IS 10430 (2000): Criteria for Design of Lined Canals and Guidance for Selection of Type of Lining [WRD 13: Canals and Cross Drainage Works]

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REAFFIRMED

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भारतीय मानक

अस्तर लगी नहरों की डिजाइन के माप दण्ड तथा अस्तर प्रकार के चुनाव के मार्गदर्शी सिद्धांत

(पहला पुनरीक्षण)

Indian Standard

CRITERIA FOR DESIGN OF LINED CANALS AND GUIDANCE FOR SELECTION OF TYPE OF LINING

(First Revision)

ICS 93.160

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

October 2000 **Price Group 6**

AMENDMENT NO. 1 AUGUST 2005
TO
IS 10430 : 2000 CRITERIA FOR DESIGN OF LINED CANALS AND GUIDANCE FOR SELECTION OF TYPE OF LINING

(First Revision)

[*Page* 1, *clause* **3**(r)] — Substitute the following for the existing:

'r) Availability of suitable construction material within economic leads, such as:

1) Cement of requisite quality;
2) Building lime of requisite class;
3) Flyash for use as pozzolana;
4) Suitable clay for manufacture of calcined clay pozzolana;
5) Coarse and fine aggregates;
6) Soil of suitable quality for manufacture of burnt clay tiles/bricks;
7) Pulverized fuel ash-lime and/or clay flyash building bricks; and
8) Stones of required size and quality.'

[*Page* 3, *clause* **6**(a)] — Substitute the following for the existing:

'a) **Rigid Lining**

1) Stone-pitched lining;
2) Burnt clay tile or brick lining;
3) Burnt bricks or pulverized fuel ash-lime bricks or burnt clay flyash building bricks lining;
4) Precast cement concrete/stone slab lining;
5) Cement concrete tile lining;
6) In situ cement/lime concrete lining;
7) Stone masonry lining;
8) Soil cement/soil cement and flyash lining;
9) Shotcrete lining;
10) Ferrocement lining; and
11) Asphaltic cement concrete lining.

[*Page* 4, *clause* 6(b)(1)] — Substitute the following for the existing:

1) Geomembrane like High Density Polyethylene (HDPE), Polvinyl chloride (PVC), Low Density Polyethylene (LDPE) with cover comprising layer of bentonite with adequate earth/burnt clay tile brick or pulverized fuel ash-lime brick or burnt clay flyash building brick/precast cement concrete.'

(WRD 13)

Reprography Unit, BIS, New Delhi, India

Irrigation Canals and Canal Linings Sectional Committee, WRD 13

FOREWORD

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

Lining of canals is an important feature of irrigation projects as it improves the flow characteristics and minimises the loss of water due to seepage. The water thus saved can be utilised for the extension and improvement of irrigation. Lining of water courses in the areas irrigated by tubewells assumes special significance as the pumped water supply is relatively more costly. The reduced seepage also prevents rise of the sub-soil water table and thus reduces the possibility of damage to the adjoining areas by water logging. Further, due to adoption of higher velocities in a lined canal there is a saving in the cross-sectional area of the canal and land width required, with corresponding saving in the cost of excavation and masonry works. It helps in retention of shape of the canal. Lining also results in improvement of command and larger working head for power generation.

This standard deals with design of lined canals. However, before lining of a canal is decided, techno-economic justification for the same should be established. Selection of a particular type of lining should be arrived at based on materials available and overall cost *vis-a-vis* saving in seepage and head. Performance data for various types of lining shall be collected and consulted before deciding on a particular type of lining.

Only general guidelines with regard to factors influencing the selection of the type of lining are given in this standard, for the assistance of the designer. But each project should be individually analysed taking into consideration its peculiar features.

This standard was first published in 1982. The first revision has been taken up in the light of the comments received from the Irrigation departments of various states. In this revision functions of lining and various types of lining have been included. Changes in side slopes, free board, etc, have also been incorporated.

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

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 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

CRITERIA FOR DESIGN OF LINED CANALS AND GUIDANCE FOR SELECTION OF TYPE OF LINING

(First Revision)

1 SCOPE

This standard lays down design criteria for lined canals and presents guidelines for selection of type of lining.

2 REFERENCES

The following Indian 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*
4558 : 1995	Code of practice for under drainage of lined canals (*second revision*)
9451 : 1994	Guidelines for lining of canals in expansive soils (*second revision*)

3 NECESSARY INFORMATION

For arriving at a suitable design of a lined canal and for selection of type of lining the following information is necessary for the entire length of the canal:

a) **Capacity** — Capacity required for the canal to irrigate the command depends on the crop pattern, irrigation intensity, rotation period, water required during critical period, transmission losses, etc. For fixing the canal capacity, a design statement, or capacity statement should be separately prepared, reach by reach. The section of a particular reach should be designed for the maximum discharge in that reach.

NOTE — Suitable transmission loss (m^3/s per million square metre of wetted perimeter) for lined canal depending upon the type of lining, climatic conditions shall be assumed.

b) Longitudinal-section along the canal alignment plotted generally to a horizontal scale of 1 in 10 000 and a vertical scale of 1 in 100. Vertical scale may be changed, if desired, depending upon the drop in the ground levels;

c) Full supply level (FSL), bank level and the bed level of the parent canal (if any);

d) Cross-sections along the canal alignment an intervals not more than 300 m for a uniform terrain and at closer intervals for undulating terrain. The cross-sections should extend at least 10 metres beyond the limits of canal section on both sides;

e) Road and railway crossings, cart/pedestrian tracks, drainage crossings, etc;

f) Nature and quantity of sediment likely to be transported;

g) Profile of soil up to at least half the full supply depth or 1 m whichever is more, below the canal bed level along the canal alignment at 500 m intervals. However, if any variation in soil strata is found, the spacing shall be at shorter intervals. Soil samples should be tested for usual soil properties including permeability, swelling pressures, and dispersive properties;

h) Salt content of the soil, specially presence of sulphates, to be determined at suitable intervals;

j) Sub-soil water level and its quality along the canal alignment;

k) Availability of skilled and unskilled labour;

m) Availability of construction machinery;

n) Cattle traffic;

p) Climatic and other local conditions;

q) Thickness of ice formation (if applicable);

r) Availability of suitable construction materials within economic leads, such as:

1) Coarse and fine aggregate for canal lining;
2) Soil for making tiles/bricks; and
3) Stones of required size, specific gravity and soundness for stone lining.

4 FUNCTIONS OF LINING

4.1 The functions of lining are:

a) Seepage control,
b) Prevention of water logging,
c) Increased hydraulic efficiency,
d) Increased resistance to erosion/abraison,

e) Reduction in cross-section area and consequential smaller structures, and

f) Low operation and maintenance cost.

4.1.1 *Seepage Control*

The seepage control mainly depends on the soundness and impermeability of lining. Seepage losses also depend on nature and permeability of soil, depth of water in the canal and position of sub-soil water table below the bed level.The permissible seepage losses depend on the local conditions such as value of water and any likely damage to land and other property by water loggings, etc.

Generally canal reaches of sufficient length having permeability of 1×10^{-6} cm/s or less need not be lined when the velocity in the canal does not exceed the permissible velocity. However, reaches of permeability 1×10^{-6} cm/s or less may be lined, particularly in power channels, for hydraulic efficiency and erosion resistance. Canal reaches of greater permeability may be lined with suitable material.

4.1.2 *Increased Hydraulic Efficiency*

The discharge carrying capacity of a canal varies inversely with the value of rugosity coefficient of a particular type of lining. It may, however, undergo changes with passage of time, it may decrease with the lining undergoing deterioration and consequent increase in roughness.

4.1.2.1 The values of rugosity coefficient (n) to be used in Manning's formula for various types of linings are given in Table 1.

4.1.2.2 *Effective rugosity coefficient*

An effective rugosity co-efficient is possible to be derived in such situation where the sides and bed are having different types of lining. For such channels the equivalent manning's 'n' can be calculated by the following formula:

$$n = \frac{\left[\left(\sum_{i=1}^{N} (n_i^{3/2} p_i)\right)\right]^{2/3}}{p^{2/3}}$$

where

p_i = lengths of different portion of perimeter with corresponding roughness;

n_i = roughness of portion p_i; and

p = Σp_i.

Co-efficients as given in Sl No. (v) and (vi) of Table 1 are suggested for some cases, where an analytical derivation, as above, is not feasible.

Table 1 Values of Rugosity Coefficient (n) for Lined Canals with Straight Alignment

(*Clauses* 4.1.2.1 *and* 4.1.2.2)

Sl No.	Surface Characteristics	Value of 'n'
(1)	(2)	(3)
i)	Concrete with surface as indicated below:	
	a) Formed, no finish/PCC tiles or slabs	0.018-0.020
	b) Trowel float finish	0.015-0.018
	c) Gunited finish	0.018-0.022
ii)	Brick/tile lining	0.018-0.020
iii)	U.C.R./Random rubble masonry with pointing	0.024-0.026
iv)	Asphalt	
	a) Smooth	0.013-0.015
	b) Rough	0.016-0.018
v)	Concrete bed trowel/float finish and slopes as indicated below:	
	a) Hammer dressed stone masonry	0.019-0.021
	b) Coursed rubble masonry	0.018-0.020
	c) Random rubble masonry	0.020-0.025
	d) Masonry plastered	0.015-0.017
	e) Stone pitched lining	0.020-0.030
vi)	Gravel bed with side slope characteristics as given below:	
	a) Formed concrete	0.02-0.022
	b) Random rubble in mortar	0.017-0.023
	c) Dry rubble (rip-rap)	0.023-0.033

NOTES

1 For canals with an alignment other than the straight, a small increase in the value of 'n' may be made or alternatively bend losses may be accounted for. In case of canals with relatively higher discharges in straight reaches, lower values of 'n' indicated may be adopted.

2 The 'n' value shall be decided in view of the age of lining, surface roughness, weed growth, channel irregularities, canal alignment, silting, suspended material and bed load, etc.

4.1.3 *Increased Resistance to Erosion*

Sometimes the canal transports considerable amount of sediment which can damage the lining by abrasion. The lining shall, therefore, be able to withstand such abrasion.

NOTE — Cement concrete and stone masonry linings provide better abrasion resistance as compared to brick tile lining.

4.1.4 *Prevention of Water Logging*

There is increase in ground water level if the canals remain unlined. This condition, if unchecked, brings alkali salt to the surface rendering land unfit for cultivation. Lining of canals reduces the seepage appreciably and thus prevents the occurrence of water logging condition.

4.1.5 *Reduction in Cross-Sectional Area*

With the increase in efficiency of canal due to lining and higher velocity, reduced areas of cross-section is required to pass same discharge. Consequently, there is large saving in the cost of land acquisition and also of canal structures.

4.1.6 *Low Operation and Maintenance Cost*

Unlined canals require considerably increased operation and maintenance cost for periodical removal of silt, minor repairs, removal of weeds and water plants. The provision of lining reduce these costs considerably.

5 REQUIREMENTS OF LINING

5.1 General

The following are the important requirements for the selection of type of canal lining:

a) Economy;
b) Structural stability;
c) Strength and durability;
d) Repairability and easy maintenance;
e) Maximum hydraulic efficiency;
f) Impermeability;
g) Resistance to erosion;
h) Ability to prevent weed growth;
j) Resistance against burrowing animals; and
k) Reasonable flexibility.

The lining material shall be so selected that it should meet most of the requirements for the specific site.

5.1.1 *Economy*

The selection of suitable type of lining for any project is mainly a question of economics and availability of;

a) material available within economical leads;
b) skilled and unskilled labour;
c) construction machinery and equipment; and
d) time required during which the work should be completed.

The type of lining selected should not only be economical in initial costs, but also in repair and maintenance in the long run.

5.1.2 *Structural Stability*

The sides of the canal to be lined should preferably be kept at the stable slope of the soil so that there is no earth pressure or any other external pressure against the lining. Pressure due to saturated backfill and the differential water head across lining should be avoided. Arrangements like weep holes, graded filter behind weep holes shall be made so that no water gets behind the lining from an external sources.

Where the side slopes are made steeper than the stable slopes of the soil, or where external pressures cannot be avoided, the lining will have to be designed accordingly in such special case.

To provide relief from differential pressure, adequate sub-soil drainage arrangements and pressure release arrangements (*see* IS 4558) shall be provided wherever necessary.

5.1.3 *Strength and Durability*

The canal lining shall be able to withstand the effect of velocity of water, rain, sunshine, frost, freezing and thawing (where applicable), temperature and moisture changes, chemical action of salts, etc. With suitable treatment, lining should be able to withstand the effect of gypsum, black cotton soil/bentonite. It should also be able to withstand the damaging effect caused by abrasions, cattle traffic, rodents and weed growth.

5.1.3.1 For the purpose of economic analysis, the life expectancy of concrete, brick/tile and stone pitched lining may be assumed to be of the order of 60 years. However, experience gained from data on lined canal in the vicinity can be utilized to review the life expectancy of lining.

5.1.4 *Repairability/Easy Maintenance*

Since with lapse of time the lining may get damaged, it should be such that it can be repaired easily and economically.

5.1.4.1 Brick/tile, stone-pitched and precast slab linings are more easily repairable or replaceable than *in-situ* concrete lining.

5.1.5 *General*

Other factors indicated in **5.1** (e) to **5.1** (h) are achieved to different extent by various options available for lining.

The multi-dimensional effect of choice on the various parameters affecting the requirements thus require a judicious evaluations before a final choice.

6 DIFFERENT TYPES OF LININGS

a) **Rigid Lining**
   1) Stone-pitched lining;
   2) Burnt clay tile or brick lining;
   3) Precast cement concrete/stone slab lining;
   4) *In-situ* cement lime/concrete lining;

5) Stone masonry lining;
6) Soil cement lining;
7) Shotcrete lining; and
8) Asphaltic cement/concrete.

b) **Flexible Lining**

1) Geomembrane like High Density Polyethylene (HDPE), Polyvinyl chloride (PVC,) Low Density polyethylene (LDPE) cover comprising layer of ben to rite with adequate/ earth/burnt clay tile brick/precast cement concrete,
2) Bituminous or bituminous/asphaltic felt lining,
3) Fibre reinforced plastic tissue as phallic membrane, and
4) Composite membrane/rubber lining.

c) **Combination Lining (membrane in the bed and brick/tile or concrete lining on sides)**

7 SELECTION OF LINING

7.1 Considerations for Selection

Taking into consideration all the above factors, suitable types of lining for different sizes of canals will be selected on the basis of type of subgrade, position of water table, climatic conditions, availability of materials, speed of construction, time schedule, performance of lining in the existing canals in the adjoining areas. Adoption of a particular type of lining will require careful consideration of all these factors.

7.2 After collecting necessary information as given in **3.1**, the entire canal or specific reaches to be lined, may be decided as per **4.1.1**. The types of lining generally suitable for the site condition may be listed in the light of **5** and **6**. The most economical of the linings selected from amongst the suitable linings may be evaluated as per Annex A for economical viability. To select type of lining to keep seepage within desirable limits, reference may also be made to performance data of existing canals. There may be other intangible factors like presence of high population intensity, aesthetics, limitations of land availability, etc, which may influence the final selection of type of lining.

8 PARAMETER FOR DESIGN OF LINED CANALS

8.1 Side Slopes

8.1.1 *Inner Slopes of Lined Canals*

Lining is usually made to rest on stable slopes of the natural soil; so slopes should be such that no earth pressure or any other external pressure is exerted over the back of the lining. Sudden drawdown of water level in the lined canal should be controlled by strict operation rules and regulations to avoid external pressure on the lining. However where chance of sudden drawdown in the canal is considerable, the canal slopes should be checked for stability using slip circle analysis as given in IS 7894. In addition, other suitable measures like adequate drainage should be provided before lining work commences. As a rule, steeper slopes are economical but stable slopes depending on type of soil are preferred. For general guidance, the following side slopes as given in Table 2 are recommended.

8.1.2 *Outer Slopes of Lined Canal*

Suggested outer slopes for lined canals are seen in some of the typical sections such as given in Fig. 1A, 1B, 2A, 2B, etc. However, engineering properties of

Table 2 Recommended Side Slopes

(*Clause* 8.1.1)

Sl No.	Type of Soil	Side Slopes (Horizontal : Vertical)
i)	Very light loose sand to average sandy soil	2 : 1 to 3 : 1
ii)	Sandy loam	1.5 : 1 to 2 : 1 (in cutting) 2 : 1 (in embankment)
iii)	Sandy gravel/murum	1.5 : 1 (in cutting) 1.5 : 1 to 2 : 1 (in embankment)
iv)	Black cotton	1.5 : 1 to 2.5 : 1 (in cutting) 2 : 1 to 3.5 : 1 (in embankment)
v)	Clayey soils	1.5 : 1 to 2 : 1 (in cutting) 1.5 : 1 to 2.5 : 1 (in embankment)
vi)	Rock	0.25 : 1 to 0.5 : 1

NOTE — The above slopes are recommended for depth of cutting/height of embankment up to 6 m. For depth/height in excess of the above, special studies for the stability of slopes are recommended.

soil shall govern the design of outer slopes giving due consideration to stability of slopes for functional situations (like moist conditions of fill, etc.) The need for introduction of berms will also be kept in view where the fill height is in excess of 6 m.

8.2 Free Board

Free board shall be measured from the full supply level to the top of lining. Minimum free boards for various canal discharge are given below:

Canal Discharge	*Free Board*
More than 10 cumecs	0.75 m
Between 3 to 10 cumecs	0.60 m
1 to 3 cumecs	0.50 m
Less than 1 cumec	0.30 m
Less than 0.1 cumec (Water Course)	0.15 m

8.3 Berm

In deep cut reaches of canals with discharge capacity exceeding 10 cumecs, it is desirable to provide berms of 3 m to 5 m width on each side for stability, facility of maintenance, silt clearance, etc (*see* Fig. 1C). In such sections, the inner sides above the berms may be provided with turfing.

8.4 Bank Top Width

The width of the banks may vary according to the importance and capacity of the canal. In case of distributaries, service road should be provided on one bank for inspection and maintenance purpose. However, in case of main and branch canals service road should be provided on both the banks. The minimum values recommended for top width of the bank are as follows:

Discharge (m^3/s)	*Minimum Bank Top Width* Inspection Bank/ Wider Bank m	Non Inspection Bank/Other Bank m
0.15 to 1.5	4.0	1.5
1.5 to 3.0	4.0	2.0
3.0 to 10.0	4.0 + dowel	2.5
10.0 to 30.0	5.0 + dowel	4.0
30.0 and above	6.0 + dowel	5.0

NOTES

1 Bank widths given above may be altered when justified by specific conditions.

2 For distributary canals carrying less than 3.0 cumecs and minor canals, it is generally not economical to construct a service road on top of bank as this usually requires more materials than the excavation provides. In such cases, service road suitably lowered below top of lining may be provided on natural ground surface and adjacent to the bank; however, the importance of providing adequate service roads where they are needed should always be kept in view. The service road should be above normally encountered high flood level (HFL) with some free board.

3 Where the stability of the embankment is required, wider bank widths can be provided. Turfing should be provided on the outer slopes.

4 In hilly terrain where it is not possible to provide above bank widths, the bank widths may be suitably reduced.

5 When the bank widths are reduced on exceptional ground, refuges after every 100 m should be provided for passing and sheltering of opposing traffic.

8.5 Dowla (Dowel 'Dwarf Bund')

Suitable dowels may be provided on the canal side of the service road, on one or both the banks depending upon the type and size of the lined canal. From economic consideration, dowels may be replaced by parapets particularly in case of high embankments. However, the parapet should not be considered additional free board. To check the ingress of rain water behind the lining of the side slopes of the canals, horizontal cement concrete coping 100 mm to 150 mm thick, depending upon size of canal should be provided at the top of lining. The width of coping at the top shall not be less than 225 mm for discharge up to 3 cumecs, 350 mm for discharge more than 3 cumecs and 550 mm for discharge more than 10 cumecs.

8.6 Roadway and Drainage

Wherever additional spoil banks are to be provided on the land side of the embankment, adequate drainage channels shall be provided with suitable slope on the roadway sloping away from the canal side. No rain water shall be allowed to flow or percolate towards the canal slope behind the linings.

8.7 Typical Cross-Sections

Typical cross-sections of the lined canals in cutting and filling are given in Fig.1 and 2. Three typical cross-sections of lined canals in rock cutting are shown in Fig. 3. Depending upon the quality of rock, full supply discharge, velocity, depth of flow and bed width, similar arrangements may be adopted.

8.8 Cross-Section, Discharge and Velocity

8.8.1 The cross-section of lined canal may be

a) trapezoidal with or without rounded corners (*see* Fig. 1). This section can be used for all types of lined canals.

b) cup shaped (*see* Fig. 2). It may be used for distributaries/minors for discharge up to $3 m^3/s$ as far as possible.

8.8.2 The discharge that can pass through a canal section is calculated by

$$Q = A \times V_{mean} \ (m^3/s)$$

where

A = area of cross-section in m^2, and

V_{mean} = mean velocity in m/s.

8.8.3 The mean velocity V_{mean} is given by :

$$V_{mean} = \frac{R_h^{2/3} S^{1/2}}{n} \ (m/s)$$

where

R_h = hydraulic mean depth (= A/P) (m);

A = cross sectional area (m^2);

P = wetted perimeter (m);

S = longitudinal slope of water surface (m/m); and

n = rugosity coefficient as given in Table 1.

8.8.4 The critical velocity ratio should be aimed at higher than unity or by any other method, it should be ensured that silting will not take place in the lined canal.

8.8.5 *Limiting Velocities in Different Types of Lining*

The maximum permissible velocities for guidance for some types of lining are given below:

a) Stone-pitched lining	1.5 m/s
b) Burnt clay tile or brick lining	1.8 m/s
c) Cement concrete lining	2.7 m/s

9 UNDER DRAINAGE

9.1 Embankments of relatively permeable soil do not need drainage measures behind the lining. However, the following conditions require suitable under drainage measures to be provided to protect the canal lining in accordance with IS 4558.

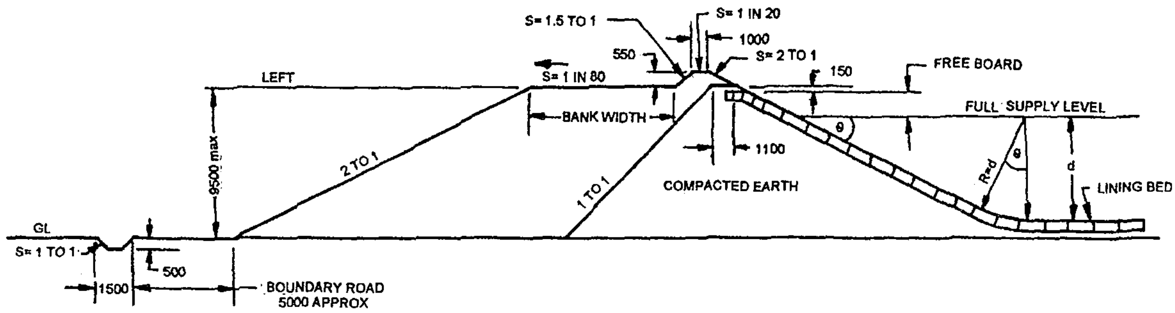
i) Where the lined canal passes through an area with seasonal ground water level higher likely to be higher than the water level inside the canal,

ii) Where sub grade is sufficiently impermeable to prevent the free drainage of seepage or leakage from the canal, and

iii) Where there is built up pressure due to time lag between drainage of the sub-grade following drawdown of canal.

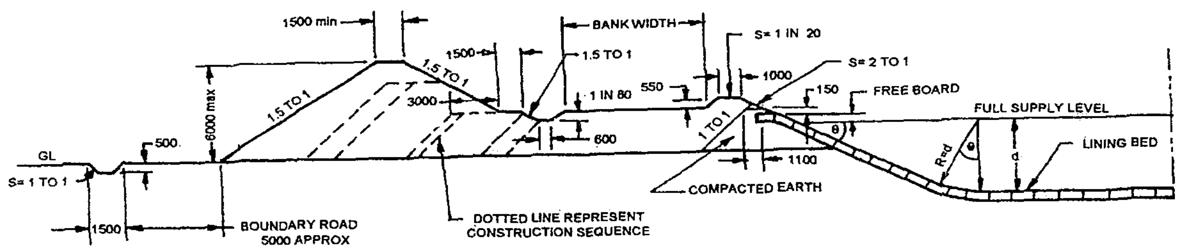
10 EXPANSIVE SOIL

10.1 In reaches of expansive soil where swelling pressure is more than 50 kN/m^2 reference may be made to IS 9451.



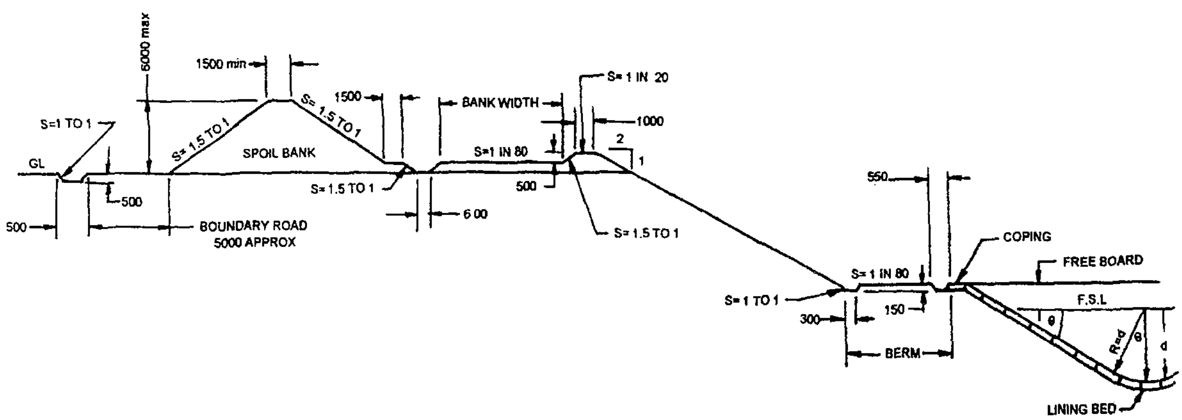
All dimensions in millimetres.

FIG. 1A NATURAL GROUND BELOW BED



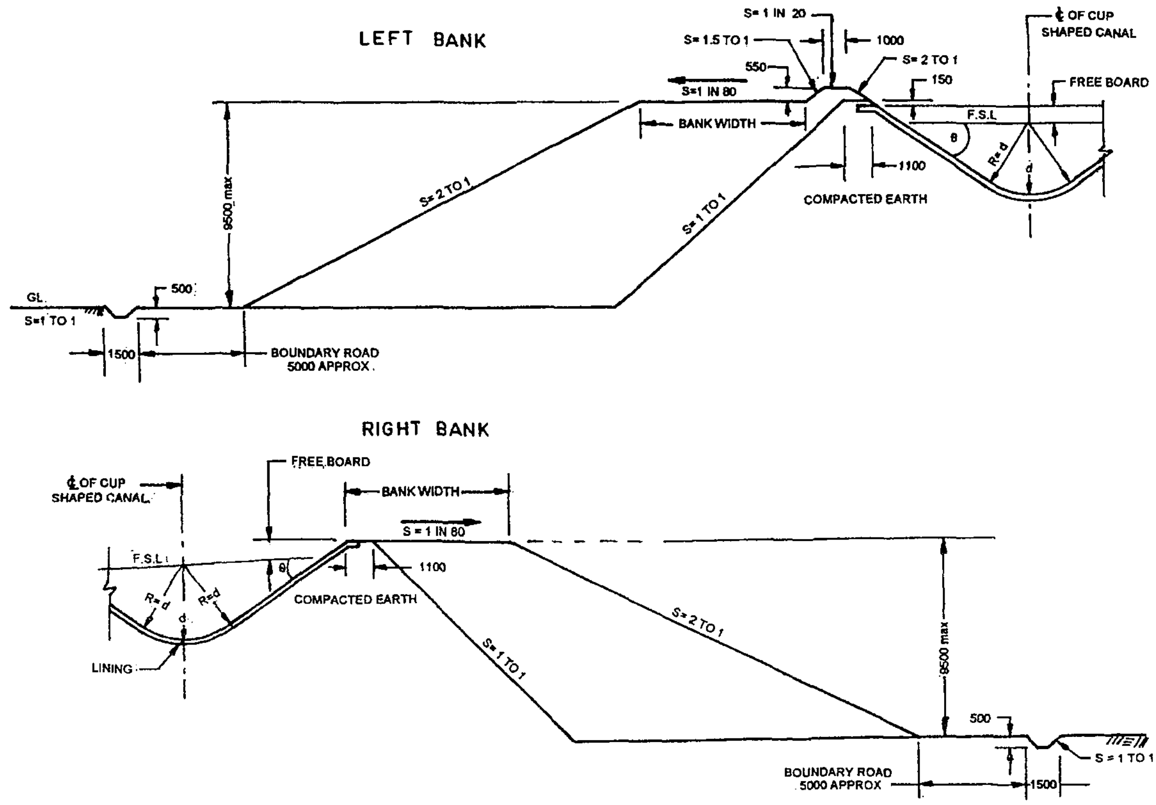
All dimensions in millimetres.

FIG. 1B NATURAL GROUND BETWEEN BED AND FULL SUPPLY LEVEL



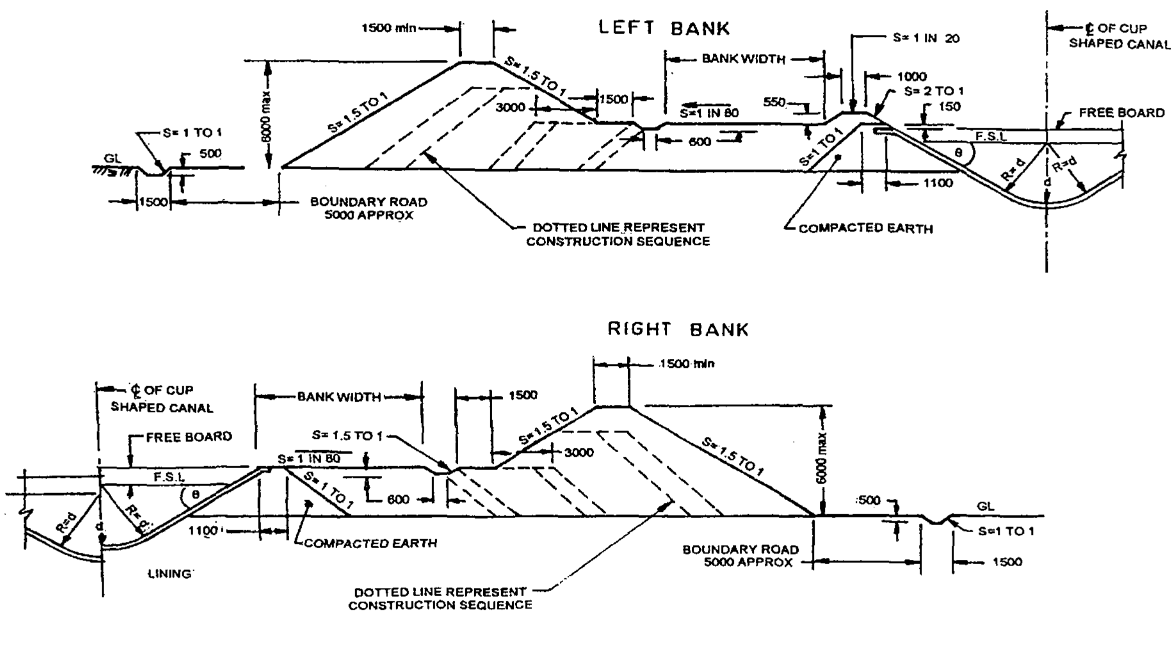
All dimensions in millimetres.

FIG. 1C NATURAL GROUND IS AVOVE TOP OF LINING



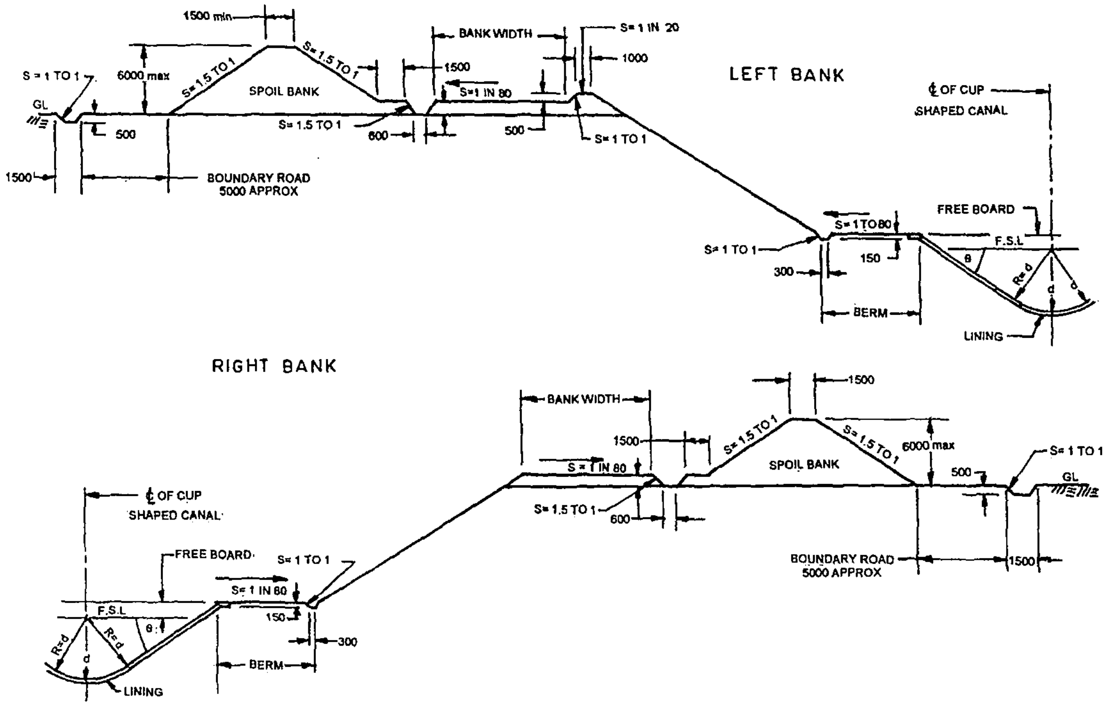
All dimensions in millimetres.

FIG. 2A NATURAL GROUND BELOW BED



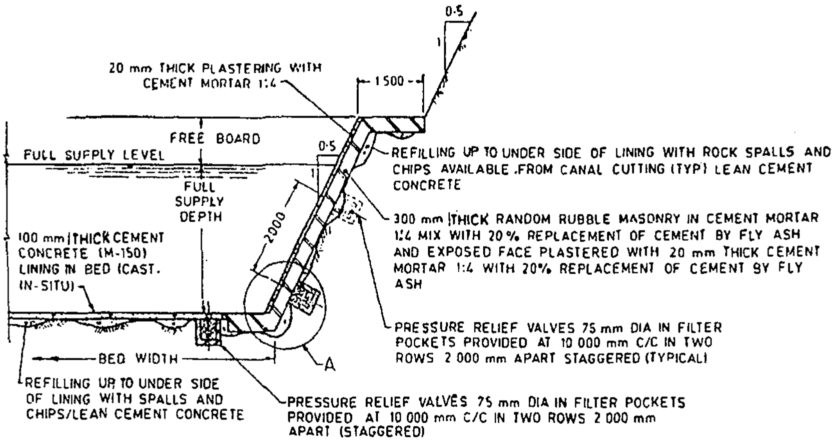
All dimensions in millimetres.

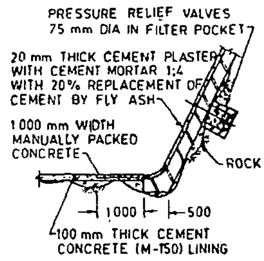
FIG. 2B NATURAL GROUND BETWEEN BED AND FULL SUPPLY LEVEL



All dimensions in millimetres.

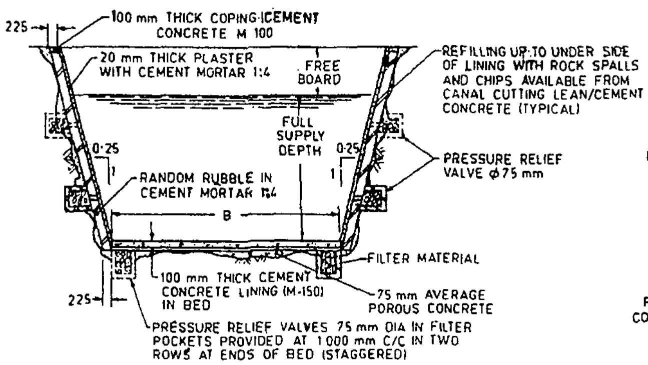
FIG. 2C NATURAL GROUND IS AVOVE TOP OF LINING



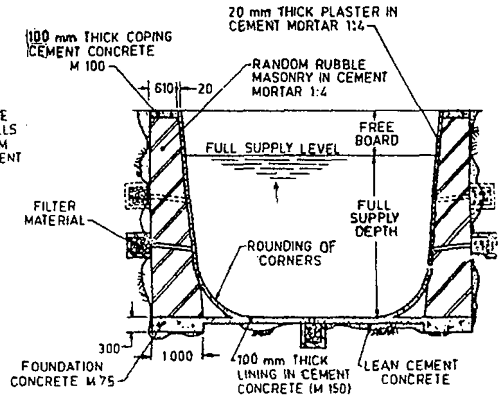


DETAIL AT A

3A CAST-IN-SITU CEMENT CONCRETE LINING IN BED AND RANDOM RUBBLE MASONRY LINING ON SIDES



3B CAST-IN-SITU CEMENT CONCRETE (M-150) LINING IN BED AND RANDOM RUBBLE MASONRY LINING ON SIDES



3C CAST-IN-SITU CEMENT CONCRETE (M-150) LINING IN BED AND RANDOM RUBBLE MASONRY LINING ON SIDES

NOTES

1 In case of sound rock, cement concrete lining may be provided in bed and sides. On sides, the lining may be anchored suitably to the rock behind.

2 All the dimensions are in millimetres unless otherwise specified.

FIG. 3 TYPICAL CROSS-SECTIONS OF LINED CANALS IN ROCK CUTTING

ANNEX A

(*Clause* 7.2)

ECONOMICS OF CANAL LINING

A-1 NOTATIONS

A-1.1 For the purpose of analysis for determining the maximum rate of expenditure on lining that is economically justifiable, the following notations should apply:

C : Cost of lining in rupees per square metre including the additional cost of dressing the banks for lining.

C' : Saving in the land, earthwork and structures (bridges, cross drainage works, etc) due to reduced section on account of lining, in rupees.

s and S Seepage losses in unlined and lined canal respectively in cubic metres per square metre of wetted surface per day.

p and P Wetted perimeter in metres of unlined and lined sections respectively.

T = Total perimeter of lining in metres.

d = Number of running days of the canal per year.

W = Value of water saved in rupees per cum.

L = Length of the canal in metres.

Y = Life of the canal in years.

M = Annual saving in rupees in operation and maintenance due to lining.

B = Annual estimated value in rupees of other benefit for the length of canal under consideration. These will include prevention of water logging, reduced cost of drainage for adjoining lands, reduced risk of breaching, etc.

X = Percent rate of interest per year.

a = Total annual benefits resulting from the lining of canals.

A-2 METHOD

A-2.1 The annual value of water lost by seepage from the unlined section = $p\,L\,s\,d\,W$ rupees

The annual saving by lining in value of water otherwise lost by seepage if unlined $=(pLsdW - PLSdW)$ Rs $= \{LdW(ps - PS)\}$ Rs

Total annual benefits resulting from the lining of canals, a $= \{Ldw\,(ps - PS) + B + M\}$ Rs ....(1)

A-2.1.1 Additional capital expenditure on construction of lined canal = Rs $TLC\ C'$. If the prevalent rate of interest is X, the net present worth (NPW) of the total annual benefits a, over the life of the canal (Y years) is determined from the following formula:

$$NPW = a\,\frac{(1+X)^{Y} - 1}{X\,(1+X)^{Y}} \quad ....(2)$$

For the lining to be economically feasible the additional initial cost of the lined canal should be equal to or less than Net Present Worth of savings.

that is, $TLC - C' \leq NPW$

NOTE—In the above analysis it may be noted that the actual evaluation of benefits grouped under item B and M is very difficult to ascertain particularly on a new project. It can only be approximately estimated on the basis of experience on similar existing projects.

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