Design of Minor Canal from an Existing Parent Canal to Decrease Duty of Flow to Adjacent Areas

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Abstract— Engineers are attempting their utmost to get the channel layout to maximize the flow and to minimize the scouring rate. This Research introduces channel design using Lacey's Design Method. This technique is used by many designing firms for their project design reasons. This project focuses on the comparative layout of a minor channel that reinitiates from a parent channel. The main goal of this project is the comparative analysis of a canal and its Lining design and estimation. This research is intended to perform a thorough evaluation of the different parameters used during design. On the grounds of place, parameters such as quantity of water flowing per unit length, catchment area, type of soil, water table, etc. The primary issue encountered today is the absence of water release. This is due to some losses that can be detected by bad canal design. I will rectify this issue in this study by offering lining to the canal to save intake and other losses as water flows through the canal. I have also produced such a design that will require less surface area and provide more discharge. I have performed information analysis to obtain excellent outcomes and better comprehension.

Keywords: Lacey’s Regime Theory, Parent Canal, Soil

I. General Introduction

The Open Channel Design and Distribution Network is presently being carried out in accordance with the mentioned Government Circular. Consideration was given to the review of these guidelines. Govt therefore worked together to review these guidelines taking into account the requirements of the appropriate Indian Standards (IS), channel design processes in other nations, CBIP recommendations, CPWD manual provisions and expertise obtained in our nation from 1995 onwards. Recently, the research group has made its suggestions. The current channel design rules released under reference are assessed and updated guidelines are provided as below, taking into account the research group's suggestions. The revised guidelines ' main objective is:

1) Reduce channel and distribution network building expenses and eventually decrease general irrigation project expenses.
2) Designing and building maintenance-free channels, i.e. designing channels for non-silting non-scoring speeds, leading in minimal maintenance expenses and reduced rotation time owing to greater speeds.
3) Minimize channel widths to minimize the purchase of property.
4) Channel design for the implementation and facilitation of water supply and fair volumetric allocation.

Minimize the discretion in choosing parameters for channel design and coherent channel design practice for all projects, regardless of the designer. Design effective channels to guarantee water supply in all retailers with design discharges. Some fresh dimensions (parameters) are introduced in the present rules in order to attain the above goals, e.g. finalization of channel discharge design, channel efficiency, rotation period, capability considerations, step-by-step channel design method, tunnel design, channel operation schedule, channel alignment, declaration cutting, etc.

Similarly, some provisions in ancient circulars are removed because of their utility viz. Dowels (Daula), Barrow Pits, Shrinkage Allowance and Profile Walls other provisions are amended taking into consideration the regulations contained in IS recommendations and procedures in other Indian states with similar circumstances in our nation. The most significant service that canal operators provide to farmers is the delivery of irrigation water. Freedom in the following terms:

- Timing,
- Flow rate, and
- Duration of irrigation applications is ideal from a farmer's point of view.

II. Objectives of the Research

Civil engineers play a major part in the irrigation system and its systematic way of distribution. So, I was very interested in doing a study on a current project, keeping this in mind. After a lengthy debate with my supervisor on this subject, I came to understand if I'm going to cope with this study, working on current and actual project is going to be incredibly great.
Some objectives of this research are listed below:

- Performance and Evaluation of canal irrigation system.
- Impact of minor irrigation canal and its implication for development.
- To design Minor canal by the use of Lacey’s Regime theory.
- To decrease the duty of water on existing parent canal.
- To know the process of designing economical and convenient irrigation system.
- To design a canal on the known required discharge.

III. Overview of the Methodology

Nowadays, the method used by engineers to design a channel depends on the kind of soil available. There are two ways a channel can be designed, i.e. Kennedy's theory and Lacey's method. But it is found that Lacey's method is important as it relates to silt action on all the wet surface of the canal. Lacey also distinguished between the "initial" scheme and the "final" system in the event of canals. A channel built with measurements other than the size of the system will adjust the path and achieve a working balance called the original scheme. The channel will alter the size and slope with time, however, to achieve the final scheme. Say the channel will continue to flow in the initial scheme in circumstances where such adjustment is not possible because the sides are not erodible.

IV. LACEY'S REGIME THEORY.

Lacey carried out a stable survey of the channel, i.e. That was not silenced either by a situation he called "Regime Condition" and came out with Lacey's so-called Regime Theory. Lacey argued that the channel should carry and flow through an endless alluvium of the same size and personality as the sediment being transported to produce regime requirements. In any situation, the above conditions are hardly fully met. However, they are mainly encountered by channels to the extent that the discharge and sediment load remains substantially unchanged. The bed and sides are not completely without cohesion, of course, and it is easier to deposit compared to erosion. There may also be separate characteristics of the bed and sides. However, Lacey's theory can be used to a sensitive extent in most alluvial channels. The waterways situation is quite different as both the discharge and the sediment load vary significantly.

Conditions approaching the system can only be accomplished partially during high temperatures and thus only during floods Can Rivers at best achieve what is called quasi-regime conditions.

In determining the dimensions of the regime channel, Lacey also regarded the sediment size as an significant parameter and introduced what he called the silt factor "f" in relation to the mean sediment size as follows:

$$f = 1.76 \sqrt{d}$$

where 'd' is the sediment diameter in millimeters.

Plotting all the available data, Lacey obtained the following equations in SI units for a regime channel:

$U = 10.8\ R^{2/3}\ S^{1/3}$

$P = 4.75\ \sqrt{Q}$

$R = 0.48\ (Q/f)^{1/3}$

$S = 0.0003\ f^{5/3} / Q^{1/6}$

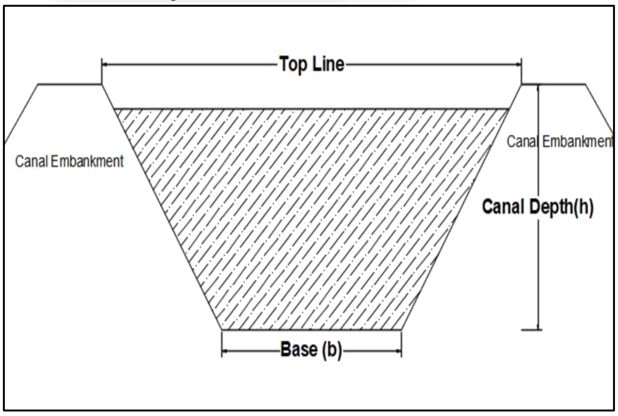

Fig. 1: Figure showing parameters to be designed for discharge required.

The above equations are called Lacey's regime equations, completely describe a channel's path and dimensions once the "d" size of the "Q" and sediment release is defined and can thus be used for design.

V. DESIGN OF MINOR CANAL BY MAKING USE OF LACEY'S THEORY

The full supply discharge for any canal is always fixed before starting a design. The value of "f" for particular site may be calculated using below equation:

$$R = 2.46\ V^2/f$$

Where R= Hydraulic Mean Radius
V= Regime Velocity
f = Silt factor

Thus, when Q and f are known design can be done in the following steps:

1) Find out "f" using following equation:
$$V = 0.4382(Q.f^2)^{1/6}$$
2) Calculate value of "R" using equation below:
$$R = 2.46V^2/f$$
3) Calculate wetted perimeter "P_w" using Lacey's regime perimeter equation:
$$P_w = 4.825\ Q^{1/2}.$$
4) Calculate cross sectional area "A" from equation:
$$Q = AV.$$
5) Assuming side slopes, calculate the full supply depth from A, P_w and R.
6) Calculate the longitudinal slope of the channel using equation:
$$V = 10.8\ R^{2/3}\ S^{1/3}$$

Type	Lined canal	Un-lined canal
Branch canal	0.95	0.85
Distributary	0.90	0.85
Sub Minor	0.90	0.85
Field Channel	0.90*	0.90*
Field Application efficiency	0.75	0.75
Overall efficiency (i.e. root zone to canal Head)	0.52	0.41

Table 1: Canal efficiency.
(* both lined only selectively)

Fig. 2: Parent canal without lining.

A. Soil Analysis

A collection of sieves of varying pore dimensions such as 10, 22, 44, 60, 85 and 120 mm tested the soil sample (100 g) on a plastic sheet. It was gathered on each sieve after the sieving of the retained soil. The distinct percentage of the sieved sample was weighed individually. The proportional structure of distinct soil separates based on weight was determined to determine the soil sample's texture class. The soil is split by 10-mm to 22-mm. Sieves are a fraction of sand in the soil, separating 44-mm and 60-mm in a similar way. The sieves are the silt fraction of 85-and 120-mm. Together with the sieved soil they form the clay portion of the soil. The soil sample particle size was determined by comparing the soil passing through sieves, based on the proportionate proportion of sand, silt and clay structure. The particle's size was 9 mm.

VI. DESIGN ROTATION PERIOD OF CANAL

Depending on the type of soil, plant pattern and climate, the rotation period (i.e. the interval at which the crop is provided with canal water). To determine the appropriate agro-climate area rotation period, it would be preferable to use the soil-crop-climate database. However, as the real crop pattern used by farmers is not known, it is very hard to exercise real plant water demand in the field at the design point of the canal. Thus, the rotation period may be accepted for the design purpose, including on and off schedule as shown below, until the final science method is made accessible (Table 2). The channel agent will decide the rotation period in each season based on the real plants in control during future irrigation management.

S. No	Crops	Plantation Period	Duration Days	Percentage C.C. A
1	Summer Vegetables	15Jan - 30 May	104	20
2	Sugarcane	15-30 June	105	3
3	Rice	16-31 July	135	35
4	Wheat	1-15 oct	135	32
5	Barley	1-15 oct	120	5
6	Mustard	16-31 oct	135	3
7	Berseem	1-15 Nov	165	2

Table 2: Monthly Water Requirement of Crops.

Maximum water required is in April 55744 ha.mm =557440 cubic meter

Add for losses 10% of 557440 cum = 55744cubic meter

Volume of water = 613184 cubic meters

Discharge required (25 *X* 24 *X* 60 *X* 60) = 613184 m^3

=0.28 cubic meter per second

(Taking base period 25 days)

VII. DESIGN OF IRRIGATION CANAL BY MAKING USE OF LACEY'S THEORY

Before starting a design, a fixed value of discharge is considered to design a canal. The factor "f" varies site to site and can be calculated:

$R=2.46\ V^2/f$

Where R= Hydraulic Mean Radius

V= Regime Velocity

f= Silt factor

Thus, the following steps can be used when Q and f are known to be designed:

Use equation V=0.4382(Q.f2)1/6

To find "f." calculate "R" value using R=2.46V2/f

Calculate the "Pw" wetted perimeter using the Pw=4.825 Q1/2 perimeter of Lacey's system.

Calculate the Q= AV equation cross-sectional region "A."

Calculate the complete supply depth from A, Pw and R, assuming side slopes.

Use equation V=10.8 R2/3 S1/3 to calculate the longitudinal path of the channel

VIII. ANALYTICAL DESIGN OF CANAL

Canal section is intended for discharge as outlined in the cut-off statement column ' Cumulative Discharge.' For a group of adjacent outlets, the same section may be adopted if the variation in the discharge is nominal. For economic section design, the bed width v / s depth ratio as shown below should be followed.

Discharge required "Q" = 0.28 cumec

Particle size (As per field observations) = 9mm

Silt Factor "f" = $1.76\sqrt{d} = 1.76\sqrt{9} = 5.28$

Velocity "V" = $0.4382(Q.\ f^2)^{1/6}$

= 0.618 m/s

Hydraulic mean radius "R" =$2.46V^2/f$ = 0.0484 m

Wetted Perimeter "P_w" = $4.825\ Q^{1/2}$ = 2.553 m

Required cross sectional area "A" = Q/V

= 0.28/0.618

= 0.453 m^2

Now

A = BD + $D^2/2$ (For Trapezoidal Section)

$0.453 = BD + D^2/2$ ------------------(1)

$P_w = B + \sqrt{5}\ D$

$2.553 = B + \sqrt{5}\ D$ ------------------ (2)

By solving above two equations: -

B= -0.27m, 2.09m

D= 1.26m, 0.21m

Thickness of base lining = 10 cm

Free Board = 30 cm

Depth required = 0.21+0.10 + 0.30 = 0.60 m

Depth Provided (D)= 1m

Thickness of Lining on walls = 0.10 m

Width of canal (B)= 2.09 m + 2(0.10) = 2.19 ≈2.5 m

The longitudinal slope of canal is given by

$V = 10.8\ R^{2/3}\ S^{1/3}$

$0.618=10.8(0.0484)^{2/3}S^{1/3}$

S = 0.07998≈ 0.08

Hence providing longitudinal slope of 2/25.

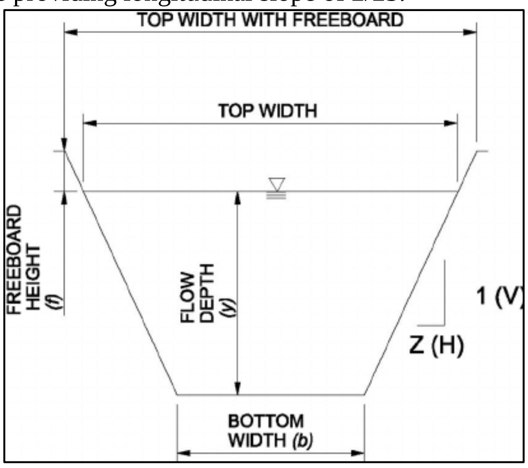

Fig. 3: Typical cross section of trapezoidal canal.

Excavation of soil per meter = 0.453 x 1 = 0.453m^3

Discharge capacity of canal = 0.28 cumec

Full discharge capacity "Q" = AV

= (BD + D2/2) (0.618)
= (2.5+1/2) (0.618)
=1.854 cumec
Grade of concrete to be used = M20
Volume of concrete per meter = 2.553 x 0.10 x 1= 0.2553 m^3

IX. CONCLUSION

The water speed in the channel will improve as the surface of the channel will be smooth owing to an enhanced coefficient of roughness as the lining will be supplied on the current unlined channel. This will enhance the ability of the current discharge channels. Due to the suggested canal lining, flood losses, water logging, silting and maintenance expenses of the canal can be decreased considerably. Any amount of water saved for irrigation can be used. A project called "Design of Minor Channel from a current parent channel to reduce the flow obligation to neighboring fields" was carried out in which the sizes for the necessary water flow were calculated. Canal was intended using Lacey's design method in which information, hydraulic speed radius and canal slope were used to calculate three coefficients of roughness (Manning, Chezy and Darcy Weisbach).

Fig. 4: Inspection of canal to check its physical conditions.

Conclusion from the findings of this research could be drawn from the following conclusions.

1) The flowing water velocities in the lined channel were found to be maximum compared to the unlined channel.
2) The investigators observed different aspects related to the study and the purpose was to prepare an observation guide. Each team member maintained the observation diary to preserve the data they captured during the field visit, which was later used to design and give a complete view of the situation.
3) Because of a mix of factors, there was a need to revise the cost of the project again. These factors included steep increases in labor and material costs and changes in the design of some major structures following detailed investigations. The concept of feeder channel selective lining changed and the decision was made to increase the length for feeder channel lining.
4) From the above debates and suggestions, it would be obvious that lining should be performed in irrigation canals, which have been in service for centuries, after appropriate field inquiry. Considering the fact that there is little scope for redesigning current channels and some loss of slippage may always be allowed from the point of perspective of the indirect advantage of groundwater recharge, choice of lining stretches should be sensible and based on appropriate justification. The Department of Central Design, Irrigation & Waterways must approve any deviation from the guidelines.
5) Seepage occurs in almost every embankment to some extent. To maintain properly, monitoring and controlling any inlet is essential. The amount of flow can vary from wet spots to high quality flows. Uncontrolled flow (large flows or sediment-bearing flows) indicates internal erosion, weakening the embankment, foundation, or abutments; creating voids; and leading to failure of the embankment. The quantity of input should be measured and recorded in a log book where possible. Weirs and devices for water measurement may need to be built and installed.

REFERENCES

[1] IS: 10430 -1982 “Criteria for design of lined canals and guidelines for selection of type of lining”.
[2] IS: 4558-1983 “Code of practice for under design of lined canals” (First revision).
[3] IS: 5968-1987 “Guidelines for planning and layout of canal system for irrigation” (Reaffirmed 1992).
[4] IS: 7112-1973 “Criteria for design of cross-section for unlined canals in alluvial soils”.
[5] Design and Analysis of canal section for minimum water loss by Yousry Mahmoud Ghazaw.
[6] IS: 9451-1985 “Guidelines for lining of canals in expansive soils” (first revision).
[7] Design and Analysis of canal section for minimum water loss by Yousry Mahmoud Ghazaw.
[8] Application of Different Algorithms to Optimal Design of Canal Sections by A. Kentli and O. Mercan. Source: SCIELO (Journal of applied research and technology).