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VoR (Version of Record)

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Harun-ur-Rashid, Md., Mohammed A.K. Mridha, Ian K. Smout, and Robert J. van Bentum. 2019. "Buried Pipe Systems for Irrigation in Bangladesh". figshare. <https://hdl.handle.net/2134/29034>.



WATER, ENVIRONMENT AND MANAGEMENT

Buried pipe systems for irrigation in Bangladesh

Md. Harun-ur-Rashid, Md. Abdul Karim Mridha, Ian K Smout and Robert J van Bentum



ABSTRACT

A study of eight cement concrete buried pipe schemes in Bangladesh was carried out during 1989-91 to evaluate both technical and management performance.

Leakage through joints and pipe walls, averaged 0.9 leaks per 100m of pipeline, while 42% of outlet valves were observed to leak. Conveyance losses within the pipelines averaged 0.33 lps/100m by the tank test method and 0.69 lps/100m by inflow-outflow method, with earth channel losses averaging 7.69 lps/100m by the inflow-outflow method. Machine spun pipes performed better and "plain end pipe jointing" was found appropriate. Measured head losses for different pipe sizes and pump discharges were found compatible with theoretical values when using the Colebrook-White Equation with $K_s = 0.6$ mm. Low pump discharge (60% of design), low periods of pump operation (12% of advised), small command areas (42% of intended) and low yields of irrigated crops were commonly observed. Seasonal repair and maintenance expenditure on pipeline systems varied from Tk 4.64/ha to Tk. 127.19/ha, with the average of Tk. 54.06/ha being only 18% of expenditure in earthen channels. Poor farming as well as water management practices contributed to poor levels of irrigation performance.

Farmers' cooperatives were found either not to be functioning or operating only very poorly, and many institutional problems existed.

Pipe systems are more economical than channel systems when the initial cost is affordable. There is however considerable potential to increase the net returns from buried pipe schemes through more efficient utilisation.

INTRODUCTION

The most common form of buried pipe distribution system found worldwide is a closed low pressure system with a branching pipe layout of concrete or uPVC pipe. Such a pipe system would receive water from a pump, canal or reservoir and distribute this over a command area in the range of 50 to 100 ha via 12 to 24 outlets, supplying water to individual field plots via earthen field channels. With the pipeline buried, the only above ground structures are inlet structures at the head of the pipe system, outlets, air vents and surge risers for the control of pressure fluctuations along the pipeline.

The use of buried pipe systems for surface irrigation in Bangladesh began about a decade ago. Since then a number of buried pipe systems, using mostly cement concrete (CC) pipe, have been installed. Different organisations are using different designs, construction methods, and pipe jointing techniques. Most of these CC systems experience problems with leakage from both the pipe joints and pipe bodies. Because of under utilisation of the system and poor management of the facilities the targeted objectives in terms of command area and productivity are often not achieved. Therefore, a study was undertaken to identify the weaknesses and strength in construction, efficient operation, management and utilisation of these schemes.

The study examined eight buried pipe schemes constructed during 1987-90 by Tangail Agricultural Development Project (TADP) under German Technical Assistance (GTZ), in Tangail district of Bangladesh. Work was conducted jointly by the Bangladesh Agricultural Research Institute (BARI) and Loughborough University of Technology (LUT), UK with funding from both LUT and the Overseas Development Administration (ODA).

The study area falls under the Madhupur tract which has silty clay loam soils, undulating topography, annual rainfall of about 2100 mm, mean monthly temperatures of 11 to 39°C and relative humidities of 49 to 88%. November to April is the water deficit period. Diversified cropping achieved an overall cropping intensity of 233%, with the main crops being rice (transplanted aus, aman boro), wheat, watermelon, and soybean.

RESULTS AND DISCUSSION

1. BURIED PIPE TECHNOLOGY

Pipes

Non-reinforced Cement Concrete (CC) pipes are used in Bangladesh because of their low cost (8" PVC pipe Tk. 770/m; 10" CC pipe Tk. 308/m) and ready availability. Normally, they are suitable for operating heads or pressure not exceeding 6 metres (0.6 Kg/sq cm). Pipes available in the open market are of very poor quality, but with care good quality pipes can be manufactured for use in irrigation. CC pipes are either made by hand or machine (by the centrifugal spinning process). In this study, it was found that machine made pipe was superior to that manufactured by hand. Hand made pipe had an irregular wall thickness, higher pore-space (poorer compaction), a higher incidence of leakage, and generally lower strength. Many pipe manu-

facturers do not give adequate attention to curing. On some government owned farms PVC plastic pipe systems have been installed.

Pipe installation and jointing

The pipes are laid on undisturbed soil at a depth of 60 to 100 cm and in a reasonable straight trench. Extra compaction and sand filling is usually avoided to keep installation costs low. Pipes are usually laid at the natural land grade.

Three types of pipe jointing were used in early systems: (i) Tongue and groove joint, (ii) Bellmouth-socket and spigot joint, and (iii) Plain end pipe joint. The plain end pipe joint has proved less expensive (the cost of the pipe is lower), simpler to construct, though prone to some leakage and it is now the most commonly used method.

Outlets

All the pipe schemes have 20 or 21 outlets of 2 cusec (56 l/s) capacity, except Binnakhaira where 50 outlets of 1 cusec (28 l/s) have been installed. Two cusec outlets were found to be inconvenient under the management and irrigation methods practised. One cusec outlets, provided for every 2 to 3 acres (1 ha), and operating two at a time were found to be more suitable. Outlets with flat lids proved to be more water-proof than those with grooved and/or slanting edged lids.

Leakages

Unreliable jointing technology, insufficient supervision during pipe manufacture and pipeline construction and the use of poor quality materials were responsible for much of the leakage (Table 1.) The highest number of leaks (360) occurred at East Kutubpur and were attributed to the use of hand made pipe, bellmouth-socket and spigot jointing with inadequate curing and poor quality materials. The occurrence of leaks was found to be greatest in the section of pipe between the pump and the first outlet of each line as well as in the sections crossing roads.

2. HYDRAULICS

Pump and outlet discharge

Tubewell discharge decreased during the dry season as the groundwater level declined (Table 1.) Because of leakage in the pipeline and through the outlet valves, discharge at the outlet was always less than the pump discharge. Because of engine problems including low running speeds, the low height of air-vents and the own fuel system of operation (with low engine speeds), pump discharge was always less than design.

Conveyance loss

Very high conveyance losses occurred at Hazipara scheme because of a fractured pipe in the line. Due to the higher hydrostatic heads conveyance losses measured by the inflow-outflow method were always greater than that with

the tank test method. However conveyance losses in the pipeline were only 9% of those measured in the open channels (7.69 lps/100m) (Table 1).

Head loss

Pipe friction head losses were greater where leakages were higher. Therefore, the greatest head losses were found on the pipe section between the header tank and the first outlet. However the measured head loss values (Table 2) agreed with theoretical values where the Colebrook-White Equation was used, with K_s (roughness height) equal to 0.6 mm.

3. IRRIGATION AND AGRONOMIC PRACTICES

Pump operation

Very low durations of pump operation (12% of advised) were observed (Table 1). Weak organisation and poor management were mainly responsible for this low period of operation. However higher fuel prices (doubling in 1 year) and the lower water requirements of diversified crops, also contributed to the low levels of pump use.

On-farm water use

No farmer was found to be following recommended irrigation scheduling or water management practices.

Crops were frequently under irrigated, with many non-rice crops receiving no irrigation at all. Due to the own fuel system of operation (where farmers provide fuel when they want water) excessive irrigation intervals were observed. Water application methods used included basin for rice, furrow for several non-rice crops and flooding for most other irrigated non-rice crops.

Water distribution system

Farmers did not follow rotational allocation systems but operated either, on a first come (with fuel) first served or, according to an indent system with pipeline flow frequently switched between different parts of the command. This resulted in higher transit and distribution losses than would occur under a rotational system.

Reliability, adequacy and equity of water supply

The adequacy of irrigation supply for boro rice was measured and found to be between 0.89 and 0.95. When surveyed only 77% farmers considered they received an adequate supply indicating some inequity in the distribution of the water supply. The own fuel and first come first served methods of operation, were considered responsible for the inadequate and inequitable water supply. In a number of schemes mechanical problems with the diesel engines and factional disagreements within the scheme management, contributed to a loss of confidence among the farmers in the reliability of the water supply.

Command area

On average the irrigated command area was 42% of the target area (Table 1) mainly because of poor management and inadequate extension services, rather than any short coming in the technology.

Crop yields

Crop yields were below national averages (Table 3). Out-dated agronomic practices (including inappropriate cropping patterns and incorrect fertiliser doses) and poor water management practices were mainly responsible for the low yields.

4. SOCIO-ECONOMIC

Scheme management

Management problems existed in all schemes and included general mistrust and conflict among cooperative members. KSS meetings were held infrequently and when held were poorly attended (27%). Most important decisions were taken by the president and manager and the manager frequently acted as the chief executive and as the contact point for all services.

Financial aspects

All schemes regularly defaulted in their DTW loan repayments. Reasons for the poor rate of loan recovery included insincerity on the part of scheme management, as well as the loan collector and poor government policy decisions. Different water charges were set for each crop and collected in cash on the basis of the area of crop irrigated. The rate of defaulting on water charge payment was high. However Table 3 shows that irrigated crops give a seven times higher net return than non-irrigated crops and buried pipe schemes are economically viable (benefit-cost ratio: 5.49).

Interaction of farmers and extension workers

Field visits by staff of the extension service were infrequent and interaction between farmers and extension workers very limited. Coordination between field departments within the extension service was often observed to be poor.

Table 1 : Hydraulic and operational information.

Parameters	Range	Average	Remarks
Discharge, lps			
a) Pump	31-39	34	60% of design (56.6 lps)
b) Outlet	25-33	27	80% of pump discharge
Command Area (ha)	9-22	17	42% of target (40 ha)
Conveyance loss in pipeline (lps/100m)			
a) Tank test	0.1-1.2	0.33	4.3% of earthen channel
b) inflow-outflow	0.35-1.4	0.69	9% of earthen channel
Conveyance loss in earthen channel by inflow-outflow (lps/100m)	5.9-9.4	7.69	22% of pump discharge per 100m of channel
Pump operation			
a) hours/day	1.9-6.2	4.4	22% of advised (20 hours)
b) days/month	9-18	14	54% of advised (26 days) (ie in total 12% of advised time pump was in operation)
Leaks on pipeline			
a) Total	2-48	19	40% of leaks in bodies (Exception at East Kutubpur: 360 Nos)
b) per 100m	0.11-2.2	0.9	60% leaks in joints (Exception at East Kutubpur: 20.4/100m)
Outlet valve leaking			
a) Total	3-36	-	Mostly design and manufacturing faults
b) Percent	14-72	42	

Note : Tk. = Taka, Bangladesh currency
Tk. 38.4 = 1 \$, 1991.

Table 2. Head Loss (m/100m)

Pipe size (inches)	Flow (lps)		Head loss (m/100m)	
	Range	Average	Range	Average
12	29-44	37	0.1-0.2	0.15
11	28-39	30	0.12-0.21	0.15
10	28-40	31	0.15-0.51	0.26
9	28-39	31	0.21-0.54	0.32
8	14-23	19	0.21-0.43	0.30

Table 3. Socio-economics

Parameters	Range	Average	Remarks
BP maintenance cost (Tk/ha)			
i) 1989-90	5-127	54.06	18% of earth channel (Tk. 300)
KSS meeting held seasonally	6-10	8	Much better than in other areas
Members present per meeting,	10-56	27	
Irrigation cost (Tk/ha)	1901-5616	3445	
Water charge collection (%)	64-85	73	National average Minor - 23% Major - 2 to 3%
Yield of Crops (t/ha)			National Average 4.5-7
a) Boro	3.1-3.4	3.3	
b) Wheat	0.9-1.7	1.2	4-4.9
c) Watermelon	9.1-35.6	14	60-80
d) Soybean	0.6-0.9	0.8	1.5-1.8
Scheme Indices			
Annual gross return ('000 Tk.)	707-1462	1104	
Annual gross production cost ('000 Tk.)	189-221	203	
BCR	3.6-7.7	5.54	
Net return ('000 Tk./scheme)			
a) Before DTW	107-256	171	
b) After DTW	814-1719	1275	

5. CONCLUSION

The buried pipe system was found to be effective in reducing conveyance losses (by about 90%) and maintenance costs (by about 82%). However, for the study schemes, periods of pump operation were very low with ample scope to increase the period of irrigation (upto 8 times). Effective extension advice in both agronomic and water management practices is essential if increases in areas commanded as well as in crop yields are to be achieved. The "own fuel" and "first come first served" systems of water supply led to frequent switching of water supply between pipelines resulting in higher losses of water because of repeated pipeline filling. Rotational water distribution if practised would considerably improve system operation and performance. The limited numbers (20 to 21) of two cusec outlets were found inconvenient and resulted in longer field channels and higher conveyance losses. Larger numbers of one cusec capacity outlets would be preferable.

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