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भारतीय मानक

प्रसरणशील मृदा में नहरों के आस्तर के मार्गदर्शी सिद्धान्त

(दूसरा पुनरीक्षण)

Indian Standard

GUIDELINES FOR LINING OF CANALS IN EXPANSIVE SOILS

(Second Revision)

(Incorporating Amendment No. 1)

UDC 626.823.917 (1026)

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FOREWORD

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

Canals excavated in expansive soils, such as black cotton soil, pose several problems involving stability of slopes and shape of section. To have economical sections and prevent erosion due to design velocities, it is necessary to line the canal bed and slopes. Precast cement concrete slabs for side slopes and *in-situ* concrete for bed are common types of lining adopted for canals in cutting and embankment. However, it is often experienced that the lining materials directly placed against the expansive soils undergo deformation by heaving, disturbing the lining and throwing the canal out of commission. This deformation is traced to the characteristics of swelling and swelling pressure developed by expansive soils, when they imbibe water in their intra-layers. Adequate thickness of cohesive non-swelling soil (CNS) material is found to resist swelling pressure and prevent the heaving of underlying soil. From experiments in laboratory and field it is concluded that deformations may be correlated to the thickness of CNS layer and swelling pressure characteristics of expansive soil. This standard lays down guidelines for the treatment of expansive soils by introduction of a cohesive non-swelling soil layer of suitable thickness between the expansive soil mass and the lining material to counteract the swelling pressure and resultant deformation of the lining material on a scientific basis.

This standard was first published in 1980 and the first revision was taken up in 1985. The second revision has been taken up in view of the experience gained during the course of these years in the use of this standard. The following major changes have been incorporated in this revision:

1) Identification and properties of expansive soil have been referred to the relevant Indian Standard.
2) Instead of three types of treatment only one type of treatment has been provided.
3) Modifications have been incorporated in Table 1.
4) Construction procedure for canal in cutting and embankment has been added in detail.
5) Clauses on under-drainage arrangements and joints in lining have been elaborated.
6) Fig. 1 and 2 have been incorporated.

This edition 3.1 incorporates Amendment No. 1 (September 2000). Side bar indicates modification of the text as the result of incorporation of the amendment.

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

GUIDELINES FOR LINING OF CANALS IN EXPANSIVE SOILS

(Second Revision)

1 SCOPE

1.1 This standard lays down guidelines for lining of canals in expansive soils.

NOTE — Black cotton soils are a type of expansive soil.

2 REFERENCES

2.1 The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 TERMINOLOGY

For the purpose of this standard the definition of terms given in IS 1498 : 1970 shall apply.

4 GENERAL

4.1 Expansive soils in side slopes and bed of canal in cutting or embankment when in contact with water swell, exerting a swelling pressure which may range from 50 to 300 kN/m^2 or more. This characteristic of swelling and the swelling pressures of black cotton soils is attributed to the pressure of montmorinolite or combination of montmorinolite and illite clay minerals. A wide range of properties of expansive soils are found in India (*see* IS 1498 : 1970 for identification and properties).

The swelling pressure and free swell index tests should be done in accordance with IS 2720 (Part 40) : 1977 and IS 2720 (Part 41) : 1977. Expansive soil met within the locality has to be analysed for swelling pressure before deciding the type of treatment.

For testing the expansive soil for determination of swelling pressure the expansive soil specimen should be remoulded at zero moisture content to the density obtainable at any time in the year in the field at a depth beyond 1.0 m (in expansive soil). The swelling pressure should be determined under no volume change condition when moisture content is increased from zero to full saturation level.

4.2 Cohesive Non-swelling Soils (CNS) for Treatment

4.2.1 They are soils possessing the property of cohesion of varying degree and non-expanding type clay minerals such as illite and kaolinite and their combination with low plasticity with liquid limit not exceeding 50 percent.

4.2.2 Some of the soils which may be considered as cohesive non-swelling soils are all adequately compacted clayey soils, silty clays, sandy clays, gravelly sandy clays, etc, exhibiting cohesive properties and containing predominantly non-expanding type clay minerals.

4.2.3 CNS material should be non-swelling with a maximum swelling pressure of 10 kN/m^2 when tested in accordance with IS 2720 (Part 41) : 1977 at optimum moisture content and minimum cohesion (unconfined compression strength on saturated compacted soil, remoulded at OMC and compacted to standard proctor density) should be 10 kN/m^2 when tested according to IS 2720 (Part 10) : 1991.

4.2.4 If given CNS material is not available, designed mix to produce blended CNS may be used. The artificial CNS should satisfy all the requirements of CNS. If stabilized material is to be used, special mix design needs to be evolved.

4.2.5 Most murums of laterite, laterite type and siliceous sandy clays exhibit CNS characteristics, however some murums may be of swelling type. Unlike swelling soils, they do not exhibit cracking during summer, nor heaving and stickiness during rainy season. Structures constructed on such soil do not exhibit heave though they may sometimes settle. The CNS are generally red, reddish yellow, brown, yellow, white, whitish grey, whitish yellow, green and greenish grey in colour. Although, several soils containing non-expanding type clay mineral exhibit CNS properties, the following range helps in locating such types:

	Percent
Clay (less than 2 microns)	15 to 20
Silt (0.06 mm-0.002 mm)	30 to 40
Sand (2 mm-0.06 mm)	30 to 40
Gravel (Greater than 2 mm)	0 to 10
Liquid limit	Greater than 30, but less than 50
Plasticity index	Greater than 15 but less than 30

5 CRITERIA FOR FIXING THE THICKNESS OF CNS LAYER

5.1 Thickness of CNS materials is related to swelling pressure and the resultant deformation, the permissible deformation being 2 cm.

5.2 Guidelines for choosing the thickness of CNS materials required for balancing the different swelling pressures is given in Table 1. Slopes should be in accordance with IS 10430 : 1982.

Table 1A Thickness of CNS Layer, Carrying Capacity Less Than 2 Cumecs

Discharge in Cumecs	Thickness of CNS Layer in cm (*Min*)	
	Swelling Pressure 50-150 kN/m^2	Swelling Pressure More Than 150 kN/m^2
1.4-2	60	75
0.7-1.4	50	60
0.3-0.7	40	50
0.03-0.3	30	40

Table 1B Thickness of CNS Layer, Carrying Capacity of 2 Cumecs and More

Swelling Pressure of Soil	Thickness of CNS Materials
kN/m^2	cm (*Min*)
50 to 150	75
150 to 300	85
300 to 500	100

NOTE — However, optimum thickness of CNS materials needs to be determined for different swelling pressures by actual experiments both in field and laboratory; if required.

6 CONSTRUCTION PROCEDURE

To counteract the swelling pressure and prevent deformation of the rigid lining materials, a CNS material of required thickness depending on the swelling pressure of expansive soil, is sandwiched between the soil and the rigid lining material. The thickness of CNS layer should be measured perpendicular to the surface of expansive soil.

6.1 Canal in Cutting

6.1.1 Long deep cuts in expansive soils should be avoided and where possible a detour should be considered.

In cutting special care will be necessary to compact the CNS materials against the excavated surface of the cuts. The material should be spread uniformly in their horizontal layers of specified thickness (15 cm thick). Care also is necessary in obtaining a good joint between the two materials, by thoroughly wetting the excavated surface, so as to avoid slips at the junction plane.

The construction should be carried out in the following steps:

a) While excavating provision should be made for accommodating required thickness of CNS layer on bed and sides. The subgrade on which CNS layer is to be laid should generally not be kept exposed for more than four days, prior to the placement of the CNS layer.

b) Serrations should be provided in expansive soil to prevent contact slides between CNS materials and expansive soil.

c) Proper moisture should be added to CNS materials.

d) CNS materials should be compacted in layers by appropriate equipment to ensure proper density.

e) CNS on side slopes should be trimmed to the required thickness. The thickness is measured perpendicular to the surface of expansive soil.

f) Suitable canal lining over CNS material should be provided depending on the site and economy condition.

g) To avoid slipping and rain cuts during the rainy season, it is advisable to provide CNS right up to the ground level.

h) In deep cuts CNS material should be provided not only behind the lining of the canal but also above the canal prism, all along the excavated surface, so as to prevent large scale heaving above the canal level. The CNS material above the canal prism may be of lesser thickness, say 15 to 20 cm. However, full design thickness behind the lining should be continued at least 100 cm above the top level of the lining (illustratory arrangement shown in Fig. 1).

j) The stability of the slopes, particularly in the case of cuts, is very adversely affected by rain water finding its way into the tension cracks and exerting hydrostatic force on the slipping mass of the soil. Covering the surface of the slopes by CNS materials and proper surface drainage will reduce the chances of rain water finding its way into the cracks.

k) It is necessary to stack the excavated soil away from the cuts to prevent it inducing slips by surcharge.

6.2 Canal in Embankment

The construction should be carried out in the following steps:

a) Proper moisture should be added to CNS material and expansive soil.

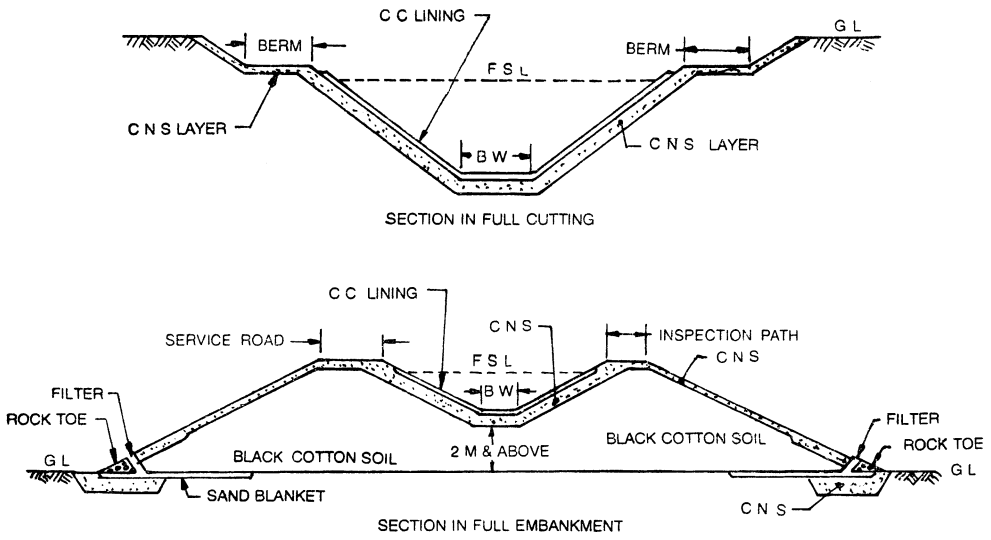

FIG. 1

b) Expansive soil and CNS material above ground level should be compacted simultaneously, in layers, with appropriate equipment to ensure proper density.

c) The CNS materials in embankment should be laid and compacted in layers simultaneously with the body of the banks, so as to obtain good compaction and to avoid any slippage plane being developed between the two materials. The compaction of CNS materials should also be to the standard proctor density with optimum moisture content. It may be done either with sheep foot rollers or 8 to 10 ton ordinary rollers.

d) Provision of surface drain and internal drainage filter should be made to minimize external/internal erosion. A rock toe with inverted filter may be provided at either end of canal bank.

e) Special care is required to be taken to provide internal drainage for the banks, having bed filling of 2 metres or more. A sand blanket is spread on the base of the bank and rockfills with regular inverted filters are also necessary at the outer toes.

f) For both the cuts and banks, paved surface drains should be provided at the berms, etc, to avoid erosion of the finished surface. As far as possible, water from these drains should be drained away from the canal.

g) The drainage properties of the CNS material itself need to be given due consideration as water locked up in this saturated layer is likely to cause pore pressures on the lining during canal draw-down conditions.

h) Murum (gravelly soil) material on outer slopes of canal embankment should be trimmed to the required thickness.

j) To protect outer slopes from erosion, proper turfing should be used.

6.3 Similar procedure should be followed for canals in partial cutting and embankment.

6.4 Pride

6.4.1 The problem of effectively compacting the subgrade for side lining on slopes is very important in case of black cotton expansive soil zone in cutting or embankments, where backfill of CNS material is required to be placed for the sides and bed, in addition to design thickness. Twenty cm or so (perpendicular to side slope) of extra pride may be provided and compacted in horizontal layers to the required density. This pride should be removed only just prior to the placement of lining, thus making a fresh and well compacted surface available for bedding.

6.4.2 For cutting in soft material where the CNS backfilling is not required the best method is to leave the cutting 20 cm or so undercut (perpendicular to the canal slope) and remove this undercut only just prior to the placement of concrete lining. Similar procedure may be adopted in case of cutting in hard strata.

6.5 Use of Polyethylene Sheets Below Concrete Lining

The use of polyethylene sheet below concrete lining could be either for achieving better ultimate imperviousness of the lining as a whole or it may be used only for limited purpose as an assistance, during construction, for avoiding the cement slurry from concrete escaping in the subgrade below. Use of Low density polyethylene (LDPE) sheets 200 gauge (50 micron) is to achieve only the latter limited purpose. If overall imperviousness is proposed to be achieved, it would be necessary to use High molecular mass high density polyethylene (HDPE-HM) sheet of sufficient thickness, strength, toughness and durability.

7 LINING

7.1 The lining may be cement concrete (IS 3873 : 1993), burnt clay tile (IS 3872 : 1966), stone pitched (IS 4515 : 1993), stone masonry (IS 11809 : 1993) or lime concrete (IS 7873 : 1975).

8 UNDER DRAINAGE ARRANGEMENTS AND JOINTS IN LINING

8.1 The drainage properties of CNS material itself need to be given due consideration as water locked up in this saturated layer is likely to cause pore pressure on the lining during canal draw down conditions. To release the same if holes are provided for drainage in concrete lining, care will have to be taken to provide inverted filters at the back of the holes so as to avoid the CNS material being washed away by fluctuating water levels in the canal. Such drainage holes are, however, not advocated for general adoption.

8.2 It is recommended to provide regular drainage arrangements using porous concrete sleepers, 7.7 cm × 20 cm with 50 mm perforated G.I. pipes at 3 m centre to centre coming out through the sides of the lining. Two porous concrete sleepers on either side of the bed, below the side may be provided. A 50 to 75 mm thick sand mat below the bed and side cast *in-situ* lining (below the polyethylene sheet) should be provided.

Where the sand mat is not economically feasible additional porous concrete sleepers may instead be provided at right angles to the longitudinal rails (along the cross section of the canal) at 3 m centre to centre. The porous concrete sleepers have to be encased in filter material.

An illustratory arrangement is shown in Fig. 2.

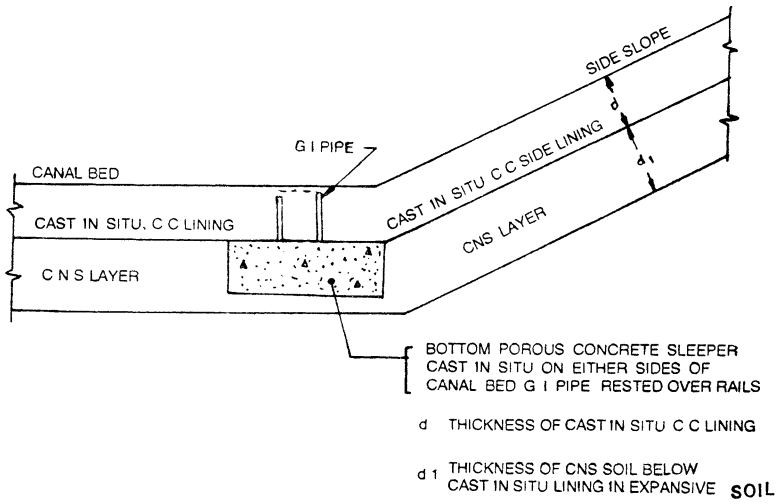

FIG. 2 ILLUSTRATORY DETAIL OF BOTTOM RAILS

ANNEX A

(*Clause* 2.1)

IS No.	*Title*
1498 : 1970	Classification and identification of soils for general engineering purposes (*first revision*)
2720 (Part 10) : 1991	Methods of test for soils : Part 10 Determination of unconfined compressive strength (*second revision*)
2720 (Part 40) : 1977	Methods of test for soils : Part 40 Determination of free swell index of soils
2720 (Part 41) : 1977	Methods of test for soils : Part 41 Determination of swelling pressure of soils
3872 : 1966	Code of practice for lining of canals with burnt clay tiles
3873 : 1993	Laying cement concrete/stone slab lining on canals — Code of practice (*second revision*)

IS No.	*Title*	*IS No.*	*Title*
4515 : 1993	Code of practice for stone pitched lining for canals (*first revision*)	11809 : 1993	Lining for canals by stone masonry — Code of practice
7873 : 1975	Code of practice for lime concrete lining of canals	10430 : 1982	Criteria for design of lined canals and guidelines for selection of type of lining

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Amendments Issued Since Publication

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