IMPROVEMENT OF STORM WATER DRAINAGE SYSTEM IN THE BUSIEST AREAS OF KHULNA CITY: CONSTRUCTION PROCESS AND PROGRESS

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ABSTRACT

The construction of an urban drainage system in Khulna city is very important, as there is a risk of flooding in various parts of the city due to tidal water from neighboring rivers. Moreover, an urban drainage system is also required for the management and drainage of storm water. Currently, drainage system construction is being implemented to bring Khulna city under the drainage system. However, the construction of drains in different areas is facing various challenges. In this paper, the step-by-step drain construction process in Khulna and the challenges related to the u-drain construction process, socio-economic factors, and environmental considerations will be discussed and analyzed in light of practical experience. Some of these challenges are unique and exceptional. All these challenges have been identified through regular site monitoring and investigation. The objective of this paper is to highlight the construction process of urban drainage systems to junior engineers and undergrad students who are interested in developing their careers in this field. The main findings from this paper are the step-by-step drain construction procedure at Khulna city, project implementation delays resulting from various issues, pollution of the surrounding environment due to the drain construction process, design considerations and socio-economic factors affecting the drain construction process. This paper will be beneficial in the future implementation of urban storm water drainage system construction in other cities, including Khulna, by overcoming the challenges identified in this paper or coordinating them in the case of some unique challenges.

Keywords**:** *Drainage system, construction process, construction progress, construction challenges, storm water drain, urban drain*

1. INTRODUCTION

Drainage is a crucial component of different environments or regions (e.g. urban, rural, forest, and agricultural etc.) to eliminate excess water volume which may cause flash flood (Parkinson, 2003; Mcdonough and Braungart, 2010). It is the process of removing unnecessary or undesired water from any surface or subsurface region, either naturally or artificially (Coterell, 1980; Alberta Environment, 1999). The majority of road drainage systems in rural regions are intended to divert water into ditches beside highways. These drainage systems are vulnerable to erosion, which can lead to sedimentation issues in adjacent bodies of water. (Pidwirny, 2006). The urban environment is denser and more congested compared to other places. To remove excess water volume from metropolitan areas, a strategically designed and spacious drainage system is also required (APWA, 1976; Ahmed & Islam, 2014). During periods of intense rainfall and natural disasters, a poor or insufficient drainage system obstructs normal water movement, causing water logging and flash floods. The ignorence dumping of solid wastes in to the drains offen clog the flow (Bari & Alamgir 2011). Therefore, a suitable drainage system is essential for a secure and long-lasting urban environment (Kirby & Laurson, 1932).

Khulna city is known as the third-largest city of Bangladesh, situated in the south-western part at 22°49′0″N and 89°33′0″E. Khulna is a rapidly growing urban centre facing numerous challenges related to urbanization and climate change. Effective storm water management is essential to prevent flooding, property damage, and health risks in the city. U-drains are a common infrastructure component in urban drainage systems, designed to channel storm water and wastewater away from populated areas. However, the construction of U-drains can be hampered by a variety of problems that impede successful implementation. Rainwater in Khulna city first passes through the existing and newly constructed drains, then falls into the river through canals. First the various canals of Khulna city like Taltala canal, Saheb Khali canal, Khetrakhali canal, canal adjacent to nursing institute, canal adjacent to truck terminal, Mayur river etc. act as primary outlets and later Rupsha and Bhairab rivers act as final outlets. Existing drainage systems are being used in busy areas of Khulna city to save Khulna city from flooding caused by rain water accumulated on the roads and tidal water from nearby rivers and new drains are being created by breaking the dysfunctional drains. Existing and previous drainage systems are proved to be inefficient due to inappropriate slope and cross sectional area. Previous drainage systems became non-functional due to solid waste disposal in the drain which is shown in Figure 1 (a) and Figure 1 (b).

Figure 1(a): Previous drainage system became stagnant due to solid waste disposal.

Figure 1 (b): Previous brick drain with ineffective slope and inadequate cross sectional area.

At present RCC drain, brick drain, surface drain are being constructed for rain water drainage in Khulna city. In the construction of these types of drains, the construction work has to be carried out step by step according to the design.

However, there are several challenges that stand in the way of successfully implementing a sustainable urban stormwater solution in countries with limited resources. (Silveira *et al.*, 2001; Silveira and Goldenfum, 2004). Urban drainage management measures cover a wide range of issues, including architectural design, legal and economic issues, and technical engineering solutions. To ensure that the chosen actions provide the anticipated effects, each of these issues must be taken into account in together with the others. The climate and socioeconomic circumstances of emerging nations make it challenging to apply solutions developed in temperate regions. (Silveira *et al.*, 2001). New construction of drain is easier than re-construction of old drain in terms of waste generation. In any re-construction process a large amount of demolition wastes generates compared to construction wastes (Saifullah et. al. 2009; Hasan et. al. 2011; Hassan et. al. 2015).

This paper will describe each step of drain construction which will be helpful for junior engineers to work on drain construction sites in future. This paper can be used as a proof document for the construction of drains in any city in future. Moreover, in the construction of drains, the various challenges that have to be faced, all the challenges will be identified in this paper and the ways to solve the challenges will be described.

2. METHODOLOGY

Methodology followed on this paper is to study previous research works mostly are mentioned in the introduction section for comparison. Previous research works are then explored and drawn some conclusions from this studies which have been added to this paper. Types of drains are discussed in the following section. Different classification of drains in Khulna are applied in the previous era are described in article 3.2

At least 30 drain construction sites were observed and regularly monitored in every step as a part of the methodology of this paper. During inspection of those sites, the construction procedure of every step including site clearance, lay out, base preparation, wall preparation and top slab preparation was observed and recorded.

Challenges including land acquisition, disruption of livelihood, limited community engagement, water pollution during the implementation phases were observed and noted through regular site monitoring. Then the solution to those problems have been analyzed with the help of senior engineers and consultants.

3. OBSERVATION AND DISCUSSTION

A drainage system acts as a conduit for superfluous rainfall, which would otherwise overflow low-lying regions and result in serious issues, such as property damage and even fatalities. It further offers a conduit for treated wastewater, storm water runoff, stream canalization, etc.

U drain can be defined as a storm water drain which is u shaped and is a type of drainage system used to transport rainfall runoff. Hazardous wastes and sewage are not intended uses for it. Runoff is transported by open ditches or subterranean pipelines, where it is released untreated into nearby rivers, streams, and other bodies of surface water.

3.1 Types of Drains

Surface Drain: Surface drainage systems use ditches or channels to remove excess water from the surface of the ground. The ground surface may occasionally be graded or formed to provide slope towards the channels. Levees, grassed streams, humps and hollows, and open drains are a few examples of surface drainage systems. An excellent illustration of a surface drainage system is a cast-in-place trench drain.

Subsurface Drain: Systems for subsurface drainage are put in place below the top layer of soil. They eliminate extra water at the root level and are sometimes called French drains.

Slope Drain: Water can drain from a structure in a downhill direction with the help of slope drainage systems. It is constructed through a u-shaped RCCC drain or with the help of pipes that lower the slope. The installed pipe or RCC u-shaped drain directs water through the pipe and quickly removes it from the structure since it is fixed to an inclination.

Downspouts and gutter system: The first line of protection for a building against stormwater oversaturation is its gutter and downspout systems. They are frequently drained into a rain bucket, underground drainpipe, aluminium extension, or another container. The idea is to divert water and direct it into other sidewalk or street drainage systems. Gutter drains or "underground drains" are occasionally even used to link them to an underground sewage pipe.

3.2 Types for Khulna

There are two type of drain in Khulna city based on covering:

- Open Drain: Open drains are normally bigger size drains. These drains are of rectangular or trapezoidal cross section usually.
- Closed Drain: The opening size of closed drains normally varies from 400 mm to 2 m. These drains are of rectangular cross section.

There are two type of drain in Khulna city based on construction material:

- Brick Drain: Brick drains normally act as primary drain in Khulna city. These drains have relatively smaller rectangular cross section.
- RCC Drain: RCC drains have larger cross section. These drains have rectangular or trapezoidal cross sesction.

There are two type of drain in Khulna city based on the shape of cross section:

- Rectangular Drain: These drains have rectangular cross section. Rectangular drains have normally larger cross section.
- Trapezoidal Drain: These drains are of trapezoidal cross sectional area. Normally there are no cover slabs upon the trapezoidal drains. In some cases, they have brick retaining walls on both sides.

3.3 Process Applied in Drain Construction at Khulna

3.3.1 Site Clearance and Lay out

Site clearance: Complexities related to land ownership are resolved with the help of state officer of the Local Government Department and a Ward Councillors and local residents. Then the place is identified and demarcated.

Lay out of the site: The proposed location is marked before the start of the drain work. The marking is done through the marking of points according to the design. After the lay-out, the construction firm stockpiles their materials at the site.

3.3.2 Foundation Bed Preparation

Earth excavation: Generally, the earth cutting is started after providing the layout of the drain. If there are any old walls or any other obstructions in the proposed area while cutting the soil, they are removed. The soil is excavated according to the recommended depth. The excavated soil is removed from the site by usually excavators. Palasiding is done for earth support if required to prevent them from the side falling.

Sand filling and compaction application on the drain bed: Sand filling is done after cutting the soil, as the Khulna soil shows clayey characteristics with very low BC, under the drain up to the design level. Compaction is done on the bed sand filling to achieve proper bed compaction. Compaction is usually done by applying the required water. Other measures are adopted as per requirements, like roller movement, hand compactors, etc. The compaction test is done by the DCP test to ensure the required bed compaction. A polythene sheet is laid on top of compacted sand filling to prevent the leakage of water and to separate the concrete of the drain bed from the sand filling portion.

CC casting: At first, formwork is prepared for cement concrete (CC) casting. CC casting is done according to 1:3:6 proportions. During the excavation and casting, a proper slope of 2.5% to 3% is maintained. For example, the range is 25 mm to 30 mm per 1 m. The slope of the drain is corrected for the regular design flow. CC casting of the drain bed at the site is shown in Fgure 2 (b).

Plastering work: In the case of a brick drain, brickwork is done first by bricks. Then plastering is done using cement mortar with cement and sand, and the ratio between them is usually 1:1.

Reinforcement placement: After CC casting, a reinforcement bar is provided at the drain bed. Reinforcement bars are tied as per design. GI wire is generally used for reinforcement bar ends. Welding may be used in special cases. The spacing of main and binder rebar usually varies from 100 mm to 200 mm, depending on the structural design and estimate.

Clear cover and formwork: Formwork is done for base casting. Formwork is done using wood or steel. Blocks of the proper size as per design are used to fix the clear cover of the reinforcement bar from the bottom. A clear cover at the sides and bottom is ensured before casting. During casting, the upper clear cover of the bed is maintained by using a rebar chair and cc block normally.

Bed cleaning before casting: If there is any dirt or mud in the drain bed, it is removed, and the bed is cleaned and made suitable for casting.

RCC base casting: The drain base is prepared for casting by providing formwork and proper rebar binding. Preparation of wooden formworks for drain bed casting is shown in Figure 2(a). RCC base casting is done according to the ratio of 1:1.5:3 on CC casting. Fresh concrete is prepared in the proper proportion of material as per design. Materials used for casting are PCC CEM II A-M cement, fine aggregate, coarse aggregate, and water. The w/c ratio is normally 0.4, according to the structural design. Bases are cast according to the specified level to maintain the slope of the drain. RCC drain base casting at the site is shown in Figure 2 (c). Water stoppers are installed as construction joints at the beginning and end of welding to prevent water leaks. Usually, electric concrete shakers are used to remove the honeycomb. Normally, a 12 mm steel reinforcement bar is used as the main bar for the drain base, and a 10 mm or 12 mm steel reinforcement bar is used as the binder or distribution bar for the drain base, depending on the design and load condition. Normally, 420-grade rebar is used for the drain construction.

For road crossing structures, usually a 16-metre steel reinforcement bar is used as the main bar, and a 10- or 12-metre steel reinforcement bar is used as the binder or distribution bar for the drain base, depending on the design and load condition.

Figure 2 (a): Wooden formworks are being prepared for drain bed casting.

Figure 2(b): CC casting of drain bed is on progress at site.

Figure 2 (c): RCC drain base casting is ongoing at site.

3.3.3 RCC Wall preparation

Vertical wall reinforcement: At the time of base casting, the main reinforcement bar binding of the wall is done according to the design. Figure 4 (a) shows that rebar binding is being inspected at the site. Binder reinforcement bars are also set by design before wall casting. Normally, a 12 mm steel reinforcement bar is used as the main bar for the drain wall, and a 10 mm steel reinforcement bar is used as a binder or distribution bar for the drain wall, depending on the design and load condition. The spacing of rebar usually varies from 100 mm to 200 mm, depending on the structural design and estimate.

For road crossing structures, usually 16 mm or 20 mm steel reinforcement bar is used as the main bar, and 10 mm or 12 mm steel reinforcement bar is used as the binder or distribution bar, depending on the design and load condition. The spacing of rebar usually varies from 100 mm to 150 mm, depending on the structural design and estimate.

Vertical wall formwork: Formwork is required for wall casting. Formwork is usually made of steel. In special cases, wood can be used. Steel shutters are better than wooden ones for smooth surfaces.

Lubricants are used on the surface of the formwork to obtain a smooth surface. Figure 4 (b) presents the formwork preparation for the drain vertical wall.

Vertical wall casting: Vertical wall casting is done by casting in the correct proportions of all the elements. Clear cover and reinforcement bar placement are ensured prior to wall casting. RCC casting of the drain vertical wall at the site is shown in Figure 3 (b). Finishing surface of RCC drain vertical wall after casting at site in Figure 3 (c). Casting is done at a certain depth. Wall casting is done up to 1200 mm in height. If the height of the wall is more than 1200 mm, the wall is welded up to the specified height by formwork again. Holes are placed in the walls at regular intervals to drain the rainwater from the road. Water stoppers are used on vibrators to prevent honeycombing.

Figure 3 (a): Rebar binding is being inspected at site.

Figure 3 (b): RCC casting of drain vertical wall is on progress at site.

Figure 3 (c): Finishing surface of RCC drain vertical wall after casting at site.

3.3.4 RCC Top Slab Preparation

Formwork for slab: Formwork is done first for casting the top slab of the drain. Figure 5 (a) shows formwork and rebar binding preparation at the site for slab casting.

Reinforcement placement for slab: Reinforcement bar placement is done for the top slab on the formwork. Reinforcement is interrupted as per design, and proper clear cover is ensured. According to the estimate and design, polythene film is used to make the formwork impermeable. Normally, a 12 mm steel reinforcement bar is used as the main bar for the top slab, and a 10 mm steel reinforcement bar is used as the binder or distribution bar for the drain top slab, depending on the design and load condition.

For road crossing structures, usually 16 mm or 20 mm of steel reinforcement bar is used as the main bar, and 10 mm or 12 mm of steel reinforcement bar is used as the binder or distribution bar, depending on the design and load condition.

Top slab casting: Casting is prepared in proper proportions of all the ingredients, and RCC top slabs are cast. Vibrators are used to remove air voids and obtain smooth surfaces. RCC casting of the drain top slab and the top slab of the RCS is in progress at the site is shown in Figure 4 (a) and 4 (b). According to the design, if there is a manhole anywhere, it is placed and casted by formwork.

Curing: Curing of concrete is done after one day of casting when the concrete is fully hardened, and curing is performed for the whole curing period. The duration of curing is normally 14 to 28 days at the site. The covering method and spraying method of curing are applied to the drain wall and base. Usually, pond curing and spraying methods are applied to the drain top slab.
Removable top slab casting: The removable top slab is cast in the correct proportion after the proper placement of the reinforcement bars as per design, ensuring clear cover. RCC casting of the drain top removable slab at the site is shown in Figure 4 (c).


Figure 4 (a): RCC casting of drain top slab is on progress at site.


Figure 4 (b): RCC casting of drain top monolithic slab of road crossing structure is on progress


Figure 4 (c): RCC casting of drain top removable slab is ongoing

3.3.5 Total Finishing Work of Drain Cover

Finishing work: If the design requires manhole, parking tiles or stamp concrete over the cover slab and removable slab, then the suitable type of finishing work are placed over the slabs according to the design. Saucer drain and grating: Saucer drains are constructed if required and for this net finishing is done on CC castings. Grating is placed for wall openings to ensure the draining out of the water of the road surface easily. Bitumen fill up: All expansion or construction joints are then filled with bitumen normally.

3.3.6 Regular Maintenance Work

Cleaning Drain Bed: The drain bed is cleaned by removing the sediment and trashes from the drain bed. Side Filling: After casting of the vertical wall of a drain, the gaps of both sides of the wall are filled with sand and then the filled portion is compacted. Average duration of drain construction per kilometer of drain in both side of the road is nearly 2 to 3 months depending upon the cross section of the drain.
Concreting Method: Normally concrete mixer method is used for the mixing of the cement, fine aggregates, coarse aggregates. Then the freshly mixed concrete is then placed manually by laborers. After placing the concrete, mechanical vibration is used for the compaction of concrete.

4. DESIGN CONSIDERATIONS, DESIGN SECTIONS AND STANDARD

For the final design of storm water drains, there are several factors to be emphasized on the design period. The factors which are considered for the design of drains are:

- Topographic survey
- Determination of catchment area
- Rainfall data analysis of the catchment area
- Canals and rivers which sorround that area
- Inlet and outlet selection

- Determination of the required capacity of the drain
- Determination of the size of the section
- Required slope implemented at site
- Required depth to be excavated at site

The parameters of drain design are adopted from Urban Drainage Manual (1998) of Local Government Engineering Department (LGED) which can be considered as the standard of design and construction of drains at Khulna City.

After completion of the design, a design report is then prepared. Hardcopies of the design report are then handed over to the client, consultants, and construction company. Two drain sections from the design report is shown in Figure 5.

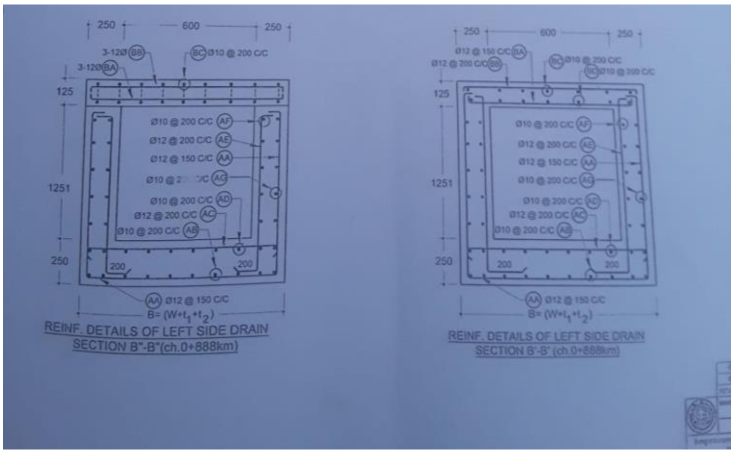

Figure 5: Drawing of drain sections from the design report.

5. CHALLENGES AND ENDORSEMENT IN DRAIN CONSTRUCTION IN KHULNA CITY

5.1 Land Acquisition

Land acquisition for drainage construction can be difficult in a number of ways, particularly in crowded urban areas. A common feature of urban area is their scarcity of available land. It can be difficult to locate enough land for U drain construction, particularly in locations with a high density of homes. Finding and negotiating with a large number of parties and property owners can be difficult and time-consuming. The resolution of property ownership conflicts and the procurement of approval might cause delays in the schedules for projects. It can be difficult to navigate the legal and regulatory frameworks pertaining to property rights, land use, and acquisition. The procedure may become more difficult due to many jurisdictions and local rules, necessitating close adherence to prevent legal problems. Because they fear being uprooted, having their livelihoods disrupted, and maybe having their property values negatively impacted, businesses and residents in the affected area may oppose land purchase. It can be controversial to decide what is a reasonable reimbursement for property owners. Conflicts and delays in the land purchase process may result from disagreements about compensation rates. Complexities related to land acqisition, electric poles in the area of construction, negative attitude of local people towards constructon etc cause dealy of project. The time delay of the construction of some drain with starting date and completion date at Khulna city is shown in Table 1.

A graphical representation of the time delays (days/km) of different drains in Khulna city is shown in Figure 6. From the figure, it is observed that the maximum value of time delay is for the preservation of the lake beside Yousaf School and the construction of a drain up to the outlet, and the minimum value of time delay is for the construction of a drain at Hazi Ismail Road.

Table 1: Time delay of the construction of some drain with starting date and completion date

Sl. no.	Name of the drain	Drain length (km)	Starting date	Estimated completion date	Actual completion date	Delay (Day)	Delay (day/km)
1	Construction of Drain including Footpath in both Side of Upper Jessore Road (from Picture Palace Mor to 1 No. Custom Ghat)	2.61	28/09/22	30/05/23	14/12/23	198	75.86
2	Construction of Drain on both side at KD Ghosh Road including Footpath (from Clay Road to Circuit House)	2.52	06/09/22	30/06/23	14/12/23	167	66.27
3	Construction of Drain at Jessore road (Mohesshwar pasha to 400 m)	1	16/11/22	20/04/23	24/06/23	65	65
4	Construction of Drain at Hazi Ismail road	1.02	16/11/22	30/04/23	26/06/23	57	55.88
5	Construction of Drain at Jamuna Road	0.62	11/10/22	20/01/23	30/04/23	100	161.30
6	Preservation of Lake beside Yousaf School and Construction of Drain upto Outlet	0.75	12/10/22	28/02/23	30/08/23	183	244

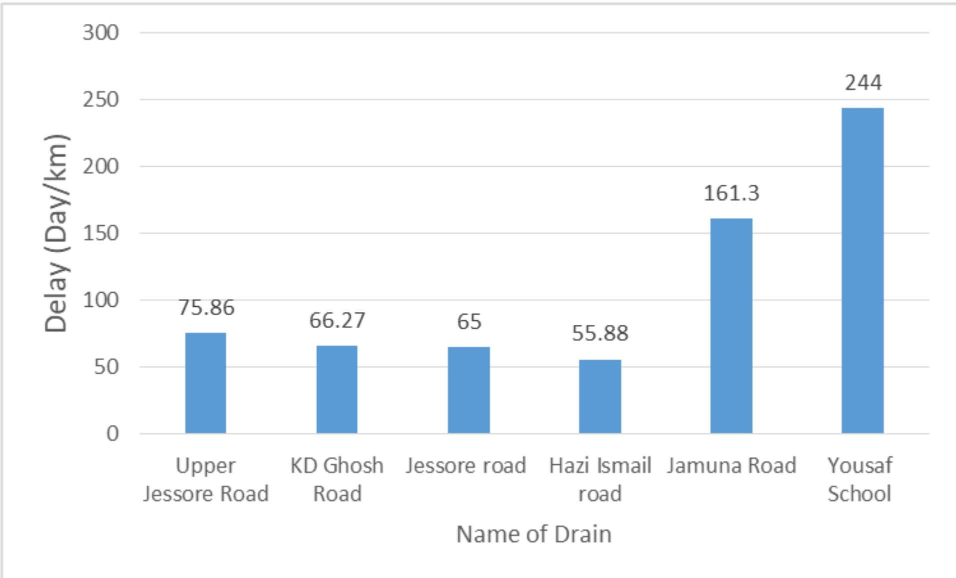

Figure 6: Time delays of different drain construction at Khulna city.

5.2 Disruption of Livelihoods

The construction of U drains in a city can indeed disrupt livelihoods, especially when the construction takes place in densely populated urban areas. U drain construction may require temporary closure or relocation of businesses, particularly if they are situated along the construction route. This can lead to financial losses for business owners and employees. Access to markets and customers can be hindered due to construction activities, impacting sales and revenue for businesses located near the construction site. Construction work can lead to road closures, diversions, and reduced accessibility. This can affect the movement of walkers, goods, customers, and employees, causing delays and inefficiencies.

Construction activities generate noise, dust, and other pollution, which can disturb the environment and disrupt the normal functioning of nearby businesses and residents. If the construction of U drains requires the use of public spaces such as sidewalks or parking areas, this can reduce available space for vendors, street vendors, and outdoor businesses. At dead end of any road, normally construction is challenging due to narrow width of the road. Usually, the dead end point of the road is considered as the inlet or the starting point of the drain.

Pedestrian foot traffic may be rerouted away from certain areas during construction, affecting businesses that rely on foot traffic for customers. Informal workers such as street vendors, waste pickers, and others who operate in public spaces may face displacement due to construction, impacting their daily income. Construction work can bring safety hazards, potentially affecting the health and safety of nearby residents and workers. This can lead to concerns and reduced comfort levels in the area. So, construction activities can disrupt local businesses and livelihoods, causing resentment among residents and affecting community support for the project.

5.3 Limited Community Engagement

Insufficient community involvement in U drain construction inside a city can result in many adverse consequences, including as misinterpretations, and less than ideal project results. Community people may not be aware of the construction project's goal or any possible effects if they are not properly engaged. Misconceptions and confusion may result from this. Construction operations may be opposed by communities not involved in the planning process because of mistrust, fear, or perceived bad effects. Delays, disputes, and even legal challenges may arise from this. Project planners can better comprehend the specific demands of the area by including the community.

Communities frequently possess insightful local knowledge that may inspire creative problem-solving or more effective project ideas. Missed chances for progress might arise from low participation. Insufficient community involvement in the planning stage may cause miscommunications, opposition, and hold-ups. In order to guarantee that the interests and concerns of stakeholders and local inhabitants are taken into consideration, effective community involvement is necessary. Positive attitude and help from local people creates positive impact on the constuction process.

5.4 Water Pollution

Water pollution may occur when contaminants like chemicals, silt, and building materials are carried into adjacent water bodies by runoff from construction projects. If appropriate steps are not taken to manage and regulate the runoff and garbage created during the building process, u-drain construction in a city may result in water contamination. The soil is frequently disturbed by construction activity, which causes erosion and silt flow. Pollutants including chemicals, heavy metals, and nutrients can be transported by sediments into adjacent bodies of water. Different chemicals are used on construction sites for cleaning, curing, and mixing concrete. Storm water discharge may become contaminated if these compounds are handled and disposed of improperly. Excess concrete, cement slurry, or washout water that is not properly disposed of can leak alkaline chemicals into the environment, changing the pH of water bodies and endangering aquatic life. Fuel leaks can occur from construction machinery and equipment, including fuel and oil. These materials have the potential to pollute water and may harm aquatic ecosystems if they end up in water bodies. Waste products from building sites include metals, polymers, and construction detritus. These materials have the potential to pollute storm water runoff if improperly managed. Construction-related operations have the potential to momentarily alter natural drainage patterns, creating standing water that might serve as a haven for mosquitoes and other disease-carrying insects. Water sources may get contaminated by bacteria and other microbes introduced from construction sites, which poses a risk to public health. U-drains may become conduits for pollution, contaminating nearby water bodies, as a result of poor maintenance and inappropriate garbage disposal. Due to lack of proper sanitation facilities of the workers, risk of water pollution increases in the sorrounding areas of the site.

6. SIGNIFICANCE OF THIS PAPER

The knowledge of the paper will be very useful for the current students and junior engineers who are interested to join the construction industry as fresh graduate engineers. This research will be helpful for the future researchers to study about the drain construction practices in Khulna. It will provide knowledge about the pollution, disruption of daily life, community engagement due to construction progress in Khulna. Future studies can recommend any change or improvement in the construction procedure after studying this paper.

7. CONCLUSIONS

Urban modernization requires elimination of waterlogging in a city**.** Drainage in a city requires well-planned construction of drains. In the present context, in Khulna and other cities, RCC or brick U drains are constructed to remove road rainwater. For rain water management, this paper will be helpful for future engineers to construct such drains according to proper norms. The construction of U-drains in Khulna faces a range of challenges including socio-economic factors, and environmental considerations. Addressing these challenges requires a holistic approach that involves careful planning, stakeholder engagement, and consideration of environmental impacts. Solutions to the challenges faced during drain construction are briefly discussed in this paper which will be useful for junior engineers or students working in the field. By implementing the recommendations proposed in this paper, the city of Khulna can improve its urban drainage system and contribute to a more resilient and sustainable urban future.

The major findings are:

- Sound conceptual idea about step by step drain consrtruction procedure at Khulna city through knowledge gained from regular construction site monitoring.
- Project implementation delays might result from the settlement of land ownership disputes and obtaining consent.
- Sorrounding environment can be polluted due to the ongoing construction procedure which can be prevented by taking necessary measures.
- Regular daily life can be disturbed due to the construction process. The community engagement can be enhanced so that mistrust or confusion in the local inhabitants is not created during the construction process.

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REFERENCES

Ahmed, M. F., & Islam, M. S. (2014). Urbanization and environmental problem: An empirical study in Sylhet City, Bangladesh. *Research on Humanities and Social Sciences*, *4*(3), 161-172.

Alberta. Department of Environment. Environmental Sciences Division. (1999). *Stormwater management guidelines for the Province of Alberta*. Government of Alberta.

American Public Works Association (APWA). (1976). History of public works in the United States: 1176-1976. Chicago, IL.

Bari, Q. H., and M. Alamgir (2011) Waste Generation in Cities of Bangladesh: A Review and Further Estimation. In The Proc. Sardinia 2011, Thirteenth Int. Waste Management and Landfill Symposium, 3 - 7 October, S. Margherita Di Pula, Cagliari, Italy.

Coterell, A. (1980). The encyclopedia of ancient civilizations. Rain bird Publishers, 176-178.

Hasan, M. J., Hossain, M. J., Kuddus, M. A. and Q. H. Bari (2011) Practices of Demolition and Renovation Waste Management in KUET. In Proc. of the 2nd Int. Conf. WasteSafe 2011, February 13-15, Khulna, Bangladesh, p. 261.

Hassan, Q. H. Bari, M. I. Rahman and S. B. Mahmud (2015) Study on construction and demolition waste management in Dhaka. In Proc. of the 4th Int. Conf. on SWM in Developing Countries, WasteSafe 2015, February 15-17, Khulna, Bangladesh.

Kirby, R. S. and Laurson, P. G. (1932). The early years of modern civil engineering. Yale University Press, New Haven, CT, pp. 227-2399.

McDonough, W., & Braungart, M. (2010). *Cradle to cradle: Remaking the way we make things*. North point press.

Parkinson, J. (2003). Drainage and storm water management strategies for low-income urban communities. *Environment & Urbanization*, 15 (2), 115-126.

Pidwirny, M. (2006). Causes of climate change. fundamentals of physical geography.

Saifullah I., S.M.K Uddin, A. Alam & Q.H. Bari (2009) Practice of Demolition Waste Management. In Proc. of the Int. Conf. on Solid Waste Management, 9-10 November, KUET, Khulna, Bangladesh. pp. 743-748.

Silveira, A. L. L., & Goldenfum, J. A. (2004). Sustainable approach applied for the development of urban drainage manuals in Brazil In: Novatech 2004, 2004, Lyon-França. novatech.

Silveira, A. L. L., Goldenfum, J. A., & Fendrich, R. (2001). Urban drainage control measures. *Urban drainage in humid tropics. Paris: UNESCO*, 125-156.