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(पहला पुनरीक्षण)

Indian Standard

SOIL-CEMENT LINING FOR CANALS — CODE OF PRACTICE

(First Revision)

ICS 93.160

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Canals and Cross Drainage Works Sectional Committee had been approved by the Water Resources Division Council.

Lining of canals is considered an important feature of irrigation projects which not only minimizes loss of water due to seepage but also helps in achieving consumptive use of water for cultivable land and minimizes risk of waterlogging due to rise in water table. Further, the water, thus saved, can be usefully employed for the extension and improvement of irrigation facilities. Lining of water courses in the areas irrigated by tube wells assumes special significance as the pumped water supplied is relatively more costly. Further, lining of canals permits the adoption of high velocities resulting in savings in the cross-sectional areas, the cost of excavation and masonry works, which may in certain cases offset completely the extra cost of lining. Also, the lining ensures stability of channels sections thereby reducing the maintenance cost. Due to comparative flatter bed slope which can be provided in lined canals, command or the culturable command area would improve. The benefit that accrue from lining of canals generally justify the initial capital cost and because of this there is now a better appreciation of the need for lining of canals.

Judicious selection of serviceable and economical lining at the first instance and subsequently proper execution of the work while laying the lining results in achieving considerable overall economy in the project .

Soil-cement lining is one of the cheaper types of canal lining which has been used successfully in other countries. It's use as an economic water-proof membrane is possible where soil characteristics are favourable to stabilization. While the lining will minimize absorption losses and give reduced section of the canal, it can suffer from damage from cattle trespass, weathering action and low resistance to subgrade pressures occurring due to sudden closures of the canal.

In many areas local soils mixed with water and cement may be used to construct adequate soil-cement linings. Soil-cement mixtures are relatively dry mixtures of soil, cement and water, compacted to a maximum density. The suitability of the soil and the proportions of the mix to be used shall be determined by laboratory tests before any work is undertaken.

This standard was first published in 1973. This revision of the standard has been taken up to incorporate the latest technological changes in this field as well as to account for the experiences gained during the last four decades.

There is no ISO Standard on the subject. This standard has been prepared based on indigenous data/practices prevalent in the field in India.

The composition of the Committee responsible for the formulation of this standard is given in Annex A.

Indian Standard

SOIL-CEMENT LINING FOR CANALS — CODE OF PRACTICE

(First Revision)

1 SCOPE

1.1 This standard lays down general guidelines for lining irrigation canals with 100 to 150 mm thick soil-cement lining.

1.2 The use of soil-cement lining for irrigation canals shall be restricted to small and medium size irrigation canals with capacities up to 10 cumecs and in which the velocity of water does not exceed 1 m/s.

2 REFERENCES

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

IS No.	*Title*
269 : 1989	Specification for 33 grade ordinary Portland cement (*fourth revision*)
455 : 1989	Specification for Portland slag cement (*fourth revision*)
456 : 2000	Plain and reinforced concrete — Code of practice (*fourth revision*)
1489	Specification for Portland pozzolana cement :
(Part 1) : 1991	Flyash based (*third revision*)
(Part 2) : 1991	Calcined clay based (*third revision*)
2720 (Part 7) : 1980	Methods of test for soils : Part 7 Determination of water content-dry density relation using light compaction (*second revision*)
3037 : 1986	Specification for bitumen mastic for use in water-proofing of roofs (*first revision*)
4332 (Part 3) : 1967	Methods of test for stabilized soils : Part 3 Test for determination of moisture content-dry density relation for stabilized soils mixtures
4558 : 1995	Under drainage of lined canals — Code of practice (*second revision*)
5256 : 1992	Sealing expansion joints in concrete lining on canals — Code of practice
8112 : 1989	Specification for 43 grade ordinary Portland cement (*first revision*)
12269 : 1987	Specification for 53 grade ordinary Portland cement

3 TERMINOLOGY

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

3.1 Soil-Cement Lining — Lining constructed by compacting soil-cement mix at optimum moisture content.

3.2 Optimum Moisture Content — The moisture content at which the soil-cement mixture can be compacted to the maximum dry density by a given compactive effort in a specified manner.

3.3 Maximum Dry Density — For a given compactive effort the dry density of a soil-cement mixture varies as the moisture content of the mixture varies. If the moisture contents are plotted against the corresponding dry densities, the points will normally form a parabolic curve the peak of which will indicate the maximum dry density as illustrated in Fig. 1.

3.4 Subgrade — Subgrade is the specially prepared surface against which the soil-cement lining shall be laid.

3.5 Lip Cutting — The extra width provided at the inner face of the bank under compaction to allow for any laps in compaction due to inability of sheep foot rollers to cover the edge of the bank.

4 DATA REQUIRED

Detailed soil survey shall be carried and the following information shall be obtained for the entire length of the canal before the commencement of the work:

a) Characteristics of soils and extent of various types of soils encountered on the project and the likely presents and nature of injurious salts in them.

b) The position of sub-soil water level and range of variations, and

c) The capacity of the irrigation canal and the velocity of flow.

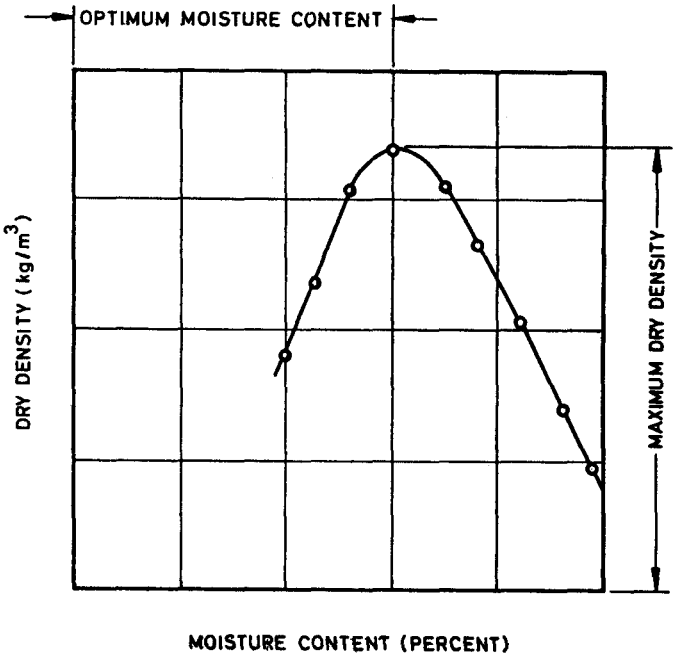

FIG. 1 RELATIONSHIP BETWEEN DRY DENSITY AND MOISTURE CONTENT OF SOIL-CEMENT

5 MATERIALS

5.1 Cement

The cement shall conform to the requirements of IS 269 or IS 455 or IS 1489 (Part 1) or IS 1489 (Part 2), IS 8112 or IS 12269.

5.2 Soil

Sandy soil or soil 100 percent passing 1.0 mm IS Sieve containing not more than 20 percent material passing a 75-micron IS Sieve shall be used for soil-cement lining. It should not contain injurious salts like sulphates, and should not have more than one percent (by weight) of organic matter.

NOTE — The liquid limit of the soil shall not normally be above 40 and the plasticity index not more than 18.

5.3 Water

Water to be used for soil-cement lining and its subsequent curing shall conform the requirements specified in IS 456.

6 LABORATORY TESTS FOR SOIL AND SOIL-CEMENT

6.1 Sieve analysis of the soil shall be conducted to verify the acceptability of the soil. Laboratory tests shall also be carried out to determine the optimum moisture content and maximum dry density in accordance with IS 4332 (Part 3).

NOTE — Light compaction shall be used in the test for the determination of the moisture content-dry density relation.

6.2 The cement content of the soil-cement mixture shall be such that the mix after being compacted at optimum moisture content, satisfies the following requirements:

a) It shall have a minimum compressive strength of 20 kg/cm^2 at the age of 7 days, the test specimens being moist cured during the period;

b) Test specimens shall effectively withstand erosion by the continuous lateral action of jets of water with a velocity of 1.5 m/s for at least 150 h; and

c) The permeability of test specimens shall not exceed 10^{-5} cm/s.

NOTE — For guidance the permeability values of soil-cement mixes with different types of soil for certain values of cement content are given in Table 1.

7 PREPARATION OF THE SUBGRADE

7.1 Reaches with Expansive Soils

Lining should be avoided, as far as practicable, on expansive clays. But, if the canal has to traverse a reach of expansive clay and no alternate route or construction type is economically feasible any one of the practices detailed under **7.1.1** and **7.1.2** shall be adopted to reduce the damage to the lining 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 kg/cm^2 in some types and as much as 10.5 kg/cm^2 or higher in others. In many cases the practices recommended in **7.1.1** and **7.1.2** may be a practicable solution.

Table 1 Permeability Values (Laboratory) of Some Soil-Cement Mixtures

[*Clause* 6.2 (c) (Note)]

Sl No.	Type of Soil	Cement Content, Percent by Weight	Permeability cm/s
(1)	(2)	(3)	(4)
i)	Fine sand	9	97×10^{-7}
ii)	Sand	8	58×10^{-7}
iii)	Gravelly course sandy loam	8	58×10^{-7}
iv)	Loamy fine sand	10	19×10^{-7}
v)	Sandy clay loam	8	4.9×10^{-7}
vi)	Loam fine sand	9	0.9×10^{-7}

7.1.1 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 with selected material, moistened as necessary, and thoroughly tamped and compacted. If the refilling is more than 150 mm thick, it should be filled and compacted in layers not exceeding 150 mm.

7.1.2 If the swelling of the clay encountered can be controlled by loading the surface with a non-expansive compacted soil or gravel, the expansive clay bed shall be over excavated to a depth of about 600 mm and filled to the grade of the underside of lining with good draining material leading away the seepage water to specially constructed points either to the outside of the canal or releasing it into the canal by provision of suitable pressure relief valves. However, the excavated surface of expansive clay shall be given a coat of asphalt with a minimum thickness of 20 mm before loading it to prevent the entry of water into the clay. The asphalt used shall conform to IS 3037.

7.2 Under-drainage

Pressure relief arrangements for under-drainage shall be provided as given in IS 4558 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.

7.3 Anti-salt Treatment

Soil in all reaches shall be tested for salt contents before the lining is started. Where the salt content is 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/m^2. To get a good bond between bitumen and soil, crude oil at a rate of 0.5 l/m^2 shall be sprayed over it in advance of spraying bitumen. In case such situation is encountered only in small pockets the replacement of subgrade up to suitable depth by suitable earth from adjoining reaches should be considered, if economical.

7.3.1 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 h after spraying.

7.4 The subgrade shall be prepared, dressed and rolled true to the level and the grade required.

7.4.1 Initial excavation shall be carried out to at least 300 mm below the final section and the cutting to final shape shall be done just before laying lining.

7.4.2 Sample profiles true to the cross-section of the canal shall be made at intervals of 3.5 m to ensure correct formation of the subgrade. Suitable wooden templates may be used to spread the soil and check the profile.

7.4.3 If at any point material of the prepared subgrade is excavated beyond the neat lines required to receive the lining, the excess excavation shall preferably be filled with the same soil-cement mix as for the lining or any other suitable material and thoroughly compacted at the time of laying the lining in accordance with **7.4.5**.

7.4.3.1 When partial filling of an existing canal is necessary to reduce the cross-sectional area to that required for lined canal the fill shall be placed and suitably compacted to avoid its settlement and rupture of the lining.

7.4.4 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 600 mm horizontally shall be provided.

7.4.5 The compaction of the subgrade shall be done at optimum moisture content in layers not exceeding 150 mm thick to a density which will not be less than 95 percent of the maximum density obtained in accordance with IS 2720 (Part 7). The compaction shall be effected by means of smooth wheeled rollers, tampers or similar suitable equipment.

7.4.5.1 Where the dry bulk density of the natural soil is equal to or more than 1.8 g/cm^3 the procedure described in **7.4.1** shall be followed.

7.4.5.2 *Bed*

Where the dry bulk density of the natural soil is less

than 1.8 g/cm^2 and the subsoil water is near the subgrade, the compaction shall be done by under cutting the bed by 75 mm and then ploughing up to 150 mm 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, consolidation shall be done by digging the canal up to subgrade level and after that loosening the earth below subgrade up to 150 mm by disc harrows, or ploughing and compacting the same to a layer of 110 mm. After that, the second layer of 150 mm of earth shall be laid over the compacted layer by taking earth from lip cutting and compacting this to depth of 110 mm. The compacted layer of 70 mm above the subgrade level shall be removed and the subgrade brought to design profile before laying the lining.

7.4.5.3 *Sides*

Compaction on sides shall be done by manual labour or suitable compactors to a depth of 300 mm to obtain a minimum dry bulk density of not less than 90 percent of the density at optimum moisture content obtained in accordance with IS 2720 (Part 7).

8 CONSTRUCTION

8.1 Pulverizing the Soil

The soil shall be pulverized manually or mechanically to make sure that there are no clods and the soil conforms to **5.2**.

8.2 Mixing Soil and Cement

The required quantity of cement shall be thoroughly mixed with the dry soil either mechanically or by hand-mixing through manual labour. The mixing shall be continued till the soil-cement mix acquires uniform colouration which can be examined under a magnifying glass. The required quantity of water will be added and mixing continued to ensure uniform distribution of the moisture throughout the soil-cement mass.

8.2.1 Batching of the materials shall be by weight. The appropriate quantities of soil and cement required for one batch shall be measured out after making due allowance for the moisture present in the soil. The correct amount of water to bring the moisture content of the mix to the optimum giving due allowance for evaporation shall be then added.

8.3 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. Care shall be taken to obtain uniformity in depth. Sufficient depth of loose material to give the required thickness after compaction shall be spread in one operation. The thickness of the soil-cement lining should be 100 to 150 cm. Generally, it is necessary to process 130 to 150 mm of loose soil to obtain a compacted thickness of 100 mm.

8.4 Compaction of the Soil-Cement Mix

Compaction shall be carried out continously 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 compaction shall be effected by means of a smooth wheeled roller, vibratory roller, tampers or any other type of equipment capable of achieving the desired degree of compaction.

8.4.1 The time between preparation of the soil-cement mixture and the commencement of the compaction shall be as short as possible, and in no case shall exceed 30 min. Compaction of any portion of the layer to required density shall be completed within 1½ h after the material has been spread.

8.5 Curing

After final compaction and finishing, the surface shall be allowed to harden and soon after it shall be kept continuously damp for at least 14 days. This may be done by any suitable method, such as fog-spraying with water or covering the surface with damp hessian, straw or sand maintained moist throughout the period of curing.

8.6 Jointing

A straight transverse construction joint shall be formed wherever there is a break of work (of even a few hours). Such joints shall be sealed leak tight with sealing compound conforming to the requirements given IS 5256 after the expiry of the curing period. As an alternative, the edge surface of the previous lining may be roughened with 1 : 3 cement sand grout not more than 12 mm thickness applied and the lining operation continued.

9 FIELD CONTROL

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

a) *Subgrade Condition* — Prior to placing of the soil-cement the conditions of the 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 the surface moist.

b) *Cement Content* — An adequate cement content is a primary control factor deserving maximum attention in the field. Samples of the mixed materials from a batch shall be frequently examined to ensure that they are uniform in colour and texture.

c) *Moisture Content* — The moisture content of the soil and soil-cement mixture shall be checked at regular intervals prior to batching and whenever the source of soil is changed from one stock-pile to another and after mixing.

d) *Compaction of the Soil-Cement Mix* — The dry density of the compacted soil-cement mix shall be measured at intervals of 1 000 m along the length of the canal at points widely distributed across its bed and slopes. In no case shall be measured dry density fall below 95 percent of the maximum dry density obtained in accordance with IS 4332 (Part 3).

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

f) *Surface Finish* — There shall not be any undulation in the level of the final surface either transversely or longitudinally of more than 5 mm under one metre template of straight-edge.

g) *Curing* — It shall be ensured that surface of the soil-cement is maintained moist continuously throughout the curing period by checking at frequent intervals.

h) *Compressive Strength* — When it is desired and when time permits the compressive strength test may be used as an additional field control measure. The compressive strength of soil-cement specimens moulded from field samples should not be less than 15 kg/cm^2 at the age of 7 days, the specimens being moist cured during this period.

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Canals and Cross Drainage Works Sectional Committee, WRD 13

Organization	*Representative(s)*
Sardar Sarovar Narmada Nigam Ltd, Gandhi Nagar, Gujarat	SHRI G. L. JAVA (***Chairman***)
Bhakra Beas Management Board, Nangal Township, Punjab	DIRECTOR (WR) EXECUTIVE ENGINEER (*Alternate*)
Central Board of Irrigation & Power, New Delhi	SHRI T. S. MURTHY
Central Water & Power Research Station, Pune	SHRIMATI V. K. APPUKUTTAN SHRI M. S. SHITOLE (*Alternate*)
Central Water Commission, New Delhi	DIRECTOR [BCD N & W & NWS] DIRECTOR (SSD & C) (*Alternate*)
Consulting Engineering Services (India) Ltd, New Delhi	SHRI S. P. SOBTI DEPUTY PROJECT MANAGER (*Alternate*)
Continental Construction Ltd, New Delhi	SHRI P. A. KAPUR SHRI. T. B. S. RAO (*Alternate*)
Indira Gandhi Nahar Board, Phalodi	SHRI R. K. GUPTA
Irrigation Department, Government of Karnataka, Bangalore	CHIEF ENGINEER (DESIGNS)
Irrigation Department, Government of Maharashtra, Nasik	SUPERINTENDING ENGINEER (GATES) EXECUTIVE ENGINEER (CSI) (*Alternate*)
Irrigation Department, Government of Punjab, Chandigarh	CHIEF ENGINEER (LINING & PLANNING) DIRECTOR (*Alternate*)
Irrigation Department, Government of Rajasthan, Jaipur	DIRECTOR (D & R) DIRECTOR (I & S) (*Alternate*)
Irrigation Department, Government of Uttar Pradesh, Lucknow	CHIEF ENGINEER DIRECTOR (*Alternate*)
Irrigation Department, Government of Andhra Pradesh, Hyderabad	CHIEF ENGINEER SUPERINTENDING ENGINEER (*Alternate*)
Irrigation Department, Government of Haryana, Chandigarh	CHIEF ENGINEER (PROJECTS) DIRECTOR (ENGINEERING) (*Alternate*)
Narmada & Water Resources Department, Government of Gujarat, Gandhi Nagar	SUPERINTENDING ENGINEER (CDO) EXECUTIVE ENGINEER (UNIT G) (*Alternate*)
Public Works Department, Government of Tamil Nadu, Chennai	ENGINEER-IN-CHIEF
Reliance Industries Ltd, New Delhi	DR V. K. SAROOP SHRI AVINESH DUBEY (*Alternate*)
Sardar Sarovar Narmada Nigam Ltd, Gandhi Nagar, Gujarat	DIRECTOR (CANALS) CHIEF ENGINEER (CD/W) (*Alternate*)
University of Roorkee, Roorkee	SHRI NAYAN SHARMA
Water and Land Management Institute, Lucknow	PROF P. K. SINHA
Water Resources Department, Government of Orissa, Bhubaneshwar	CHIEF ENGINEER (D & R)
BIS Directorate General	SHRI S. S. SETHI, Director & Head (WRD) [Representing Director General (*Ex-officio*)]

Member Secretary
SHRI R. S. JUNEJA
Joint Director (WRD), BIS

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