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ijrset@gmail.com

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Pipe Distribution Network Design and Analysis

**Prof. Amar.R. kalyane, Sharad S.Veer, Kishor.P.Bandal, Shubham. R. Hendre,
Mohammed Saleem.N.Afware**

Head of Department, Department of Civil Engineering, Navsahyadri Education Society's Group of Institutions,
Naigaon, Pune, India

UG Student, Department of Civil Engineering, Navsahyadri Education Society's Group of Institutions,
Naigaon, Pune, India

UG Student, Department of Civil Engineering, Navsahyadri Education Society's Group of Institutions,
Naigaon, Pune, India

UG Student, Department of Civil Engineering, Navsahyadri Education Society's Group of Institutions,
Naigaon, Pune, India

UG Student, Department of Civil Engineering, Navsahyadri Education Society's Group of Institutions,
Naigaon, Pune, India

ABSTRACT: To achieve more crop per drop, it is not advisable to use conventional flow irrigation system for irrigation viz canals & distributaries. There is large scale water loss in this system. The design and construction of PDN network in no. of projects is stated in Maharashtra. To have uniformity and for optimisation of design for cost reduction field engineers and planners felt need of detailed guidelines for PDN planning, Design, estimation and execution. A water is scarce natural resource, also it is fundamental to life, livelihood, food security & sustainable development. Also it is a premier resource of agricultural production on which almost all rural income depends. It is also identically important to the urban development & industrial growth. As there is significant use of water for irrigation, it is sensible to increase the water use efficiency in the 2 agricultural sector. Now a day's demand for drinking water, irrigation and non-irrigation in the state is increasing exponentially day by day. This can be solely possible by adopting Piped Distribution Network (PDN) as it overcomes the lacunas of the flow irrigation system viz. land acquisition, lavish use of water from the farmers in the upper reaches of the canal, System becomes expensive in hilly areas etc.

I. INTRODUCTION

A water is scarce natural resource, also it is fundamental to life, livelihood, food security & sustainable development. Also it is a premier resource of agricultural production on which almost all rural income depends. It is also identically important to the urban development & industrial growth. Hence its accountable use is imperative. Now a day's demand for drinking water, irrigation and non-irrigation in the state is increasing exponentially day by day. Considering above fact, the seriousness of the meaning of these Rucha's in Varunsukta can be easily understood. Since the availability of water in Maharashtra State every year is not assured, obviously the lavish use will not be possible in the coming days. In Maharashtra the variation of rainfall is uneven and variation from 2500 to 5000 mm in Konkan Region to 450 mm in Marathwada Region is observed. To achieve more Crop Per drop, it is not advisable to use conventional flow-irrigation system for irrigation Viz. Canals and distributaries. There is large scale loss of water in this system. Also almost 75% of water is used for irrigation out of total water available. In the wake of above, the Government of Maharashtra has adopted the policy to distribute irrigation water through piped distribution network, vide Govt. Resolution of 09/06/2016 and revised 13/01/2017. The usable water in the state is limited. (as per the second Irrigation Commission of Maharashtra) The total cultivable area for irrigation can be increased to a maximum of 85 lakh hectare. It is estimated that only 37.37% of the total cultivable land area (Around 226lakh hectares) can be irrigated through the total water available. Apart from this, only 41 lakh hectares irrigations possible through water conservation, local sector and agriculture department. This reveals that maximum irrigation area of 56% is only possible out of total cultivable area of 226lakh hectares, from all sources. The average irrigation potential of India is 76.44% so there is no alternative besides to increase the water use efficiency of the irrigation sector in the state. This can be possible only, by converting ongoing flow irrigation system in to micro irrigation system (Drip + Sprinkler).

This can be solely possible by adopting Piped Distribution Network (PDN) as it overcomes the lacunas of the flow irrigation system viz. land acquisition, lavish use of water from the farmers in the upper reaches of the canal, System becomes expensive in hilly areas etc.

A pipe distribution network is a network installation consisting of pipes, there fittings structures like thrust blocks, various valves & outlet, installed in the system, to supply water under pressure from the source of the water to the irrigable area. Pipelines also permit the conveyance of water uphill against the normal slope of the land and, unlike open channels, can be installed on non- uniform grades. The use of buried pipe allows the most direct routes from the water source to fields, and minimizes the loss of productive land (since crops can be planted on the fields above the pipelines).

An analogy between the Canal Distribution Network (CDN) and Pipe Distribution Network

II. SURVEY FOR PIPE DISTRIBUTION SYSTEM

2.2.1 A piped irrigation system should preferably be used for the command areas, having ground slope 1:500 or more. Piped irrigation depends upon hydraulic gradient (H.G.L.) of the source hence piped irrigation system depends upon the topography of the area and H.G.L. of the source.

VIZ- 1) Land Acquisition is not amicable or expensive.

2) In hilly areas, where construction of traditional canal become more expensive.

3) In regions like Vidarbha, where horticulture crops are popular.

4) Commands having sandy soil, where percolation losses are predominant.

2.2.2 A detailed survey should be carried out by the state of art instruments like Total station, DGPS or Drone camera. This data becomes compatible to the Geographical information system (GIS) and also to many software used for the design of Pipe distribution system (Like Water Gems).

2.2.3 Based on a detailed survey carried out, the contour map should be prepared for 0.2 m contour intervals. A single command map of 0.2 m contour interval in a scale of 1:10000 should be prepared. Also for detailed planning of the PDN, the aforesaid command map in a scale of 1:6000 or 1:4000 are also required for chak planning. Or in case of large project at least command area should be readable. The map should be inclusive of all the details like Buildings, Gavthan, Forest, Roads, Railways, Nallas, & Rivers etc. and it should be in a Auto-cad drawing format.

After finalization of entire pipe line network, the detailed ground level at every 30M chainage should be taken, to draw the necessary L- Sections.

III. CHAK PLANNING

Existing 100 ha chak is divided into sub-chaks having 8 to 10 ha ICA. 100 ha chak planning is considered as per approved maps. In preliminary planning sub-chaks are formed having GCA 16 to 20 ha.

As far as possible whole gut no is considered in sub-chak unless otherwise, it is divided by major nallas and roads. Nallas are the 1st priority to form sub-chak. Cart tracks are crossed for proper chak formation Since, ICA /CCA factor is 0.49495 (i.e. ICA is approx half of CCA). Therefore, 16 to 20 ha GCA is considered to form chak size 8 to 10 ha ICA.

Hence for preliminary planning the chak size should be between 60 ha to 100 ha, so that every farmer can easily irrigate his farm. The per hectare discharge of command area (m³/sec/ha) is a governing factor for deciding the Chak size. A minimum 10 lit/sec discharge is required at every outlet point to exercise the option of conventional flow irrigation behind pipe outlet. However actual discharge required as per modified penman method for a chak may be less than 10 lps discharge, in such cases keeping total quantum of water required to irrigate chak; we have to schedule two or three chak outlet operation in sequence.

IV. DESIGN OF PIPE DISTRIBUTION NETWORK

The general design criteria followed for this pipe distribution layout is listed in the following:

The entire design is carried out with respect to Govt. GR dt. 02.05.2017 and MKVDC circular dt. 15.02.2021. As per circular, pipe network is planned with respect to the decentralized storages.

From intake chamber water shall be delivered by piped network by gravity main to chak outlet of the command area.

The average chak size is planned as 70 to 100 ha as per Technical circular.



Levels to each junction of the Main pipe network are given manually with reference to field surveys and topography.

The average minimum and maximum velocity in the network shall be maintained in within the prescribed range as per GOM circular.i.e. Minimum velocity shall not be less than 0.6 m/sec and maximum velocity shall not be more than 1.8 m/sec.

Demand to each junction of the pipe has been given as per Net irrigation requirement.

At the location of the distribution chamber 1.20 m driving head is proposed. Accordingly dimensions of Distribution chamber will be proposed in the final design.

In order to maintain the required pressure at the junction and at each node, residual pressure shall be designed accordingly. However in the present case this has been followed always more than 0.60 m.

For design of pipe distribution network Modified Hazen Williams formula is used as per circular.

Losses in pipe segment on account of friction are also proposed at 10%.

Chak marking is shown in separate layers on village maps.

Chak outlet will be located at the highest elevation point within the chak boundary to facilitate gravity flow.

Detailed field alignment survey will be carried out from source to all chak outlets to obtain accurate elevations along all critical areas of the piped distribution system.

The distribution system is hydraulically designed as closed conduit piped system. The system is designed with the Modified Hazen Williams formula.

Velocity Calculations are as under $V = 143.534 CR r 0.6575 S 0.5525$

Where, V = velocity of flow in m/s.

CR= pipe roughness coefficient, (1 for smooth pipes; <1 for rough pipes) r = hydraulic radius in m

= A/P

= $((\pi/4)*D^2)$

πD^4

D = Pipe inner Diameter in m S = friction slope; = h/L

Frictional losses are calculated by Modified Hazen-Williams Formula as under $h = [L (Q / CR) 1.81] / 994.62 D^4.81$

Where, D = internal diameter of pipe in m h = friction head loss in m

L = length of pipe in m

Q = flow through pipe in cumecs

V. LITERATURE REVIEW

Mr. Sandesh B. Kulavmode March 2017 “Guidelines for Construction of Pipe Distribution Network (PDN) for Irrigation”

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.

Sandesh B. Kulavmode March 2017 “Feasibility of Pipe Distribution Network (PDN) over Canal Distribution Network (CDN) For Irrigation”



The PDN system is one of the best solutions to improve the OPE of an irrigation project. Results of Nagthana MI project shows that, with the implementation of PDN as a new scheme, there is remarkable increase in efficiency of overall system and it is possible to double CCA with the same volume of water. Also from the case study of Dongarwadi LI project, it is seen that despite the high investment required in the construction of the PDN system, this system will be economical as compared to CDN when the land acquisition cost for the project is taken into account and PDN will be feasible over CDN particularly when the reach of the channel passes through the deep cut of black cotton soil. Thus depending on needs and techno-economic feasibility, PDN could be planned as a new scheme or in an existing scheme. Therefore, to overcome the limitations of CDN, the modernization of the irrigation distribution system may be possible and feasible with the help of the PDN system.

Asma Sultana June 2019 “Design of Water Supply Distribution System: A Case Study”

After collecting data of distribution network of Nelatur Village, pressure, flow and velocities have been computed using EPANET and by the methodology described before, results by EPANET are obtained, analysis of results has been carried out and computed results for junction and pipes have been checked to comply with the CPH Manual. 5.1 Junction analysis Report The network includes 80 junction/nodes. The result obtained using EPANET software for Nelatur Village is calculated. The pressure computed using EPANET software was found in compliance with CPH Manual.

VI. CONCLUSION

The following conclusions are drawn from the experimental study. Material selected for PDN is P.C.C.P. PIPE (Prestressed Concrete Cylinder Pipe) for diameter more than 500 mm and H.D.P.E pipe (High Density Polyethylene) for diameters upto 450 mm which has less frictional loss, life span is near about 40 year which is more durable and maintenance is also easy. This system proves cost effective than maintenance and repair of existing canal structures. Hence replacement of CDN by PDN proves cost effective, increase in irrigation potential, minimizes losses during conveyance

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.

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