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Research Article

Modification of Risers in Buried Pipe Irrigation System to Improve their Performance

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ABSTRACT

This study identified the problems associated with the design, construction, operation, and maintenance of risers in buried pipe irrigation systems and proposed a modified design. The problems of buried pipe irrigation systems were assessed by inspecting three deep tube wells (DTWs) supplying water through buried pipes with twenty-five outlets. One DTW of the Bangladesh Agricultural Development Corporation (BADC) with five outlets in Netrokona, and one with fifteen outlets in Bara Kailati village and one with five outlets in Bali Bazar, both in Netrokona Sadar, were selected. Data were collected from farmers, field staff, and management authorities by employing pretested questionnaires and field investigations. Site visits revealed that the primary problems were the water leakage through outlets and cracks in the riser structure around the outlet. These problems were due to unsuitable outlet design of the buried pipe system. To overcome these problems, the riser design has been modified structurally, that may lead the buried pipe to suitable and durable performance of buried pipe irrigation system and reduce water losses.

Introduction

In Bangladesh, managing agricultural water is crucial to maximizing agricultural output (Basak, 2020). Different irrigation water distribution systems are available to transport water from the supply source to the crop fields. These are surface channels (such as those lined with ferrocement, brick, or dirt) and underground (buried) pipelines. There is significantly high conveyance loss of irrigation water within the system of surface channels (Hossain, 2019). Conveyance losses of lined canals ranged from 1.08 to 8.3% and that of unlined canals varied from 12.5 to 40% due to their improper design, poor management, rodent holes, insufficient channel bed slope, over topping the bank, etc. The conveyances loss was 2.8 to 9.5% in PVC and plastic pipe whereas in earthen channel it varied from 30 to 33% in silty-clay loam soil (Hossain et al., 2014; Maniruzzaman et al., 2002). Now-a-days, buried pipe serves numerous purposes particularly for irrigation systems. There is hardly any conveyance and evaporation loss, no agricultural land is misused and its maintenance cost is very low compared to the surface channel and it is more durable (Hossain, 2019). Nearly all of the conveyance losses anticipated with open channel delivery systems are mitigated with pipeline delivery systems. An effective substitute for open channel distributors in surface irrigation applications is low pressure buried pipe distribution system (Osman et al., 2016). The main benefits of underground pipe line irrigation systems are the reduction of water and land usages, the elimination of seepage losses, and the comparatively low maintenance costs (Radhakrishna and Ravikumar, 2016). The most common form of the buried pipe water distribution system found in Bangladesh is a closed low pressure system with a branching pipe layout. Non-reinforced Cement Concrete (CC) pipes and uPVC pipes are mostly used in Bangladesh. The pipeline is buried, the only above ground structures are inlet structures at the head of the pipe system, outlets and air vents for the control of pressure fluctuations along the pipeline (Rahman et al., 2011). Small to medium-sized farms could benefit from the use of non-reinforced

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concrete pipes because they are less expensive than reinforced pipes (Rakitin et al., 2017). Cement concrete pipes are not as pressure-tolerant as reinforced concrete pipes. 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 CC pipe, have been installed. Most of these CC systems experience problems with leakage from both the pipe joints and pipe bodies, cracks and faulty design in the risers. The objectives of this study were to identify the problems of the risers of the buried pipe irrigation system and to modify their design to overcome the problems.

Materials and Methods

Problems identification

The study was performed at three different irrigated rice-based areas of Netrokona Sadar Upazilla under Netrokona district in Mymensingh division. Several field visits were done to identify problems with the buried pipe irrigation system. Data was collected through interviewing farmers, field staff, and management authority. The major problems with buried pipe were encountered at risers. Some other problems with the buried pipe system found during the field visit were discussed later in the results and discussion section.

Modification of riser

To improve the performance and increase the effectiveness, riser modification was made. The following points were taken into consideration for designing the proposed riser modification for buried pipe system: the riser design should be simple in construction, it should be made with locally available materials with simple technology, different parts of the riser should be as simple as possible so that it can be made in local workshop and it should be easy to maintain. The materials used for the construction of riser were uPVC pipe (4" diameter × 1), door tee (4" diameter × 1), cross tee (4" diameter × 1), door cap (4" diameter × 3), socket (4"diameter × 3), brick, cement, sand, khoa, water, wood, polyethylene, GI wire, gum solution and strainer.

The dimensions chosen for the different elements of the riser were specifically selected to demonstrate modifications and adjustments in these elements, as well as the revised positions achieved through the development of the modification. It is essential to emphasize that, in field situations, the sizes of these elements can be modified based on specific requirements or conditions.

Installation procedure of riser buried pipe

For construction of a riser, a suitable space beside the Concrete and Material Testing Laboratory of Farm Structure and Environmental Engineering Department, Faculty of Agricultural Engineering & Technology, Bangladesh Agricultural University was selected. To install the riser base, the soil was excavated and thoroughly compacted with a tamper. Various components of riser of uPVC pipes were attached using sockets and gum solution. An air vent with strainer mounted on top (Figure 1b), two outlets (Figure 1a) and the final pipe setup are shown in Figure 1c.

(a) (b) (c)

Figure 1. (a) Two outlets with cap, (b) air vent with strainer, and (c) final joints of uPVC pipes

After properly checking all the joints, the riser was ready to be installed. The center of the pipe was also checked with a plumb bob. A concrete cover was made around the (main) buried pipe to protect the pipe from cracking and damage.

The buried pipe was covered with soil, which was compacted (Figure 2a). A trowel was used to completely level the surface and a 3-inch brick soling was built on it (Figure 2b). Rods were distributed and tied for casting for making a reinforced cement concrete (RCC) riser (Figure 2c). A 4-inch thick base was cast over the soling (Figure 2d).

(a)

(b)

(c)

(d)

Figure 2. (a) Covering the main pipe with soil, (b) brick soling, (c) reinforcement distribution, and (d) casting of riser base

In accordance with the modification, the timber formwork for casting the riser was accurately executed. This was followed by the construction of an RCC wall structure surrounding the outlet with incorporation of an air vent (Figure 3). Cement grouting was applied, and the structure was subsequently subject to frequent watering (3-4 times per day) for 28 days to facilitate curing.

Figure 3. Final structure of modified buried pipe riser with attached air vent

Results and Discussion

Five major problems of the buried pipe water distribution system were identified.

Water leakage due to defect in outlet

One major challenge associated with buried pipes is their outlet design. It was observed that rust compromises the efficiency of valve lids and threads (Figure 4a), leading to poor sealing of the outlet and resultant leakage. This flaw results in significant water loss (Figure 4b).


(a)


(b)

Figure 4. (a) Rust in outlet patches, and (b) water losses through outlet

Cracks in the underground/buried pipe

Currently, BADC in the Netrokona region utilizes uPVC pipes as the buried pipe, typically placed at depths ranging from 90 to110 mm. Upon discussions with field staff, it has become evident that one of the problems encountered during land cultivation is the cracking of buried pipes due to the weight of tractors or other loads (Figure 5). These cracks lead to leakage, subsequently escalating water loss and pumping expenses.

Figure 5. Cracks in the pipe below the ground

Problems with air vent

Buried pipelines are vulnerable to pressure restrictions; there should be plenty of room for air to escape as water fills the pipes (Woudt, 1959). CC pipes are commonly used as air vents without lids, making them accessible targets for young children in the village who unknowingly block them with stones, bricks, and other materials. This leads to clogs that prevent proper air release. Occasionally, concrete air vents break, further disrupting the operation of buried pipes (Figure 6). Moreover, when uPVC pipes are used for the buried pipeline and concrete pipes for air vents, connecting the air vent to the buried pipe becomes problematic. This mismatch results in leakage at the joint after one year of service, causing operational issues.

Figure 6. An air vent made of concrete is broken

Cracks in the structure around the outlet

Masonry structures are commonly employed around the outlet, but they tend to develop cracks more easily than RCC concrete, particularly when there is erosion or settlement of the surrounding soil (Figure 7). Consequently, during irrigation, water leaks through these cracks, resulting in substantial water loss.

Figure 7. Cracks in the CC structure around the outlet

Missing part of outlet

Many times, the lid of the outlet is stolen due to lack of proper security. Consequently, often a bag with sand is used as a lid of outlet (Figure 8). But this is not a very effective measure.

Figure 8. A bag with sand is used as a lid of outlet

To address the problems of outlet, the riser design of the buried pipe has been modified. A riser was designed with two symmetrical outlets with an air vent at the center. One outlet was left unconstructed to demonstrate the concrete covering of the buried pipe and the distribution of reinforcement. This is expected to improve performance of the buried pipes. The design features of the modified riser are elaborated in the next sections

Changes in outlet design

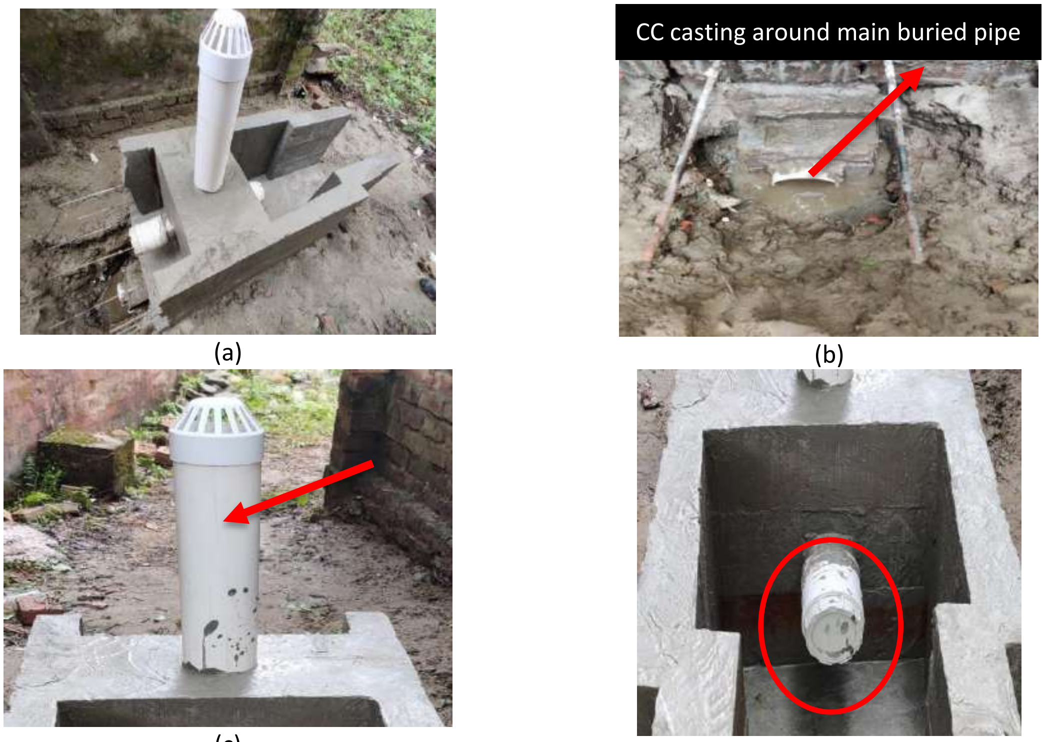
In the modified riser design, uPVC pipes serve as both the riser pipeline and outlets, effectively eliminating the risk of rust. The riser pipeline is securely integrated with the concrete structure, and two outlets extend from it, each permanently connected via a cross Tee joint. Moreover, this setup allows for the use of either one or both lines simultaneously for irrigation, potentially enhancing the efficiency of the buried pipe system (Figure 9a).

CC covering around buried pipe: A CC castinging was employed around the buried pipe to enhance its resistance to cracking and impact damage, thereby ensuring its effectiveness for buried pipe lines (Figure 9b).

Air vent repositioning: The air vent, integrated with the riser pipeline, requires no additional space and has a reduced risk of damage. It includes a strainer, effectively blocking entry of foreign materials (Figure 9c).

RCC outlet structure: In reinforcement contrete structure construction, steel is embedded in reinforced concrete. Properly designed and constructed RCC structures are resistant to major cracks. So, for overcoming the problem of cracks in outlet structure, using RCC is the best solution (Figure 9a).

Measures to prevent theft of riser lid: The proposed modification for riser outlets in buried pipe systems features a securely fitted thread joint lid that remains attached to the outlet via metal chains. This design minimizes the chances of leakage and theft of the valve lid (Figure 9d).



(a) (b) (c) (d)

Figure 9. (a) Modified RCC riser outlet, (b) buried pipe within CC structure, (c) newly positioned air vent with strainer, and (d) securely fitted thread joint lid that remains attached to the outlet via metal chains

The major problems in the buried pipe system, such as leakage, cracks, and air vent joint issues are expected to be mitigated by the modified riser design. Additionally, the modified riser design of the buried pipe irrigation system will reduce energy consumption by enabling more efficient water distribution. The durability of the riser will also be enhanced, thereby extending its lifespan and reducing maintenance costs through the use of upgraded materials and construction techniques. Therefore, the modified riser design could be adopted at the field level.

Conclusion

The major problems of buried pipe irrigation water distribution system in three upazilas of Netrokona district are leakage in outlet, faulty outlet valves, unsatisfactory jointing methods, cracks in CC structure and buried pipe, breakdown of air vent, and theft of various parts. To improve the performance of the outlet, the design of risers has been modified structurally with a view to enhancing the durability and performance of the system. The major drawback of the study is that the performance of the modified riser was not tested in practical field application. Further research and upgradation of buried pipe riser design is needed to cost effective implementation and evaluation of the modified riser in farmers' field.

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Competing interests

The authors have declared that no competing interests exist.

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