

Guidelines for Construction of Pipe Distribution Network (PDN) for Irrigation

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Abstract- The objective of this paper is to highlighting the use of Pipe Distribution Network (PDN) instead of Canal Distribution Network (CDN) to increase the overall project efficiency of irrigation project and thereby reducing the stresses due to water scarcity. In order to achieve maximum benefits from PDN, planning, designing, and construction of it should be carefully done. This paper provides a guideline for planning, designing and construction of PDN system for irrigation. It is recommended that PDN system could be economical and feasible over conventional CDN and this system is so flexible that it can be implemented as a new scheme or used to convert the existing CDN.

Keywords : Pipe Distribution Network (PDN), Canal Distribution Network (CDN), Flow Velocity, Diameter of Pipe, Hydraulic Gradient Line (HGL).

1. INTRODUCTION

Government of India aims to increase the water use efficiency by 20 percent till the end of year 2017. Also as per Maharashtra Water Resources Regulatory Authority (MWRRA) from the year 2019 onwards adoption of micro-irrigation for perennial crops is made compulsory. Maharashtra Water and Irrigation Department reports, current CCA of Maharashtra state is approximately 225 lacs Hectar (Ha). By considering the availability of surface water and ground water, the total area irrigated by surface water is 85 lacs Ha and that of ground water is 41 lacs Ha. Hence it is possible to irrigate total 126 lacs Ha, which contributing just 56 percent of total CCA.

Demand of water for civilization and industrialization is increasing at an alarming rate. This increase in demand reduces the water availability for irrigation. To overcome this water scarcity, optimum utilization of irrigation water is necessary which will help in irrigating maximum area and for this purpose there is need to modernization of existing conventional CDN system.

1.1 Irrigation and its Sources

Irrigation sector is the largest consumer of water as more than 80 percent of available water resources in India are being presently utilized for irrigation purpose. The main sources of irrigation in the country are canals, tanks and wells including tube wells. Analyzing the data relating

to net area irrigated by source from the year 2000-01 to 2011-12, it is observed that the major source of irrigation is ground water. It was found that wells (considering all types of wells viz. dug well, shallow tube-well, deep tube-well) contributed about 61 percent irrigation followed by canals with 24 percent at all- India level during 2000-01 to 2011-12, which shows that on increasing the efficiency of existing canals the problems like ground water depletion and pumping cost can be tackled.

1.2 Efficiency of Project

Conventional irrigation methods are surface gravity open channel systems such as furrows, basin, border etc. with field application efficiencies of 60 to 70 percent. The Overall Project Efficiency (OPE) of such irrigation project, at the design stage itself turns out in the range of 40 to 50 percent. But, in fact, due to various constraints the OPE during operation is only 20 to 35 percent.

2. QUALIFYING CRITERIA FOR PDN

The pipeline distribution system shall be adopted when there is

- Limited water availability and extensive command.
- Steep, uneven and undulated topography where canal system is uneconomical.
- High losses due to evaporation, seepage and water thief.
- Adoption of advance techniques for future development.
- Farmer's responses and acceptability.
- Need for Crop diversification.
- Need of Controlled irrigation for crops like orchards.
- Black cotton soil in the reach of canal.
- Availability of adequate fund.

- When high returns are expected.
- Timely availability of material, labour, advanced technology etc.
- The pipeline (gravity flow) is generally feasible in the case of sloping topography having ground slopes steeper than 1 to 500.

3. BASIC LAYOUT OF PDN

The basic layout of the PDN consists of a control head, a pipe distribution network and the hydrants.

a. Control Head

The control head includes the necessary regulating valves (shut off, check valve, air valve) placed 60 cm above ground surface, on a piece of galvanized steel threaded pipe, with tee outlet for taps and pressure gauge. This type of arrangement is also suitable for micro-irrigation systems.

b. Pipe Distribution Network

The main and sub-main pipelines (distribution network) can be of rigid PVC, buried underground. Pipes such as HDPE, quick coupler light steel or the galvanized steel threaded pipes are used on ground surface in hilly areas.

c. Hydrants

The hydrants are raised on surface and equipped with a gate valve (shut off valve), capable to deliver a flow to the manifold open ditches. Manifold open ditches can be replaced by attaching the portable light weight pipes (light steel, black polyethylene, quick couplers aluminum, lay flat hose etc) to the hydrants, for the final delivery. The irrigational water is discharged directly to the manifold open earth channel from the hydrants and then this water is diverted to the furrows, basins or strip borders through open earth channel.

4. GUIDELINES FOR PLANNING OF PDN

- i. In PDN system planning of Chak is an important factor. It is observed that, the general chak size should be in the range of 5 to 12 Ha, which can vary according to project.
- ii. Nearly equitable water distribution to all outlets and optimum cost are the two main objectives kept in mind while finalizing the network architecture.

- iii. In general, the alignment of main line should be of minimum length.
- iv. Similarly, criteria for deciding the layout of laterals is, it should serve maximum area with minimum length of pipe.
- v. Each chak to be provided with a separate lateral and considering the shape and size of chak sub-laterals to be provided according to need.
- vi. Operation scheduling should be economical and flexible from view point of irrigational management.

5. DESIGN AND OTHER REQUIREMENTS OF PDN

The various design parameters such as flow velocity through pipe, diameter of pipe, and hydraulic gradient line are discussed below

5.1 Flow Velocity

- i. Due to low velocity of flow in the pipe network, there is possibility of silt deposition. Hence the general flow velocity should be between 0.8 to 1 m/sec in whole distribution system.
- ii. In some exceptional cases for a section of smaller length the flow velocity of 0.6 m/sec. is also acceptable.
- iii. The flow velocity not to be increased beyond 1.5 m/sec and less than 0.6 m/sec.
- iv. When the pipe materials like PVC, PSC, or HDPE are used in PDN the flow velocity can be increased to 1.8 m/sec for economical consideration but in this case pressure rating should be minimum of 4 kg/cm².
- v. Scouring arrangement should be provided in the portion of pipe network where flow velocity is below 0.6 m/sec.

5.2 Diameter of Pipe

- i. A small diameter pipe may requires a lower initial investment but fails to provide enough water to command area
- ii. Similarly, a large diameter pipe involves high initial investment and provides excess water to one command area which will affect another.

- iii. Therefore, a selection of optimum conduit diameter for a particular fluid flow will be a vital economic decision.

5.3 Hydraulic Gradient Line (HGL)

- i. Hydraulic gradient is the factor which controls the flow of water through closed pipe network. Following are the some important guidelines while deciding the HGL.
- ii. To ensure the adequate pressure and full flow condition at the start of main pipe line, minimum driving head of 1.2 m should be maintained at intake chamber.
- iii. Diameter of pipe is so selected that the effective head i.e. (HGL-GL) should not be less than 0.6 m. However, in exceptional cases effective head to the extent 0.3 m may be allowed.

5.4 Installation Requirements

The pipeline should be installed at sufficient depth below the ground surface to provide protection from hazards imposed by temperatures, or soil cracking. The requirements of a cover for various diameter pipes are shown in Table 1.

Table - 1 : Requirement of Cover for Various Diameter of Pipes

Sr. No.	Diameter of pipe in mm	Minimum Depth of Cover in mm
1	25 - 60	450
2	75-100	600
3	for 125 mm or more	760

- The pipe should be laid below the ground in such way that at least 1.2 m of filling material is kept over pipe so that it should not be disturbed with the farming operations and farming equipments.
- At summit locations, air vacuum relief valves to be provided. Air vent to be provided at an interval of 300 m and to be extended upto 0.6 m above HGL.

- At the point of change in alignment, to provide the stability to pipe network thrust block should be provided. Also in case of straight reach by considering swelling pressure of soil anchor block to be provided at a suitable distance. The thrust block and anchor block should be constructed in P.C.C.

5.5 Soil Data

The information such as soil specific characteristics, compressibility, infiltration rate, soil classification, shear strength, texture of soil, existing groundwater table, soil PH etc. regarding existing strata should be collected. Soil PH can also affect the choice of material of pipe. PH less than 5 would prevent the use of iron and concrete pipe.

6. IMPORTANT ASPECTS AND GUIDELINES FOR PDN CONSTRUCTION

- i. In low lying area where hydraulic gradient is more the flow can be controlled by reducing the diameter of pipe or using valves.
- ii. For pipe segment taken in consideration, minor losses due to bends, tees etc is taken as 10 percent of frictional losses.
- iii. Generally the diameter of air valves should be kept minimum 10 percent of the pipe diameter.
- iv. Trash screens are used in the intake chamber to prevent the entry of sand, silt, debris etc.
- v. The male-female joint with rubber packing in case of R.C.C pipe should be water tight or else the roots of trees may enter through the pipe joints resulting in blocking of pipe.
- vi. PVC pipe may get brittle due to U.V. degradation when exposed in sunlight for a longer duration.
- vii. After laying the pipes, confirm the joint set and refill the surrounding portion of pipe with appropriate compaction to avoid the floating action of pipe due to seepage.

7. PRECAUTIONS TO MINIMISE LEAKAGES

No pipeline shall leak if quality of pipeline and quality of joints are good. Pipeline leaks only when there is a significant human negligence, in respect of construction and operation. Some of the precautions are:

- i. Use moist soil for the initial backfill after laying the pipe.
- ii. Minimize air circulation through a line when laying pipe and when line is not in use.
- iii. Avoid laying pipe in extremely hot, extremely cold or in wet weather.
- iv. Moreover when pipelines leak, the leaking water appears on the ground as a wet patch almost immediately and can be repaired easily. Regular inspection to attend to such eventualities is necessary.
- v. Distribution chambers to be cleared for silt or debris seasonally.
- vi. Ball to be inserted for the silt clearance.
- vii. Valve or outlet to be provided at the lowest level of the system to facilitate flushing.
- viii. Periodical flushing of the system is necessary.

8. SCOPE FOR IMPLEMENTATION OF PDN SYSTEM

PDN can be used for major, medium, minor and lift irrigation scheme. It is possible to implement this system as a new scheme or in an existing scheme. If PDN is implemented as a new project, it would be, easier to give justice to the principles of PDN. While implementing PDN system on existing scheme there could be following alternatives as given in Table 2

Table - 2 : Alternatives while Implementing PDN on Existing CDN System

Alternative	CDN	PDN
1	Main canal, Distributary, Minor	Only Field channel
2	Main canal and Distributary	Minor and Field channel
3	Main Canal	Distributary, Minor and Field channel

9. ADVANTAGES OF PDN SYSTEM OVER CDN SYSTEM

- i. As almost entire system is buried, there is considerable saving in land acquisition cost.
- ii. The losses due to seepage, evaporation, thefts can be avoided by implementation of PDN.
- iii. By use of PDN, Part of un-command area can be brought under irrigation.
- iv. Low maintenance cost- in PDN continuous maintenance is not required as in case of earthen channel.
- v. Advanced technologies such as drip, sprinklers, sub-surface irrigation system of irrigation can be implemented.
- vi. Irrigation principle may be achieved by equitable water supply from tail to head.

10. LIMITATIONS OF PDN SYSTEM

- i. Great care in design and construction of PDN is necessary.
- ii. Silt must be removed from water before supplying it to PDN.
- iii. High initial investment in pipeline- but in the long run pipelines are economical, due to saving in water, labour, maintenance, land & permanence of installation.

11. CONCLUSION AND RECOMMENDATIONS

Considering the scarcity of water, PDN system is recommended for irrigation in command area. PDN system saves water over conventional CDN system and should be preferred where land cost is comparatively high and farmers are unwilling to handover their valuable land. The pipe line distribution system would be more suitable for implementation of modern techniques like sprinkler and drip irrigation etc. The planning and design of PDN should be carefully done so that maximum benefits of the system can be utilized.

Therefore, it is recommended that PDN system could be implemented to the ongoing Lift Irrigation Scheme (LIS) as pressure head is easily available and depending upon the

techno-economic feasibility this system can be used for conversion of existing CDN in part or whole command area.

REFERENCES

- [1] Water Resources Information System Directorate Information System Organisation Water Planning & Projects Wing Central Water Commission (2015) - "Water and Related Statistics, 2015".
- [2] Water Resource Department, Government of Maharashtra, Government Resolution No. 201701131701335427 (2017) "Pipe Distribution System For Irrigation Projects".
- [3] Water Resource Department, Government of Maharashtra, Government Resolution No. 201702021324512227 (2017). "Guidelines Regarding Pipe Distribution System For Irrigation Projects".
- [4] Kolhe P. (2012). "Optimal Utilization of Irrigation Water by Use of Pipe Distribution Network (PDN) instead of Canal Distribution Network (CDN) in Command Area", India Water Week 2012 – Water, Energy and Food Security: Call for Solutions, New Delhi.
- [5] Satpute M., Khandve P., Gulhane M. (2012). "Pipe Distribution Nerwork for Irrigation – an Alternative to Flow Irrigation", Section VII Environmental Sciences Proc. 99th Indian Science Congress, Part II.
- [6] Indian National Committee of Water Resources (Constituted by Ministry of Water Resources, Govt. of India) (1998). "Pipe Distribution System for Irrigation".
- [7] Design and Optimization of Irrigation Distribution Networks Food and Agriculture Organisation of the United Nations Irrigation and Drainage Paper