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

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Abstract: ***Engineers try their utmost to get the design so that the flow is as high as possible and the minimum amount of scouring is possible. This research presents the channel design using Lacey's Design Method. This technique is used by many designing firms for their project design reasons. This project therefore deals primarily with the relative design and the outcomes acquired from the design of both a regular and an uneven schedule. The research topicwas carried out on a detailed analysis on various parameters used while designing. The parameters such as volume of water flowing per unit length, catchment area, Soil type, water table etc. are taken on the basis of a particular location. The main problem faced nowadays is due to lack of discharge of water. This is due to some losses which are found by poor design of canals. In this project I will rectify this problem by providing lining to canal so as to save seepage and other losses while flow of water through the canal. In addition to this I will also make such a design which will require less surface area and will provide more discharge.***

1. General Introduction

The Open Channel Design and Distribution Network is currently being performed in accordance with the Government Circular referenced. The reviews of these rules have been considered. Govt, therefore had teamed up to review these guidelines taking into consideration the provisions of the relevant Indian Standards (IS), channel design procedures in other countries, CBIP recommendations, CPWD manual provisions and knowledge acquired in our country since 1995. The research group has recently provided its suggestions. Considering the suggestions of the research group, the current channel design rules published under reference are evaluated and updated guidelines are given as below. The primary goal of the revised guidelines is:

a) Reduce the construction costs of channels and distributio n networks and ultimately reduce the overall costs of irri gation projects.
b) Designing and constructing maintenance free channels, i .e. designing channels so that they should have non-silting non scouring velocities, resulting in minimal mai ntenance costs and reducing the rotation time due to high er speeds.

(a) Minimize the canal widths to reduce the land acquisition.
(b) Design of the channel to implement and facilitate the supply of water and equitable volumetric distribution.

Minimize the discretion in selecting channel design paramet ers and consistent channel design practice for all projects, re gardless of the designer. Design efficient channels with desi gn discharges to ensure water supply in all distributors. In or der to achieve the above objectives, some new dimensions (p arameters) are added in the current guidelines, e.g. finalizati on of channel discharge design, channel efficiencies, rotatio n period, capacity factors, step by step channel design metho d, tunnel design, channel operation schedule, channel alignm ent, statement cutting, etc.
Similarly, due to their utility viz, some provisions in old circulars are deleted. Dowels (Daula), Barrow Pits, Shrinkage Allowance and Profile Walls other provision are modified taking into account the provisions in IS recommendations and practices in other Indian states having similarity of field conditions in our country. Delivery of irrigation water is the most important service that canal operators provide to farmers. Freedom in terms of:

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

2. Objectives of the Research

The irrigation system and its systematic way of distribution is the main role played by civil engineers. So, keeping this in my mind I was very much interested to do a research on an existing project. After a long discussion on this topic with my supervisor I came to know if I will deal with this research, it will be extremely wonderful to work on existing and real project.

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.

3. Overview of the Methodology

Engineers ' technique of designing a channel nowadays relies on the sort of soil available. There are two ways of designing a channel, i.e. The theory of Kennedy and the technique of Lacey. But it is discovered that the technique of Lacey is relevant as it refers to the action of silt on all the canal's moist surface. In the case of canals, Lacey also differentiated between "original" scheme and "final" system.

A channel constructed with dimensions other than the system dimensions will adjust the route and obtain a working equilibrium called the initial scheme.However, with time, the channel will change the size and slope to reach the final system. In situations where such adjustment is not feasible, say the channel will continue to flow in the original system because the sides are not erodible.

4. Lacey's Regime Theory

Lacey conducted a stable channel study, i.e. That was neither silenced a scenario he called "Regime Condition" and came out with the so-called Regime Theory of Lacey. Lacey claimed that the channel should bear and flow through an infinite incoherent alluvium of the same magnitude and character as the sediment being transported to generate regime demands.The above-mentioned requirements are hardly fully met in any scenario. However, to the extent that the discharge and sediment load remains significantly unchanged, they are largely met by channels. The bed and sides are not entirely devoid of cohesion, of course, and depositing compared to erosion is simpler. The bed and sides may also have distinct features. However, in most alluvial channels, Lacey's theory can be used to a sensible extent. The scenario in waterways is quite distinct because both the discharge and the load of sediments differ considerably.

Conditions approaching the system can only be partly achieved during the elevated temperatures and therefore only during floods can rivers at best attain what is called quasi-regime conditions.

Lacey also considered the sediment size as an important parameter in determining the dimensions of the regime channel and introduced as follows what he called the silt factor "f" in relation to the median sediment size:

$f = 1.76 \sqrt{d}$

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:

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

$P = 4.75\ \sqrt{Q}$

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

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

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.

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

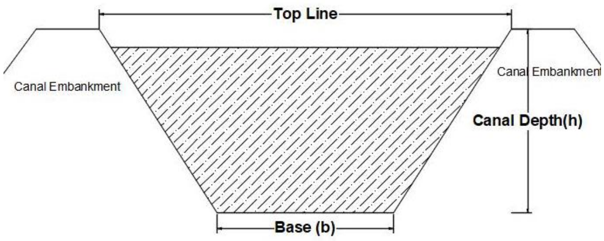

Figure 1: Figure showing parameters to be designed for discharge required.

Table 1: Canal efficiency

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

(* both lined only selectively)

Figure 2: Parent canal as the source of minor canal.

a) Soil Analysis

The soil sample (100 g) was screened on a plastic sheet through a set of sieves of different pore sizes such as 10, 22, 44, 60, 85 and 120 mm. It was collected after the sieving of the retained soil on each sieve. Weighed separately the different fraction of the sieved sample. To determine the texture class of the soil sample, the proportional composition of different soil separates based on weight was determined. The soil is divided between 10-and 22-mm. Sieves constitute a fraction of sand in the soil, similarly separating 44-and 60-mm. The sieves constitute the 85-and 120-mm silt fraction. They form the clay fraction of the soil together with the sieved soil. The particle size of the soil sample was determined by comparing the soil passing through sieves, depending on the proportionate percentage composition of sand, silt and clay. The size of the particle was 9 mm.

b) Design Rotation Period of Canal

The rotation period (i.e. the interval at which the crop is supplied with canal water) depends on the type of soil, crop pattern and climate. It would be preferable to use the soil-crop-climate database to decide the wise agro-climate zone rotation period. At the design stage of the canal, however, it is very difficult to practice actual crop water requirement in the field, as the actual crop pattern used by farmers is not known. Therefore, until the final scientific approach is made available, the rotation period may be adopted for the design purpose, including on and off schedule as shown below (Table 2). During future irrigation management, the canal officer will decide the rotation period based on the actual crops in command in each season.

Table 1: Monthly Water Requirement of Crops

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

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) =$\underline{613184\ m^3}$
=0.28 cubic meter per second
(Taking base period 25 days)

6. 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:

1) Use equation V=0.4382(Q.f2)1/6
2) To find "f." calculate "R" value using R=2.46V2/f
3) Calculate the "Pw" wetted perimeter using the Pw=4.825 Q1/2 perimeter of Lacey's system.
4) Calculate the Q= AV equation cross-sectional region "A."
5) Calculate the complete supply depth from A, Pw and R, assuming side slopes.
6) Use equation V=10.8 R2/3 S1/3 to calculate the longitudinal path of the channel

7. 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
$V = 10.8\ R^{2/3}\ S^{1/3}$
$0.618=10.8(0.0484)^{2/3}S^{1/3}$
$S = 0.07998 \approx 0.08$
Hence providing longitudinal slope of 2/25.

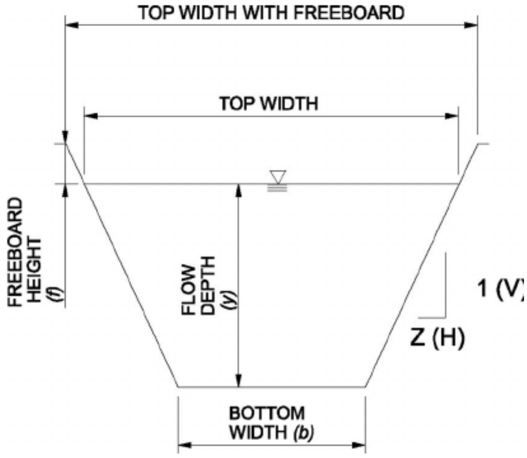

Figure 7.2: Typical cross section of trapezoidal canal.

Excavation of soil per meter = 0.453 x 1 = 0.453m3
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 m3

8. 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).

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 feederchannel 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.

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