PERFORMANCE OF FLOOD CONTROL WORKS AROUND DHAKA CITY DURING MAJOR FLOODS IN BANGLADESH

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ABSTRACT

Dhaka city has been protected by flood protective embankments, flood walls and raised roads along with flood controlling regulators, sluices, and both temporary and permanent pump houses. This study describes the performance of various flood control works around Dhaka city and tries to find out the causes of external and internal flooding of protected Dhaka during major floods in the recent past. It has been found that flood embankment and raised road around the city functioned quite well during all floods except the1998 flood. Though the performances of three permanent pump stations were found satisfactory, temporary pumps were found poor performing. However, the flood control measures of the city has come under challenge by recent issues such as gradual increase of urban encroachments inside retention pond, fill up of low lying areas, increase of social conflicts around flood control structures etc.

Keywords: *Dhaka city; embankment; flood wall; pump station; regulator*

1. INTRODUCTION

Flood is a reality for Bangladesh. As the country is located at a floodplain delta of three major river basins - the Ganges, the Brahmaputra and the Meghna (GBM), so every year, one quarter to one third of the country is inundated during monsoon season through overflowing of the rivers. However, floods of unusually large magnitude and long duration happen in the country affecting the majority of the population of the country and severely disrupting the social and economic activities. Such devastating floods are 1954, 1987, 1988, 1998, 2004 and 2007 and considered to be the worst ones.

Flood 1988 was unprecedented and floodwater entered into the core places of Dhaka city, the capital of Bangladesh, jeopardizing all important activities as a whole and compelled the policy

makers to make flood free all important and vital places of Bangladesh. Dhaka city during flood period always draws special attention due to its strategic importance. So, Dhaka West was given flood protection after flood 1988. But unfortunately, protected Dhaka West was again flooded during unprecedented flood of 1998.

Islam et al. (2002) have conducted a study on the Hydrologic characteristics of floods in 1998. Chowdhury et al. (1998) have studied the impact of 1998 flood on Dhaka city and performance of flood control works. Rahman et al. (2005) have investigated the hydrologic aspects of Flood 2004 in major rivers of Bangladesh and special emphasis has given on the floods of Dhaka city. Similarly, Islam et al., (2008) carried out a study on Flood 2007. The findings of investigations on major floods of 1998, 2004 and recent 2007 and their impacts on flood protection structures on Dhaka city and their performances have been presented in this paper.

2. STUDY AREA

Dhaka is located in the central region of the flat deltaic plain of the three large rivers, the Ganges, the Brahmaputra and the Meghna. The city is surrounded by distributories of these major rivers. They are Buriganga at the south, Turag at the west, Tongi Khal at the north and Balu at the east. Greater Dhaka city is divided into Dhaka West and Dhaka East (Figure 1).

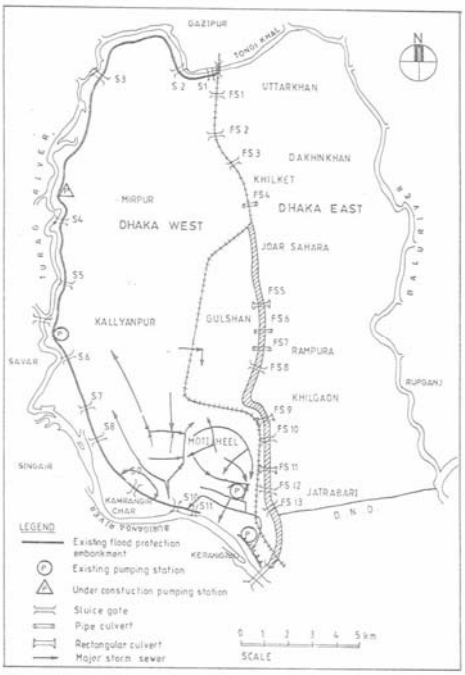

Figure 1: Existing flood control and drainage infrastructures during 1998 flood.

A common Highway runs through the middle of Dhaka West and Dhaka East and several of its parts are named as Mymensingh road, Pragati Sarani, DIT road and Biswa road. They were raised after the devastating flood of 1988 to perform as road-cum-embankment. The combined area of Greater Dhaka city is approximately 275 sq. km. (JICA, 1991). Dhaka East has an area of approximately 119 sq. km. (JICA, 1992). So, Dhaka West has an area of approximately 156 sq. km., which is protected from river flood by peripheral embankment as shown in Figure 1. Dhaka

East is in the floodplain of Balu River and most of the area is low-lying and remains under water for over half of the year, of which perhaps half is less than 2 m above mean sea level (JICA, 1992). Dhaka city is growing rapidly. The urban areas are forecast to be expanded from 200 sq. km in 1990 to 366 sq. km by 2010 and the population is expected to reach 13.5 million by the year 2010 (JICA, 1991)

2.1 Flood control works in the study area

Dhaka West have been encircled by embankments, flood walls, raised roads to give protection against riverine flood (JICA, 1991). Important components of flood protection measures are:

i) About 30 km of earthen embankment along Tongi Khal, Turag and Buriganga river,
ii) About 37 km of raised road and floodwalls in few locations of old Dhaka along the river Buriganga where intensive infrastructures do not allow any further road improvement.
iii) A total of 11 regulators (Figure 1) at the outfall of Khals to the surrounding rivers along the embankment.
iv) 1 regulator and 12 sluice gates (Figure 1) on the Khals at the crossing with Biswa road, DIT road, Pragati Sarani, Mymensingh road and Railway line at Uttar Khan.
v) Three pump stations (Figure 1) namely Kallyanpur, Goranchat Bari and Dholai Khal pump stations and to drain out rainwater from some protected parts of Dhaka West.

They are all together called flood control structures and are supposed to keep Dhaka West free from riverine floods, see Figure 1 (as per status of 1998). These flood control works were prepared and rearranged based on the study of flood mitigation and storm water drainage plan in the Master Plan for Greater Dhaka Protection Project (JICA, 1987, 1991, 1992).

3. DATA AND METHODOLOGY

3.1 Field and secondary data

Secondary information and field visits were the basis for the studies during 1998, 2004 and 2007 floods. Field visits were made to each flood control structure around the protected Dhaka West to see in-flood functioning of the structure. Available flood data were collected from site during field visits. Water level data at pump houses and at temporary pump stations were also collected during field visits. The other relevant information was also recorded such as number of working pumps, duration of pumping, pumping capacity, start date of pumping, pumping effect, management of pumping, working condition of pumps and pump houses, etc.

3.2 Tools and techniques

Available water level data from water control structures and from pump stations have been utilized to study performance of water control structures. Flood hydrographs were drawn to see the pumping effect on floodwater. Photographic evidences of the impact of each flood are documented and presented. Focus was given upon lessons learned during the flood of 1998 and their follow up during 2004 and 2007 floods. Attention was focused upon people's reaction upon flood control structures around Dhaka West and their interactions with structures during flood time. Attention was also made to new developments occurred with and around water control structures of protected Dhaka West after 1998 flood to compare with the floods of 2004 and 2007.

4. PERFORMANCE OF FLOOD CONTROL WORKS

4.1 Performance of embankment during Flood 1998

Embankment with regulators was visited during 1998 flood, when river flood level was the highest. The flood level in the river was 1.5 to 2.0 m below the crest of flood protection embankment. A section of about 2.2 km long between Lalbag Kellarmurkh to Shasanghat along Buringanga River was not closed by flood protection embankment (Figure 2). Floodwater from the Buringanga entered through this opening. The section was closed with soil filling, sand bags piling promptly by Bangladesh Water Development Board (BWDB) with active participation of local people. Unfortunately, the areas adjacent to raised sections of Mymensingh road, DIT road were inundated by the intrusion of floodwater from the Balu River into Dhaka West. This unexpected flooding was due to some unblocked culverts and unclosed regulator along the raised roads (Figure 2). During 1998 flood, passiveness of Dhaka Water Supply Authority (DWASA), BWDB, Dhaka city Corporation (DCC) was surfaced out and lack of coordination in between them was clearly demonstrated in the management of the water structures. As a result, some water control structures were remained open and areas like Maha Khali, Gulshan, Banani, Badda, Baridhara etc. were the worst affected ones.

After field inspection and discussion with local people, it was revealed that three drainage structures namely FS8, located over the Begunbari Khal on DIT road (Figure 1) and called as Rampura regulator, FS5, a 10 m wide Shajadpur bridge and located on Pragati Sarani and FS4, a 30 inch diameter Khilkhet pipe culvert located at Khilkhet and Nikunja served as flood carrying channels (Figure 1 and Figure 2**)**. Structure FS4 remained open for the whole period of flood and caused flooding in Nikunja, adjacent to airport and cantonment areas. The locations of entry points of floodwater in Dhaka West during 1998 flood through numerous openings are shown in Figure 2. Structures FS9, FS10 and FS11 on Biswa road were liable for partial flooding in Rajarbag, Gopibag, Fakirapul area but they were quickly closed.

Lessons learned: The raised road cum embankment was upgraded after 1988 flood but design height was not adequate to tolerate the flood of 1998. Moreover, coordinated efforts from the organisations like DWASA, BWDB and DCC were not observed. As a result, some culverts and regulators along the raised roads were left open in the beginning of the flood of 1998.

4.2 Performance of embankment during Flood 2004

Flood control structures during this flood functioned quite well. Some structures namely FS11, FS10, FS9, FS7 and FS6 were fully abolished during the upgrading of the road cum embankment after the flood of 1998. The coordination between DWASA, BWDB, and DCC for operation and regulation of water control structures was better than that of the flood of 1998. Their in time operation, regulation and coordination for closing of regulator and sluice gates stopped fully the intrusion of the floodwater into Dhaka West. Increase of slum habitation, growth of whole-sale markets like vegetables and fish, deposits of municipal garbage, boost of civil settlements, etc. were observed at some locations near Kallayanpur Pump Station. A huge number of dredgers at river side along the embankment after Ashulia road were observed for filling up of low-lying areas of protected Dhaka. Some water intrusion was noticed only through the structure S11 at Lalbag. The incomplete 2.2 km embankment from Kellarmukh to Buriganga Bridge-2 was found completed and Dhaka West was free from river flooding.

Lessons learned: Flood protective embankment worked very well to stop any flood intrusion from the river side. BWDB, DWASA, DCC were more coordinated during flood of 2004. But condition flood protection embankment has deteriorated due to settlement activities around it. Internal flooding is surfacing out as one of the disasters for protected Dhaka West. 2004 flood was

accompanied with internal drainage congestion along the areas like Gulshan, Banani, Motijheel commercial areas, BUET area, and etc. of Dhaka West.

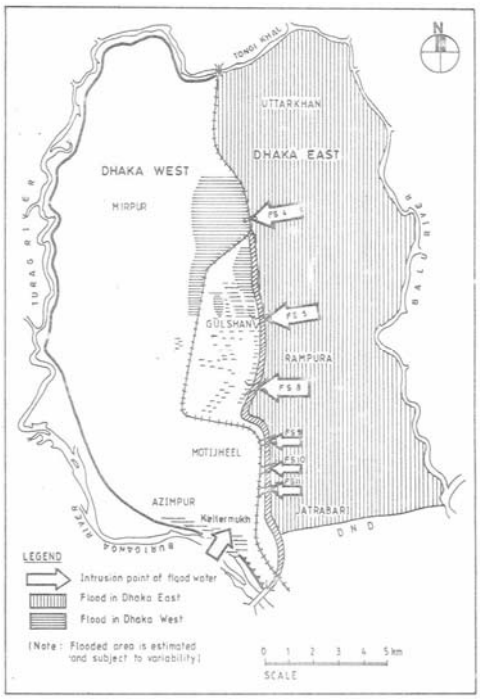

Figure 2: Areas flooded by river water and floodwater intrusion points during 1998 flood.

4.3 Performance of embankment during Flood 2007

The embankment functioned well and did not allow any flood intrusion. Increase of growth of slums, public settlements, industrial complexes, and other kinds of activities are observed.

Lessons learned: Flood protective embankment is still functioning well.

4.4 Performance of regulator during Floods 1998, 2004 and 2007

A 10-vent regulator located over the Begunbari khal is called Rampura Regulator and marked as FS8 in Figure 1. It is a very important structure for regulating gravity drainage from Dhaka West. It also prevents flood intrusion from the Balu River through the Begunbari Khal. A major part of Dhaka West drainage water gets accumulated at upstream of this Rampura regulator and is regulated by this structure. At present, there are temporary pumping facilities to reduce drainage water from inside Dhaka West to outside Dhaka East. It was reported that the gates of the regulator were not closed at right time and flood entered inside Dhaka West during flood of 1998 (Figure 2).

During field visit of 1998 flood, it was observed that 12 out of 20 pumps of individual capacity of 5 cusec (0.142 cumec) were pumping water from inside to outside at Rampura regulator. Water level differences between river side and protected side for Rampura regulator were plotted for floods of 1998, 2004 and 2007 (Figure 3). It is seen that river side and protected side water level

differences were almost same at Rampura regulator for all the mentioned floods. The regulator was not effective to stop flood water or to drain out congested rainwater from inside of Dhaka West.

During floods of 2004, all sluices and regulators were closed in time to prevent floodwater intrusion. During field visit of flood 2004 on 28th July, 35 numbers of pumps out of 40 were found on workable condition at Rampura regulator. It was also reported that pumping was started on 12th July with only 15 numbers of pumps. Still the inside water level was not getting reduced. During field visit on 8th August, 2004, additional 4 numbers of dredger pumps of higher capacity of 0.426 cumec and 1 dredger pump of 0.142 cumec were found at site and were in operation by turns. Thus, water level at Rampura regulator was reduced to some extent.

During flood 2007, about 50 small pumps operated at Rampura regulator. Similarly, it was not possible to reduce inside water level by small temporary pumps. The pumping again was an eye wash (Figure 3). From the Figure 3 and water level curves, it is clear that inside and outside water levels at Rampura regulator for all flood events were almost same.

The pumping experience of permanent pump house at Goranchat Bari during 2004 and 2007 showed that though the pump house has a higher pumping capacity (22 cumec), still it started pumping quite earlier with lower inside water level and attained higher pumping effect during full flood time and rains. So, it is our strong conviction that if pumping could be started earlier during low inside water level with sufficient number of pumps then pumping effect could be attained keeping water level much lower. Of course, if a large enough pumping station was provided then it would have an impact on flood levels.

Lessons learned: Rampura regulator is an important component of flood protection structures around Dhaka West for maintaining drainage function between Dhaka West and Dhaka East. Experiences gained from the three major floods taught us that pumping of drainage water from Dhaka West during flood time at Rmpura regulator is futile and eye washing. Not external flooding but internal water logging problem in Dhaka West is getting worse for each incoming flood and needs special attention.

4.5 Performance of large scale pumping stations during Flood 1998

During 1998 flood, there were three pumping stations in Dhaka city, namely Kallyanpur Khal to Turag with capacity of 10 cumec, Dholai Khal at Narinda with capacity of 9.6 cumec and Dholai Khal at Mill Barrack to Burigange with capacity of 22 cumec. Narinda pumping station was very old with low efficiency. Dholai Khal pump station has been designed such to include the drainage area of this Narinda pump station also. So, Narinda pump station had been dismantled by the Dhaka city Corporation in 2002. All the three pumping stations were in operation during 1998 flood.

The Kallyanpur pump station was quite effective in draining the rainwater during 1998 flood. It was observed that low lying areas such as Kallyanpur, Shyamoli, etc were dry. These areas suffered from severe flooding during 1988 flood. The water level differences between river side and protected side at the pump station are plotted in Figure 3 based on the data obtained from the records at pump station. The water level analysis supports that Kallyanpur pump station performed effectively during 1998 flood.

As a result of operation of other two permanent pump stations (one at Narinda and the other at Mill Barrack to Buringanga) on Dholai Khal, large part of Old Dhaka city was dry during 1998 flood. Water level differences at the new Dholai Khal pump station are plotted in Figure 3. This figure also shows water level differences at the crossing of Segunbagicha Khal with Biswa road. It is seen that the pumping station was quite able to reduce the protected side water level compared to that in Segunbagicha Khal, which is very close to Dholai Khal pump station. It is seen from Figure 3 that the protected side water level at the new pump station was increased suddenly on the 5th September of 1998. As per opinion of local people, an earthen bund was constructed to stop the flow over the submerged sluice gate (FS13 in Figure 1) on the Zerani Khal. The earthen bund suddenly collapsed resulting on rush of water.

Lessons learned: Large scale pumping house is very effective to reduce inside water level. Internal flooding is to become a problem after flood protection of Dhaka West.

4.6 Performance of large scale pumping stations during Flood 2004

All three large pump stations were actively pumping during 2004 flood (Figure 3). Due to in time pumping, catchment areas under pumping influence, were free from both water logging and internal flooding. During the flood of 1998, Goranchat Bari pump station on Degun Khal was under construction. It could function during the flood of 2004.

The effectiveness of Kallyanpur pump station may be seen from the Figure 3, where water level differences between river side and protected side are quite high. The retarding area of Kallyanpur pump station has been encroached through filling land and converting them into residential areas. Significant land filling has been done in several locations around Kallyanpur pump station. The area of the retention pond is gradually decreasing leading to the reduction of lead time of accumulation of drainage water in the retention pond. As a result, the pumping pressure on the existing pumping station is gradually increasing and can ultimately result in ineffective operation of the structure. It is informed during field visit that additional one pump house would be constructed at Kallyanpur pump station to manage this future anticipated increased drainage water.

The Dholai Khal pump station was good enough to keep the whole old Dhaka city free from internal flooding. Figure 3 demonstrated the truth.

Field visit to Goranchat Bari pump house during 2004 flood revealed that pumping was started quite earlier and continued keeping close observation on water level rise inside protected Dhaka as well as on rainfall so that water level could not go beyond the control of pump house. The approach gave good results and continuous pumping made it possible to keep inside water level much lower than outside (Figure 3).

Lessons learned: The areas under pumping house were free from water logging inside Dhaka West during 2004 flood. Pump house is essential for effective pumping of drainage water from inside of protected Dhaka West. Internal flooding of protected Dhaka West during any major flood has already become a permanent problem and needs its proper management. Encroachment of retarding areas of respective pumping house is also a threat for the station.

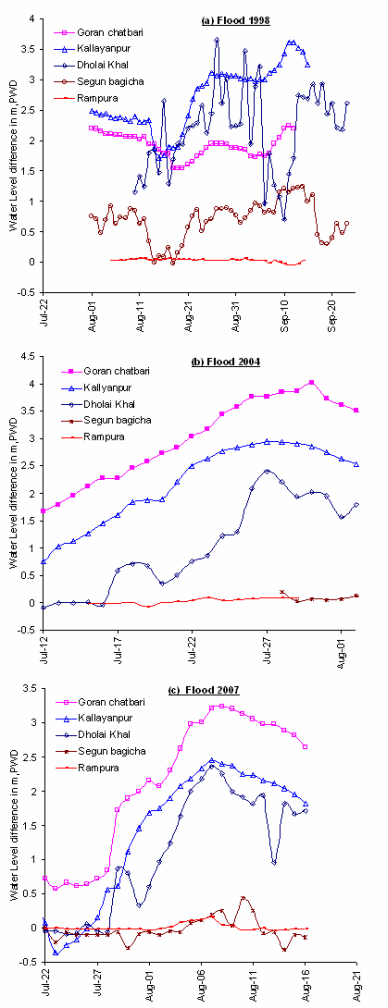

Figure 3: Difference of riverside and protected side water level during floods in (a) 1998, (b) 2004 and (c) 2007 of the surrounding major flood control works

4.7 Performance of large scale pumping during Flood 2007

During flood in 2007, the performance of Goranchat Bari pump station was very well and pumping was also started quite early to avoid any mishap. On the other hand, Kallayanpur pump station showed satisfactory performance during all the three major floods. The difference of water level was always below the flooding level of that area. It was also found from the plots that it should start pumping when water level is below 4.0 meter above datum. The permanent pump station in Dholai Khal shows satisfactory performance during all the three major floods. Water level difference was very high in this pump station even after a high intensity of rainfall.

Lessons learned: Large scale pump station functioned well in all floods of 1998, 2004 and 2007.

4.8 Performance of small scale temporary pumping during Floods 1998, 2004 and 2007

A total of 66 small pumps were installed at different locations by Dhaka WASA to drain out the accumulated water inside protected Dhaka West during flood of 1998. The capacity of each pump was 5 cusec (0.142 cumec). The internal water was accumulated rainfall, intruded flood water and domestic waste water. There were 20 pumps at Rampura regulator, 30 pumps at the crossing of Segunbagicha Khal with Biswa road, 1 pump at Goran Chadbari regulator and a total of 15 pumps along the embankment from Hazaribagh to Kellarmukh as illustrated in Figure 4.

The pumping at Rampura regulator was ineffective. The reasons have been explained earlier with the help of observed data. The total pumping capacity was also insufficient compared to the drainage area of Begunbari Khal at Rampura regulator. The pumping from Segunbagicha Khal was effective. The temporary pumping at other locations along the flood protection embankment from Hazaribagh to Kellarmukh was also moderate effective during flood in 1998.

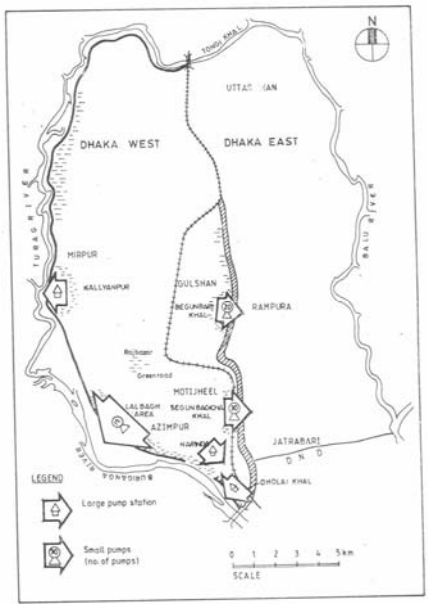

Figure 4: Locations of pumped drainage in Dhaka West during 1998 flood.

During the flood of 2004, no flood intrusion was happened from the river side to protected side. Major efforts were focused on how to drain out water from inside of Dhaka West. As Begunbari Khal is the main drainage path to drain water from a vast area of Dhaka West, so in total of 70 temporary pumps (if compared with 0.142 cumec) were in operation at Rampura regulator. The total pumping capacity was insignificant compared to the drainage area of Begunbari Khal at Rampura regulator. Drainage of Begunbari Khal was only then effective, when the Balu River water level was lowered i.e., gravity drainage happened. Thus, there were 70 pumps at Rampura regulator, 16 pumps at the crossing of Segunbagicha Khal with Pragati Sarani and a total of 20 pumps along the embankment from Rayer Bazar to Kellarmukh. The pumping effect at Segunbagicha Khal was not effective in the beginning of the flood in 2007 due to connection of Dhaka city Corporation (DCC). Pumped water again returned into Segunbagicha Khal through the connection. The incidence again showed that development of infrastructures by different development organisations like DCC, DWASA and BWDB suffers from lack of coordination.

At least 50 small pumps were operating at the Rampura regulator and 30 small pumps were operating in Segunbagicha kjhal during the flood of 2007. Along the embankment of the Buriganga between Dholai Khal pump station and Kallayanpur pump station, temporary pumps were found in more than 27 locations. In these locations 1 to 4 pumps were installed temporarily during the flood of 2007. The main purpose of these pumps was to drain out congested water inside the embankment i.e., from protected Dhaka city.

Lessons learned: The three flood studies around Dhaka city indicated that water logging as well as internal flooding inside protected Dhaka city during flood time is on increase. The protected Dhaka city faces the challenge of water management not from external flooding but from internal flooding.

5. CONCLUSIONS

The performance of three permanent pump stations at Dholai Khal, Goranchat Bari and Kallayanpur was found satisfactory. The water levels of protected side were far below than that of river side. On the other hand, the difference of the water level between country side and protected side of the Rampura regulator where temporary pumps installed was close to zero during all the major floods. Performance of the temporary pumps is insignificant and has very little effect on the drainage congestion in flood season. It was found during field visits that urban encroachments gradually have increased and reduced retention pond area of the Kallaynpur and Goranchat Bari pump stations. This will enhance water logging from a small amount of intense precipitation.

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