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Pipe Distribution Network: An Advanced and Alternative Technique to Replace Open Channel for Irrigation, a Case Study

Rahul Sahadev[1], Ankita Girigosavi[1], Kumar Bhosale[1], S. S. Motegaonkar[2]
1 (Student, Department of Civil Engineering, Pimpri Chinchwad College of Engineering, Pune – 411044, Maharashtra, India)
2(Associate Professor, Department of Civil Engineering, Pimpri Chinchwad College of Engineering, Pune-411044, Maharashtra, India)
Corresponding Author: Rahul Sahadev

Abstract:*India's 66.67% of agricultural land depends on the monsoon and ground water sources forirrigation, global warming and climatic changes are frequently creating drought circumstances.The Canal Distribution Network system has various drawbacks such as water losses, cost of maintenance uneconomical for long term. This drawback can be overcome by modernized alternative Pipe Distribution Network system. The Pipe Distribution Network system hasan edge over the conventional method. The present study deals with designing and hydraulic modeling of the Pipe Distribution Network system to replace Canal Distribution Network system. The designing and hydraulic modeling will be done using WaterGEMS Software developed by Bentley software company. The study area is KudaliMedium IrrigationProject located on Krishna basin in Satara District, Maharashtra. The present study focuses on design of PDN for a part of Kudali Medium Irrigation Project and hydraulic modeling for the designed Irrigation Network for effective water management system*

Keywords:*Canal Distribution Network, Pipe Distribution Network, Maharashtra.*

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I. Introduction

Water is the most consumed natural resource on planet. The exponential increase in population has created water stress on ground water sources as well as conserved water sources. The Central Government of India under Pradhan Mantri Krishi Sinchayee Yojana has taken initiative to accord high priority to water conservation and its management. The scheme consists of Four components:1) Accelerated Irrigation Benefit Programme (AIBP)2) Per Drop More Crop (PDMC)3) Watershed Development (WD)4) Har Khet Ko Pani (HKKP)Among the four components Har Khet Ko Pani focuses on creation and strengthening of distribution network from sources to the farm, restoration and renovation of traditional waterbodies, increasing area under agriculture. The Overall Project Efficiency (OPE) depends on various factors such as efficiency of main canals, branch canals, distributaries, minors, field channel, field application etc. The OPE of Pipe Distribution Network is in the range of 70 to 90 percent. The PDN has manyadvantages over the conventional CDN system. The Amravati Nagthana-2 Project has shown an increase of 88 percent in Cultivable Command Area by the use of Pipe Distribution Networksystem instead of conventional Canal Distribution To validate Pipe Distribution Network has high efficiency and is the best solution over Canal Distribution Network and design hydraulically efficient water distribution network for Kudali Irrigation Project. WaterGEMS is a water quality and hydraulic modeling solution for water distribution system with advanced interoperability, optimization, geospatial model-building and asset management tools.The software helps to understand infrastructure behavior as a system, how it reacts to operational strategies, how it should grow to meet the demands due to increase in population.

1.1 Objectives of the Project Work

1. To study the salient features and limitations of open channel flow required for the design
2. To design a Pipe Irrigation Network
3. Hydraulic modeling of PDN using WaterGEMS

II. Study Area Details

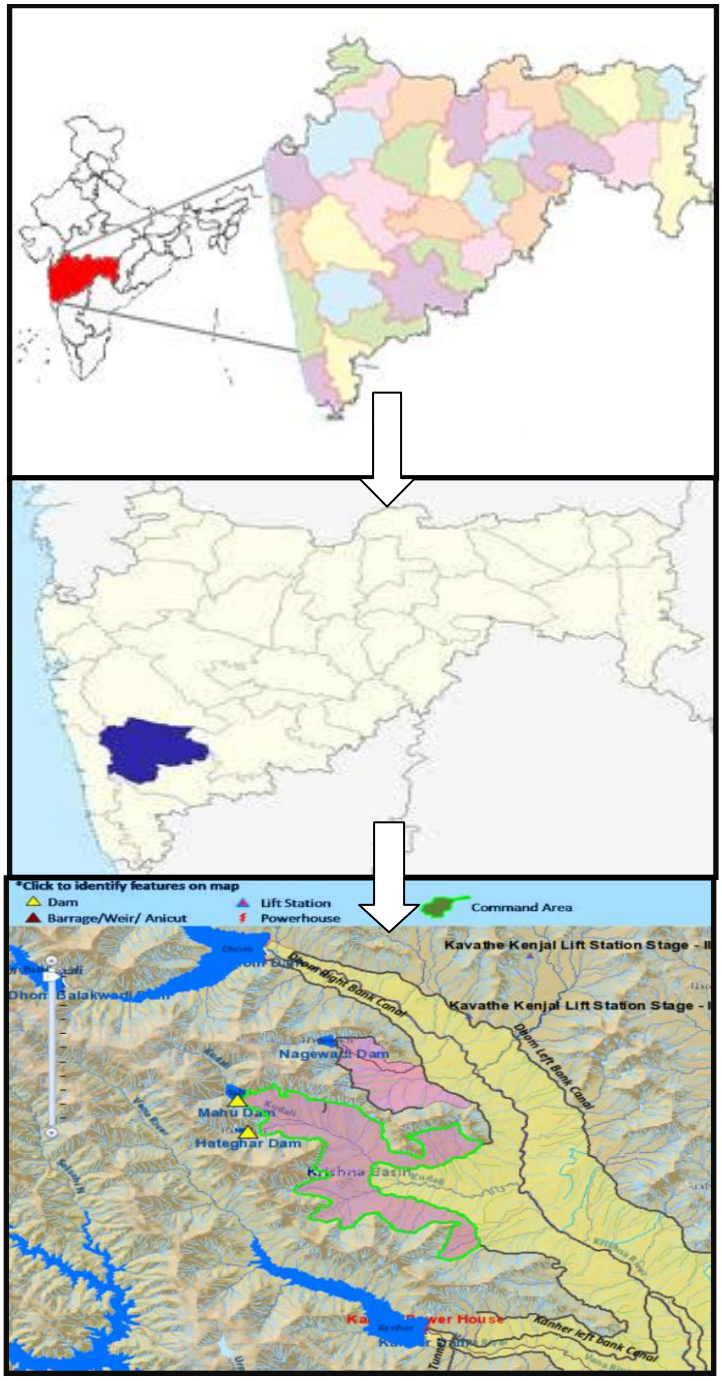


Fig. 1: Kudali Medium Irrigation Project Command Area (Source WRIS)

Table 1: Salient Features of Kudali Medium Irrigation Project

Sr. No.	**Attributes**	**Value**
1.	Irrigation Project Name	KudaliMedium Irrigation
2.	Irrigation Project Name (Alias)	Krishna Stage 2 Irrigation
3.	Purpose	Irrigation
4.	Type	Medium
5.	Engineering Type	Storage
6.	Status	Ongoing
7.	State	Maharashtra
8.	District Benefited	Satara
9.	**Location Latitude and Longitude**	**17.8886° N, 73.8051° E**
10.	Basin	Krishna
11.	River	Kudali, HategharNala
12.	Work Started in 5-year plan	X- Plan
13.	Year of approval	2009
14.	Cost of Project	271.79 Cr.
15.	Cultivable Command Area	5.98 Ha
16.	Ultimate Irrigation Potential	8.48 Ha
17.	Project in Drought prone area program (DPAP)	Yes

III. Head Loss (hr) Equation

1.Chezy-Manning Equation

Commonly used for open channel flow

$$hf = \frac{Ln^2V^2}{2.22R^4/3}$$

Where,
L = Pipe Length
n = Manning's Roughness Coefficient
V = Flow Velocity, R = Hydraulic Radius

2. Darcy-Weisbach Equation

The most theoretically correct formula.

$$hf=\frac{fDLV^2}{2gD}$$

Where,
L = Pipe Length
f_D = Darcy-Weisbach friction factor
V = Flow Velocity
D = Pipe Diameter
g = Gravitational acceleration

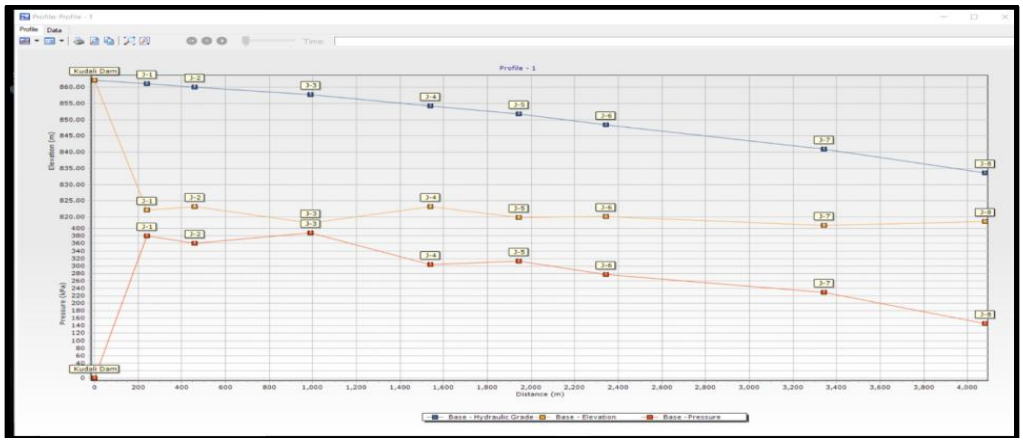
3. Hazen-Williams Equation

• The most commonly used head loss formula.
• Unlike Darcy-Weisbach, this equation does not require the use of Reynold's number or viscosity of water to calculate head loss due to friction

$$hf = \frac{10.44\ LQ^{1.85}}{C^{1.85}d^{4.87}}$$

Where,
L = Pipe Length,
Q = Discharge,
C = Hazen-Williams Roughness Coefficient,
d=Pipe Diameter

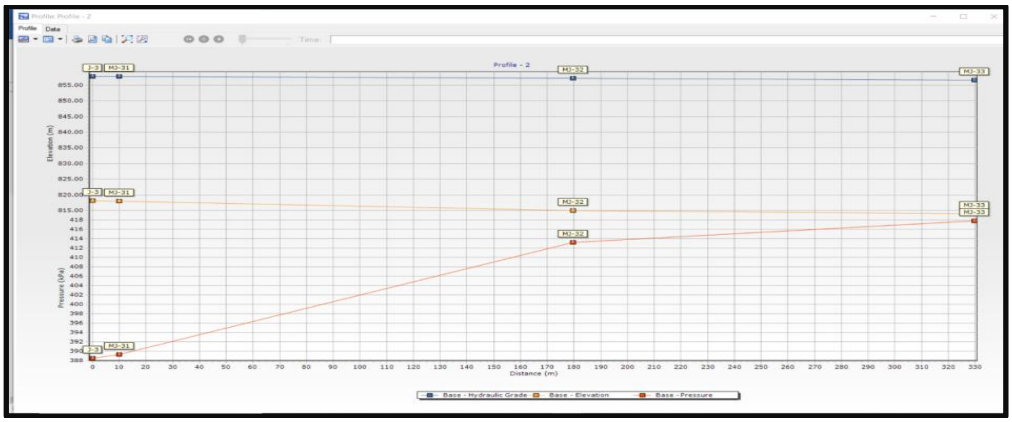
IV. Results and Discussions



Graph 1: Pressure (kPa), Elevation (m) and HGL V/S Distance (m) for Main Pipeline

From the above graph, it is observed that, as the length of the main pipeline is very large, there is a tremendous drop in HGL

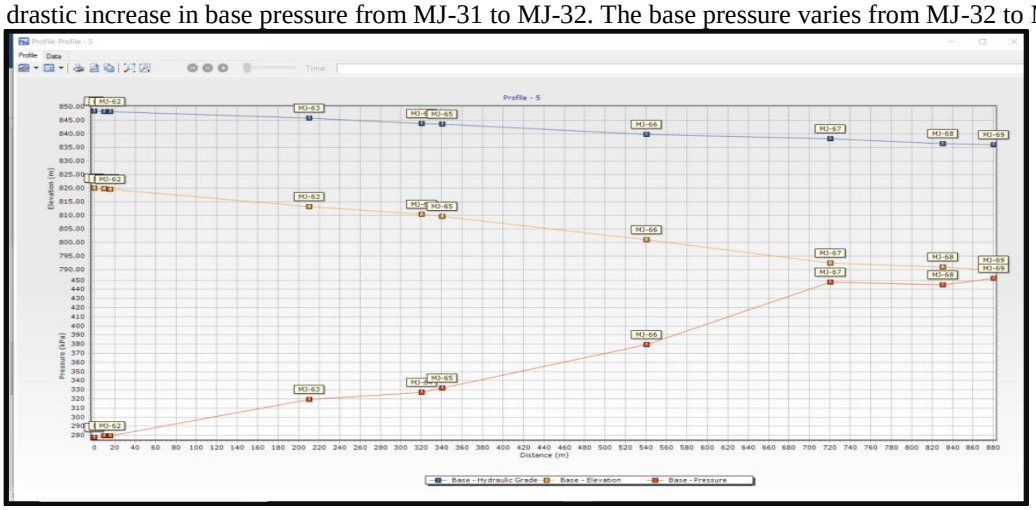
Head loss is increased between the first and the last point (i.e. Kudali Dam and J-8 point) There is a sudden increase in pressure due to sudden decrease in elevation, which shows that pressure and elevation are inversely proportional



Graph 2: Pressure (kPa), Elevation (m) and HGL V/S Distance (m) for Minor No. 3

From the above graph, it is observed that, there is less change in elevation over the 3rd minor. Hence, the head loss is minimum.

There is drastic increase in base pressure from MJ-31 to MJ-32. The base pressure varies from MJ-32 to MJ-33



Graph 3: Pressure (kPa), Elevation (m) and HGL V/S Distance (m) for Minor No. 6

From the above graph, it is observed that, there is decrease in HGL due to increase in distance. Also, it is observed that as the elevation is decreased, pressure is increased. But, from junctions MJ-67 to MJ-68 there is no drastic change between pressure and elevation. Similar study was carried out for Minor Numbers 4, 5, 7 & 8 and significant results were obtained.

V. Conclusion

Based on the experimental work carried out in the present study the following conclusion are drawn.

1. The Pipe Distribution Network has greater advantage over the conventional Canal Distribution Network and proves that it is the best solution over the problems faced by CDN.
2. Using design parameters from CWC and PIN Manual like velocity, pressure head at every junction to decide pipe diameters helps to achieve approximately cost-efficient diameter of pipe. There is no need to use different economic/cost analysis method for deciding pipe diameters.
3. Hydraulic modeling displays the data in the form of profile which helps to identify the problems that will be faced during the execution of PDN.
4. In addition, hydraulic modeling gives exact values of velocity, pressure, hydraulic gradient loss at each and every point.
5. The software helps to design the Piped Irrigation Network in a very simple manner with high accuracy and consumes less time.

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