(9c) Canal in expansive soils : review of past performance and future course of action.

GOVERNMENT OF MAHARASHTRA
Irrigation Department,
Government Circular No.MIS 1094/(143/94)MP(Adm.)
Mantralaya, Bombay-400032.
Dated the 17th Feb.,1995.

GOVERNMENT CIRCULAR MEMORANDUM

Preamble :

1. Canals passing through expansive soils have been causing concern during operation and maintenance. Lining of canals in such stretches has not been helpful. Approach to proper design of canals in expansive soils so as to ensure proper up-keep needs to be decided.

2. Black cotton soils cover many areas of the State. They are expansive soils because they undergo deformation by swelling. This deformation is attributed to the swelling pressures for which simple tests are now prescribed under the Indian Standards. These soils are met with particularly in the areas close to the river banks. The depth of black cotton soil varies from shallow near the main canal to very deep near the river bed.

3. Extensive work has been done in I.I.T. Bombay by Dr. Katti. In areas of expansive soil the technique of CNS layer (cohesive non swelling) was developed. The origin of the technique was Malaprabha project area in Karnataka. Standard procedure for adopting CNS layer is now available.

4. The CNS technique depends upon increase in strength of the soil for taking up the additional stresses. Lining would provide further strength. Black cotton soils are generally impervious and no separate lining in such soils is to impart stability. Thus the CNS technique with lining depended upon increasing the strength of the embankment with the aid of CNS layer and lining. During the last ten years CNS technique has been adopted on many canal systems in Maharashtra, in black cotton soil areas.

Concrete lining was provided with the CNS layer between lining and the black cotton soil. However, the performance has been less than satisfactory. In many cases the entire lining has failed in spite of this treatment. Black cotton soils are highly clayey in nature and do not go well in contact with a rigid lining like concrete. Perhaps that is why in spite of a large thickness of CNS layer, performance of concrete lining has not been adequately satisfactory.

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5. Canal lining is provided generally with one of the following :

i) Cement concrete
ii) Stone masonry
iii) Brick lining.
iv) Bitumen
v) Polythene lining
vi) Soil cement.

All these types of lining provide an impervious barrier to the movement of water and, therefore, in all such cases it is necessary to provide adequate strength to the embankment material against stresses development because of swelling. Lining with previous material like murum, can be an option.

6. One of the problem stretches in Maharashtra was the Purna canal in Km. 20 and 21. This had been causing concern for many years. The matter was referred to Dr. Katti and also to Maharashtra Engineering Research Institute. The possible solution was to provide a CNS layer. However, CNS material was not readily available in the area and would have to be produced by blending. The solution to provide CNS layer and/or to flatten the slopes of embankment was therefore costly and impracticable. Costly because CNS material had to be blended. Impracticable because of costly lands which would have to be acquired. Alternative solution had therefore to be looked for.

7. In the 1 Kilometer stretch of expensive soil on the Purna Canal, various trials were made with different types of treatment for providing stability to expansive soil. Most of these trials depended upon drainage of the swelling soil rather than providing strength by way of CNS technique. Following alternatives were found effective to a smaller or a larger degree in providing stability to the embankment:

a) Murum backing with adequate filter.
b) Rubble pitching over metal and murum
c) Pitching with defined panels over metal and Murum.
d) As in (c) above but with small toe walls below the canal bed.

It will be noticed that in all these cases there is a proper drainage of the embankment. Of these various alternatives the one with pitching contained in panels with sand filling and toe walls on the bottom was found to be quite successful. This kind of treatment is still in position after many years of functioning. Details of this treatment have been

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presented at the VIth International Conference in Expansive Soils, New Delhi 1987 (Treatment of expansive soils in canal embankment Purna Project a case study-by Shri D.N. Kulkarni, Chief Engineer and Shri N.R. Sawaleshwarkar, Executive Engineer) and this paper won the C.B.I.P. Medal in 1988.

8. The Central Design Organisation conducted a detailed diagnosis of the failures of canal lining in expansive soils. The study done by Central Design Organisation brought out the following important points.

(i) Black cotton soils are quite unstable when they come in contact with water because of the swelling action. Any rigid type of lining leads to a unsuitable structural situation.

(ii) To avoid the softening of the soil by absorption of water, quite a thick layer of CNS soils is required.

(iii) The slopes required to maintain the geometry of the canal cross-section are too flat viz. 5.5 : 1.

(iv) For counter acting swelling action of the expansive soils, CNS Layer has to be quite thick. However, good quality CNS Material is not available within the economic leads at most situations.

(v) In the absence of good quality of CNS material a flexible lining with efficient drainage arrangement can be a proper alternative.

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1.0 Considering the experience of the failures of canalllinings in expansive soils in the past and keeping in view the studies done by Maharashtra Engineering Research Institute and the recommendations made by Central Design Organisation, following directions are now given for future work of treatment of canal slopes in expansive soils.

(A) Murum backing with adequate filter support (The details are shown in Figure No.1) Murum of good quality may be used to counter the swelling pressure induced by the expansive soil. The thickness of the murum may be restricted to 600 mm. In order to facilitate easy drainage, 300 mm thick sand filling may be provided behind murum. Adequate rock toe arrangement may also be provided as shown in the figure. Rubble filling of 30 mm thickness and metal and sand filling 150 mm thick each may be provided at the bed.

The function of rock toe at the bottom is to facilitate drainage and to provide a solid support while the sand bed behind murum serves the purpose of relieving the swelling as well as pore

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pressures. Similarly rubble filling in the bed will provide a good ballastic support and metal and sand filling will act as a good cushion base against the swelling pressure. The critical slip circles pass through the toe. So the rock toe proposed will help in preventing the likely slips.

No rigid lining is provided over the murum base except turfing. After settlement of murum, rigid lining may be considered in due course of time after a few years.

(B) Murum backing below the metal lining with panels (Details are shown in fig. No.2).

The theoretical analysis reveals that it is practically uneconomical to have a full-proof solution against the damage due to having pressures of expansive soils.

The dry pitching by metal should be adopted. The thickness of this metal layer varying from 0.6 m at bottom to 0.3 m at top should be provided. The provision of panels is to be kept as it is so as to have semi-rigid lining. Rock toe is provided at the bottom to serve as a drainage arrangement and as a solid base. Only sand bedding of 150mm is to be provided in the bottom. If murum is not available yellow soil with low expansive characteristics may be used.

(c) Murum backing with filter.
Murum backing with sand & filter
(Details are shown in fig. No.3)

From the experience it is felt that murum backing (CNS layer) is obligatory to counter balance the swelling pressure. Similarly filter is required to facilitate good drainage. Considering the above points, one meter thick murum is to be provided over 300 mm thick sand filter. The rock toe arrangement and dry rubble stone base over 150 mm sand layer at the bottom may be as shown in the figure 3. If murum is not available yellow soil with low expansive characteristics can be used.

(d) Murum backing with Geo-textile as filter material (Details are shown in fig No.4).

As B.C. soil has very low permeabili ty a good drainage arrangement is necessary along the slopes as well as the bed of the canal to relieve the pore pressures. Also filter material of good quality may not be available at

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economical leads from the canal alignment. Moreover, by providing an efficient drainage arrangement with good murum backing frequent canal slips and concequent loss can be avoided. So use of "Geo-textile" as a drainage arrangement can be advantageous. However, before using it on large scale it is necessary to study its performance by constructing experimental reaches with "Geo-textile" as a filter material.

2. Different alternative for canal lining in expansive soils based on available data have been discussed above in detail. Out of the four different types of lining proposed, first two types are expected to give good results. On every canal initially a few patches should be tackled in areas expansive soils. The most efficient remedial measure for a particular condition can be decided on the basis of the performance of these experimental patches.

3. Hereafter no rigid lining should generally be provided in canal stretches where expansive soil Black cotton soil is met with. Treatment to be provided should be only of the flexibile type with proper drainage. The methods adopted on Purna project which have been found to be successful are described above. Further improvements in the treatment are possible by using Geo-textile etc. In no case, however, should rigid lining like concrete lining or stone masonry lining or brick lining should be provided in such reaches without specific approval of the Central Designs Organisation.

These orders will apply to all canals and distributaries with a capacity of more than 0.75 cumecs (750 Lit/Sec.).

(N. D. Dalal)
Deputy Secretary to Govt. of Maharashtra.

D.A.: Two drawing Plates.

Copy to :

All Chief Engineers, Irrigation Department.
All the Superintending Engineers Irrigation Department.

2. Superintending Engineers are requested to endorse the copy of this circular to all Executive Engineers under their control.

All Technical Officers in Irrigation Department, Mantralaya.
All Technical Desk in Irrigation Department, Mantralaya.
MP (R) for collection.

sbc/14295.

NO./N.I.C./PB-T-1/CIRCULAR/1708
To, The Ex. Engrs. (All In circle)
for information and necessary action.

10 MAR 1995
Nashik Irr. Circle
Nashik; dt. 13/95

B.G. Asstt. Supdt. Engr.
G. N. I. C. Nashik.

Technical Desks (in P.B) in circle office.

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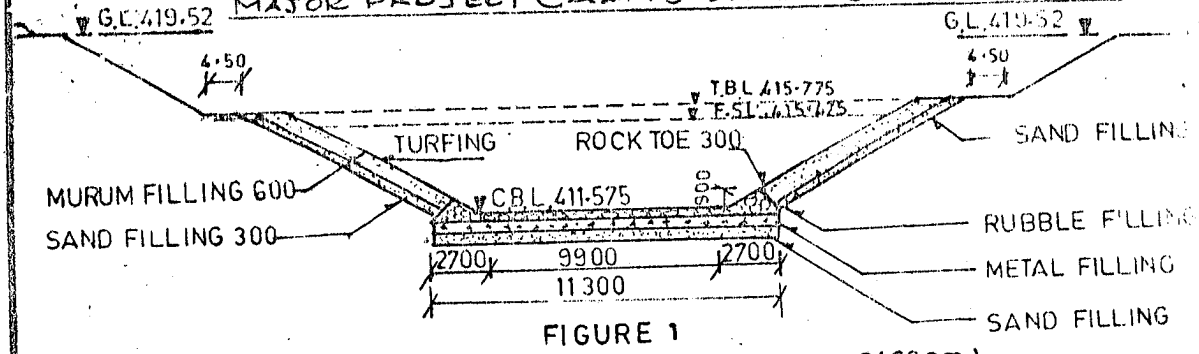

FIGURE 1

CANAL LINING USING MURUM BACKING (60cm)
WITH ADEQUATE FILTER SUPPORT
(TYPICAL SECTION OF PURNA CANAL)
(NOT TO SCALE)

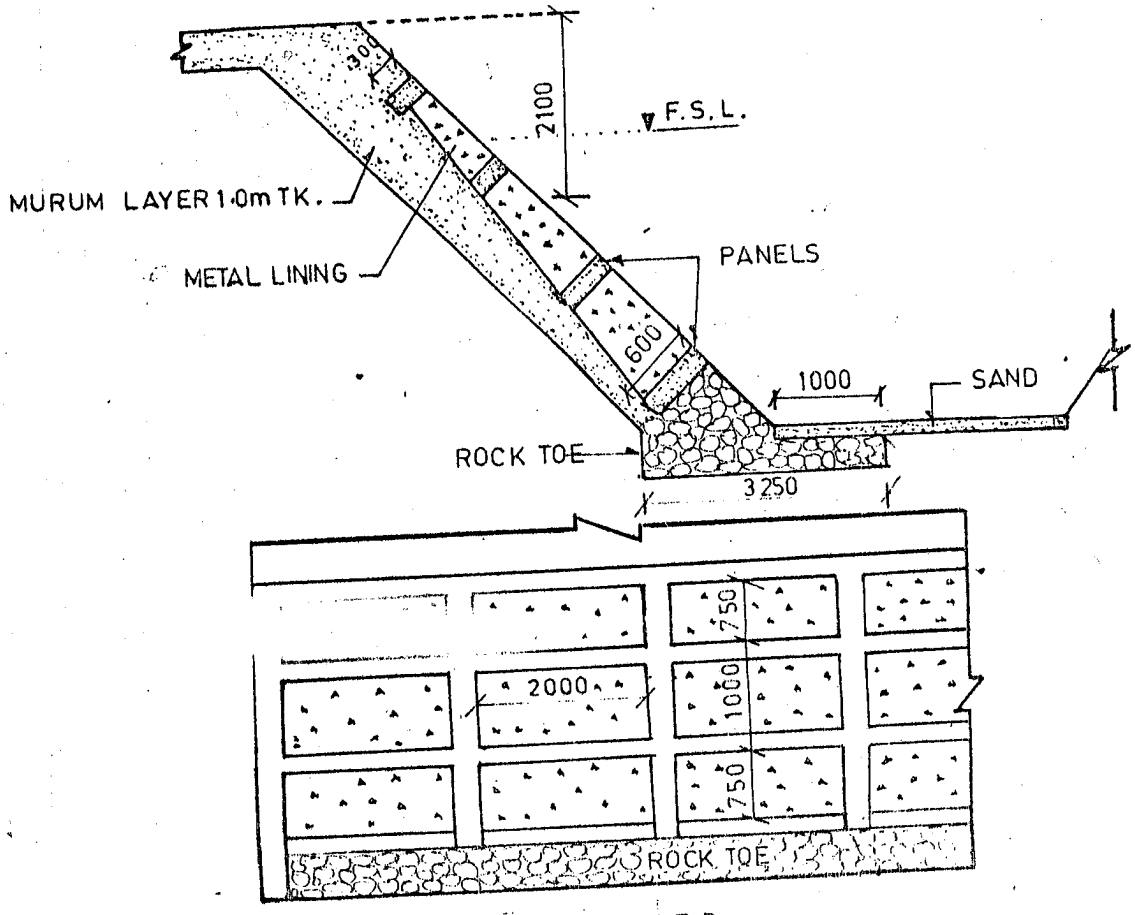

FIGURE 2

METAL LINING OF VARYING THICKNESS
WITH MURUM BACKING
(NOT TO SCALE)

NOTE :- DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPEC

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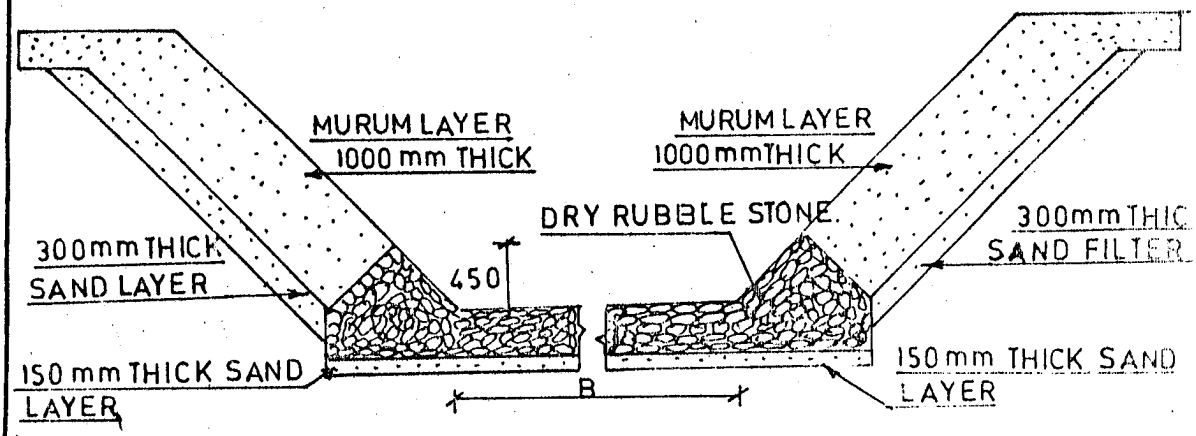
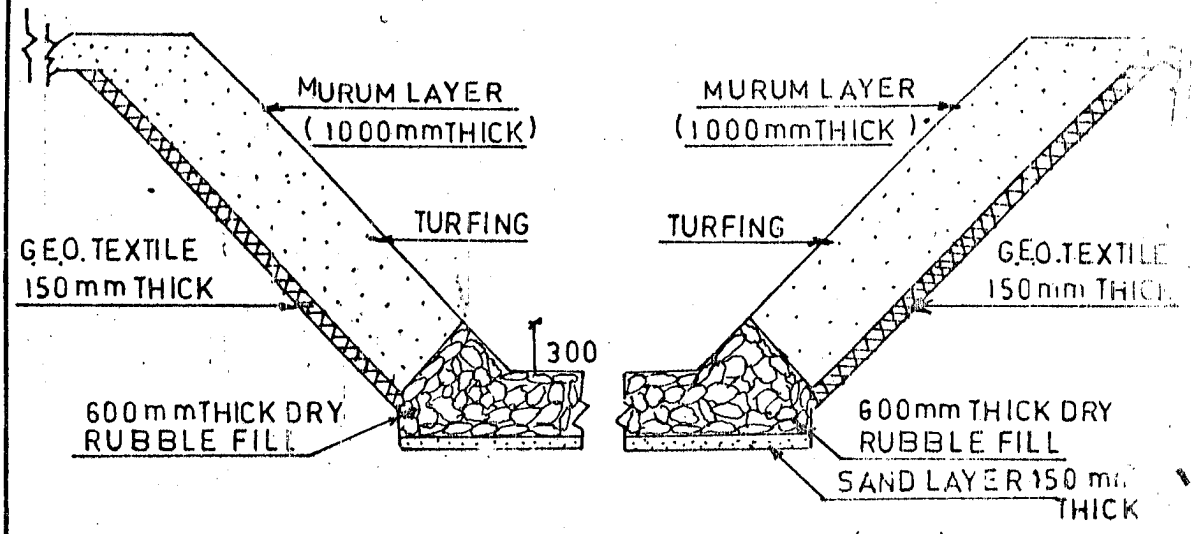


CANAL LINING USING MURUM BACKING (1·0 m)
WITH SAND FILTER

FIGURE 3

(NOT TO SCALE)



CANAL LINING USING MURUM BACKING (1·0 m)
WITH GEO TEXTILE AS FILTERMATERIAL

FIGURE 4

(NOT TO SCALE)

NOTE:- DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED