OVERFLOW OF MIRZA KHAL OF CHITTAGONG CITY AND IT'S EFFECTS ON ROAD

M. A. Hossain* & S. K. Palit

Department of Civil Engineering, Chittagong University of Engineering and Technology, Chittagong, Bangladesh
**Corresponding Author: altafsunnycuet@gmail.com*

ABSTRACT
Chittagong is the business capital and one of the most important cities of Bangladesh. The effect of uncontrolled runoff during monsoon becomes a burden and possesses a serious threat to urban road, human health & wellbeing of citizen. Overflow is one of the main causes which damages the road and disrupts the normal life of city dwellers. For ensuring a normal city life and efficient road network system, overflow must be prevented by any means. The present investigation on the overflow of Mirzakhal reports the identification of the causes of overflow, effects on road and remedial measures. Using waste water data, run-off co-efficient and rainfall data, the flow through the canal is measured. After completion of the run-off estimation, it is found that the total discharge is higher than present drainage capacity of the canal, which results overflow. Besides, siltation, vegetation, disposed solid waste, formation of excessive bends etc. are also causes of overflow of the canal. People, living in this area, face a lot of problems especially during monsoon period. The roads passing through this area are badly damaged and hence various types of pavement distresses and deteriorations create that affect the safety and riding quality of the pavement. To eradicate the overflow problem, some remedial measures have been suggested for the Mirzakhal.

Keywords: Overflow problem; Chittagong city (Mirzakhal); drainage capacity; roads damage

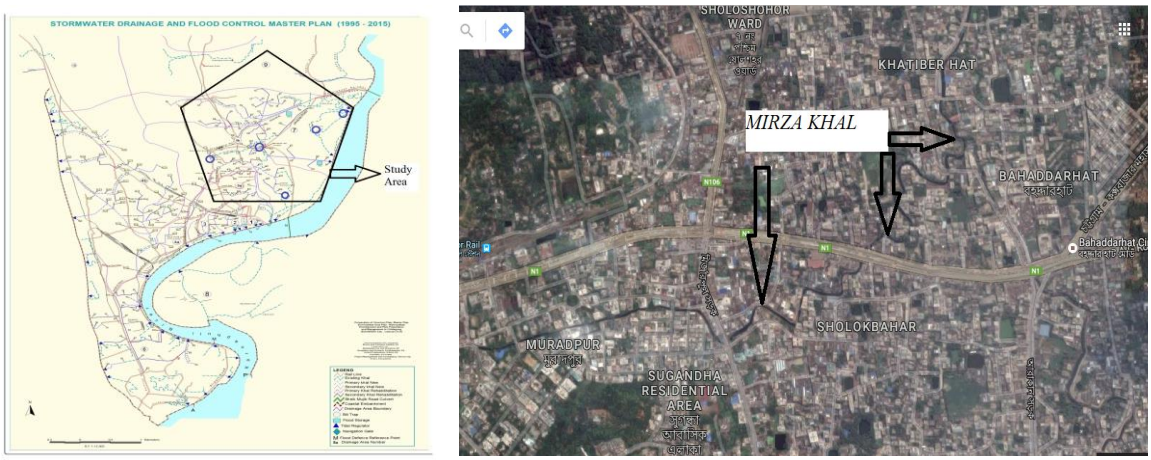
INTRODUCTION
The rapid development of an urban area largely depends on its proper drainage system which may be disturbed due to overflow of water from canal. When the discharge of a water body is more than its design capacity, it is said to be overflowing. Roads get damaged in the rainy season due to water logging as water is the main contributor to the failure and damage of roads. Many researches evidently representing that poor drainage can adversely affect pavement performance. Owuama et al. (2014) suggested that construction of road network in an urban or semi – urban settlement requires a good drainage system that can convey rainfall surface runoff from impermeable surfaces created by road surface and built up areas. The efficiency of such a drain depends upon the road, construction standard and ethics adopted, and maintenance culture. Rokade et al. (2012) stated that inadequate drainage leads to major cause of pavement distresses due to large amount of costly repairs before reaching their design life. Cedergreen et al. (1973) evaluated early field tests that included both drained and undrained pavement sections. Based on the field data, he estimated that a flooded undrained pavement experiences 10 to 70,000 times the damage from a load event compared to a drained pavement. To achieve proper drainage, drains or ditches a long side of road are essential to collect water from road surface and surrounding areas and lead it to an exit point where it can be safely discharged.

Chittagong is located in the tropical zone. Annual rainfall in the city fluctuates between 2100mm and 3800mm, of which 2400mm occurs only during the monsoon (Arafat, 2015). However, such climate has been there for centuries, while water logging is a comparatively recent phenomenon. The problem of water logging in Chittagong has reached such an extent that the first monsoon rain is enough to shut down the city. In the last decade or so, this problem has been increasing due to population growth, economic agglomeration with unplanned urbanisation, illegal refilling of natural water channels, and encroachment of drains. Most of the drainages are obstructed by building structures,

that have overtaken the natural gravitational drainage systems of the city, which were organised enough to cope with the natural rainfall.

Study Area

Mirzakhal is one of the most important natural drainage systems in Chittagong city. The study drainage system covers the area like Muradpur, Chittagong Development Authority (CDA) Avenue, Nasirabad, Shulakbohor and some portion of Bahaddarhat. The location of Mirzakhal in Stormwater Drainage and Flood Control Master Plan, 1995 (Chittagong Development Authority) and in Google Earth is shown in Fig. 1 (a) and Fig. 1 (b) respectively.



(a) (b)

Fig. 1: Study Area

Drainage Capacity of Existing Khal

During field investigation, different cross section along the canal has been measured at which overflow occurs. A critical section near the Asian Housing Society has been considered for measuring the drainage capacity of the existing canal which is shown in Fig. 2. The cross section has been considered as a smooth trapezoid section and total discharge from this channel section is calculated by using the formulae of open channel hydraulics (Chow, 1959) which is 22.02m^3/sec.

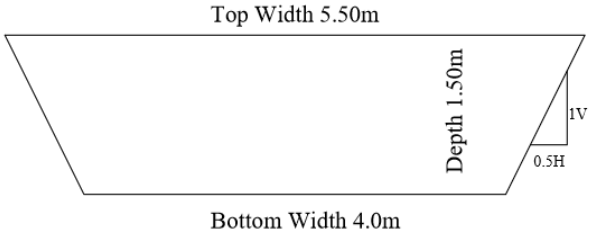


Fig. 2: Existing dimension of canal

The primary objective of this paper is to investigate the effects of overflowing on roads and urban people's life. To achieve this objective a field survey program was conducted on Mirzakhal. The field survey was carried out by visual inspection to evaluate the existing conditions of the drainage system and investigate its effects on road performance.

CAUSES OF OVERFLOW

Overflowing occurs mainly during the period of heavy rainfall. The drainage system cannot drain out of excess water. Also during monsoon period, tidal flows enter into the natural drainage which has connection with surrounding river. Siltation, vegetation, topography, poor management system, lack of public awareness etc. are responsible for overflowing in a drainage system.

Excessive Rainfall

Heavy rainfall is one of the main reasons for water logging in Chittagong City. Relatively low intensity of rainfall also causes serious water logging problems for certain areas of the city. Average monthly precipitation over the year (Rainfall, Snow) in Chittagong is given in Table 1 (World Weather & Climate Information, 2016).

Table 1: Average monthly precipitation in Chittagong, Bangladesh

Month	Rainfall (mm/30days)	Month	Rainfall (mm/30days)	Month	Rainfall (mm/30days)
January	6	May	256	September	330
February	36	June	537	October	168
March	64	July	600	November	59
April	148	August	528	December	9

Calculation of actual discharge

Estimation of Run-off

For determining the actual discharge, total catchment area is divided into 19 small areas consisting of 1.13 km^2 which are illustrated in Fig. 3 and calculated total run-off is run-off 7.13m^3/sec.

Fig. 3: Various Catchment Areas for determining the actual discharge in Mirza khal

Estimation of waste water discharge

Total waste water coming from the drains situated in 2 no. gate to Bahaddarhat area is 12.55m^3/sec. Disposed waste water in Mirzakhal from the area of Shulokbohor, West Sholoshahar, Panchlaish, East Sholoshahar and Muradpur are 5.0 m^3/sec, 3.25 m^3/sec, 2.90 m^3/sec, 1.60 m^3/sec and 3.21 m^3/sec respectively (Chittagong City Corporation¸ 2015). Total waste water discharge is 28.51 m^3/sec and total discharge is 35.64 m^3/sec. As, the drainage capacity of the existing canal is less than the total discharge consists of runoff estimation and waste water discharge, so overflow will occur at that section.

Siltation Problem

Siltation problem reduces the width of the canal. Many residents of the city have blamed that a number of sluice gates operated by Chittagong Water and Sewerage Authority (CWASA) and these gates are causing siltation in rivers and water logging. So that one of main natural drainage system of Chittagong city lost its runoff capacity and increased impervious area due to siltation. Significant amount of siltation in Mirzakhal has taken place during the last few years which is shown in the following Fig. 4.

Vegetation Problem

Water logging tends to exclude oxygen from the soil and plants have evolved many ways to deal with this, leading to the evolution of hundreds of specialist wetland and waterside species which is known as vegetation. Vegetation problem arises after siltation takes place in the canal. Many places along the Mirzakhal are covered by the vegetation problem which is illustrated in Fig. 5.

Solid Waste Disposal

Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets, industrial and hospital solid waste deposition along the Mirzakhal is creating obstacles in the flow path of water is shown in the Fig. 6.

Illegal Construction works

Developmental work like construction of high rise buildings, office centre etc. are operated illegally on the bank of the Mirzakhal shown in the following Fig. 7. It bends excessively in some places like Mirzapool, Nasirabad, and Asian Housing Society. The unplanned development activities and growth of population are causing encroachment or retention areas and natural drainage path with little or no care of natural drainage system that creating obstacles to properly drain out the urban runoff.

Fig. 4: Siltation in Mirzakhal

Fig. 5: Vegetation problem in Mirzakhal

Fig. 6: Solid waste in Mirzakhal

Fig. 7: Construction work on the bank of Mirzakhal

EFFECTS OF OVERFLOW

Urbanization disrupts natural drainage patterns. Natural water course are destroyed, and existing drainage system cannot drain excess water. It causes overflow. The increase in volume and rate of runoff causes erosion and siltation. It causes various problems like disruption of traffic movement, disruption of normal life of the urban inhabitants, damage of structure, water pollution, and increase of water borne diseases.

Social Problem

Overflow affects various social sectors. It disrupts normal traffic movement. Where the storm water cannot drain out, puddles will form. Overflow creates inconvenience for road users which is shown below in Fig. 8 and Fig. 9.

Fig. 8: Disruption of normal traffic flow (Location: 2 No. Gate)

Fig. 9: Inconvenience for road users (Location: Muradpur)

Fig. 10: Road damaged due to water logging (Location: Muradpur)

Fig. 11: Bad effect of overflow on road (Location: Bahaddarhat)

Physical Problem

Overflow accelerates the damages of structure, infrastructures, and underground service lines. It contributes to ground heave, subsidence and dampness. Water logging causes the damage to roads (both paved and unpaved) in the rainy season every year leading to the movement problem and interrupts the journey. Serious damage of road has occurred in many locations of study area, few examples of which are illustrated in the Fig. 10 and Fig.11.

Environmental Problem

Storm water generated from the catchment areas carry significant amount of pollutants. In poorly drained areas, urban runoff mixes with sewage from overflowing latrines and sewers, causing

pollution and a wide range of problems associated with water borne diseases. Sometimes the poor people had to rely on surface or shallow groundwater sources that are polluted as they don't have access to potable water during the monsoon period. Moreover contamination of groundwater also leads adverse health impacts.

Economic Problem

As it is stated earlier that water logging reduces the life span and damages the roads and metalloid pipes of various underground utility services such as water, telephone, sewerage etc. It needs a huge cost to replace these facilities. The city authority had to spend about Taka 7 to 8 billion every year to replace and maintain infrastructures damaged by water logging. Damage to substructure brick foundations, houses in slums and low-income areas due to water logging means the huge economic losses for the inhabitants.

DISSCUSSION

Rapid population growth, unplanned land filling to develop new residential areas, uncontrolled and haphazard disposal of solid wastes and garbage into the existing drainage system, and encroachment on lakes, canals and rivers with unauthorized construction are the summarized general man made activities related to the disappearance of natural drainage system. Lack of comprehensive and planned maintenance program, equipment, adequate budget, staffing, proper monitoring program and institutional set up to effectively operate and maintain the drainage, natural siltation, indefinite drainage outlets are accounted for main causes of blockage in drainage system and overflow.

REMEDIAL MEASURES

The Mirzakhal which earlier had a depth of 15 feet has now become as shallow as 2 feet. As a result the canal becomes unable to pass the water fully in a normal way due to the obstruction in natural flow path and turning of the wide flow path into a narrow one. Due to the overflow problem of Mirzakhal, water logging occurs measuring up to 6/7 feet even when there is light rain leaving the residents in immeasurable trouble. Following are the some remedial measures proposed to minimize overflow problem.

Reducing excessive bends

Mirzakhal includes many places where excessive bend has taken place. Formation of excessive bend along Mirzakhal in Shulokbohor has been shown in Fig. 12. The excessive bends of the canal should be reduced by ensuring that the bank of the canal is protected from illegal possession. The channel with excessive bends can be abandoned by the formation of a straighter and a shorter channel or by introducing artificial cut off. Three important junctions have been identified shown in Fig. 12, where artificial cut-off can be applied to reduce the excessive bend. The proposed alignment after applying artificial cut-off is shown by dark line in Fig. 12 and proposed artificial cut-off near N. Mohammad Plastic Industry is shown in Fig. 13.

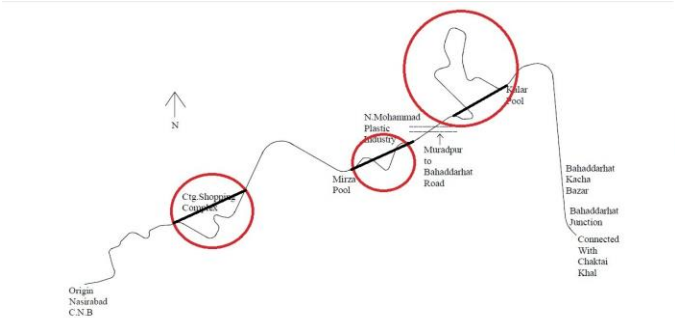


Fig. 12: Proposed alignment of Mirzakhal by the formation of shorter and straighter channel

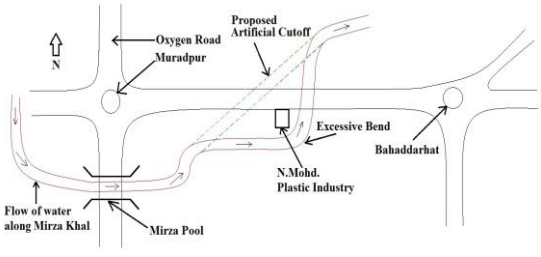


Fig. 13: Proposed artificial cut-off near N. Mohammad Plastic Industry

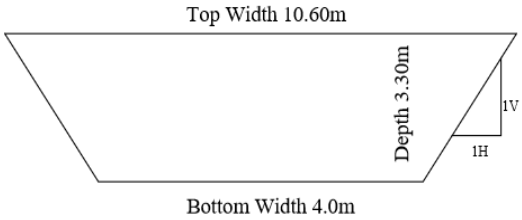
Silt trap construction

Silt trap can be placed at that point of the canal where siltation occurs frequently. It has a basket with an approximate 50 litres capacity which is easy to remove, ensuring simple, low cost servicing and

maintenance of the canal. When water flows along the canal, carrying silt, the silt will be trapped into the box. Regular cleaning of the box will help to keep the water depth sufficient enough.

Proposed Design section of Mirzakhal based on flow capacity

Alignment of the canal should be fixed before going for developing structure along it so that sudden excessive bend can be avoided. A channel section is designed based on the flow capacity of Mirzakhal by using the formulae of open channel hydraulics (Chow, 1959) illustrated in Fig. 14.



Design parameters:
Bottom width= 4.0 m, Side slope = 1H : 1V
Velocity of flow = 1.5 m/sec
Design:
Discharge= 35.64 m^3/sec
Hence, Area=23.78 m^2, Depth= 3.30 m Top width=10.6m
Slope of canal= S = 0.000449 or 1 in 2226

Fig. 14: Proposed Channel Section

CONCLUSION

The study investigated cases of pavement failures and damages due to overflow of Mirzakhal experienced during the last few years on a number of roads in Chittagong city. On Basis of the previous experiences in design and construction of drainage, the study proposes design channel section, a straighter and a shorter channel alignment and introduction of artificial cut-off in order to reduce excessive bends and construction of silt trap to reduce siltation problem as well as vegetation for a proper and efficient drainage system. The concerned authority should ensure regular and careful maintenance of Mirzakhal through proper monitoring program to stop illegal construction works. Consistent yearly evaluation of drainage systems is an essential part of maintaining and managing road. Drainage facility should be improved before making any pavement surface improvements. It is most efficient and effective to plan and upgrade drainage as part of road surface improvements.

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