

CONVERSION OF CANAL BASED IRRIGATION NETWORK SYSTEM TO PRESSURIZED PIPE BASED NETWORK SYSTEM INTEGRATED WITH SOLAR PLANT A CASE STUDY IN UTTAR PRADESH, INDIA

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ABSTRACT

Badaun irrigation project was designed many years back by the Government of Uttar Pradesh on Canal Based Irrigation Network. The project could not be completed in so many years. Only the major part of the Main Canal was completed that too at substantially escalated project cost and after long delays, but none of the branch canals and the distributaries could be completed.

The Champatpur Branch Canal with its distributaries as such was taken up on Pressurized Piped Irrigation Network basis, considering the advantages as mentioned in the Central Water Commission PIN Manual of Government of India of July 2017. The project has been designed as per the instructions of the UP government, adopting modern irrigation system is proposed to be brought under sprinkler irrigation integrated with Solar Plants of the Champatpur branch system, by which irrigation can be done in more areas with less water.

The paper discusses design aspects, all costs and comparative costs in detail, which will help engineers at the threshold of converting Canal Based Irrigation Network to Pressurized Pipe Based Irrigation Network.

1. INTRODUCTION

The Champatpur Branch Canal with its distributaries was taken up on Pressurized Piped Irrigation Network basis, considering the advantages as mentioned in the Central Water Commission PIN Manual of Government of India of July 2017, which are as follows:-

- (i) As most of a piped distribution system underground, right of way problems are significantly reduced, allowing more direct and rational layouts to be chosen. Because outlet location is not limited by topography, pipe systems are better able to accommodate existing patterns of land ownership with the minimum of disruption compared with new irrigation development using CDN.
- (ii) Cross Drainage and Cross Masonry (Communication) structures can be omitted or minimized.
- (iii) Irrigation works become obstacles in the way of free drainage of water during rainy season and thus results in submerging standing crops and even villages.
- (iv) No damage due to heavy rainfall or flood during monsoon.
- (v) More Suitable option for flood-prone area.
- (vi) No hindrance in movement to the farmers and farm equipments.

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- (vii) Increase in CCA as compared to canals, as the water losses are negligible and acquired land for canal network can also be used for cultivation as Piped Irrigation Network is under ground.
- (viii) Better option for undulating fields.
- (ix) Because of shorter transit times for water from source to field, lower conveyance losses and the smaller volumes of water in the conveyance system, pipe systems can deliver a supply which is more flexible in both duration and timing, in a way not possible CDN, so enabling intensification and diversification into higher value crops.
- (x) Less execution time for PIN as compared to CDN.
- (xi) The important targets of the modernization of irrigation schemes and digital management will be achieved when water is delivered through Piped Irrigation Network.
- (xii) In case of canals, the marshes and the ponds caused by excessive seepage, in course of time become the colonies of the mosquito, which gives rise to vector borne diseases and this can be minimized by adopting Piped Irrigation Network. Further salinity and water logging can be reduced.
- (xiii) Increase in project efficiency of the Piped Irrigation Network is about 20% as compared to CDN.
- (xiv) Fertilizers/chemical can also be mixed with the water.
- (xv) Quantity of water supplied by Piped Irrigation Network is easily measurable; hence water auditing can be accurately measured.

2. PREAMBLE TO THE AONLA SPRINKLER IRRIGATION SYSTEM IN DISTRICT BAREILLY IN UP, INDIA

At present, there is no facility available for irrigation in the canals in Tehsil Sadar and Tehsil Aonla of Bareilly district and Tehsil Dataganj of Badaun district, located between Rivers Ganges and Ramganga. The irrigation here mainly depends on ground water and rain water. For the last several years, most of the Badaun district is being irrigated by tube wells. For this reason, the situation of ground water level is very poor in most parts of Badla and Bareilly district of Aonla Tehsil, which often fails to provide most of the tube well irrigation facility due to bad ground water levels in summer. Irrigation project has been now prepared to provide irrigation facilities to the Kharif crops from canals in the area. Under the project, the gross command area is 66877 ha, the agricultural land area is 53504 ha, and the proper and sure irrigation area of Kharif crop is 37453 ha (70% of CCA). Recommended discharge for the planning of the project in clear hydrology by Central Water Commission is 1: 100 liters 10900 m³/sec and 1: 500 of the total 13940 m³/sec.

Under the Badaun Irrigation Project, the Champatpur branch emerges from the bank of 4.800 km from the main canal. The length of the Champatpur branch is 34.00 km, and the length of its Rajwaha and Alpi is approximately 163.00 km. Head discharge of Champatpur Branch is proposed as 23 m³/sec (812.13 ft³/sec), CCA 21248 ha, and PPA 14874 ha.

In compliance with the above instructions of the UP government, project for sprinkler irrigation of Champatpur Branch system was prepared. The project has been designed with Ductile Iron pipeline for the entire Champatpur branch system in the project, which is proposed to be laid in the Main and Sub-main lines.

3. SUMMARIZED SNAPSHOT OF AONLA SPRINKLER IRRIGATION SYSTEM IN DISTRICT BAREILLY - DESIGN AND ESTIMATES AND COMPARISON AGAINST CANAL BASED IRRIGATION NETWORK SYSTEM

3.1 T-diagram layout

The T-diagram layout of the proposed Canal based design of Champatpur Branch under Badaun Irrigation Project is given in Fig-1 below. The sky coloured shaded portion in the diagram is the Champatpur Branch of Badaun Irrigation Project (currently known as, Aonla Sprinkler Irrigation System in district Bareilly).

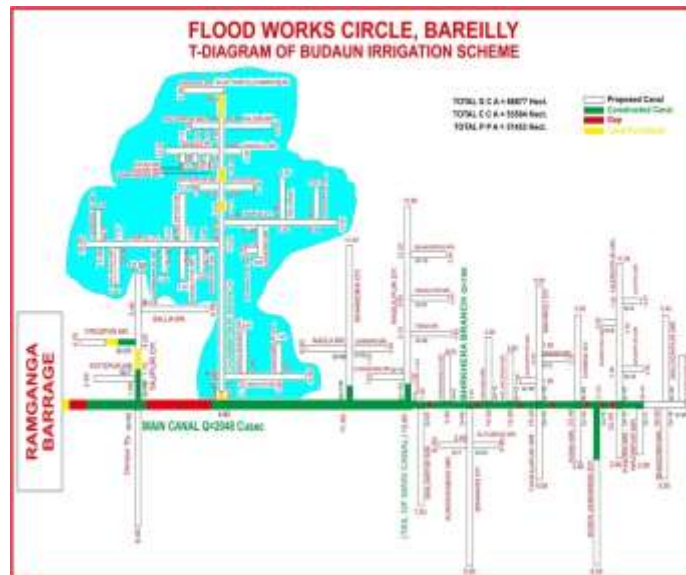


Figure 1. The T-diagram of proposed Canal based design of Champatpur Branch under Badaun Irrigation Project (currently known as, Aonla Sprinkler Irrigation System in district Bareilly).

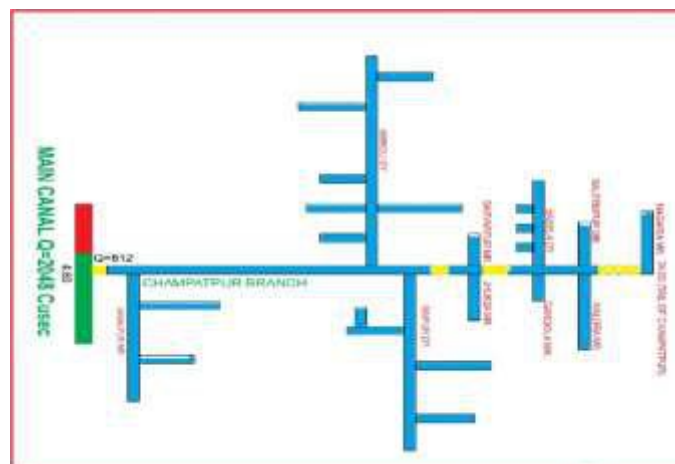


Figure 2. T-diagram layout of proposed Canal based design of Champatpur Branch (currently known as, Aonla Sprinkler Irrigation System in district Bareilly).

3.2 Salient features of the project in pipe-based design

Some salient features of the project in pipe-based design are presented below.

Table 1. Location details of Aonla Sprinkler Irrigation System.

Location	
State	Uttar Pradesh (India)
District (s)	Bareilly & Badaun
Tehsils	Aonla, Badaun, Dataganj
Location	0.5 km d/s of the road bridge on Bareilly- Badaun SH-33 and about 10 km south of Bareilly city.
Nearest Rail head	i. Ramganga station on Chandausi- Bareilly loop line. ii. Bareilly junction about 10 km from the project site.
Nearest airport	15 km

Table 2. Pipeline scheme details of Aonla Sprinkler Irrigation System.

Main Canal	
Length	15.6 km
Bed width	30 m at the head
Water depth	2.20 m at the head
Bed Slope	15 cm/km
Discharge	56 m ³ /sec up to silt ejector and 51 m ³ /sec after that.
Lined/Unlined	0.3 km lined, 15.3 km unlined
Branches - Champatpur branch	
Off-take of the Main canal at km.	4.800 km from the left bank
1. Length	34.00 km
2. Head discharge	23 m ³ /sec
3. Bed slope	as per Design
4. Canal Duty per 1000 Acre	7 ft ³ /sec
5. Solar Plant	16.82 MW
Proposed areas under the scheme	
Gross Command Area (GCA)	25841 ha
Culturable Command Area (PPA)	18001 ha
Total Cost of Project (Base Year 2018-19)	INR 8578 million
Cost/hectare	INR 0.477 million per ha.
Benefit-Cost Ratio	1.9:1

3.3 Abstract of cost for the project

Table 3. Abstract of cost for the project (without the cost of field distribution network)

Sl. No.	ITEM	COST (INR IN MILLION)
1	Preliminary	43.56
2	Land	103.59
3	Works	
A	Pipelines - Mains	2965.05
B	Pipelines - Sub-mains	1637.48
C	Cost of Solar power	629.18
	Total cost excluding GST =	5378.86
	Add SGST @ 6% =	322.73
	Add CGST @ 6% =	322.73
	Total Cost including GST =	6,024.32
	Add Centage charge @ 6.875% =	414.17
	Labour Cess @ 1% =	60.24
	Add 5% Contingency Rs. =	301.22
	Add 5% operation and maintenance for 5 years Rs. =	301.22
	Grant Total =	7101.2 million

Table 4. Abstract of cost for the project (with the cost of field distribution network)

Sl. No.	ITEM	COST (INR IN MILLION)
1	Preliminary	43.560
2	Land	103.59
3	Works	
A	Pipelines - Mains	2965.05
B	Pipelines - Sub-mains	1637.48
C	Cost of Field Distribution Network	1,118.63
D	Cost of Solar power	629.18
	Total cost excluding GST =	6497.49
	Add SGST @ 6% =	389.85
	Add CGST @ 6% =	389.85
	Total Cost including GST =	7277.19
	Add Centage charge @ 6.875% =	500.31
	Labour Cess @ 1% =	72.77
	Add 5% Contingency Rs. =	363.86
	Add 5% operation and maintenance for 5 years Rs. =	363.86
	Grant Total =	8578 million

3.4 Consideration of Rates

1. The rates of cutting, clearance, earthwork – excavation, backfilling, etc. are taken from Construction Division SOR of Bareilly, Uttar Pradesh.
2. Rates of providing, lowering, laying, aligning, fixing in position and jointing of pipes are considered by evaluating the market rates.
3. Rates of supplying and fixing valves, actuators, flow-meters, and surge protection arrangements including thrust blocks and SCADA for the operation of individual pump house up to mains/sub-mains, Construction of Thrust Block, Valve Chambers, escape channels, etc. are taken as @ 4.0% of pipe cost.
4. Rates for construction of structures for nalla crossings, road – canal crossings by siphoning or by construction of pedestals, approach roads to valves, etc. are taken as @ 3.0% of the cost of pipe network.
5. Rates of supplying and installation of pumps and motors for 1.5 times of the power requirement for lifting water are taken as @ INR 25,000 per kw of power requirement including all Hydro Electro-Mechanical works as per market rate analysis.
6. Rate of crop compensation and land is taken 0.2 million/ha while the average rate for acquisition is 12.5 million/ha.

3.5 Design criteria

1. This cost is estimated for GCA 25841.64 ha and CCA of 18001.30 ha.
2. Canal Duty is calculated at 1.0 m³/sec per 1000ha
3. Provision for two step de-silting arrangement at the mouth of pressure pipe network and filtration arrangement at sub-chak level/diggies are

incorporated in this estimate. As per the silt load measured and grain size analysis final arrangement for de-silting/ filtering would be decided.

4. Total annual power requirement of the scheme is 16.82 MW.
5. Capacity of Solar Power Plant will be 20 MW.
6. Presently for estimation purpose planning on sample chak of size about 70 ha has been done.
7. Design criteria for the pipeline have been adopted from CWC guidelines.

3.6 Cropping pattern

Selection of cropping pattern depends on quantity and timing of rainfall/water availability. In years of well-distributed rainfall large area is covered under kharif crops while in years of late rainfall rabi crops are taken. This is a project for Kharif Irrigation, and in the Kharif presently Maze, Paddy, Pulses, oilseeds are shown in table 5 below.

Table 5. Cropping pattern

Sl. No.	Kharif Crop	Irrigation Intensity in Percentage
1	Paddy	20.0 %
2	Pulses	15.0 %
3	Maize	10.0 %
4	Oilseeds	15.0 %
5	Sugarcane	20.0 %
Total =		80.0 %

Total CCA of the project - 18001.30 ha.

ICA of the project for Kharif Season is proposed - 14401.04 ha.

Water allowance for designing the complete water carrier system including all losses has been calculated for CCA 18001.30 ha, based on peak monthly crop water requirement of 1.0 m³/sec per 1000ha

Note:

The intensity of irrigation is the percentage of the culturable commanded area proposed to be irrigated during either a crop season or during a year. The cropping intensity of irrigation can be more than 100%.

3.6 Layout plan of sub-main

The layout has been designed considering the average chak size of 70 ha, i.e., discharge from one outlet (N1, N2... in figure 3) can irrigate 70 ha land, and hydrant point is provided at every 4.0 Ha sub chak. The outlet point is preferably expected to be on khasra boundaries in the middle area within a sub chak.

3.7 Details of Pipeline

For efficient distribution of water, the whole command is proposed to be divided into two sub-areas fed with the help of two main pipelines. These sub-areas are proposed to be further fed with the help of the Sub mains/Laterals. The whole network has been designed on the concept of capitalized cost of the pipe and pumping unit along with

the power required to operate the pumping unit. The pipeline has been designed on a telescopic basis, i.e., increasing towards head reach according to the increase in flow rate. As per the design pipe required for main lines, Ductile Iron Pipes conforming to IS 8329: 2000 and Mild Steel Pipes conforming to IS 3589: 2001 are proposed to be used for Main and Sub main/laterals along with required specials, valves, etc.

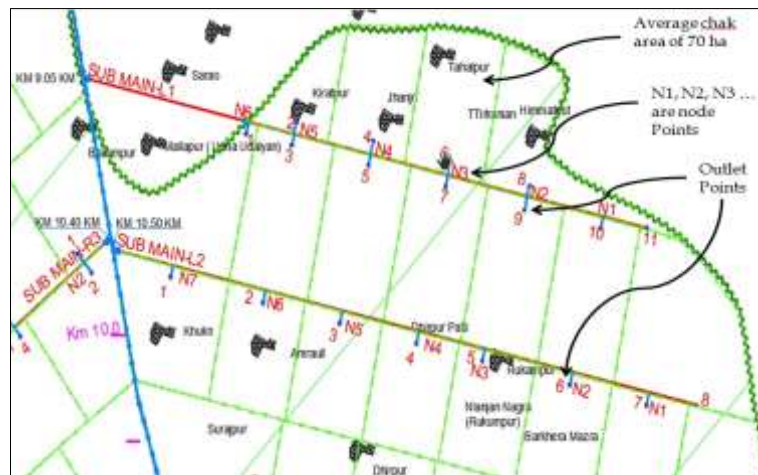


Figure 3. Layout plan of sub-main of Aonla Sprinkler Irrigation System.

The pipeline/pipe network beyond outlet point is proposed to be of HDPE Pipe. The pipes conforming to IS 4984: 1995 are proposed to be used for supplying water to cultivators through the hydrant provided at sub chak area of 4.0-5.0 ha.

1. RD 0.00 M to 1500.0 M of Feeder

From RD 0 to 1.5 km land already acquired in sufficient width, therefore it would be economical to construct this reach as open gravity channel.

2. RD 1500.00 M to Tail

For rest of the reach MS/DI pipelines have been proposed to carry the water up to the off-take point of proposed sub-mains. Looking to the operation suitability two separate mains are proposed to be laid for feeding the command situated on the left side and right side of the Main respectively.

(i) Left Side (RD 1500 M to 34000 M):

From RD 1500 meter to 24000 meters one MS pipeline flowing under Pressure is planned and designed to feed the command situated on the left side of the Main. The internal diameter of the pipes is varying from 1300 mm to 2100 mm.

From RD 24000 meter to 34000 meters one pressurized DI pipeline is planned and designed to feed the rest command situated on the left side of the Main. The nominal diameter of the pipes is varying from 700 mm to 1200 mm.

On the left main about twelve sub-mains of varying discharge capacity & Head as per design requirement, off-take at different RD of the Main.

(ii) Right Side (RD 1500 M to 35100 M):

From RD 1500 meter to 21850 meters one MS pipeline flowing under pressure is planned and designed to feed the command situated on the Right side of the Main. The internal diameter of the pipes is varying from 1400 mm to 1700 mm.

From RD 21850 meter to 35100 meters one MS pipeline flowing under pressure is planned and designed to feed the rest command situated on the left side of the Main. The nominal diameter of the pipes is varying from 200 mm to 1200 mm.

On the Right main about fourteen sub-mains of varying discharge capacity and head as per design requirement, off-take at different RD of the Main. Alignments of the proposed pipe network have been planned on the relevant survey data available/ provided.

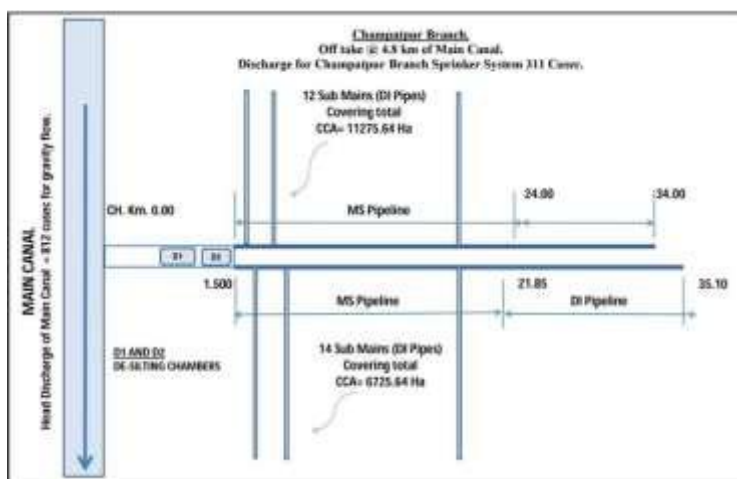


Figure 3. Layout plan of the pipeline of Aonla Sprinkler Irrigation System.

4. COMPARISON BETWEEN OPEN CANAL AND PIPED IRRIGATION

Table 5. Comparison between the open canal and piped irrigation system.

Sl. No.	Description of activity	Open channel system (without sprinkler system)	Piped Irrigation system (without sprinkler system)	Piped Irrigation system (with sprinkler system)	Remarks
1	Head Discharge	812 ft ³ /sec	311 ft ³ /sec	311 ft ³ /sec	Savings of around 500 ft ³ /sec in Piped Irrigation for additional area to be irrigated.
2	Total area to be irrigated	14,874 ha	18,001 ha	18,001 ha	(for pipeline system total design duty is calculated based on the CCA)
3	Cost comparison	INR 5787 million	INR 7101.2 million	INR 8578 million	Piped irrigation consists of Gravity/ Pressure mains and sub-mains, field distribution in sprinkler, 20 MW Solar Power Plant, pump house and siltation chamber/sump wells, filters and valve arrangements, electro-mechanical works, cost of operation and maintenance.
4	Cost per ha	INR 0.322 million	INR 0.395 million	INR 0.464 million	
5	Permanent Land required (in ha)	433 ha	7.88 ha	7.88 ha	In piped irrigation only RoU (right of use)/crop compensation and land is required, whereas in an open channel system, land acquisition is required, resulting in enormous delays. The average rate of crop compensation and land is taken 0.2 million/ha while the average rate for acquisition is 12.5 million/ha.
6	Cost of Land	INR 5412.5 million	INR 117.714 million	INR 117.714 million	
7	Revenue generation	Nil	INR 4.8 million	INR 4.8 million	Considering 6 months excess generation of 20MW @ INR 40,000

Sl. No.	Description of activity	Open channel system (without sprinkler system)	Piped Irrigation system (without sprinkler system)	Piped Irrigation system (with sprinkler system)	Remarks
	through the solar plant				per MW for one year.

5. CONCLUSIONS

In this manner, India is gradually shifting towards Pressurized Pipe Based Irrigation Network System integrated with Solar Plants in place of Canal Based Irrigation System as has been described above. The change is gradual, but irreversible because the Government of India is supporting this decision as a policy for implementing irrigation projects in a faster manner, at a lower overall cost and by utilizing less amount of water.

6. REFERENCES

- Guidelines for Planning and Design of Piped Irrigation Network (Part – I & II), published on July 2017 by Ministry of Water Resources, River Development & Ganga Rejuvenation, Central Water Commission, Government of India.
- IS 8289: 2000 (Centrifugally Cast (SPUN) Ductile Iron Pressure Pipes for Water, Gas and Sewage – Specification).
- IS 3589: 2001 (Steel Pipes for Water and Sewage (168.3 to 2540 mm Outside Diameter) Specification).
- IS 4984: 2016 (High Density Polyethylene Pipes for Water Supply – Specification).
- Standard Schedule of Rates, Construction Division, Bareilly, Uttar Pradesh, India.