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LINING OF IRRIGATION CANALS AND ECONOMICS OF LINING, THE REVIEW AND SELECTION OF LINING

Mrudula Kulkarni[1] & Narsing Katke[2]

[1]Research Scholar, School of Civil Engineering, MITWPU Campus Kothrud, Dr. Vishwanath Karad MIT World Peace University, Pune, India

[2]Research Scholar, Department of Water Resources, Government of Maharashtra, Pune, India

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ABSTRACT

Irrigation canals should be aligned and laid out, so that the velocity flow is uniform under all conditions, and the water reaches the irrigated area at an elevation sufficient to ensure desired distribution. Generally, two types of channel sections are adopted, triangular channel section for smaller discharges and trapezoids channel section for larger discharge. Selection of a particular type of lining, keeping in consideration the general requirements, as well as site specific requirements including structural stability, economy, availability of construction materials, machinery and equipment, skilled and unskilled labor, subsequent reparability, ability to prevent weed growth, resistance against burrowing animals, structural stability during and after construction. The existing irrigation canals in west Ben- gal have very little scope for redesigning. These canals have some amount of seepage loss. Based on soil type and soil characteristics at various locations, the districts of irrigation projects have been classified in four zones. The selection of stretches for lining should be judicious and based on appropriate and adequate justification. The water resources department at Odisa, Bhubaneswar recommends the guidelines for lining of irrigation canals in accordance with IS 10430:2000. It also recommends expansive soil criteria for fixing maximum thickness of Cohesive Non-swelling Soils (CNS) layer. The U.S. Department of interior Bureau of reclamation, a technical memorandum Of research, prioritizes of enhancement of canal infrastructures sustainability. The canals infrastructures draft road map laid down by them, provides the comprehensive description of research need, including the adverse outcome currently used in irrigation practices. The Amendment no. 1 August 2005 to IS 10430:2000, amendment no. 1 September

2000 to IS 3873:1993 and amendment no. 1 September 2000 IS 9451:1994, Recommends guidelines for selection of type of lining, laying of cement concrete stones slab lining on canals and guidelines for lining of canals in expansive soil. This study reviews prevailing guidelines, IS codes, design manuals and recommends selection process for appropriate canal Lining.

KEYWORDS: *Stability, Hydraulic Efficiency, Canal Lining, Soil Erosion, Expansive Soil, Shrinkage*

INTRODUCTION

Irrigation canals should be aligned and laid out, so that the velocity flow is uniform under all conditions, and so that the water reaches the irrigated area at an elevation sufficient to ensure even and distribution. High velocities of flow can be permitted by taking the advantage of hard-wearing surface, so as to ensure a hydraulically efficient channel. Very high flow velocities, even if not damaging to lining, but do entail extra expenditure at turnouts, and require higher walls to take

care of pulsations and wave action. While aligning the channel, sharp curves should also be avoided, as they not only reduce the velocity of flow, but also require higher-walls on the outside to retain the water as it rounds the curve. Generally, two types of channel sections are adopted, triangular channel section for smaller discharges and trapezoids channel section for larger discharge.

Selection of a particular type of lining is done considering the general requirements, as well as site specific requirements including structural stability, economy, availability of construction materials, machinery, equipment, skilled and unskilled labor, subsequent repairability, ability to prevent weed growth, resistance against burrowing animals, structural stability during and after construction. [1]The design and construction manual for lining in irrigation canals in the state of West Bengal recommends for general soil characteristics encountered in various zones and districts, especially permeability of sub-grade soil, position of ground water table, Availability of construction materials and common difficulties faced during construction. The economy in design, without sacrificing stability and durability loser during and post construction. [2], [1] Government of Odisha and Department of Water Resources, Bhubaneshwar approved the guidelines for lining of irrigation canals. The water lost through seepage in an unlined canal can be saved by construction of appropriate canal lining. The rigid lining, semi-rigid lining, flexible lining and combination lining. The materials used for lining are in-situ cement concrete and cement fly ash concrete and reinforced cement concrete, precast cement concrete, and tile and cement concrete slab and cement fly ash concrete tile and fly ash brick or tile lining. Flexible lining includes Geo-membrane, like high density polyethylene (HDPE), polyvinylchloride(PVC) and low density polyethylene (LDPE). Combination lining includes Membrane in the bed and brick and tile or concrete line on sides, selecting the type of lining. [3], [2] The U. S. Department of interior Bureau of reclamation a technical memorandum of research priorities of enhances canal infrastructures sustainability. The canals infrastructures draft road map which provides the compressive description of research need, including the adverse outcome currently used irrigation practices. [4]The lining of irrigation canals and economics of lining a text book recommends annual benefits and annual cost with benefit cost ration must be greater than unity. Also, guidelines for the type of lining there construction, uses ling of canals in expansive size and safety ladders in lined canals. [5] Canal lining by Charles Burt and Cal Poly ITRC recommends stabilization of canal bank, reduced maintenance, reduced seepage, renovation of old canals with irregular earth cross section and weed sand use of essential and excellent canals lining for economy materials. [6]

MATERIALS AND METHODS

The design manual for irrigation canal lining in West Bengal illustrates that, there is little scope of redesigning the existing canals with some amount of seepage loss. The soil type and soil characteristics at various locations of the districts of irrigation projects have been classified in Zone I, Zone II, Zone IV and Zone V off our zones. The selection of stretches for lining should be judicious and based on adequate justification. Approach methodology for preparation of the Manual are based on the discharge capacity of the canals; General soil characteristics encountered in various zones and districts, especially permeability of sub grade soil; position of ground water table; Availability of construction materials; Common difficulties faced during construction and economy in design, without sacrificing stability and durability both during construction and post construction. Guidelines for choosing the thickness of CNS materials required for balancing the different swelling pressures is given in Table below. Slopes are recommended in accordance with IS: 10430:2000.

However, optimum thickness of CNS materials needs to be determined for different swelling pressures by actual ex-these canals are prominent, and they are unable to carry the design discharge. Renovation, re-sectioning & reduction in seepage loss are essential for smooth functioning of these canals. The lined canals and existing canals may also be considered to be converted to lined canals in due course in a phased manner for prevention of seepage loss and for optimal and judicious use of water, as the guidelines fromIS10430:2000 also recommends expansive soil criteria for fixing maximum Cohesive Non-swelling Soils (CNS) layer.

The lining is an impermeable layer provided for the bed and sides of canal to improve the life and discharge capacity of canal like Rigid Lining, Semi-Rigid Lining, Flexible Lining and Combination Lining. The lining work in existing earthen canals may be done in such a way that the canal hydraulic particulars such as Full supply level (FSL) and Full supply design discharge will remain unaltered after lining. After lining of earthen canal, Manning's Rugosity Coefficient (n) will be reduced and there will be increase in the velocity.

Cement Concrete lining (Is 3873:1993): Preparation compaction of sub grade for concrete lining, Thickness of in-situ concrete lining, grade and mixing, placing & lining section

Parameter for Design of Lined Canals (Is 10430:2000): Inner side slopes, outer side slopes, free board, beam, coping, cross sections and velocity, under drainage, pressure relief arrangements, longitudinal drains, transverse drains, and pressure relief valves.

Lining of Canal in Expansive Soil: Expansive soils are soils that expand when water is added, and shrink when they dry out. The Cohesive Non-swelling Soils (CNS) material should be non-swelling with a maximum swelling pressure of 10 KN/m2.

Criteria for Fixing Minimum Thickness of CNS Layer

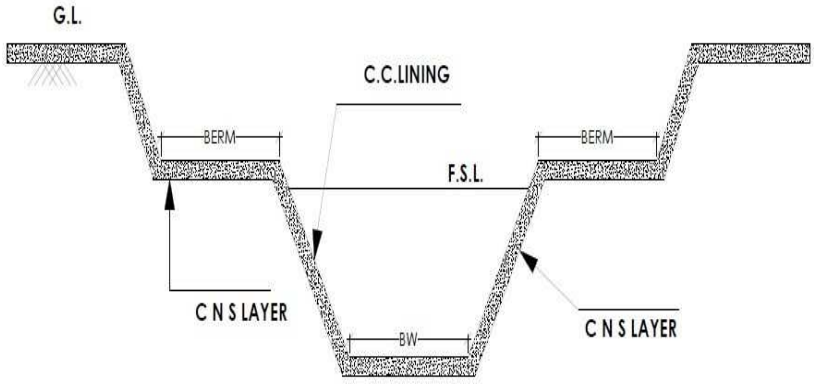

Figure 1: Section in Full Cutting.

Table 1: Thickness of CNS Layer, for Canal Carrying Capacity Less Than 2.0 Cumec

Discharge in Cumec	Thickness of CNS Layer in mm (Min) Swelling Pressure 50 to 150 KN/m^2	Swelling Pressure more than 150 KN/m^2
1.40 to 2.00	600	750
0.70 to 1.40	500	600
0.30 to 0.70	400	500
0.03 to 0.30	300	400

Table 2: Thickness of CNS Layer, for Canal Carrying Capacity 2.0 Cumec and More

Swelling Pressure of Soilkn/M^2	Thickness of CNS Layer in Mm (Min)
50 to 150	750
150 to 300	850
300 to 500	1000

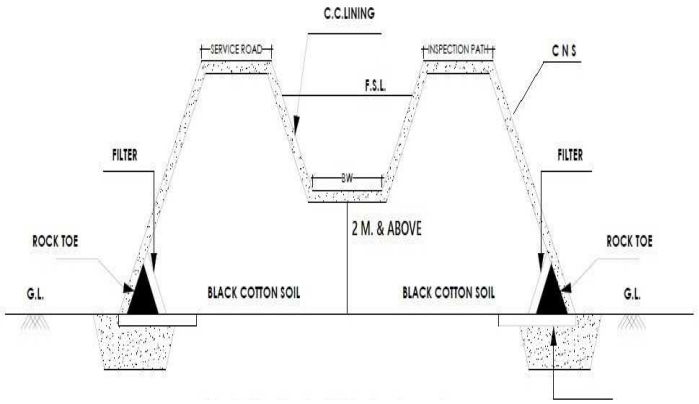

Figure 2: Section in Full Embankment

Table 3: The Size, Thickness and Typing of Lining for All Zones and All Categories of Sub Grade and Soil Condition Recommends

0-5	65	65
5-50	75	75
50-250	90	90 (in Slope Only)
250-500	125	-

Table 4: Thickness of In-Situ Concrete Lining (Is: 3873-1993).

Capacity of Canal (Cumecs)	Depth of Water (m)	Thickness of Lining (mm)
0-5	0-1	50-60
5-50	1-2.5	60-75
50-200	2.5-4.5	75-100
200-300	4.5-6.5	90-100
300-700	6.5-9.0	120-150

DESCRIPTION ALLOWABLE LIMIT

Tolerance in Concrete Thickness, Alignment, Grade (IS: 3873-1993)

Departure from established alignment Departure from established grade Variation in concrete, lining thickness

20mm on straight reaches 50 mm on partial curves or tan- gents 20 mm on small canals10 mm provided average thick- ness is not less than specified thickness

The under-drainage arrangements and joints in lining. Other important work includes anti-salt treatment, curing, quality control, tests for lining. The rehabilitation remodeling of structures. The preparation of Detail Project Report (DPR) includes Specification of Materials, Specification of Works, Quality Control and Assurance hence, these guidelines and provisions are specified in the technical specification.

The U. S. Department of interior Bureau of reclamation a technical memorandum of research priorities of enhances canal infrastructures sustainability. The canals infrastructures draft road map which provides the compressive description of research need, including the adverse outcome currently

THE FINANCIAL JUSTIFICATION AND ECONOMICS OF CANAL LINING:

Annual Benefits and Annual Costs Irrigation water is sold to the cultivators at a rate. Let this rate be rupees R_1 per cumecs. If m cumecs of water is saved by lining the canal, annually, then the money saves by lining = mR_1rupees. Lining will also reduce maintenance cost. The average cost of annual up keep of unlined channel can be worked out from previous records, Let it beRs.R_2 If p is the percentage fraction of the saving achieved in maintenance cost by lining the canal, then the amount saved=pR_2rupees.

The total-annual benefits = $mR_1 + pR_2$,

The Annual Cost Is:

If the capital expenditure required on lining is-C rupees, and the lining has a life of say γ years, then the annual depreciation charges will be $\frac{C}{\gamma}$ rupees. If r percent is the rate of annual simple interest, then a locked up capital of C rupees would earn, annually $C\frac{r}{100}$ rupees as interest charges, and since the capital value of the asset decreases from C to zero in γ years, the total annual costs of lining used irrigation practices. The effective canal detection methods or technologies for use by engineers or field staff to more clearly define seepage paths, underwater canal lining repair materials and methods for cracked, buckled, or bulged linings (Under water crack sealants, grouts, etc.), Under water canal panel placement material or method, Tools to control or prevent animal burrowing in canals, Effective methods for repair of animal burrows in canals

Tools to control or prevent woody vegetation in canals, Tools to control or prevent water-borne vegetation in canals (Algae blooms, water, grass, etc.), Methods and materials for under- water placement of canal linings. The manual recommends priorities draft research road map canals infrastructures like canal sub grade, canal lining, siphons, gates turnouts, with outcome, process, cause, gap analysis and research needs.

A text book of lining of irrigation canals and economics of lining includes advantages of lining like seepage control of water logging, increase in channel capacity, increase in commanded area, reduction in maintenance cost such as removal of silt, periodical plugging of holes burrowed by rats, insects, removal of weeds and elimination of flood dangers.

For project justification, benefit cost ratio must be greater than unity.

The canal lining by Charles Burt and Cal Poly ITRC gives the answer the typical justification stabilization of canal bank, reduced maintenance, and reduces seepage. A clean and smooth concrete cross section can pass a higher flow rate than an irregular earth cross section with weeds. Therefore, there is a natural tendency to use a new lined canal of a smaller cross section than the unlined canal it replaces. Hence, a small amount of lining costs less than a large amount of unlined canals.

The objective is simply seepage reduction and the soil are medium textured, you might consider vibratory compaction of the canal bank and sides, the excellent soil compaction and bed preparation for any rigid canal lining such as concrete, masonry, lining projects have failed because of lack of attention to this simple detail. The cost money to over excavate and properly prepare the soil, but it saves money in the long term. The cross section of synthetic lining braking off and floating down stream and lodging against bridges of geo- membrane cracking. Hence, the height of the lining and tying into the soil specially with geo-membranes, are very important.

$$= \frac{C}{Y} + \frac{C}{2} \times \frac{r}{100}$$

Bene f it cost ratio = $= \frac{Annual\ Bene\ f\ its}{Annual\ Costs}$

$$= \left(\frac{m.R_1 + p.R_2}{\frac{C}{Y} + \frac{C}{2} \times \frac{r}{100}} \right)$$

If p is taken as 0.4 then

Bene f it cost ratio $= \left(\frac{m.R_1 + 0.4\ R_2}{\frac{C}{Y} + \frac{C\ r}{2\ 100}} \right)$

Table 5: Canal Discharges Less Than 2 Cumecs

Discharge in Cumecs	Thickness of CNS Layer in cm (Minimum) Swell Pressure in 50-150 KN/m^2	Swell Pressure More Than 150 KN/m^2
1.4-2.0	50.0	75.0
0.7-1.4	50.0	60.0
0.3-0.7.0	40.0	50.0
0.03-0.30	30.0	40.0

Table 6: Canal Discharge More Than 2 Cumecs.

Swell Pressure in KN/m^2	Thickness of CNS Layer in cm (Minimum)
50-150	75.0
150-300	85.0
300-500	100.0

THE IS CODE RECOMMENDATIONS

IS10430:2000,criteria for design of lined canals and guidance selection of type of lining recommends function of lining, requirements of lining, different types of linings with typical cross section of lined canals.

Typical Cross-Section of Lined Canal (Figure 3 and Figure 4)

ECONOMICS OF CANAL LINING

The Purpose of Analysis for Determining the Maximum Rate

L = Length of the canal in meters.

γ = 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.

= Percent rate of interest per year.

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

The annual value of water lost by seepage from the unlined section =p Lsd W rupees.

The annual saving by lining in value of water otherwise lost by seepage if unlined

= (PLSDW-PI.SDW)RS.

= {LdW (ps-PS)}Rs.

Total annual benefits resulting from the lining of canals,

a = {LDW (PS-PS) + B + M}RS.

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:

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

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 meters per square meter of wetted surface per day.

P and P: Wetted perimeter in meters of unlined and lined sections respectively

T = Total perimeter of lining in meters.

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

W = Value of water saved in rupees per cum.

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. NPW may be approximately estimated on the basis of experience on similar existing projects.

Amendment No.1 September 2000 to IS3873:1993 laying of cement concrete lining on canals recommends preparation of sub grade, the concrete used for lining should be design mix concrete of grade M10 or M15, laying of in-situ concrete lining which includes slump, thickness, mixing, placing, finishing curing, surface drainage, joints, laying of precast concrete tile sand stone slab lining, details safety ladders.

Amendment No.1September 2000 to IS9451:1994 guide lines for lining of canals in expansive soils recommends treatment for Cohesive Non-swelling Soils (CNS), criteria for fixing the thickness of CNS layer, construction procedure and under drainage arrangements and joints in lining.

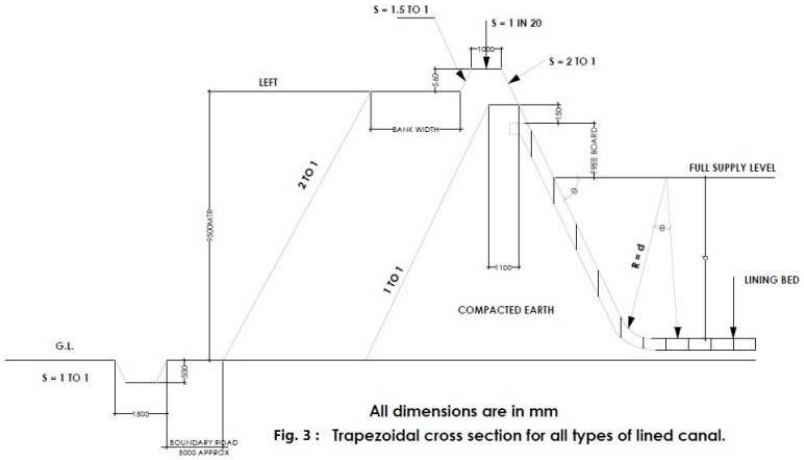

Figure 3: Trapzoidal Cross Section for All Types of Lined Canal.

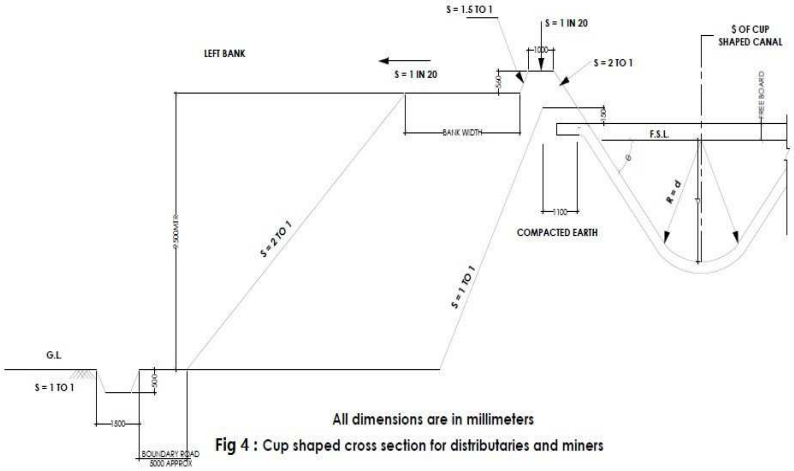

Figure 4: Cup Shaped Cross Section for Distributaries and Mines.

CONCLUSIONS

The lining of canal is an important feature of irrigation projects as it improves the flow characterizes and minimized the loss of water due to seepage. Lining is an impermeable layer provided for the bed and sides of canal to improve the life and discharge capacity of canal. 60 % to 80 % of water lost through seepage in unlined canal can be saved by construction of appropriate canal lining. Rigid lining, semi-rigid lining, flexible lining and combination lining of selecting for the engineer-in-charge should collect information on the position of water table, climatic conditions, availability of construction materials type of sub grade, time schedule, performance of lining in the existing canals in the adjoining areas. The seepage loss, economy, structural stability, strength and durability, reparability and ease maintenance, resistance to erosion, maximum hydraulic efficiency are required to be consideration.

The canal lining material and concussion the geo-membrane and combination of lining geo-membrane and concrete lining on sides it costs money to over excavate and property prepare the soil, but it saves money in the long term and gives both physical durability and seepage redactors, consider combinations of a geo-membrane covered with and material. Hence, this recommendation must be approval that lining in irrigation canals. The type of lining selected should not only be economic in its initial cost, but also in repair and maintenance cost.

The canal lining works needs underwater canal lining repair materials for cracked, buckled or bulged linings, under water cracks, sealants and grouts for best construction practices course for the different repairs.

The study recommends thickness of in-situ concrete lining from Government of West Bengal manual is too safer side. Hence, the Water Resources, Odisha which is based on

IS 10430:2000 applicable throughout India? The laying of cement concrete and stone slab lining on canals useful from IS 3873:1993.The thickness recommends for Cohesive Non- swelling Soils(CNS)layer as per guidelines from West Bengal and Odisha manuals, India. Moreover, the canal lining economics method from text book for lining of irrigation canals useful for lining the existing canals where as IS10430:2000,the canal lining economics method useful for new irrigation projects and existing canal linings.

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AUTHOR PROFILE

Mrudula Kulkarni Professor of Civil Engineering,

Narsing Katke Senior Engineer, Water Resources Department.