IS : 7873 - 1975

Indian Standard

CODE OF PRACTICE FOR LIME CONCRETE LINING FOR CANALS

(Second Reprint JUNE 1990)

UDC 627.841.034.92:666.972

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

Gr 3

January 1976

Indian Standard

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0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 25 November 1975, after the draft finalized by the Canals and Canal Linings Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Lime concrete lining had been used with success on some canal systems. The question of their selection for use on a particular project, however, would be governed by the economics of the proposal which would depend to a very great extent on the availability of good banker for manufacturing lime *vis-a-vis* the availability of cement.

0.3 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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1. SCOPE

1.1 This standard covers lining of canals using kankar-lime concrete and any other type of cheap lining where kankar is available.

1.2 The use of this type of lining shall be restricted to small medium size irrigation channels with capacities up to 200 cumecs and in which the velocity of water does not exceed 2 m/s.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 3872-1966† shall apply.

3. NECESSARY INFORMATION

3.1 The following information shall be procured for the entire length of the canal before commencing the work:

a) Nature of soil (physical properties) up to suitable depth below the canal bed,

*Rules for rounding off numerical values (*revised*).
†Code of practice for lining of canals with burnt clay tiles.

b) Subsoil water levels,

c) Salt contents of soil, and

d) Longitudinal and cross sections of the canal.

4. MATERIALS

4.1 Lime — Kankar lime composition and quality shall conform to IS : 712-1973*.

4.2 Sand (or Kankar Grit) — Sand shall conform to IS : 2116-1965† and IS : 1542-1960‡ as specified by the Engineer-in-charge.

4.3 Coarse Aggregate — Brick ballast, stone ballast or kankar coarse aggregate.

4.4 Water — Water used for both mixing the mortar and curing shall be free from injurious amounts of deleterious materials. Potable waters are generally considered satisfactory for mixing and curing.

4.4.1 Water containing excessive acid, alkali or salt may not be suitable. As a guide, the following concentrations represent the maximum permissible values:

Concentration	*Percent*
Organic	0·02
Inorganic	0·30
Sulphate	0·05
Alkali chlorides	0·10

5. PREPARATION OF SUBGRADE

5.1 Reaches With Expansive Soils — As far as possible lining should be avoided in expansive clays. But if the canal has to traverse a reach of expansive clay with no alternate route of economically feasible condition, it may be done with any of the practices detailed under **5.1.1** and **5.1.2** to reduce the damage depending upon the swelling properties of the soil encountered.

NOTE — Clays vary so much in characteristics that the pressure required to prevent expansion may be less than 0·07 kgf/cm² (·068 kN/m²) in some types and as much as 10·5 kgf/cm² (10·297 kN/m²) or higher in others. In many cases the practices recommended in **5.1.1** and **5.1.2** may not be adequate needing detailed investigations to find out a practicable solution.

5.1.1 If the expansive clay is in thin layer or in small pockets in an otherwise suitable subgrade it shall be over excavated and replaced with a suitable non-expansive soil and compacted suitably.

*Specification for building limes (*second revision*).
†Specification for sand for masonry mortars.
‡Specification for sand for plaster.

5.1.2 Swelling of the clay encountered can be controlled by loading the surface with a non-expansive compacted soil or gravel 60·0 cm and filled to the grade of the underside of lining with good draining material leading away the seepage water to specially constructed point either to the outside of the canal or releasing it into the canal by providing suitable pressure-relief valves. However, the excavated surface of expansive clay shall be given a coat of asphalt before loading it to prevent the entry of water into the clay.

5.2 Preparation of Subgrade Consisting of Rock — The subgrade shall be prepared and dressed true to level and according to the required cross section of the canal.

5.2.1 All excavation including overbreakage below lines of underside of lining shall be filled completely up to the lines of the underside of lining with compacted graded filter material. Care shall be exercized in selecting refill material for use over fractured rock or cobbles because of the danger of washing fines into the subgrade voids and thus losing lining support. The selected material shall be such as to resist such piping and, otherwise, shall be selected for impermeability and ease of placement.

5.3 Preparation of Subgrade Consisting of Earth — The subgrade shall be prepared, dressed and rolled true to level and according to the required cross section of the canal to form a firm compacted bed for the lining.

5.3.1 In other than predominantly sandy reaches where the dry bulk density of the natural soil is not less than 1·8 g/cm^3, initial excavation shall be done up to about 30 cm above the final section and the cutting to final shape shall be done immediately before lining (*see* also **5.3.6**).

5.3.2 Sample profiles true to the cross section of the canal shall be made at suitable intervals of 3 to 5 metres to ensure correct formation of subgrade. To ensure uniformity of side slopes a chord shall be stretched across two-third spacer which shall be run under the chord to check the evenness of the surface. This process shall be repeated at short intervals along the slopes till the surface between two profiles is properly levelled and dressed from top to bottom. Suitable wooden templates may be used to lay and check the profile.

NOTE — In straight reaches, an interval of 3 to 4 m is recommended for sample profile.

5.3.3 If at any point material as prepared subgrade has been excavated beyond the neat lines required to receive lining the excess excavation shall be filled with material compatible with subgrade material and thoroughly compacted in accordance with **5.3.5** and **5.3.6**.

5.3.3.1 When partial filling of an existing canal is necessary to reduce the cross-sectional area to that required for lined canals the fill shall be

placed and suitably compacted to avoid its settlement and rupture of the lining.

5.3.4 To cover up any lapses in the compaction of the inner core of the banks near the edges and to allow sufficient width for a labourer to work conveniently a lip-cutting width of not less than 50·0 cm horizontally shall be provided. Depending upon the nature of soil and the side slopes of the canal the lip cutting width may be in the range of 50 to 100 cm.

5.3.5 *Compaction of Subgrade in Predominantly Sandy Reaches*

5.3.5.1 *Bed* — The compaction of the bed shall be done by oversaturating the bed by flooding it with water before lining is laid.

5.3.5.2 *Sides* — The compaction of sides shall be done preferably by vibrocompactors. To prevent loss of moisture of the lining, suitable measures should be adopted. Wherever there is over cutting, refilling should be done with lean concrete.

NOTE — Admixtures of 5 percent cement are generally found satisfactory.

5.3.6 *Compaction of Subgrade in Other Than Predominantly Sandy Reaches* — All compaction shall be done at optimum moisture in convenient layers not more than 15·0 cm thick to obtain a dry bulk density of not less than 95 percent of the density of optimum moisture content obtained in accordance with IS : 2720 (Part VII)-1965*.

5.3.6.1 Where the dry bulk density of the natural soil is equal to or more than 1·8 g/cm^3, the procedure described in **5.3.1** shall be followed.

5.3.6.2 *Bed* — Where the dry bulk density of the natural soil is less than 1·8 g/cm^3 and the subsoil water is near the subgrade, the compaction shall be done by under cutting the bed by 7·5 cm and then ploughing up to 15·0 cm below the subgrade level. The loosened soil shall then be recompacted with sheep foot rollers or other suitable devices. Where the subsoil water is low, requiring no dewatering and the dry bulk density of the natural soil is less than 1·8 g/cm^3, compaction shall be done by digging the canal up to subgrade level and after that loosening the earth below subgrade up to 15·0 cm by disc harrows, or ploughing and compacting the same to a layer of 11·0 cm. After that, the second layer of 15·0 cm of earth shall be laid over the compacted layer by taking earth from lip cutting and compacting this to a depth of 11·0 cm. The compacted layer of 7·0 cm above the subgrade level shall be removed and the subgrade brought to design profile before laying the lining.

5.3.6.3 *Sides* — Compaction of sides shall be done by manual labour or suitable compactors to a depth of 30·0 cm to obtain a minimum dry bulk density of not less than 90 percent of the density of optimum moisture content obtained in accordance with IS : 2720 (Part VII)-1965*.

*Methods of test for soils: Part VII Determination of moisture content-dry density relation using light compaction.

5.4 Underdrainage — For a lined canal where the ground water level is higher or likely to be higher than water level inside the canal so as to cause damaging differential pressures on the lining, or where the subgrade is sufficiently impermeable to prevent free drainage of the underside of lining in case of rapid draw down, pressure relief arrangements for underdrainage shall be provided in accordance with IS : 4558-1968*.

5.5 Anti-salt Treatment — Soil in all reaches shall be tested for salt contents before the lining is started. Where the salt contents are over 1·00 percent or sodium sulphate is over 0·36 percent, the subgrade shall be first covered with about 2 mm thick layer of bitumen obtained by evenly spraying bitumen at a rate of about 2·35 l/m². To get a good bond between bitumen and soil, crude oil at a rate of 0·5 l/m² shall be sprayed over it in advance of spraying bitumen. In case such a situation is encountered only in small pockets the replacement of subgrade by suitable earth for a suitable depth from adjoining reaches shall be considered, if economical.

5.5.1 Before spraying crude oil, subgrade shall be perfectly dry, clean and free from dirt, and crude oil shall be allowed to penetrate the subgrade surface. Bitumen shall be heated to a temperature of 175°C and applied to the subgrade by a suitable sprayer. Immediately following the application of bitumen, dry sand shall be uniformly spread. Lining should be started 6 to 12 hours after spraying.

6. LAYING OF CONCRETE LINING

6.1 Lime concrete mix should be proportioned in such a way that, after compaction, it shall have a minimum compressive strength of 50 kgf/cm² (4 903·3 kN/m²) at the age of 28 days, the specimens being moist cured during the period. For determining compressive strength unconfined compression tests on cylindrical specimens with a height to diameter ratio of two shall be carried out according to IS : 2541-1974†. The mix should have a minimum flexural strength of 14 kgf/cm² (13·729 kN/m²).

6.2 Lime concrete to be used for lining shall also meet the following additional requirements:

a) Test specimen shall effectively withstand erosion by the continuous lateral action of jets of water with a velocity not less than 4 m/s for at least 150 hours.

b) The permeability of lime concrete test specimen shall not exceed 10^{-7} cm/s.

*Code of practice for underdrainage of lined canals.
†Code of practice for preparation and use of lime concrete (*first revision*).

6.3 The following proportions of the materials in normal case will meet the requirements given in **6.2**:

1 : 1½ : 3 of kankar lime : kankar grit or sand : kankar aggregate, stone aggregate or brick ballast. Kankar grit or sand shall have a uniform grading with overall fineness modulus determined according to specified practice not less than 2·0. Kankar aggregate, stone aggregate or brick ballast will have the maximum size of 2 cm with not more than 5 percent passing.

6.4 Thickness of Lining — The thickness of lining may vary from 10 to 15 cm for discharge ranges up to 200 cumecs.

6.5 Lines and Grade — Concrete lining shall be constructed in canal prism where shown on the drainge or as directed by engineer-in-charge.

6.5.1 Abrupt departure from and return to alignment and grade shall be avoided.

6.6 Mixing — Mixing shall be continued until there is uniform distribution of the materials and the mass is uniform in colour and consistency, but in no case the mixing shall be done for less than two minutes.

6.6.1 When hand mixing is permitted by the engineer-in-charge, it shall be carried out on a water-tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency.

6.7 Transporting — Concrete shall be handled from the place of mixing to the place of final deposit as rapidly as practicable by methods which will prevent the segregation or loss of any of the ingredients. If segregation does occur during transport, the concrete shall be remixed before being placed.

6.7.1 During hot or cold weather, concrete shall be transported in deep containers; the deep containers, on account of their lower ratio of surface area to mass, reduce the rate of loss of water by evaporation during hot weather and loss of heat during cold weather.

6.8 Placing — The mixed material shall be discharged uniformly on to the prepared subgrade and distributed to a uniform loose layer by means of shovels and rakes. It will be compacted to uniform thickness by mechanical vibrators. Compaction shall be carried out continuously as the mixed material is spread, but the equipment shall be kept sufficiently far back from the free edges of the layer to prevent lateral movement of the mixed material. The time between the discharge of the mixed material and the commencement of the compactions shall be as short as possible, and in no case shall exceed 30 minutes. Compaction of any portion of the layer to the required thickness shall be completed within 1½ hours after the material has been spread.

6.9 Finishing — After compacting the final finish shall be obtained by wooden and steel floats.

6.10 Curing — Immediately after final compaction and finishing, the surface of concrete shall be kept continuously damp for at least 14 days. This shall be achieved by fog spraying with water or covering the surface with damp hessian, straw or sand maintained moist throughout the period of curing.

6.11 Repairs to Concrete Placed with Forms — The surface of concrete finished against forms shall be smooth and shall be free from projections, honeycombing and other objectionable defects. Immediately on the removal of forms all unsightly ridges or lips shall be removed and undesirable local bulging on exposed surface shall be remedied by tooling and rubbing. Repairs to concrete surfaces and additions where required shall be made by cutting regular openings into the concrete and placing fresh concrete to the required lines. The chipped openings shall be sharp and shall not be less than 7·0 cm in depth. The fresh concrete shall be reinforced and chipped and welled to the surface of the openings. The concrete shall be placed in layers not more than 2·0 cm in thickness after being compacted and each layer shall be compacted thoroughly. All exposed concrete surfaces shall be cleaned of impurities, lumps of mortar or grout and unsightly stains.

7. JOINTING

7.1 In order to minimize cracking the lime concrete shall be laid in panels of suitable size depending upon the size of the channel. A panel of 3 × 3 m or 9 m^2 is recommended. The joints between the adjacent panels, after the curing is over, will be sealed leak-tight with suitable sealing compounds, such as asphaltic materials. A straight transverse construction joint shall be formed, whenever there is a break of even a few hours during the lining operation. Such a joint shall be sealed leak-tight with a suitable sealing compound after the expiry of the curing period.

8. FIELD CONTROL

8.1 The following factors shall be checked for controlling field conditions during the progress of the work:

a) *Subgrade Condition* — Prior to placing of the lime concrete, the condition of subgrade shall be checked to ensure that it is well compacted (to a density not less than 95 percent of the standard maximum for the soil), clean and surface moist.

b) *Thickness of Processed Layer* — This shall be checked continuously during the construction to ensure that the correct thickness is being laid.

c) *Regularity of the Surface* — There shall not be any depression in the level of the final surface either transversly or longitudinally or more than 5 mm under 3 m template or straight edge.

d) *Curing* — It shall be ensured that the surface of the lime concrete is maintained moist continuously throughout the curing period by checking at frequent intervals.

e) *Quality of Concrete* — The quality of lime concrete shall be controlled in the field in accordance with IS : 456-1964*.

*Code of practice for plain and reinforced concrete.

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)

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