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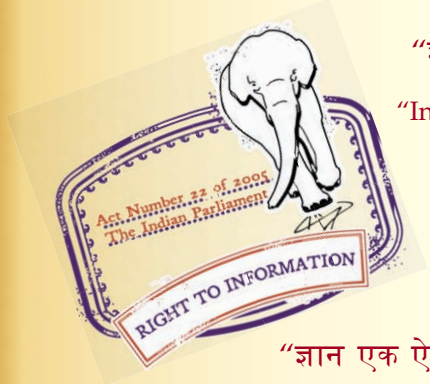

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Indian Standard

CODE OF PRACTICE FOR *IN SITU* CONSTRUCTION OF WALLS IN BUILDINGS WITH SOIL-CEMENT

(First Revision)

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Indian Standard

CODE OF PRACTICE FOR *IN SITU* CONSTRUCTION OF WALLS IN BUILDINGS WITH SOIL-CEMENT

(First Revision)

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Indian Standard

CODE OF PRACTICE FOR *IN SITU* CONSTRUCTION OF WALLS IN BUILDINGS WITH SOIL-CEMENT

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 31 October 1980, after the draft finalized by the Building Construction Practices Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Stabilized soil (soil-cement in particular) has been considered a satisfactory material for construction of permanent buildings. Its main use is in load-bearing and partition walls of single-storeyed buildings with a wall height not exceeding 3·2 m and with a minimum wall thickness of 300 mm for load bearing and 200 mm for non-load bearing walls.

0.2.1 Generally stabilized-soil construction is recommended in superstructure which is above the level of plinth. The wall below the level of plinth is usually built with conventional materials like bricks, lean concrete, etc. However, stabilized soil with a richer proportion of cement may be used advantageously for this type of construction also wherever such material is economical, provided the usual damp-proofing courses are inserted to prevent access for moisture, and also precautions are taken against attack by termites.

0.3 This standard which was first published in 1962 is intended to provide guidance with respect to the construction of walls in single storeyed buildings with soil cement and other stabilized soil. The present revision has been taken up to incorporate the improvements found necessary in the light of the usage of the standard and the suggestions made by various bodies implementing it. In this revision the minimum thickness and shuttering arrangement for non-load bearing, partition walls have been specified. The syringe test specified in the earlier version as a preliminary quick test for determination of plastic limit of soils has been deleted.

0.4 This standard is intended chiefly to cover the technical provisions relating to *in situ* construction of walls in buildings with soil cement and it does not include all the necessary provisions of a contract.

0.5 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.

1. SCOPE

1.1 This standard covers *in situ* construction of walls in buildings with soil-cement or other stabilized soil.

1.1.1 This type of construction is recommended for single-storeyed buildings with a wall height not exceeding 3·2 m and with a minimum wall thickness of 300 mm for load bearing and 200 mm for non-load bearing walls.

1.2 The same procedure as recommended in the standard may be adopted for rammed *in situ* wall construction with unstabilized soil, provided the surfaces of the wall are protected with a waterproof mud plaster, a typical specification for which is given in Appendix A.

2. TERMINOLOGY

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

2.2 *BHUSA* — Wheat straw.

2.3 Borrowed — Procured by excavation.

2.4 Soil-Cement — Soil, the strength and engineering properties of which have been improved by addition of cement.

3. MATERIALS

3.1 Raw Soil

3.1.1 The soil used in soil-cement mixture for construction of walls shall be free from deleterious contents, such as organic matter of vegetable origin, mica, schists, and saline impurities. Its grading shall be such as to require the least amount of admixture to make it suitable for stabilization with cement. Black cotton soils and similar soils which are uneconomical to stabilize shall be excluded.

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

3.1.2 The soil used to prepare soil-cement mixture shall conform to the following requirements:

Sl No.	*Characteristics*	*Requirements*
i)	Sand content, percent by mass	35, *Min*
ii)	Plasticity index, percent	8·5 to 10·5
iii)	Total soluble salts, percent by mass	1, *Max*
iv)	Sodium salts, percent by mass	0·1, *Max*
v)	Liquid limit, percent	27, *Max*

NOTE 1 — Soils other than high plastic clays and black cotton soil can be stabilized with cement, but from considerations of economy only soil of the above composition is recommended.

NOTE 2 — 'Sand content' is the fraction of the soil that passes 425-micron IS Sieve and is retained on 75-micron IS Sieve.

3.2 Cement — This shall conform to either IS : 269-1976* or IS : 455-1976† or IS : 1489-1976‡.

3.3 Water — The water used shall be free from harmful salts like sodium sulphate so that the total salts in the mixture do not exceed 1 percent.

3.4 Admixture

3.4.1 *Sand* — It is the fraction of the soil that passes 425-micron IS Sieve and is retained on 75-micron IS Sieve.

3.4.2 *Clay* — An aggregate of microscopic and sub-microscopic particles derived from the chemical decomposition and disintegration of rock constituents. It is plastic within a moderate to wide range of water content. In these soils, more than half of the material is smaller than 75 micron by mass.

4. PREPARATION OF STABILIZED SOIL

4.1 Selection of Borrow Pit

4.1.1 The area from which raw soil is to be borrowed, shall be within an economical distance from the site of work, and such economical distance shall be judged with respect to the type of conveyance available for transport of the material.

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

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

‡Specification for Portland pozzolana cement (*third revision*).

4.1.2 The area for borrowing shall be reconnoitred visually for soil of required specification. Having selected the area, it shall be divided into 30 × 30 m squares. Preliminary quick tests to determine the texture and plasticity index for soil shall be applied to soil samples taken from the centre of each square and the results recorded on a chart. From this chart the most suitable squares shall be selected. As far as possible, the soil strata in the borrow pit shall be homogeneous in nature. The selected squares shall be further subdivided into 15 × 15 m square for digging the pits.

4.2 Procurement of Raw Soil

4.2.1 The soil may be dug out from one or more borrow pits as necessary, the size of the pits being 15 × 15 m. The top loose soil shall be rejected, and the excavation may go further down to a depth of 300 mm for procuring the soil, or more up to required depth.

4.3 Sampling and Analyzing the Soil — Samples shall be taken from the borrow pit from five points along its diagonals and mixed properly. The representative sample shall be analyzed according to the relevant Indian Standards for soil analysis. On the basis of gradation and plasticity index, the quantity of admixtures, such as sand or clay required for bringing it in conformity with the provisions of **3.1.2**, as the case may be, shall be worked out.

4.4 Pulverising

4.4.1 The soil shall be pulverised to such fineness that all nodules and clods, as judged visually, pass through 8-mm screen. Soils of plasticity index up to 10 percent generally admit of very easy pulverisation.

NOTE — Actual screening is not essential as it is expensive.

4.4.2 The admixture for soil that is required to be added shall also be pulverised in the same manner.

4.5 Stacking and Mixing

4.5.1 The pulverised soil shall be stacked to size 15 × 15 m with a uniform height of 300 mm. The required quantity of admixture shall then be spread over the stack in an even layer and then mixing done by manual labour starting from the edges. This operation shall be repeated twice or thrice to ensure uniform mixing of the ingredients. The stack shall then be again formed to a uniform height of 300 mm.

4.5.2 Samples shall be taken once more from five points along the diagonal and analysed to see if the soil conforms to the specified requirements. Any further adjustment necessary as a result of this test shall be

carried out and the mixture finally brought in conformity with the requirements of **3.1.2**.

4.5.3 The optimum moisture content for compaction of the soil and the moisture present in the soil shall be determined by tests on the samples performed in accordance with relevant Indian Standards on soil testing.

4.6 Addition of Water

4.6.1 The top of the stack finally prepared as in **4.5** shall be levelled, and the top surface divided into a number of equal compartments of convenient size by bunding for the purposes of adding water.

4.6.2 The amount of water to be added shall be such as to make up for the difference between the optimum moisture content required for compaction and the moisture already present in the stacked soil. Allowance shall be made for evaporation and other losses of water during processing of soil prior to compaction. The quantity of water thus worked out shall be kept stored in convenient containers so as to be readily available for use.

NOTE — Empty bitumen drums have been found to be quite useful for storing the water.

4.6.3 The water shall be added by distributing it equally to the compartments mentioned in **4.6.1**. In each compartment, its portion of water shall be added evenly over the surface. Suitable means may be adopted for this purpose. Care shall be taken that water thus added spreads and distributes itself equally over the compartment. Workers shall not be allowed to walk on the dry stack before watering, as this will create pockets of loose and unequal compaction, and water from the surface will distribute itself unevenly into the soil.

4.6.4 The water shall be allowed to get dispersed for a period not less than twelve hours, preferably overnight.

4.7 Wet Mixing — After the water added has got dispersed in the stacked soil as mentioned in **4.6.3**, slightly dry soil from the side slopes of the stack shall be taken and spread evenly over the moist top surface of the stack. The whole stack shall be then worked with spade, starting from the sides, so as to get a uniformly moistened soil.

4.8 Addition of Cement

4.8.1 After the stack of moist soil is prepared (*see* **4.7**), cement shall be mixed as and when necessary to convenient portions of the stack as explained in **4.8.2**, to obtain the required quantity of stabilized soil. The soil-cement shall be prepared only in such quantities at a time as would be used in the work within half an hour.

4.8.2 The specified quantity of cement (*see* **4.8.3**) shall be spread over the portion of the top surface of the stack, which is conveniently chosen so as to contain a volume of soil required for the work. The soil in this portion shall then be worked with spade starting from one side of the stack, and the cement and soil mixed thoroughly. The spading shall be repeated twice or thrice to ensure a uniform mixture.

4.8.3 The cement content of the mix when determined according to the procedure given in IS : 4332 (Part VII)-1973* shall be such as to satisfy the requirements given in **4.9** but shall not be less than the quantities given below:

a) For construction of walls, generally	2·5 to 3·5 percent by mass of the dry soil, depending upon the density possible to attain in the field
b) For construction of walls below plinth level and for construction of copings	5 to 7·5 percent by mass of the dry soil so that the crushing strength of standard test blocks made of this soil-cement mix shall not be less than 1·4 N/mm² (14 kgf/cm²) for the dry condition

4.8.3.1 For calculation purposes, the unit weight of dry soil may be taken as 1 300 kg /m³, and that of cement as 1 440 kg/m³. The net weight of cement per bag will be 50 kg, and the volume of dry soil which would require a bag of cement for stabilization when the rate of addition is 2·5 percent, will be about 1·5 m³.

4.9 Requirements for Soil-Cement for Use in Wall Construction — The cement stabilized soil shall conform to the requirements specified in **4.9.1** to **4.9.4**.

4.9.1 *Density* — The maximum dry bulk density (the dry unit weight defined by the peak of the compaction curve) of the soil-cement shall not be less than 1·8 g/cm³ when determined in accordance with the requirements given in IS : 4332 (Part II)-1967† and IS : 4332 (Part III)-1967‡.

*Methods of test for stabilized soils: Part VII Determination of cement content of cement stabilized soil.

†Methods of test for stabilized soils: Part II Determination of moisture content of stabilized soil mixtures.

‡Methods of test for stabilized soils: Part III Test for determination of moisture content-dry density relation for stabilized soil mixtures.

4.9.2 *Compressive Strength* — The compressive strength of soil cement shall not be less than 1·4 N/mm^2 (14 kgf/cm^2) in dry condition, and not less than 0·7 N/mm^2 (7 kgf/cm^2) for the saturated condition when determined in accordance with the requirements given in IS : 4332 (Part V)-1970*.

4.9.3 *Weather Resistance* — The weather resistance shall be determined in accordance with the requirements given in IS : 4332 (Part IV)-1968†. The loss of strength in the test shall not exceed 5 percent.

4.9.4 Samples of the soil-cement shall be procured periodically and tested for the requirements given in **4.9.1** to **4.9.4** before use in the construction. It will be advantageous to have a field laboratory for testing purposes.

5. SHUTTERING

5.1 Construction of Shuttering

5.1.1 Any timber found suitable in local practice may be used for shuttering. The planks shall be not less than 200 mm in width and 50 mm in thickness. A typical arrangement of shuttering properly assembled both for straight wall lengths and for corners is given in Fig. 1.

NOTE — Figure 1 shows the shuttering arrangement required for load bearing walls. The same shuttering arrangement shall hold good for internal non-load bearing walls also.

5.1.2 The shuttering shall generally be in lengths ranging from 1·8 to 3·3 m depending upon the length of the wall to be compacted.

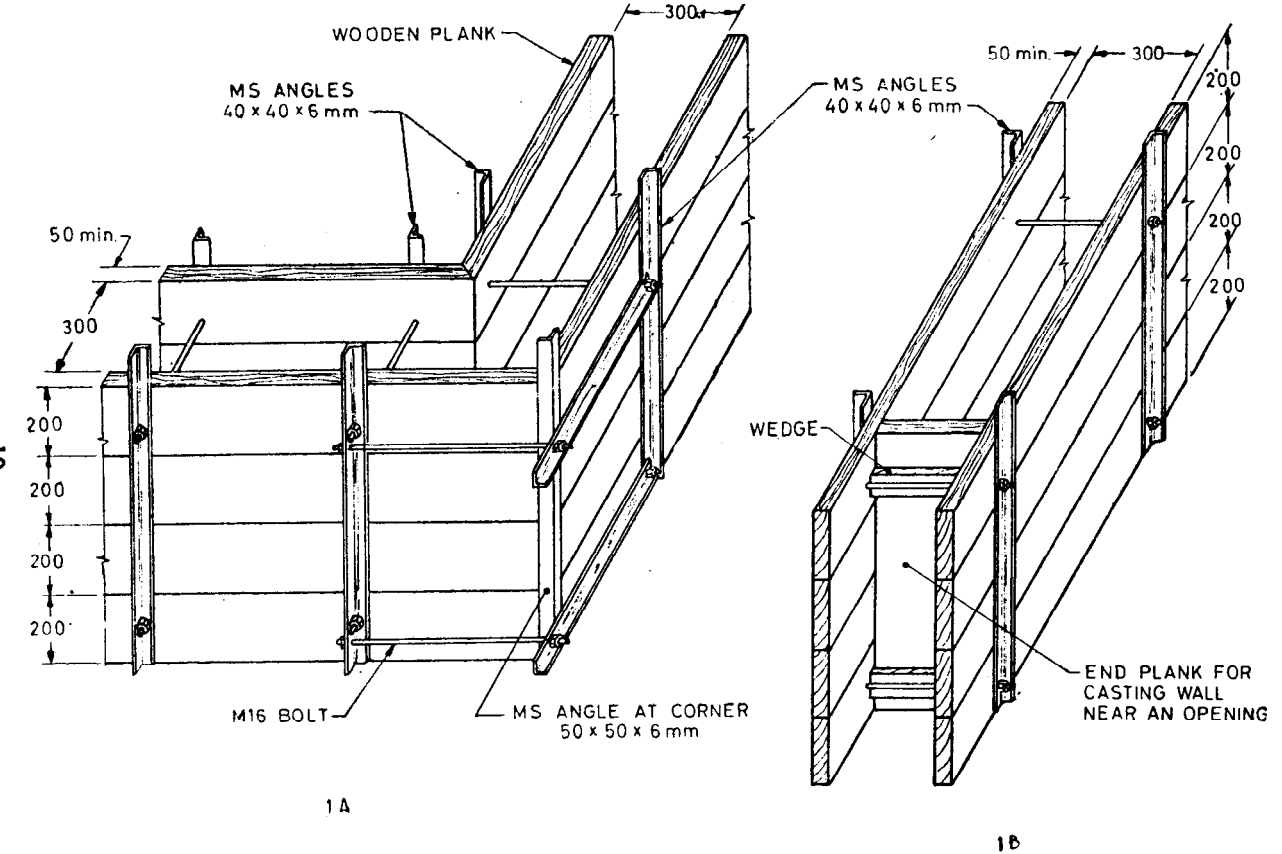
5.1.3 The height of shuttering for one lift shall be about 600 mm clear for casting the wall plus 200 mm for holding on to the portion of the wall below compacted in the previous lift.

5.2 Lifting — The shuttering may be lifted immediately after first lift is well compacted. For lifting the formwork to the next height the operations as given in **5.1.1** and **5.1.2** shall be followed.

5.2.1 The bolts holding the lowest planks shall be withdrawn slowly after carefully unscrewing them. When the bolts are withdrawn the vertical angle iron pieces release the lower three planks which shall be removed carefully. The angle iron pieces shall be turned about the top

*Methods of test for stabilized soils: Part V Determination of unconfined compressive strength of stabilized soils.

†Methods of test for stabilized soils: Part IV Wetting and drying, and freezing and thawing tests for compacted soil-cement mixture.



NOTE — If the thickness of wall is greater than 300 mm the shuttering details will have to be suitably modified.

All dimensions in millimetres.

FIG. 1 TYPICAL DETAILS OF SHUTTERING FOR 300 mm THICK WALL

bolts after slackening the bolts, if necessary, so that they point vertically up above the bolts. The top bolts shall then be tightened back so that the plank holds to the wall firmly. The three lower planks shall then be placed on top of the plank now held in position by the bolts, and the shuttering shall once more be assembled as shown in Fig. 1 and brought in plumb.

5.2.2 The lifting process shall be repeated till the construction reaches the top of the wall.

6. WALL CONSTRUCTION

6.1 Pouring of Soil in Shuttering — After the shuttering is erected, the moist stabilized soil shall be poured into the shuttering in layers of 75 mm at a time. The layer shall be uniform in depth. To control this depth, suitable templates may be used which may be placed cross-wise at intervals of about one metre.

6.2 Compaction — Compaction shall be done by workers standing inside the shuttering by means of iron rammers with about 80 × 80 mm base and of about 7 kg weight. Compaction shall be started at the side and worked inwards. Ramming on the sides shall be evenly distributed to avoid tilting of the shuttering. Verticality of the shuttering shall be carefully checked periodically as compaction proceeds.

6.2.1 Samples of the compacted soil shall be taken and tested for dry bulk density. The minimum number of samples shall be at the rate of one for every 3 metres of wall length. The dry bulk density of the soil in the wall shall be not less than 1·8 g/cm^3 at the completion of compaction.

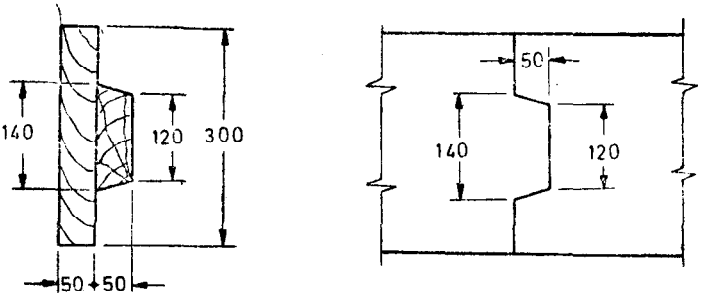
6.2.2 All the holes left after taking cores for the purpose of testing density shall be carefully filled up and rammed before the next layer is spread.

6.3 Curing — The walls shall be cured for 15 days after removal of the shuttering. Curing shall be done by light sprinkling of water at short and regular intervals with rose cans.

6.4 Provision of Joints

6.4.1 Vertical joints in the wall shall be provided at a spacing not more than 2 m apart. These shall be done by means of a tongued and grooved dowel (*see* Fig. 2). The vertical joints shall also be staggered.

6.4.2 Horizontal joints shall be formed by finishing smooth the rammed surface at the end of each lift.



2A Section of Plank Used for Making Vertical Joint

2B Plan of Vertical Tongue and Groove Joint

All dimensions in millimetres.

FIG. 2 TYPICAL DETAILS OF CONSTRUCTION JOINT IN *In Situ* SOIL-CEMENT WALLS OF 300 mm THICKNESS

6.5 Fixing Frames — Frames for doors, windows and other openings shall be fixed in the wall by means of iron hold-fasts inserted in the wall beforehand. For fixing hold-fasts in the wall, a circular hole of diameter sufficiently large to accommodate the hold-fast (generally 50 mm and 300 mm deep) shall be bored with an auger in the constructed wall, and the forked end of the hold-fast shall be inserted and the hole plugged with a rich mix of cement concrete. The frames shall then be fixed to the hold-fasts by means of bolts.

6.6 Bearing of Roof

6.6.1 Where a light roof-framework is resting on the wall, the portion of the wall directly below it shall be built for a depth not less than 150 mm below the batten level, with either burnt clay bricks laid in cement mortar mix 1 : 6 (cement : sand), or with soil having 7·5 percent cement content.

6.6.2 Beams shall rest over cement concrete bed-plates embedded in the stabilized soil wall with truly horizontal bedding surfaces.

6.6.3 Trussed or flat roofs resting on the wall shall also be given a bearing course of brickwork of depth not less than 150 mm laid in cement mortar mix 1 : 6.

6.7 Fixing of Lintels

6.7.1 Precast reinforced brick or reinforced cement concrete lintels may be used to span door, window or other openings in the soil-cement wall.

The lintels shall bear at least 300 mm on the wall. The space above the lintel shall be filled either with soil-cement rammed *in situ* or precast soil-cement blocks laid in cement mortar mix 1 : 10 (cement : sand).

6.8 Parapet — The parapet shall be of brickwork laid in cement mortar mix 1 : 6 (cement : sand). A drip course shall be provided to drain rain-water from the parapet and away from the lower portions of the walls on to the roof surface. The plaster finish of the roof shall be continued from the roof surface right up to the drip-course in the parapet. Suitable water-proofing treatment shall be given over the roof finish as further protection to the wall against moisture seepage.

6.9 Fixing Wooden Gutties (Plugs)

6.9.1 Wooden gutties would be required to be fixed into the wall for purposes of fixing electric wiring, fixing curtain brackets and hanging pictures, etc. A hole shall be drilled into the wall as for fixing hold-fasts, but smaller in size and scrapped round to make it wider at the farther end. After removing loose material, a cement wash consisting of one part of cement and four parts of water shall be given. The back of the hole shall then be painted with sodium silicate (water glass). The wooden gutties about 40 mm diameter and slightly wider at the farther end shall then be struck on to the sodium silicate painted back of the hole. This hole shall be about 20 mm or so wider than the guttie. The space round the gutties shall then be filled in with cement mortar of mix 1 : 5 (cement : sand). The guttie will set hard in about a week's time, after which it will be ready for fixing screws into it.

7. PLASTERING THE WALLS

7.1 The stabilized soil wall shall be plastered with cement-plaster of mix not leaner than 1 : 5 (cement : sand). The plaster shall be in a single coat of thickness not less than 12 mm and it shall be done in accordance with IS : 1661-1972*.

7.1.1 The plaster shall be applied only after drying the wall for a period of not less than four weeks. The wall surface shall be given a wash with neat cement mixed with water before application of cement plaster.

*Code of practice for cement and cement lime plaster finishes on walls and ceilings.

APPENDIX A

(*Clause* 1.2)

TYPICAL SPECIFICATION OF WATERPROOF MUD PLASTER

A-1. PREPARATION OF CUT-BACK BITUMEN

A-1.1 The cut-back bitumen shall be of grade 80/100 conforming to IS : 217-1958*. Melt the cut-back on gentle fire. To this add the proportions of kerosene oil and of paraffin wax as specified in **A-1.2** and mix well to obtain a homogeneous mixture.

A-1.2 The proportions of ingredients in the preparation shall be 80 parts of bitumen, 20 parts of kerosene and one part of paraffin wax by mass.

A-2. PREPARATION OF MUD

A-2.1 The soil used shall have a sand content of about 45 to 50 percent by mass. Mix 64 kg of *BHUSA* for every cubic metre of dry soil; add water and mix well. Allow the *BHUSA* to rot for a week.

A-3. PREPARATION OF WATERPROOF PLASTER

A-3.1 Add the cut-back bitumen prepared as in **A-1** to the mud mortar prepared as in **A-2** at the rate of 38 kg/m^3 of soil used. Mix thoroughly with feet and spades till the whole mixture is of uniform colour.

A-4. APPLICATION OF THE PLASTER

A-4.1 Moisten the surface to be plastered and then apply the plaster prepared as in **A-3** over the surface to thickness not less than 10 mm.

A-5. *GOBRI-LEEP*

A-5.1 The *GOBRI-LEEP* shall consist of one part of cow-dung and five parts of soil by weight and shall be made to a thin paste by addition of water. After the plaster applied as in **A-4** has almost dried, the *GOBRI-LEEP* shall be applied over the surface to fill up the cracks and to give smooth appearances.

NOTE — For greater water resistance of the plaster during the preparation of *GOBRI-LEEP*, 80/100 cut-back bitumen may be added to the *GOBRI-SOIL* mixture in the proportion five percent by mass of the latter before water is added to obtain a paste.

*Specification for cut-back bitumen.

(*Continued from page 2*)

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SURVEYOR OF WORKS, MADRAS CENTRE CIRCLE	Public Works Department, Government of Tamil Nadu, Madras

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002

Telephones: 331 01 31, 331 13 75 Telegrams: Manaksanstha (Common to all Offices)

Regional Offices:	*Telephone*
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002	331 01 31 331 13 75
*Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola, CALCUTTA 700054	36 24 99
Northern : SCO 445-446, Sector 35-C, CHANDIGARH 160036	2 18 43 3 16 41
Southern : C. I. T. Campus, MADRAS 600113	41 24 42 41 25 19 41 29 16
†Western : Manakalaya, E9 MIDC, Marol, Andheri (East), BOMBAY 400093	6 32 92 95

Branch Offices:

'Pushpak', Nurmohamed Shaikh Marg, Khanpur, AHMADABAD 380001	2 63 48 2 63 49
‡Peenya Industrial Area 1st Stage, Bangalore Tumkur Road BANGALORE 560058	38 49 55 38 49 56
Gangotri Complex, 5th Floor, Bhadbhada Road, T. T. Nagar, BHOPAL 462003	6 67 16
Plot No. 82/83, Lewis Road, BHUBANESHWAR 751002	5 36 27
53/5, Ward No. 29, R.G. Barua Road, 5th Byelane, GUWAHATI 781003	3 31 77
5-8-56C L. N. Gupta Marg (Nampally Station Road), HYDERABAD 500001	23 [illegible]83
R14 Yudhister Marg, C Scheme, JAIPUR 302005	6 34 71 6 98 32
117/418 B Sarvodaya Nagar, KANPUR 208005	21 68 76 21 82 92
Patliputra Industrial Estate, PATNA 800013	6 23 05
T.C. No. 14/1421, University P.O., Palayam TRIVANDRUM 695035	6 21 04 6 21 17

Inspection Offices (With Sale Point):

Pushpanjali, First Floor, 205-A West High Court Road, Shankar Nagar Square, NAGPUR 440010	2 51 71
Institution of Engineers (India) Building, 1332 Shivaji Nagar, PUNE 411005	5 24 35

*Sales Office in Calcutta is at 5 Chowringhee Approach, P. O. Princep Street, Calcutta 700072 — 27 68 00

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