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# Design of Canal by Closing out Debits of Current Canal System

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***Abstract: Canals are natural streams channels, or manmade streams, for water movement, or to support water movement, or to support water transport vehicles. Fundamental capacity of waterway is to convey water from water assets for irrigation or domestic utilization of water. The whole water movement framework for water system, containing the fundamental channel, branch waterways, major and minor distributaries. Water is a valuable asset. It is needed by human in doing distinctive day by day exercises. This valuable asset while going through the canal is lost from the channels through leakage from the sides and lower part of the canals and by evaporation from the top water surface of the canals. This project aims at modelling a canal section using HEC-RAS conducting flow analysis such that there is no silting and scouring in the canal. HEC-RAS is a computer program that help model the hydraulics of water flow through natural rivers and artificial or natural channels. The objective is to estimate evaporation and seepage losses and suggest necessary remedies in order to avoid these water debits from the canals.***

***Keywords: Canal, Water, Debits***

## I. INTRODUCTION

Canal word is a derivative of the old French word 'chanel' which means channel. Canals are manmade/ artificial or natural streams of waterways that permit the flow of water from one point to another. The two major types of canals are transportation and aqueduct. Nowadays, due to availability of more efficient modes of transportation have been developed, there has been a reduction in the need for canals, but in parts of the globe they still play a vital role which have the ability to impact global commerce. However, aqueduct canals are primarily used for agriculture and hydroelectric power generation. Fresh water is a very limited entity on our planet. At this point of time where there are unprecedented floods and drought conditions, it very necessary to use water efficiently and effectively. Water while transported from one point to another, results into various losses. Primarily, this water is lost either due to seepage or evaporation. The seepage losses are occur more in unlined natural channels through channel bed and channel sides. The evaporation losses occur from the top surface of the water. These losses go on increasing along the canal length. These losses are of very high order of 25% to 50%. This project aims at designing an optimum canal section such that there is no scouring and silting also reducing the water losses in it. In the design of a canal one has to find out bed width (B) depth (D), longitudinal slope (S), and velocity of flow (V), if discharge (Q) and silt factor (f) are given. This aspect limits only finding the sectional dimensions of the canal. But how to compute the discharge at a particular reach is an important aspect of canal design. Discharge in the off-taking canal does not remain constant throughout the length. Outlets fixed on the canal at regular intervals draw discharge from the canal and supply it to the fields for irrigation. Canal designing and analysis can be done by using physical modelling or numerical modelling. This project aims as using HEC-RAS for numerical modelling of the optimum canal section. HEC-RAS stand for Hydrologic Engineering Centre River Analysis System developed by the U.S. Army Corps of Engineers. It is an integrated system of open source software majorly used for analysis of natural rivers, artificial canals and streams. The system consists of a graphical user interface (GUI), hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities. The applications of HEC-RAS are as follows: decision making, policy making, planning, flood risk assessment, environmental impacts, mitigation and restoration. The analysis components are as follows:

*A.* Steady flow water surface profile computations;
*B.* Unsteady flow simulation (one-dimensional and two-dimensional hydrodynamics)
*C.* Movable boundary sediment transport computations; and
*D.* Water quality analysis.

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## II. AIM & OBJECTIVES

1) *Aim*: Design of most efficient canal using HEC-RAS and to compute water losses.
2) *Objective*
a) To evaluate most efficient trapezoidal canal dimensions.
b) Model building on HEC-RAS.
c) Setting boundary conditions and simulating flow.
d) Comparative Analysis for lined and unlined canal.
e) Compute Seepage and Infiltration losses.
f) Suggest remedial measures for canal debits.

## III. STUDY AREA


Fig. 1 Study Area

The canal originating from the Khadakwasla Dam Reservoir was selected for this project. A straight stretch of 1000m at a suburb Fursungi located at south of Pune city.

## IV. METHODOLOGY

### A. *Canal Dimensions*

The most economical trapezoidal channel section is half of the regular hexagon. The channel cross section was assumed to be the most economical cross section. The top width of 20m was considered for the canal as computed from Google Earth. Accordingly, all the other canal dimensions were computed using the below mentioned formulae. For most economical trapezoidal channel

$$B = \frac{2y}{\sqrt{3}}$$

$$T = \frac{4y}{\sqrt{3}}$$

$$D = \frac{A}{T} = \frac{3y}{4}$$

$$R = \frac{y}{2}$$

$$P = \frac{6y}{\sqrt{3}}$$

$$A = \sqrt{3y^2}$$

1) Top Width= 20m
2) Bottom Width= 11m
3) Depth= 9m
4) Freeboard= 1m
5) Slope= $\frac{1}{\sqrt{3}}$
6) Check= R= $\frac{y}{2}$ (satisfied)

$$check = R = \frac{y}{z}$$

$$R = \frac{(B + my)y}{2B + 2my}$$

$$R = \frac{(11 + \frac{1}{\sqrt{3}} \times 9)9}{2 \times 11 + 2 \times \frac{1}{\sqrt{3}} \times 9}$$

$$R = \frac{9}{2}$$

Hence Satisfied.

*B. Geometry Creation*

A straight stretch of 1000m was created in HEC-RAS. The channel geometry was given dimensions as computed above. Two different geometries were created with different Manning's number representing lined and unlined canal. To compute the average velocity between two cross sections of upstream and downstream, the reach was divided into 10 interpolated cross sections. The more the number of cross sections, more accurate is the result. The lined canal was given Manning's number 0.013 and unlined canal was given 0.035. Cross sections were created using the Geometry tool of HEC-RAS. Initially, downstream cross section was created. Geometry can be created using the station and elevation relationship. For our case, station bottoms of 0 m, 4.5 m, 11.5 m and 20 m were given elevation values of 10 m, 0 m, 0 m, and 10 m respectively. For creation of upstream cross section, downstream cross section was copied and elevation of 3m was added for each station elevation. The downstream length was given 1000 m. The bed slope of the geometry was 0.003.

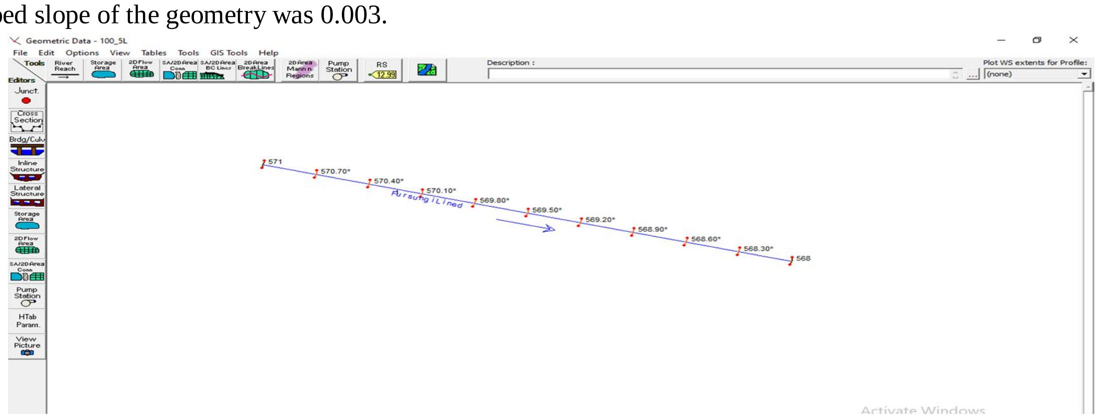


Fig. 2 Reach with interpolated cross sections.

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### C. Boundary Conditions

For hydraulic analysis of canal flow, input data has to be entered in HEC-RAS. In ideal conditions a rating curve or a stage discharge relationship established for a canal is the desired. In this case, the flow simulation was run on varying discharges for lined and unlined canal. The discharges of 100 cumec, 125 cumec and 150 cumec for a flow depth of 9 m was considered. 2 Geometries and 6 cases of simulations were run in the entire process.

### D. Estimation of Losses

#### 1) Seepage Loss

The seepage losses in this case were computed using two empirical formulae mentioned below.

*a)* Mortiz Formula (USSR)

$$S = 0.2 * C * (Q/V)^{0.5}$$

Where,
S: is the seepage losses in cubic foot per second per mile length of canal
Q: is the discharge (ft3/sec),
V: is the mean velocity (ft/sec),
C is a constant varies from 0.34 for clay and 1.1 for sand soil.

*b)* Indian Formula

$$S = C * a * d$$

Where,
S is the total seepage losses in ft3/sec
a: the area of wetted perimeter in million ft
d: the depth in ft; and
C: factor depends on soil types and varies from 1.1 to 1.8

#### 2) Evaporation Losses

The evaporation losses were computed by multiplication of the top surface area of the flow at depth of 9 m and the evaporation rates for different seasons and months. The rate of evaporation was taken from the PWD handbook for monsoon, winter months of Nov to Feb and summer months of March, April and May. The rates given were average values for the Deccan plateau region.

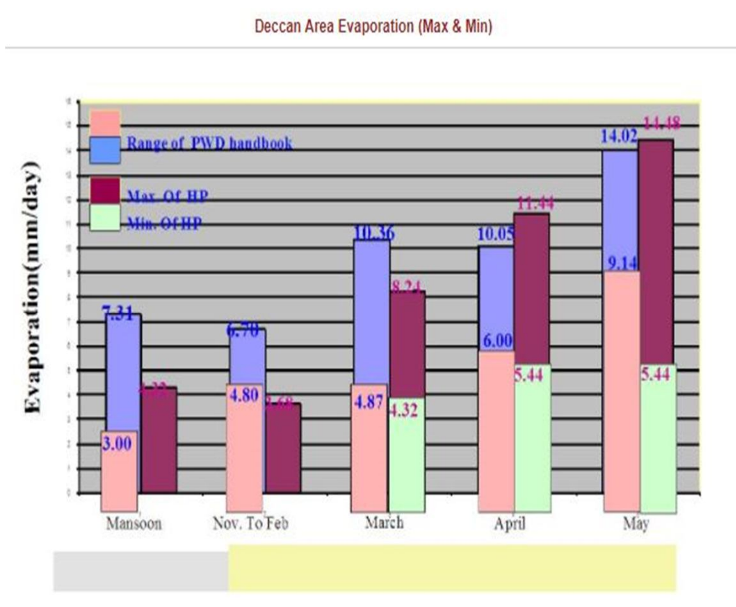


Fig.3 Rate of evaporation

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## V. RESULT

### *A. Simulation*

The software has a tendency to run the simulation only if the geometry and boundary conditions are found to be in order, else, it will show errors and will not complete the simulation. For this project, 6 simulations were successfully run for discharges of 100 cumec, 125 cumec and 150 cumec for lined and unlined canal respectively. The table below shows velocity difference for lined and unlined canal for varying discharges.

Table 1 Hydraulic Analysis

| Hydraulic Analysis | | | |
|---|---|---|---|
| Discharge | Depth of flow (m) | Velocity (m/s) | |
| | | Lined | Unlined |
| 100 | 9 | 1.22 | 1.15 |
| 125 | 9 | 1.53 | 1.39 |
| 150 | 9 | 1.83 | 1.62 |

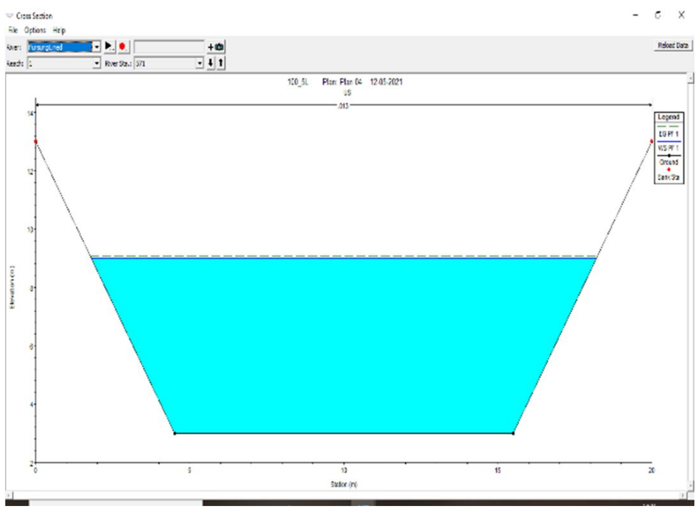

Fig. 4 Flow across cross section.

In order to avoid the sediment siltation in a flow, the velocity of flow should be such that it does not allow siltation/ sedimentation. To compute the minimum/ critical flow velocity Lacey gave the equation.

$$v=0.55my^{0.64}$$

Where,
$v$ =Critical velocity in the channel.
$y$ = water depth in channel in m _
$m$=Critical Velocity Ratio (0.7-1)

Table 2 Permissible Velocity

| Maximum Permissible velocity | |
|---|---|
| Lined | Unlined |
| 2.5-2.7m/s | 1.5-1.8m/s |
| Minimum Permissible velocity | |
| Lined | Unlined |
| 0.6-0.9m/s | 1.103m/s |

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### B. Seepage Loss

The rate of seepage was calculated using the Mortiz formula and Indian formula for three varying discharges. The seepage rates in $ft^3/s$ is shown in the table below.

Table 5 Seepage Losses

| Infiltration loss | | |
|---|---|---|
| Mortiz Formula | | |
| Discharge ($ft^3/s$) | Velocity(ft/s) | Seepage rate($ft^3/s$) |
| 3531.47 | 3.77 | 2.0812 |
| 4414.3375 | 4.56 | 2.1157 |
| 5297.205 | 5.31 | 2.1478 |
| Indian Formula | | 12.540096 |

### C. Evaporation Losses

The evaporation losses were computed by multiplying the top area in contact with the atmosphere to the rates of evaporation.

Table 6. Evaporation losses

| Evaporation losses | | |
|---|---|---|
| Month | Rate of evaporation(PWD Handbook) mm/day for Maharashtra | ($m^3$) of water lost |
| Monsoon | 7.31 | 119.8109 |
| Nov-Feb | 6.7 | 109.813 |
| March | 10.36 | 169.8004 |
| April | 10.05 | 164.7195 |
| May | 14.02 | 229.7878 |

## VI. DISCUSSION

Upon calculation the minimum self-cleansing velocity was found to 1.1 m/s. The average flow velocities in this project are more than the self-cleansing velocity. The seepage losses can be minimized by lining the earthen channels. The earthen channels have a higher tendency of seepage as compared to concrete or asphalt. Therefore, lining of channels is to be done. Since the most expensive part is canal lining, to reduce the canal lining cost, most economical channel section was assumed. The Channel dimensions were also computed accordingly. In order to reduce the evaporation losses, solar panels can be put up along the length of the canal, covering the flow from direct contact of the sun, at regular intervals wherever feasible. This will help reduce the evaporation losses and help energy generation as well.

## VII. CONCLUSION

Channel dimensions were calculated using most economical trapezoidal section and a geometry for those dimensions was created for a stretch of 1000m with different Manning's constant representing lined and unlined conditions. Simulations were successfully run for varying discharges of 100 cumec, 125 cumec and 150 cumec respectively. The unlined canal velocities were lesser than that of lined canal. The canal was designed in such a way that the flow velocities were non-silting and non-scouring. The flow velocity was such that it was greater than the minimum self-cleansing velocity. Water debits such as seepage losses were calculated using Mortiz and Indian formula. Canal lining was suggested as a necessary measure to reduce seepage losses. Evaporation losses were calculated manually, and covering the canal top surface with solar panels was suggested to reduce the evaporation losses and also encourage renewable energy generation.

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