled with the mortar to about half height and the layer compacted by tamping it with the tamping rod (*see* **A-2.4**) in a uniform manner over the mortar surface in such a way as to produce full compaction of the mortar with neither segregation nor excessive laitance. The mould shall then be completely filled and the upper layer of the mortar compacted in a similar manner, after which the surface of the mortar shall be struck off plane and level with the top of the mould, using a trowel (*see* **A-2.5**).

A-5.2 Curing and Storage of Test Specimens — The specimens shall be stored at a place free from vibration, either in moist air at a temperature of $27 \pm 2°C$ and relative humidity of not less than 90 percent or under damp sacks, matting or other suitable damp material covered

completely with polyethylene or other similar imprevious sheeting, at a temperature of $27 \pm 2°C$ for 1 to 3 days, depending on the early strength of the mortar, from the time of adding the water to the other ingredients. The specimen shall then be marked for later identifications, removed from the moulds and stored in clean water until the time of test. The temperature of the storage water shall be $27 \pm 2°C$.

> NOTE — Lime mortar cubes may, however, be stored in the laboratory air at a temperature of $27 \pm 2°C$ for the entire curing period.

A-5.2.1 When cubes are made at site, records of the maximum and minimum air and water storage temperature shall be kept during the period, using maximum and minimum thermometers or continuous recording instruments. The cubes shall be sent to the testing laboratory when they are not less than 3 days nor more than 7 days old, well packed in damp sand or in wet sacks, and when necessary enclosed in polyethylene bag or sealed container, so that they arrive at the laboratory in a damp condition not less than 24 h before the time of test. On arrival at the testing laboratory, the cubes shall be stored in clean water maintained at a temperature of $27 \pm 2°C$ until the time of test.

A-5.3 Number of Specimens — Three or more specimens shall be made for each period of test specified.

A-6. PROCEDURE

A-6.1 The specimen shall be tested immediately on removal from the curing water in which it has been stored and while it is still in a wet condition. Any loose material shall be removed from the sides of the specimen. The dimensions of the specimen shall be noted before testing. The bearing surfaces of the testing machine shall be wiped clean and the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cube as cast, that is, not to the top and bottom.

A-6.2 The axis of the cube shall be carefully aligned with the centre of thrust of steel plates bearing the testing machine. No packing other than auxiliary steel plates shall be used between the faces of the specimen and steel platens of the testing machine.

A-6.3 The load on the specimen shall be applied without shock and at a uniform rate of $2N/mm^2$ to $6N/mm^2$ per minute until failure occurs.

A-6.4 The maximum load at failure shall be noted.

A-7. CALCULATION

A-7.1 The compressive strength shall be calculated as follows:

$$\text{Compressive strength (N/mm}^2) = \frac{\text{Maximum load at failure (N)}}{\text{Cross-sectional area (mm}^2)}$$

A-7.1.1 The individual results shall be calculated to the nearest 0·05 N/mm².

A-8. REPORT

A-8.1 The average of all the determinations shall be reported.

APPENDIX B

(*Clause* 9.1.1)

DETERMINATION OF CONSISTENCY OF MASONRY MORTAR

B-1. OBJECT

B-1.1 To determine the consistency of masonry mortar.

B-2. APPARATUS

B-2.1 This shall consist of a standard cone weighing 300 ± 2 g, 150 mm in height, and a diameter at a base of 75 mm. The cone is mounted on a vertical shaft fastened to an adjustable holder. The holder has a mechanism which releases the shaft. The apparatus has also an instrument dial which records the depth of penetration of the cone into the mortar mix kept in a conical container below.

B-2.1.1 The conical container for mortar shall be 180 mm deep with a diameter at top of 150 mm.

B-2.2 Flow Table — This shall be as given in IS : 5512-1969*.

B-3. PROCEDURE

B-3.1 The conical container shall be filled with mortar mix to a level that is 1 cm below its rim. Mortar mix shall be placed in a conical mould in one continuous operation and shall be compacted by tamping

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*Specification for flow table for use in tests of hydraulic cements and pozzolanic materials.

rod as given in **A-2.4**. The mould filled with mortar mix is bumped 5 or 6 times over a flow table so as to level the surface of the mortar. The container shall be placed over the base below the penetration cone of the apparatus, as shown in Fig. 3. The apex of the penetrating cone shall be brought first in contact with the surface of the mortar and the cone clamped in position. The instrument dial is set to be in contact with a cone at this position. The cone is then released and allowed to sink into the mortar mix. After the cone has stopped penetrating into the mortar, the dial is once more set to record the position of the cone and the difference between dial readings before and after penetration gives the depth of penetration of the cone into the mortar.

B-3.1.1 The test shall be repeated on another sample of the mortar.

B-4. REPORT

B-4.1 The average of the two determinations shall be reported as the consistency of the mortar.

B-5. FIELD TEST

B-5.1 For quick field determination, the procedure may be further simplified. The shaft of the cone shall be held by hand in a perpendicular position so as to be in contact with the surface of the mortar and gently released to sink into the mortar taking care that the shaft remains vertical during penetration. The depth of penetration may be computed from the measurement of the wetted depth along the surface of the cone.

A P P E N D I X   C

(Clauses 2.8 *and* 9.3 *)*

DETERMINATION OF WATER RETENTIVITY OF MASONRY MORTAR

C-1. OBJECT

C-1.1 To determine the water retentivity characteristics of masonry mortar.

C-2. APPARATUS

C-2.1 Apparatus Assembly for the Water Retention Test — For the retention test, an apparatus essentially the same as that shown in Fig. 4 shall be used. This apparatus consists of a water aspirator or other
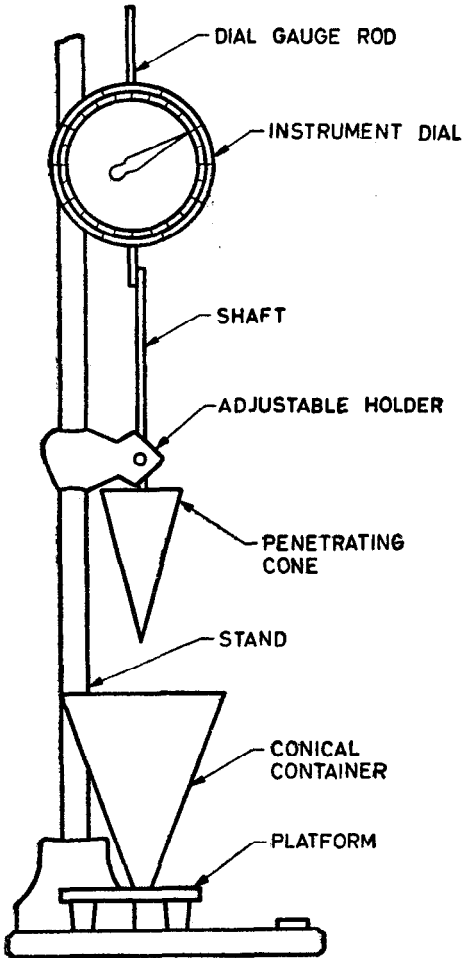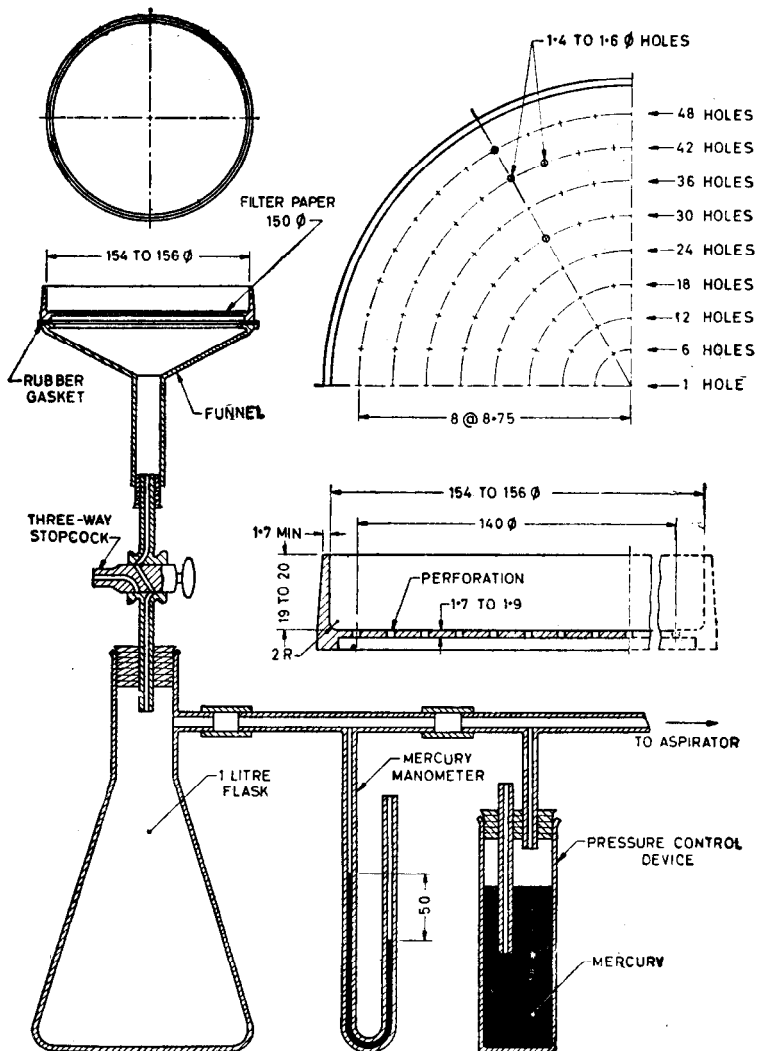
FIG. 3   STANDARD CONE APPARATUS

All dimensions in millimetres.

FIG. 4   APPARATUS ASSEMBLY FOR WATER RETENTION TEST

source of vacuum controlled by a mercury column relief and connected by way of a three-way stopcock to a funnel upon which rests a perforated dish. The perforated dish shall be made of metal not attacked by masonry mortars. The metal in the base of the dish shall have a thickness of 1·7 to 1·9 mm and shall conform to the outline shown Fig. 4. The bore of the stopcock shall have 4 mm diameter, and the connecting glass tubing shall have a minimum inside diameter of 4 mm. A mercury manometer, connected as shown in Fig. 4, indicates the vaccum. A synthetic rubber gasket shall be permanently sealed to the top of the funnel and shall be lightly coated with petrolatum or light cup grease during the test to ensure a seal between the funnel and the dish. Care shall be taken to ensure that none of the holes in the perforated dish is clogged from the grease used on the rubber gasket. Hardened filter paper of a grade equivalent to Carl Schleicher & Schuell filter paper No. 576 or to Whatman No. 50 filter paper shall be used. It shall be of such diameter that is will lie flat and completely cover the bottom of the dish.

C-2.2 Straight Edge — Steel straight edge should be not less than 200 mm long, and not less than 1·5 mm nor more than 3 mm in thickness.

C-2.3 Other Apparatus — Other apparatus required for the water retention test shall conform to the requirements specified in Appendix A.

C-3. PROCEDURE

C-3.1 Adjust the mercury relief column so as to maintain a vacuum of 5 cm as measured on the manometer. Seat the perforated dish on the greased gasket of the funnel. Place a wetted filter paper in the bottom of the dish. Turn the stopcock to apply the vacuum to the funnel and check the apparatus for leaks and to determine that the required suction is obtained. Then turn the stopcock to shut off the vacuum from the funnel.

C-3.2 Mix the mortar to a consistency to give a flow of 110 to 115 (*see* **3.1**). Immediately after making the flow test return the mortar on the flow table to the mixing bowl and remix the entire batch for 15 seconds at medium speed. Immediately after remixing of the mortar, fill the perforated dish with the mortar to slightly above the rim. Tamp the mortar 15 times with the tamper. Ten of the temping strokes shall be applied at approximately uniform spacing adjacent to the rim of the dish and with the long axis of the tamping face held at right angles to the radius of the dish. The remaining five tamping strokes shall be applied at random points distributed over the central area of the dish. The tamping pressure shall be just sufficient to ensure filling of the dish. On completion of tamping, the top of the mortar should extend slightly above

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the rim of the dish. Smooth off the mortar by drawing the flat side of the straight edge (with the leading edge slightly raised) across the top of the dish. Then cut off the mortar to a plane surface flush with the rim of the dish by drawing the straight edge with a sawing motion across the top of the dish in two cutting strokes, starting each cut from near the centre of the dish. If the mortar is pulled away from the side of the dish during the process of drawing the straight edge across the dish, gently press the mortar back into contact with the side of the dish using the tamper.

C-3.3 Turn the stopcock to apply the vacuum to the funnel. The time elapsed from the start of mixing the cement and water to the time of applying the vaccum shall not exceed 8 minutes. After suction for 60 seconds quickly turn the stopcock to expose the funnel to atmospheric pressure. Immediately slide the perforated dish off from the funnel, touch it momentarily on a damp cloth to remove droplets of water and set the dish on the table. Then, using the bowl scraper, flow and mix the mortar in the dish for 15 seconds. Upon campletion of mixing, place the mortar in the flow mould and determine the flow. The entire operation shall be carried out without interruption and as quickly as possible, and shall be completed within an elapsed time of 11 minutes after the start of mixing the cement and water for the first flow determination.

C-4. CALCULATION

C-4.1 Calculate the water retention value for the mortar as follows:

$$\text{Water retention value} = \frac{A}{B} \times 100$$

where

A = flow after suction, and

B = flow immediately after mixing.

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