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Construction cost study on improved earthen canal, pre-cast canal and buried pipe irrigation systems

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ABSTRACT

A research work was conducted on water distribution systems in three different shallow tubewells (STW) irrigation schemes at Nalchity Upazila in Jhalakati district, Bangladesh. Water distribution systems were improved earthen canal, pre-cast canal and buried pipe irrigation system. The main objectives of the study were to estimate construction cost and compare among improved earthen canal, pre-cast canal and buried pipe irrigation systems for water distribution to the field providing useful information for the improvement of command area for surface irrigation. The capacity of selected three STWs was 14 litre/sec. The construction costs of improved earthen canal, pre-cast canal and buried pipe system were Tk. 43.85 Tk. 285.5 and Tk. 590.25 per running meter respectively. The command area of the STW under improved earthen canal, pre-cast canal and buried pipe system were found 3.22 ha, 4.6 ha and 6.13 ha respectively. The highest serviceable life and command area was found for buried pipe distribution system. Considering construction cost, command area and serviceable life of canals, the buried pipe distribution system was economically superior to others for command area development.

Introduction

Irrigated agriculture has been playing a vital role for increasing crop production in Bangladesh. Farmers, in this country, used to irrigate their lands in the long past using traditional devices like Don and Swing basket. By these devices, they could irrigate only a very small piece of land by lifting surface water to a small height.

Small scale irrigation using modern technologies was introduced in early sixties. These technologies included low lift pumps (LLP), deep tubewells (DTW) and shallow tubewells (STW). While LLPs were limited to areas where surface waters were available, tubewell irrigation was feasible anywhere in the country because of existence of vast ground water resource at a relatively shallow depth.

Of the two types of tubewell technologies, STW began to be more popular soon after its introduction for its low cost and simpler technology. In the eighties, components of STW became readily available in the market at reasonable prices. As a result, the STW technology began to spread all over the country at an accelerated rate.

Proper water distribution system and its efficient management play very important role in the command area development of any irrigation project. In Bangladesh, use of earthen open channel for water distribution is common in the minor irrigation sector. These earthen open channel distribution systems generally have very low conveyance and distribution efficiencies, resulting in less irrigated area (Sattar *et al*. 1988; Sanjit and Tareq, 1996; Hasan *et al*. 1992) and high maintenance cost. It is fact that, traditional earthen channel distribution systems confront some physical obstructions and canals suffer from high seepage, leakage and evaporation losses. One of the major weakness of the minor irrigation sector is the huge amount of losses of irrigation water that occur to lack of knowledge of management as well as, to some extent, due to negligence of farmer.

Field open channels in surface water distribution systems in Bangladesh generally originate from a DTW or a STW, or even from a major canal outlet, run in a random manner with a little consideration of topographical features of the areas (BARI 1988). Seepage and evaporation losses are high in such systems. Besides these, Michael (1987) reported that about 2 to 4 percent of the cultivable land area is taken up by open channels in these systems. Plausible economic solutions of some of these problems, in the areas with plain topography and having heavy to medium textured soils, include construction of improved (compact) earth channel with necessary water control structures and strengthen operation and maintenance to improve performance of the system. Water loss depends upon season, water table, soil land topography, channel geometry and other flow characteristics. Amongst the water losses, water lost through the irrigation channel network is quite significant (Miah, 1984). Kraatz (1971) reported that seepage rates from channel built in sandy soil are often very high and can be fairly low if the conveyed water carries a heavy sediment load which deposits and build up a fairly impermeable layer on the bank bed of the channel. If improvement is made up in the channel network e.g. canal alignment, canal dimension, removing grass and compaction of channel, using lining material or polythene sheet, a considerable amount of pumped water can be saved. A properly designed water distribution system will make irrigation easy and efficient. Several types of structures are used to convey, divert and control irrigation water on the farm. Good irrigation structures are essential part of an irrigation layout. Earthen channel can be built stable side slopes with banks strong enough to carry the required flow of water safely. They should have ample capacity to carry the design discharge at no-erosive velocities. Side slops should be flat enough so that the banks will neither cave in nor slide when they saturated with water. However, the buried pipe distribution system (BPDS) may be the best solution to these problems (Bentum and Smout, 1993), especially for uneven topography and light textured soils (Jenkins, 1983).

Various studies have been carried out for addressing the issues and problems associated with both the operation and management of those irrigation scheme. Among those issues irrigation structures and command area development is frequently and prominently talked about. Hence the main objective of this work was to estimate construction cost and compare among improved earthen canal, pre-cast canal and buried pipe irrigation systems for water distribution to the field providing useful information for the improvement of command area for surface irrigation and for efficient use of water at the farm level towards reducing cost of irrigation.

Materials and Methods

Location of the study area

The study site is located at Nalchity Upazila under Jhalakati district which is about 20 km away from district headquarters. The study was conducted on demonstration of irrigation canals. The land distribution of the area is mostly as follows:

High land	19%
Medium high land	30%
Medium low land	16%
Low land	20%
Homestead and water bodies	15%

More or less all the areas are dominated by sandy loam soil. The topography of the land is relatively medium and flat. There are shallow tubewells and deep tubewells in these areas with a fairly good water distribution system.

The climate of the study area is tropical. The average annual rainfall in this area as recorded at the nearest meteorological station, Barisal was 170 cm. The highest mean monthly temperature was 37^0C in May and the lowest was15^0C in February. The percentage of relative humidity ranged between 46% and 84%. The mean monthly evaporation rate varied from 58 mm to 131 mm over the year. From the relationship between the rainfall and the evaporation, it was found that the period from November to April was moisture deficit period. The dry season is very important for the farmers to determine irrigation water application.

Design of the canal section

The normal discharge capacity of a STW in Bangladesh is 14 L/s. The canals are to be designed so that it can carry this discharge 20-25% free board is generally considered canal, in this study the canal was designed for a capacity amounting16L/s.

Improved earthen canal

From Maning's formula, as suggested by (Michael, 1978) for lined canal,
Velocity, $V = \frac{1}{n} \mathrm{R}^{2/3} S^{1/2}$……………… (1)

Where,
V = Velocity of flow, m/sec, A = Area of cross section, m^2, n = Roughness co-efficient, R = Hydraulic depth, m, S = Bedslope,Q = Discharge, m^3/s

For improved earthen canal of shallow tubewell Q = 0.014 m3/sec, Side slope = 1:1, Rugosity or roughness' co-efficient, n = 0.023
Let us assume, Bed width B; Design Depth of water = D
Assumed Section: Trapezoidal
Here, A = (B+D) D

For best trapezoidal section, B = 2D tanϕ/2
Where ϕ is the angle between horizontal and side line

For slope 1:1, B = 2D tan $45^0/2$ = 0.82843 D
A = (B + D) D = (0.82843 D + D) D= $1.828431D^2$
P=B+2X2^0D = B + 2.82843 D = 0.82843 D + 2.82843 D =3. 65686 D
R = A/P = 0.5 D
We Know, Q = AV ………………………… (2)
From equation (1) and (2)
D = $(Q \times S^{1/2})^{3/8} \times \frac{1}{50}$

The dimensions of canals are below:
Discharge, Q = 0.014 m^3/s, Bed slope = 0.001, Depth of water = 0.17 m, Bed width = 0.20 m, Free board = 0.05, Top width = 0.58 m, Bank width =0.15 m, Width of canal base = 0.88 m, Height of canal bed from field = 0.03 m, Height of canal base = 0.25 m

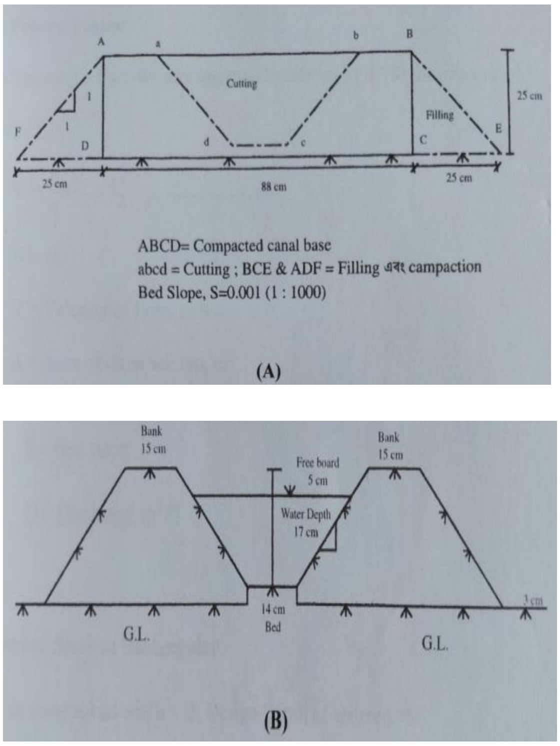

Figure 1: Cross section of improved earthen canal

Pre- cast canal

Formula, as suggested by Michael (1978) for lined canal,

Velocity, $V = \frac{1}{n} R^{2/3} S^{1/2}$……………… (3)

Where,
V = Velocity of flow, m/sec, A = Area of cross section, m^2, n = Roughness co-efficient, R = Hydraulic depth, m, S = Bed slope, Q = Discharge, m^3/S

Assumed Section: Rectangular

Let us assume, bed width B; Design Depth of watered =D, Rugosity co-efficient, n = 0.015,
A = BXD and P = B+2D

For best hydraulic section of rectangular section
A = $2D^2$, P = 4D, and R = 0.5D
From equation (3), D = $(Q \times S^{1/2})^{3/8} \times \frac{1}{83.993}$

The dimensions of canals are below:
Discharge, Q = 0.014 m^3/s, Bed slope = 0.001, Depth of water = 0.14 m, Bed width = 0.28 m, Free board = 0.05, Top width = 0.36 m, Bank width =0.15 m, Width of canal base = 0.66 m, Height of canal bed from field = 0.03 m, Height of canal base = 0.22 m

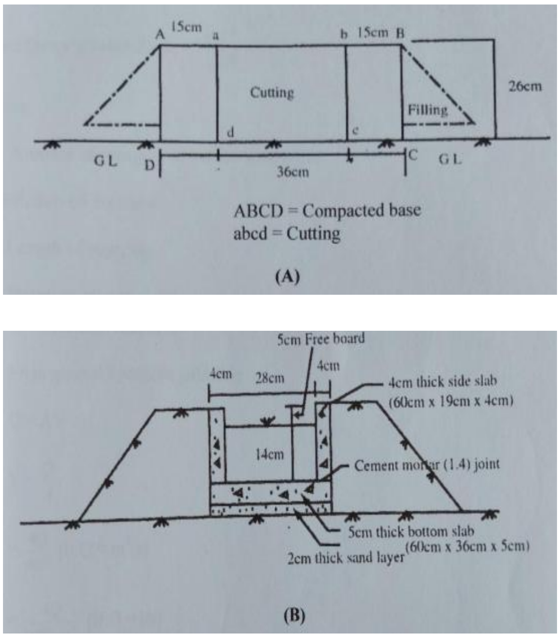

Figure 2: Cross section of a pre-cast canal

Buried pipe system

Irrigation pipe

From Darcy's Formula, $h_f = f\frac{L}{2g}\frac{V^2}{R}$……….... (4)
Where,
h_f = Amount of energy loss due to friction, m f =Friction co-efficient L =Length of pipe, m**,** V = Velocity of water, m/s, G =Gravitational acceleration, m/s^2, R = Hydraulic radius, m = D/4, D = Diameter of pipe, m
From general hydraulic guideline, Q = AV
$V = \frac{4Q}{1000\pi r^2}$ (When Q = l/s), Hence, from equation (4)
$h_f = 0.331 \times 10^{-6} \times f\frac{LQ^2}{D^5}$…………………………(5)

Assumed, f = 0.009 (Michael, 1981), Q = 14 l/s, L = 200m

Entrance head, $h_e = 0.5 \times \frac{V^2}{2g} = 0.083 \times 10^{-6} \times \frac{Q^2}{D^4}$ …….. (6)

From equation (4), (5) and (6) and analysis, Internal diameter of main cc pipe = 15 cm, Internal diameter of pump stand = 60 cm, Height of pump stand = 2.25 m, Diameter of rises pipe = 15 cm, No. of rises pipe = 4, No. of air vent = 5

Height of air vent = (2.16, 2.12, 1.52, 1.21, 0.65)

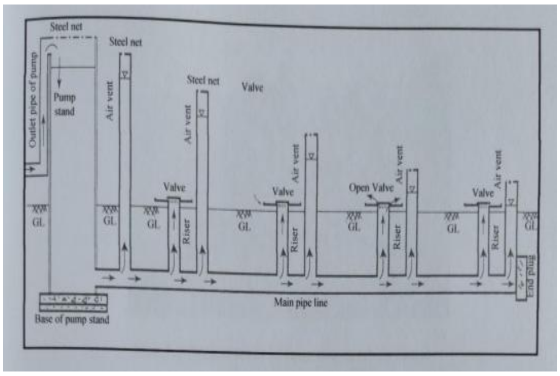

Figure 3: Line figure of buried pipe irrigation system

Construction of canal

Improved earthen canal

The canal was constructed according to design dimensions. The length of the canal was 200 meter. The side and bottom slope were maintained properly according to design criteria. The side and bottom slope were used for checking bottom slope and a wooden from constructed according to designed dimensions was used to maintain uniform side slope. The canal bed and sides were compacted by wooden hammer. The constructed earthen canal is shown in Figure 4 and 5.

Figure 4: Preparation of improve earthen canal

Figure 5: Finished improve earthen canal

Pre-cast canal

Bed slab (60 cm x 36 cm x 5cm) and side slab (60 cm x 19 cm x 4cm) were constructed by cement, sand, khoa (1/4") at the ration of 1:2:4. After earth work, the slabs were set-up according to designed criteria. Bed slabs and side slabs were adjusted by cement mortar (1.4). Bed slope was maintained in pre- cast canal as well as in improved earthen canal. The constructed pre-cast canal is shown in Figure 6 and 7.

Figure 6: Curing of pre-cast rectangular slab

Figure 7: Finished pre-cast rectangular canal

Table 1: Quantity of works for the buried pipe

Item No.	Description of work Item No.	Length of width (m)	Depth Height(m)	Number	Unit	Quantity
01	Earth work in excavation					
	a). Foundation trench	200	0.7	0.9	cum	126
	b). Under pipe joints	0.9	0.38	0.15	cum	5.64
	c). Under tree bend etc	0.15	0.3	0.15	cum	0.07
	d). Trench for pump stand	Dia = 9m		12	cum	0.76
	Total					**132.47**
02	Sand filling					
	a) Foundation trench	200	0.7	0.15	cum	21
	b). Under pipe e joints	0.9	0.38	0.075	cum	2.82
	c). Under tree bend etc	0.15	0.3	0.075	cum	0.03
	d). Trench for pump stand			0.075	cum	0.02
	Total					**23.88**
03	Sand filling					
	a). Main line	200		2.08	rm	200
	b). Air vent pipe			1.05	rm	10.4
	c). Rise pipe (.9+.15+.3)				rm	4.2
	Total					**214.6**
04	Jointing pipe					
	a) Mortar (1:3:6) bonded single flatsoling	0.25	0.38	0.105	sqm	10.45
	b) cc (1:3:6) at the pipe side along length	0.25	0.075		cum	0.43
	c) Braiding in cement slurry, cc mortar (l :3), Jute, bandage etc				nos	120
05	Construction of outlet structure					
	a) Flat soling below tee joint	0.25	0.25	1.2	sqm	0.25
	b) cc around pipe (out side dimension 25cmx 25cm)				cum	
	c) Flatform (.3 x .3m) (l) flat soling	0.6	0.6	0.075	sqm	1.44
	(2) cc (1:3:6) 7.5 mm thick	0.6	0.6	0.15	cum	0.11
	d) brick work (1.6) 12.5mm wide	1.8			sqm	1.08
	e) Plastering (1:2) with NCF				sqm	2.5
06	Construction of air vent structure					
	a) Flat soling below tee joint	0.255	0.25	1.2	sqm	0.25
	b) cc around pipe (outside dimension (25cm x 25cm)				cum	0.27
	c) double layer FI wire netting at the top			1.33	nos	5

	d) Painting air vent pipes with synthetic enamel				sqm	3.13
	e) Plastering (1.2) with NCF				sqm	1.50
07	Supplying, fixing outlet valve				nos	4
08	Construction of Pump stand					
	a) Flat soling	Dia = .09m		0.075	sqm	064
	b) 33 (1:3:6)	Dia = .09m		0.15		
	c) cc pipe, dia =.60m, 5mm thick			3.3		
	d) making stepping with MS angle (.38mm x .3mm) and MS bar dia 19.06mm					
9	Construction of outlet value					
	a) Supplying, fixing 3000mm dia 3mmthick plate				nos	1
	b) Picing 150mm thick, 400mm dia cc (l :3:6) at the end				cum	0.02
10	Back filling					
	a) Main trench	200	0.7	0.6	cum	84
	b) Trench of pump stand	Dia = .90m		0.9	cum	0.57
	Total				cum	84.57
11	Connection between pump and pump stand					
	a) PVC pipe with socket and necessary fittings, water grade 100 mm dia	5			rm	5
12	Commissioning the pipe line with necessary fuel and oil				nos	1

Buried pipe

As underground pipeline water distribution system consists of buried pipes and some allied structures for the efficient functioning of the system. The use of this system is usually limited to areas irrigated by wells using pumps. With pumps, the necessary pressure head to operate the underground distribution system can be obtained with very little extra power. Some important components of a typical buried pipe system are: Pump stand, Conveying pipe line, Riser pipe, Delivery valve, Outlet platform, Air vent, End plug.

Cost of construction

The cost construction of improved earthen canal, pre-cast canal and buried pipe systems includes (i) labour cost and (ii) material cost. The cost of construction material and labour vary widely from place to place and from year to year. These costs were estimated according to present market prices. The construction cost reduces greatly at a place where suitable materials are available at or near the irrigation field.

Irrigation cost

Irrigation cost of improved earthen canal, pre-cast canal and buried pipe systems includes (i) fixed cost and (ii) variable cost. The serviceable life for improved earthen canal, pre-cast canal and buried pipe systems were considered 1.5 years, 15 years and 50 years respectively. To calculate variable cost electric bill and driver's honorarium were considered.

Cost of different types of canals

To determine the cost of construction of per-cast canal, the cost of earthwork and cost of making slabs were considered. The cost for construction of 200 m long canal was calculated. The cost of materials was done on the basis of present market price. The cost of construction of improved earthen canal, pre-cast canal and buried pipe systems includes (i) Labour cost and (ii) Material cost. The cost of construction material and labour vary widely from place to place and from year to year. These costs were also estimated according to present market prices. The construction cost reduces greatly at a place where suitable materials are available at or near the irrigation field. Thus, the costs for construction of different types of canals were compared.

Results and Discussion

Irrigation water supplies to the field without losses or even negligible losses at lower initial costs are always preferable from the view point of economic consideration. Proper utilization of canal for the whole year without damage is also an important factor to the farmers of developing countries. Hence, to minimize initial costs and water losses and to have efficient water distribution system at farm level, the feasibility and suitability of earthen canal, pre-cast canal and buried pipe system were experimented.

Cost analysis

The detailed breakups of costs for the construction of different canals are shown in Tables 2, 3 and 4. The total cost of the construction of improved earthen canal, pre-cast canal and buried pipe were found to be Tk. 8770, Tk. 39100 and Tk. 118049, for 200 running meter, respectively. The comparisons of costs are presented in Figure 8. But considering the irrigation cost (fixed cost and variable cost) under different canals as given in Table 5 and 6, the maximum cost was observed for improved earthen canal and minimum for buried pipe distribution system. The fixed costs of improved earthen canal, pre-cast canal and buried pipe system were found to be Tk. 5847, Tk. 2573 and Tk. 2361 per year. The variable costs of these canals were found to be T k. 4625, Tk. 3129 and Tk. 2237 per hec respectively.

Table 2: Detail breakup cost for the construction of improved earthen canal

Name of item	Design Capacity(l/s)	Description of works	Unit of work	Rate of work (Tk)	Amount of work (m)	Total Cost (Tk)
Improved earthen canal	14	i) Preparation of map showing command area ii) Construction of canal	Running meter	43.85/-	200	8770

Table 3: Detail breakup cost for the construction of pre-cast canal

Name of item	Design Capacity(l/s)	Description of works	Unit of work	Rate of work (Tk)	Amount of work (m)	Total Cost (Tk)
Pre-cast canal	14	i) Preparation of map showing command area ii) Construction of canal	Running meter	285.5/-	200	57100

Table 4: Detail breakup cost for the construction of buried pipe

Item No.	Description of work Item No.	Unite of rate	Quantity	Rate (Tk.)	Cost (Tk.)
01	Earth work in excavation				
	a). Foundation trench				
	b). Under pipe e joints				
	c). Under tree bend etc				
	d). Trench for pump stand				
	Total	Cum	132.47	85/-	10597.6
02	Sand filling				
	a) Foundation trench				
	b). Under pipe e joints				
	c). Under tree bend etc				
	d). Trench for pump stand				
	Total	Cum	23.88	450	10746
03	Sand filling				
	a). Main line				
	b). Air vent pipe				
	c). Rise pipe (.9+.15+.3)				
	Total	rm	215	185	39775
04	Jointing pipe				
	a) Mortar (1:3:6) bonded single flatsoling	sqm	10.45	250	2612.5
	b) cc (1:3:6) at the pipe side along length	cum	10.43	4350	14080.5
	c) Braiding in cement slurry, cc mortar (l :3), Jute, bandage etc	nos	120	35	4200

	Total		120	174.10	20893.0
05	Construction of outlet structure				
	a) Flat soling below tee joint	sqm	0.25	220	55
	b) cc around pipe (outside dimension 25cmx 25cm)	cum	0.22	4350	957
	c) Flatform (.3 x .3m) (l) flat soling	sqm	1.44	220	478.5
	(2) cc (1:3:6) 7.5 mm thick	cum	0.11	4350	478.5
	d) brick work (1.6) 12.5mm wide	sqm	1.08	450	486
	e) Plastering (1:2) with NCF	sqm	2.5	140	350
	Cost per outlet structure each		4	660.425	2643.3
06	Construction of air vent structure				
	a) Flat soling below tee joint	sqm			
	b) cc around pipe (outside dimension (25cm x 25cm)	cum			
	c) double layer FI wire netting at the top	nos			
	d) Painting air vent pipes with synthetic enamel	sqm			
	e) Plastering (1.2) with NCF	sqm			
	Average cost per air vent structure	Each	5	714.36	3571.8
07	Supplying, fixing outlet valve	nos	4	1800	7200
08	Construction of Pump stand				
	a) Flat soling	sqm	0.64	220	140.80
	b) 33 (1:3:6)	sqm	0.1	4350	435
	c) cc pipe, dia =.60m, 5mm thick	rm	3.3	1500	4950
	d) making stepping with MS angle (.38mm x .3mm) and MS bar dia 19.06mm	nos	2	1250	2500
	Total cost for structure	each	1	8025.8	8025.8
9	Construction of outlet value				
	a) Supplying, fixing 3000mm dia 3mmthick plate	nos	1	500	500
	b) Picing 150mm thick, 400mm dia cc (l :3:6) at the end	cum	1	4350	4350
	Total	each	1	4850	4850
10	Back filling				
	a) Main trench	cum	84	65	5460
	b) Trench of pump stand	cum	0.57	65	37.05
	Total	cum	84.57	65	5497.05
11	Connection between pump and pump stand				
	a) PVC pipe with socket and necessary fittings, water grade 100 mm dia	rm	5	650	3250
12	Commissioning the pipe line with necessary fuel and oil	nos	1	1000	1000
Total cost					118049.55

Table 5: Irrigation cost (fixed cost)

Sl.N0	Canal condition	Construction cost (Tk.)	Serviceable life (year)	Scrap Value (Tk.)	Cost/year (Tk.)
1	Improved earthen canal	8770	1.5	500	5847
2	Pre-cast canal	57100	15	900	3807
3	Buried pipe system	118049	50	1700	2361

Table 6: Irrigation cost (variable cost)

Sl.N0	Canal condition	Total cost (Tk.)	Command area (hec.)	Rate of irrigation Cost(Tk./hec)
1	Improved earthen canal	18112	3.22	5625
2	Pre-cast canal	14393	4.6	3129
3	Buried pipe system	13709	6.13	2237

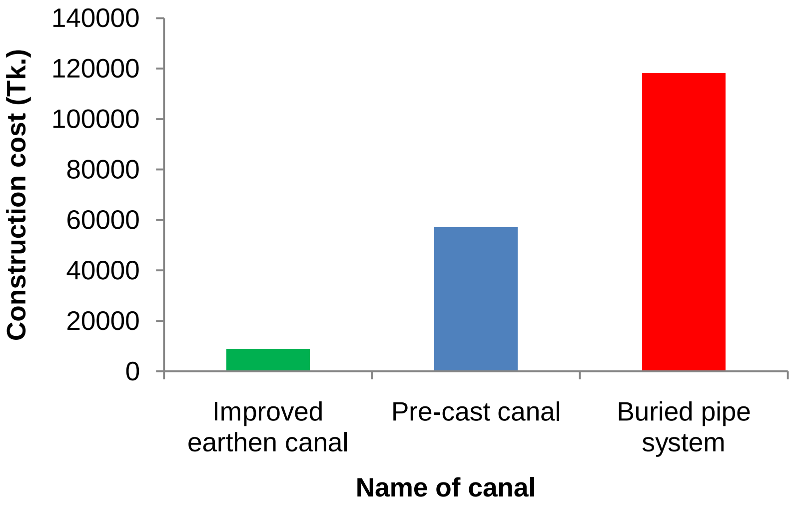

Figure 8: Comparison cost of different canals

Command area Development

Command area under improved earthen canal

Assumed, (Michael, A.M. 1987)
Highest evapotranspiration during Boro season = 4.5 mm/day, Crop coefficient = 1.25, Discharge of pump= 141/s, Running time of irrigation pump = 18hr/day, Field efficiency = 40%, Conveyance efficiency = 50%

Net irrigation requirement $= \frac{(45 \times 1.25)}{(0.50 \times 0.40)}$ = 28.12 mm = 0.0281 m

Total discharge of irrigation pump per day $= \frac{14 \times 60 \times 18}{1000}$ = 907.2 m

Estimated command area, CA $= \frac{907.2}{0.0281}$ = 32284.6 m^2 = 3.22 hec

Command area under pre-cast canal

Assumed, (Michael, A.M. 1987)
Highest evapotranspiration during Boro season = 4.5 mm/day, Crop coefficient = 1.25, Discharge of pump= 141/s, Running time of irrigation pump = 18hr/day, Field efficiency = 40%, Conveyance efficiency = 72%

Net irrigation requirement $= \frac{(45 \times 1.25)}{(0.72 \times 0.40)}$ = 19.53 mm = 0.0195 m

Total discharge of irrigation pump per day $= \frac{14 \times 60 \times 18}{1000}$ = 907.2 m

Estimated command area, CA $= \frac{907.2}{0.0195}$ = 46523.07 m^2 = 4.6 hec

Command area under pre-cast canal

Assumed, (Michael, A.M. 1987)
Highest evapotranspiration during Boro season = 4.5 mm/day, Crop coefficient = 1.25, Discharge of pump= 141/s, Running time of irrigation pump = 18hr/day, Field efficiency 40%, Conveyance efficiency = 95%

Net irrigation requirement $= \frac{(45 \times 1.25)}{(0.95 \times 0.40)}$ = 14.80 mm = 0.0148 m

Total discharge of irrigation pump per day $= \frac{14 \times 60 \times 18}{1000}$ = 907.2 m

Estimated command area, CA $= \frac{907.2}{0.0148}$ = 64340.4 m^2 = 6.13hec

Comparison of command area development in different canals

The cultivable command area of shallow tube well under improved earthen canal, pre-cast canal and buried pip distribution systems were 3.22 hec, 4.6 hec and 6.13hec respectively. It was observed that command area may be increased by saving canal water without any extra costs.

The command area development by pre-cast canal over the improved earthen canal was 43% and buried pipe distribution systems was 187% respectively. The total area covered by canals increased after pre-cast canal and buried pipe distribution system. Irrigation of this extra land reduces the production cost. Information on command area development by different canal is shown in Table 5.

Table 5: Information on command area development by different canals

Item	command area (hec)	Developing command area over improved earthen canal (%)
Improved earthen canal	3.22	
Pre-cast canal	4.60	43%
Buried pipe	6.13	187%

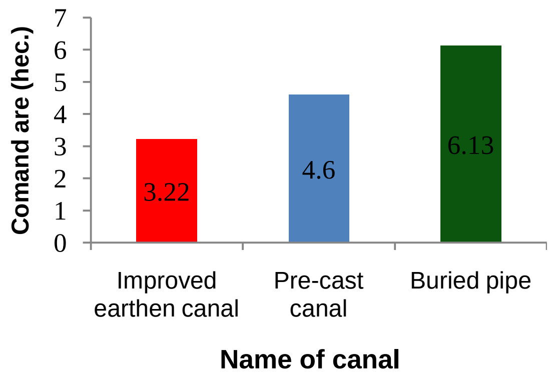

Figure 9: Comparison of comand area in different canal

Comparison of different canals

Although initial cost of earthen canal is low and is performed with unskilled labour, it is considered as temporary structure. On the other hand, in order to construct pre-cast canal and buried pipe needs skilled labour. If properly constructed and maintained, the serviceable life of pre-cast canal may be expected to the 15 years. Pre-cast canal is structurally strong enough to resist external forces like walking animals, earth or hydrostatic pressure. Buried pipe distribution system can be preferred over open canal where poorly cohesive soils would result in high seepage losses or for variation in ground level irrigable land can not be reached by an open canal when water is valuable in terms of crops and limitation of water resource. If it is properly constructed maintained, the serviceable life of buried pipe system may be expected to be 50 years or more. Considering above points it was observed that the water distribution pattern through buried pipe system was superior to these of conventional irrigation systems for economic aspect, loss reduction and command area development.

Conclusion

The construction costs of improved earthen canal, pre-cast canal and buried pipe system were Tk. 43.85, Tk. 285.50 and Tk. 590.25 per running meter respectively. The command area of a shallow tube-well under improved earthen canal, pre-cast canal and buried pipe distribution system were found to be 3.22 ha, 4.6 ha and 6.13 ha respectively. In this study, the percentage of increased land for pre-cast canal and buried pipe system were 43% and 187% respectively. Thus, command area can be increased by providing pre-cast canal and buried pipe distribution system. Considering loss and cost Buried pipe system should be given emphasis to use for irrigation.

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