

# Severity of Flood Embankments in Bangladesh and Its Remedial Approach

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## ABSTRACT

Construction of earthen flood control embankments is an established practice in Bangladesh for protecting people's lives and homes, agriculture and infrastructures. The paper reports the results of recent status of river and flood control embankments in Bangladesh based on the field visits to embankments site, collected data and information on failure and on-service embankments during field visits, necessary data related to embankments construction practice obtained from available publications and news paper information reported in the year 2007. It studies the basic features and characteristics of floods and flood hazards, and reviews the design & construction practices followed. Several cases of successful and unsuccessful river and flood control embankments are investigated and analyzed. Based on the results of analyses and discussion, it shows that the present method of embankments in Bangladesh, although requires huge amount of money for its construction and repair every year, fails to solve the flood problem effectively and permanently rather it brings many other new problems. It not only increases the siltration on the floodplains and river beds but also creates a risky situation for the inhabitants inside the boundary of embankments. On the basis of overall present situation in Bangladesh, the paper also suggests a proper design and construction method of embankments to control and minimize the extent of flood hazards in the long run.

**Keywords:** Bangladesh, embankments, river, flood, siltration, waste, recycle, environment, Bangladesh

## 1. INTRODUCTION

With growing demand for protecting people's health and homes, agriculture and city dwellers; the issue of earthen embankments especially the river embankments and flood control embankments in Bangladesh is getting much attention lately. This is because of the construction of earthen embankments in Bangladesh is the cheapest form to protect flood water in rainy season and store necessary water in the dry season. Now-a-days, it is well recognized that in Bangladesh, there is a big problem of flood in rainy season and on the other hand, there is scarcity of water in the dry season. Bangladesh is a country that lies in the largest delta on earth created jointly by three mighty rivers, the Ganges, the Brahmaputra, and the Meghna, and their distributaries faced twin problem of scarcity and over-abundance of water every year (UNDP, 1998). With growing population, urbanization, and expansion of agriculture; this problem becomes severe year to year. During the rainy seasons (June to September), more than 85% rainfall occurs that brings huge amount of silts from the origin of rivers that started from the slope of Himalaya. Therefore, in just 4 months, nearly a trillion cubic meter of water laden with about two billion tons of silt passes through the Bengal delta and the rest of the year, the area remains relatively dry (Islam, 1994).

Literature review shows that the present status of embankments has failed to solve Bangladesh's problem of excessive flood during rainy season and scarcity of water during rest of the year (Saifullah, 1988). Our studies in the year 2007 also shows that many earthen embankments breached during the rainy seasons and thus, these are not successful to control flood because of its faulty design, wrong construction and improper planning. To date, the main aim of embankments construction is to seal off the water from neighboring rivers. However, owing to the wrong design and construction method followed, these earthen embankments lead to several new problems. First, the earthen embankments can not solve the flood problem, effectively and permanently because of their ease of vulnerability with rain splash and flow of flood water. Thus, failure of embankments not only increases the siltration in the river beds and floodplains but also gives a rise of flood water level which in turn increases the water current. Second, wrong planning deprives the floodplains from the nurturing effects of regular river-inundation. Third, it creates a risky situation for the inhabitants inside the boundary of the embankments. Fourth, it brings in new problems of drainage, water logging, waste and sanitation in these areas. Finally, it costs huge amount of money every year for reconstruction and repair. Also, sudden breaches of embankments are continuously destroying human lives, crops, agriculture, poultry, fisheries etc.

In order to cope with these above problems of embankments which are based on wrong design, faulty construction and improper planning; the present article suggests a technique for alternative construction of embankments and planning to control and mitigate flood for long term basis. The basic premise of this technique is that the embankments either being fully reinforced or the surface be protected by some means so that it would be durable against rain splash and water current. Use of solid wastes, recycled materials and soil-cement or their combination can be a significant step in this direction (Vipulanandan and Elton, 1998; Hossain, Narioka, and Sakai, 2006). The disposal of solid wastes and recycled materials has become a major problem in Bangladesh. Proper use of these solid wastes and recycled materials may lead not only to quality embankments at considerable savings but also to solutions for environmental problems (Eko and Riskowski, 1999; Hossain and Sakai, 2007; Kakao, Shimizu and Nishimura, 2001). The main objectives of this research were 1) To use locally available recycled materials to reinforce the embankments soil that reduces the cost of the construction materials and conserves environment, 2) To prevent damages of embankments by increasing the strength of soil. By proper planning, flood mitigation can be possible by spreading river water over wider areas which reduces the siltration on riverbeds and floodplains. It also neither creates a risky situation for the inhabitants of floodplains nor brings in any new problem for wastage of huge amount of money. Regarding these objectives, this describes the present river and flood control embankments and analyzes the failure characteristics of some earthen embankments. Then, the fundamental facts regarding land and rivers of Bangladesh are given. Finally, it suggests a new technique for economic and durable construction of embankments and discusses various aspects of the proposed technique entails.

## **2. EXTENT AND SEVERITY**

### **2.1 Damages of Embankments**

In 2007, Bangladesh again witnessed unprecedented disruptions and damages of many embankments due to flood. Information on some of the embankments that breached in the year

2007 and earlier is shown in Table 1. It is noted that every year almost two-thirds of the country went under water and thus breached of embankments and relevant disruptions and damages caused were enormous. However, as Bangladesh tries to deal with the short term consequences of flood and embankments, she has to think seriously about the long-term strategy regarding both floods and embankments and the way to cope with the situation and consequences of embankment failure. About 20% of her budget is spending for this purpose but it does not solve the problem due to erroneous construction and wrong planning. This paper shows that unless serious steps are taken to correct this way of construction and planning, embankments and flood problem of Bangladesh are likely to become even worse with time and attain ultimately calamitous proportions.

Table 1. Some Breached Embankments (New Nation, Zazadi and Daily Star, 2007)

Sl. no.	Regions/ District	Location of Embankment	Date of breach	Damages
1	Cox's bazaar, Teknaf	Cox's Bazar Cross Dams	June 5, 2007	150 houses damaged
2	Dhaka, Gabtoli	Gabtoli Mitford connecting Embankment	June 11, 2007	Connecting road damaged
3	Sirajgonj, Khosbari	Jamuna River Khosbari Embankment	June 13, 2007	1200 meters breached
4	Gaibandha, Polasgonj	Korotoa River Embankment	May 14, 2005	Soil moved away and make huge damaged
5	Patuakhali, Baufal	Baufal Upazilla Embankment	May 18, 2007	12 villages flooded and 2000 acres land damaged

## 2.2 Breaches of Cross Dams

The breaches at cross dams and inundation of low-lying areas are shown in Fig.1. Many villages were inundated as tidal surge lashes many areas of coastline from Cox's Bazar to Khulna via Bhola. Fifty fishermen were dead including 40 fishermen were missing and scores of thatched houses were damaged in islands of St Martin and Maheshkhali as a cyclonic storm crossed Chittagong-Cox's Bazar coast. Besides, about 150 houses were damaged by the storm accompanied by tidal surge of about 3 feet and also damaged a dozen of schools and madrashas. About 50 kutcha houses were damaged. As the storm crossed the Coax's Bazar coast, the tidal surge flooded low areas of Maheshkhali, Kutubdia and Chokoria.



Figure 1. Breached at cross dams and low-lying areas inundated (The New Nation, 2007/06/02)

### 2.3 Breaches of Gabtoli- Mitford Embankment

Figure 2 shows the damage of Gabtoli- Mitford connecting embankment that occurred due to heavy rain, transportation and movement of vehicles without paying any attention of the continuous erosion of the embankment. There are much other such type of embankments which are just breaches due to improper management and leaving it without taking care timely.



Figure 2. Damaged Gabtoli- Mitford Connecting Embankment (Zazadi 2007/05/11)

### 2.4 Collapse of Jamuna Embankment

The collapse of Jamuna embankment is depicted in Fig.3. Five Sirajganj Upazilla bear the brunt, embankment collapse threatens town. Sudden swelling of the mighty Jamuna has triggered massive erosion along its western bank in five Upazilla of Sirajganj district. At least seven kilometers of the flood control embankment from Khokshabari to Bhatpiary has collapsed into the river in just two weeks. About 1200 meters of the embankment at Ranigram point collapsed and the rest 4000 meters in the same area are vulnerable. The embankment at Ranigram point is vital among five other points of the 52km Brammha-putra flood control embankment between Sirajganj and Kazipur. Sirajganj town is threatened with erosion as the embankment collapses in more areas. Water Development Board (WDB) could not take any step to repair the embankment

due to fund shortage. Erosion is a regular phenomenon but it has taken a serious turn ahead of the season in 2007.

The WDB invited tender to build an embankment on the western bank of Jamuna covering the five vulnerable points, involving Tk 1.5 crore. Government assured of funds for reconstruction of the embankment but it is yet to be mobilized. At least 3500 homesteads and about 1500 acres of croplands in 35 villages in the five Upazilla have already been devoured by the Jamuna in two weeks. The five affected Upazilla Kazipur, Sirajganj Sadar, Belkuchi, Shahzadpur and Chowhali. Kazipur, Sirajganj Sadar and Chowhali Upazilla are worst affected. People close to the river areas were dismantling their houses and shifting to safer places. Thirty-five more villages in the five Upazilla were under threat. Water level of Jamuna near Sirajganj town was also rising by two to three feet everyday. About 12000 people who lost their homesteads have taken shelter on highlands and on both sides of roads. Banis Ali, 36, of Charpara village said he lost his homestead three times in last several years. He has taken shelter on a road at Khokshabari Natunpara village. The erosion-affected villages are Ranigram, Gunergati, Khokshabari, Panchil, Dwiarpanchil, Shimla, Bhatpiari, Simantobazar, Shuvogachha, Meghai, Natun Meghai, Natuarpara, Shoydabad, Randhunibari, Gachhabari, Shahpur, Rajapur, Shohagpur, Chala, Kaijuri, Gudhibari, Beltoil, Potazia, Sonatuni, Enayetpur, Betil, Jalalpur, Gala, Khaskawlia, Ghorjan, Chowhali, Umorpur and Sowdiachandpur. More areas went into the river every year due to bank erosion. A large number of families have become homeless and over 300 hectares of cropland washed away due to erosion by Jamuna on its right bank of Takukderpara in Shariakandi upazila of Bogra district. Structures constructed at a cost Tk 175 crore have been threatened at Maghai and Shimla areas in Sirajgonj. In Chandanbaisa Union Parisad, about 50,000 people in three unions in Shariakandi affected due to the collapse of the main embankment at Talukderpara.



Figure 3. A family watches with great worries as the Jamuna erosion approaches their homestead (Left) while another homeless family in Khokshabari in Sirajganj Sadar shifting their house to a safer place (Daily Star 2007/06/02)

## 2.5 Collapse of Karatoa River Embankment

Earlier breach of Karatoa river embankment at Kishamat Cherenga village in Polashbari in Gaibandha is shown in Fig.4. Several thousands people from different villages in Polashbari upazila at a rally at Kishamat Cherenga village have appealed to the local administration and the Water Development Board (WDB) to renovate the breached portions of Karatoa river

embankment before the upcoming monsoon to save the area from flood. But the breaches are not renovated despite allocation of Tk 84 lakh for it. The villagers offered all possible help by supplying bamboo, wood and labor and said the breaches can be renovated in only two weeks if 500 laborers are engaged.



Figure 4. Breach of Karatoa River Embankment at Kishamat Cherenga Village in Polashbari in Gaibandha (Daily Star 2007/05/14)

The embankment breached at four points in Kishamat Cherenga, Nayapur, Bishawnath and Bogulagari and is vulnerable at more 24 points. Several lakhs people feared to be affected in the coming monsoon if these are not repaired. The embankment was constructed by WDB in 1991 to save the people of Hossainpur, Kishoregari and Darbastha unions from flood and erosion. The villagers alleged that the embankment breached as it was not constructed as per specification, causing recurring floods in three unions. It is known that the allocation of funds was made but the work could not be started due to complexity in land requisition. The flood in 2005 caused a loss of at least Tk 10 crore in damage to crops, cattleheads, and roads. In last three years, Karatoa changed its course in Kishmat Cherenga and took a U shape touching the embankment. Local people earlier demanded re-excavation of one kilometre area of the river to straighten it to reduce water pressure on the embankment. But no step was taken in this regard.

## 2.6 Collapse of Lohalia River Embankment

Inundated croplands in Patuakhali Sadar upazila following breach of Lohalia river embankment at Shoula village is shown in Fig.5. The tidal surge that swept the coast washed away shrimps from at least 50 farms and damaged crops on about 2,000 acres in 12 villages in Patuakhali Sadar and Baufal Upazilla. The tidal surge entered the villages as the Lohalia river dam constructed by Water Development Board collapsed at Shoula village in Sadar upazila during the tidal surge. The affected villages are Shoula, Kakrabunia, Idrakpur, Pajakhali, Palerdanga, Nazirpur, Kuripaika, Pratappur and Vaila in Sadar upazila and Bamnikathi and Adabaria in Baufal upazila. Crops like maize, grand nut, sweet potato on about 2,000 acres were totally damaged. The WDB constructed the sluice on Shoula canal at a cost of Tk 25 lakh in 2000. The sluice gate has become more vulnerable as it was not carefully planned after survey. At least three sluice gates should be constructed to control the pressure of water and protect the dam.



Figure 5. Inundated croplands in Patuakhali Sadar upazila following breach of Lohalia river embankment at Shoula village (Daily Star 2007/05/14)

### 3. CAUSES AND RECOMMENDATIONS

#### 3.1 Physical Facts of Bangladesh

In order to understand the flaws of the current embankments to flood control in Bangladesh, we need to be familiar with certain basic facts regarding the land and rivers of Bangladesh as given below. The fundamental physical fact regarding Bangladesh is that, together with West Bengal, it constitutes a delta. While most other deltas are creation of single rivers, the Bengal delta is the creation of three mighty rivers, namely the Ganges, the Brahmaputra, and Meghna (Fig.6).



Figure 6. River Systems of Bangladesh

The combined catchments basin of the Ganges, the Brahmaputra, and Meghna measures to 1758000 square kilometers, which is more than 12 times the size of Bangladesh. The amount of sediment carried annually by the rivers of the Bengal delta is about two billion tons. This is far more than any other river system anywhere in the world. Under average conditions, from June to September, 775 billion cubic meter of water flow into Bangladesh through the main rivers and an additional 184 billion cubic meter of stream flow is generated by rainfall in Bangladesh (Islam, 1994). The amount of water flow and silt will be increased more in the future due to global warming, deforestation and top soil exposure. The construction of embankments to control flood has to be thought in the context of the above facts and trends.

### **3.2 Methods Undertaken and Causes of Failure**

Flood control embankments presently used are mainly constructed based on the method of fill embankments or earthen embankments because these are the cheapest form and the initial cost required is comparatively lower than any other form of embankments such as concrete or reinforced earth embankments. According to this method, the necessary areas are bounded of in order to protect them from flooding. DND embankment which protect Dhaka, Narayanganj, and Demra from the adjoining Buriganga and Shitalkhya rivers, Brahmaputra right hand embankment which protect from Brahmaputra-Jamuna river channel are some of the examples. Also there are many other embankments that are constructed along various stretches of many other rivers. The Meghna-Dhonagoda embankment and others that have been constructed to protect cities and towns like Rajshahi, Shirajganj, Chandpur, Khulna and Barisal are belonging to this category. These embankments let the river water remain confined only to their channels and pass directly to the sea. As most of the embankments are made of earth or soil only without any surface covering, these are washed away easily with the raindrop and current or flow of water. Thus these soils increase the volume of silt and siltration causes the riverbeds to rise which increase the water level of the flood causing gradual increase of suffering and damages. Also, it is the nature of the main rivers of Bangladesh, such as, Padma, Jamuna, and Meghna to frequently change their courses over alluvial plain, and when they are set to do so, no amount of earthwork can prevent that from happening. Bangladesh's experience is full with such unstoppable examples of river power.

On the other hand, there is the possibility of such historic change of river courses like that of Brahmaputra from its old Brahmaputra channel to Jamuna, or that of Ganges from Bhagirathi to Padma. Such epochal shifts do not occur frequently. However, they cannot be ruled out. River experts are particularly worried about the Brahmaputra, which they regard as one of the world's most turbulent and dynamic rivers. They think that the way Brahmaputra is positioned on a fan of its own silt on northern Bangladesh is indicative of the possibility of another historic shift. Also note that some of the areas through which Bengal rivers pass are seismically active. This is particularly true for the Brahmaputra and the tributaries of Meghna. Hence, seismic events cannot be entirely ruled out. Even mild tremors can provoke rivers to change course and overrun the embankments. Alternatively, tremors may cause cracks in the embankments, and the pressure of river water may do the rest. Even without seismic activity, cutting new channels and moving into them is a regular phenomenon for Bangladesh's major rivers.

One recent examples of such failure is the collapse of Chandpur Irrigation Project's protective embankment in face of Meghna's onslaught during 1988 flood. The river moved 550 meter eastward and cut a 45 meter deep new channel. Similarly, all efforts at stopping erosion by

Jamuna near Shirajganj town have met with little success. Earlier in 1966, the combined flow of the Ganges and Brahmaputra, downstream of Faridpur, moved 1500 meter laterally and dug a 30 meter deep new channel. As Eastern Water Study notes, there is no force on earth that can confront such raw power of nature. Thus, to summarize, it is unnatural and downright dangerous and irresponsible to suggest that the Bengal deltaic rivers can be confined into their channels only without proper design and construction. Such a program will put the entire nation in perpetual risk. It is just a law of probability that earthen embankments without any surface covering or reinforcing will fail to protect the flood problem effectively and permanently. Present embankments will also create nightmarish new problems of siltration and environmental degradation. There are several reasons that dominated in constructing earthen embankments even its ultimate consequences are so grave and destabilizing. The main causes of these are misperception and improper handling. With little appreciation for all the advantages of the reinforced embankments, the authority thinks that the earthen embankment is the good idea to deal with the situation.

### **3.3. Considerations and Recommendations**

The facts that need to be taken into account in order to obtain desired performances of the embankments for flood control effectively and permanently are, i) to use smaller space for embankment construction, ii) to facilitate as much space as possible for ease of water flow and to construct embankment that will not breach easily. In order to accomplish the above points, the followings may be suggested, 1) construction of concrete embankment instead of earthen one, 2) Protection to the surface of earthen embankment to prevent washing out of soil, 3) Use of locally available recycled and waste materials for earth reinforcement and 4) application of soil-cement composite with mesh as a reinforcement. The construction of concrete embankment usually takes smaller space as compared to earthen embankments thus provide more space to accommodate river overflow. Therefore, the height of flooding decreases proportionately with the increase of area over which water can spread. With the progress of modernization, industrialization and urbanization, the country needs faster transportation of goods and people which can be safely implemented with the help of concrete embankments or embankment that are protected from any failure having any category mentioned above. Although the construction cost of concrete embankment or reinforced embankments may be higher than the earthen one, the total cost may be much cheaper than the one which needs to repair or reconstruct every year if one considered it on long term basis or life-cycle basis.

In order to fulfill the suggested aim, first, we can proceed by using the locally available material for construction of embankments. This will not only facilitate to reuse the material of surface water bodies such as re-excavating the rivers, ponds, khals, dighis and bils but also make riverbeds wide. Now-a-days, it is well known that Bangladesh is headed toward a situation of extremes, whereby very low lean season flow will be accompanied by very high peak season flow. Only a massive excavation program can enable Bangladesh to cope with this twin problem of extremes simultaneously. It will not only enhance surface water storage capacity, which will thereby lower the flood height but also facilitates to store water which will counteract the shortage of water during the lean season. Second, it is important fact that there is a lot of recycled materials produced in Bangladesh every year which creates environmental problems (Fig.7). These materials can be easily obtained with lower cost. This is a big advantage to repair and reinforce the earthen embankments. When necessary, new embankments can be constructed

by the re-excavated and recycled materials. However, to save money, it is always a good idea to repair the existing ones than to construct entirely new ones.



Figure 7. Recycled produced due to demolishment of buildings (Daily Star 2007/05/13)

#### 4. CONCLUSIONS

From the analyses and discussion depicted above, it is evident that construction of earthen embankments only for controlling the flood in Bangladesh is not good idea and these are easily vulnerable to the impact of rain water or current of water. It is observed that the fundamental geophysical facts regarding land and rivers of Bangladesh do not agree with the present construction methodology of embankments. The overall situation showed that the country demand the embankment that are long lasting and durable. The idea proposed in this paper can clearly overcome the present drawbacks. The main things of this idea are to use recycled materials, re-excavated materials, concrete, soil-cement for new construction or repairing the old embankments. It protects the embankments by preserving the surface soil, it mitigates flood by increasing the surface water bodies, it prevents sedimentation by preventing erosion of the earthen uncovered embankments, it minimizes the obstruction of floodplains, it restores permanent transportation and flood shelters, it does not create any risky situation, it reduces the waste and recycled materials thus conserves the environment, it enhances the aesthetics of landscape, it increases the safety and stability of the embankments, and finally, it does not entail any wastage of investment.

#### 5. ACKNOWLEDGEMENTS

The research reported in this paper is partly supported by the Research Grant No. 19405036 with funds from Grants-in-Aid for Scientific Research given by the Japanese Government. The writers gratefully acknowledge these supports. Any opinions, findings, and conclusions expressed in this paper are those of the authors and do not necessarily reflect the views of the sponsor.

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M. Z. Hossain and T. Sakai. "Severity of Flood Embankments in Bangladesh and Its Remedial Approach". *Agricultural Engineering International: the CIGR Ejournal*. Manuscript LW 08 004. Vol. X. May, 2008.

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