

Grain Size Distribution of Materials Deposited Over Floodplain Due to Embankment Failure

S.J. Md. Yasin, Md. Hossain Ali, Egramul Hoque, Sadik Ahmed
and Rezaul Hoq

Department of Civil Engineering
Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh

Abstract

Rivers in Bangladesh carry huge amount of sediment load and as a result flood embankment failure causes sedimentation over the floodplains. Nature of the sediments e.g., grain size and distribution are important factors to be considered in a numerical model for estimating the risk and extent of damage by sedimentation. Samples collected at random from the sediments deposited due to failure of the Dharala and Dudkumar river embankments by the 1998 flood show considerable variation in grain size and gradation. It has been argued that numerical models need to be calibrated for such wide range of gradations in deposits.

INTRODUCTION

Failure of river embankments during flood is a frequent natural phenomenon in Bangladesh and often it results in sedimentation over the floodplain. Apart from untimely damage to crops, this sedimentation entails potential long term damage to crop cultivation in the surrounding areas. The long-term damage potential depends on many factors, of which the characteristics of sediments carried by the river is most important. The present study is aimed at determining the grain size distribution of sediments deposited at selected locations of the floodplains of Dharala and Dudkumar rivers at Kurigram, due to breach of embankments during the 1998 flood.

EMBANKMENT FAILURE AND CONSEQUENT SEDIMENTATION

Bangladesh is a riverine country, which is criss-crossed by numerous rivers. The landmass of Bangladesh was created from the sediments carried by the major rivers. Most of the rivers have not yet attained stability from morphological point of view and carries huge amount of sediments to the sea. These sediments originate either from materials washed from the upstream or from the breaking of the riverbanks due to scouring along the river channel. Islam (1994) has shown that breaches in river embankment result in huge amount of sediment deposition over the natural levees. It was reported that during 1985-1991 ten breaches in eight embankments resulted in more than 16 million m³ of sediment deposits over the natural levees causing damage to agricultural crops of 66,700 hectares of land (Islam, 1994). A number of studies have been carried out on floodplain sedimentation due to flood inundation (e.g., Muramoto et al., 1989; Islam, 1994; Islam and Salehin, 1997). In fact, failure of river flood embankment causes greater volume of damage because of the increased economic activities in the protected area after the construction of the embankment (Chowdhury, 1996). Breach of embankment causes harm to agricultural land by depositing coarse sand whereas natural flooding of floodplains by riverbank overflow improves the fertility of land due to deposition of silt and clay.

BACKGROUND OF THE PRESENT STUDY

Since failures of flood embankments are usually accompanied by huge damages, it is necessary to make risk assessment in such a project. For this purpose numerical models are currently being used. The numerical models are based on information on the mechanism of floodplain sedimentation and physics of the phenomena. Towards this goal, “physical model laboratory tests” are necessary. Islam and Salehin (1998) reported results of few such tests. Grain size of soils used in such tests is an important parameter. In this respect, the findings of this study will help as a guideline in calibrating future experimental and numerical models and for using them in the actual analysis.

SCOPE OF THE PRESENT STUDY

The Kurigram Irrigation and Flood Project area is one of the severely affected regions of the country during the 1998 flood. The project area is bounded by two rivers, the Dudkumar river and the Dharala river. Flood control embankments, built on the right bank of Dudkumar River and on the left bank of Dharala river encompasses this area. The Dudkumar right embankment is 41.34 km long

starting from Pateshwari to proposed pumping station at Begomgonj. The Dharala left embankment is 42.30 km long starting from the Bangladesh-India border to the proposed pumping station at Begomgonj. During the flood of 1998 the Dudkumar right embankment failed at 3 (three) locations. Near Char Berubari the river eroded and engulfed about one km of the embankment. The Dharala left embankment also failed at one location; about 1.3 km of the embankment was washed away from Sitaijhar in Panchgachi union to Krishnapur in Mogalbasha union. At this location the Dharala river shifted its course meandering into the project area. Figures 1 and 2 show schematic diagram of the breached embankment and riverbank erosion near Char Berubari of Dudkumar river and from Sitaijhar to Krishnapur along Dharala river, respectively. Sedimentation occurred over huge area adjacent to these breached sections of embankment and caused immediate and long term damage to plant cultivation. This study is aimed at determining the grain size distribution of sediments from these areas.

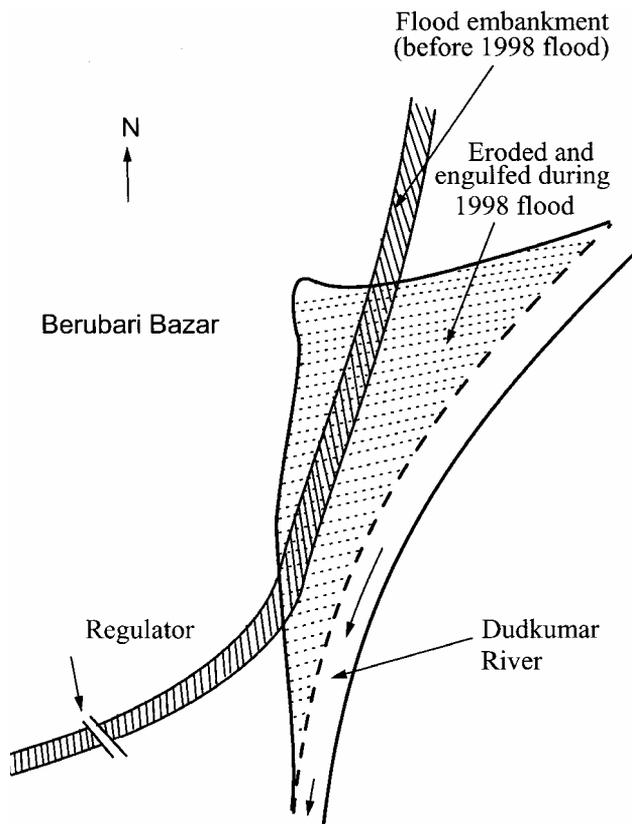


Figure 1: Schematic diagram showing breach of Dudkumar right embankment during the 1998 flood

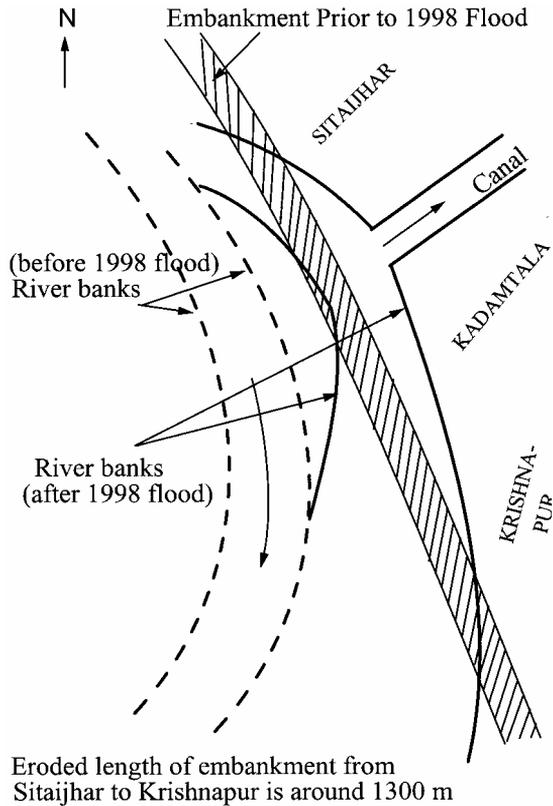


Figure 2: Schematic diagram showing the breach of Dharala left embankment during the 1998 flood

COLLECTION OF SOIL SAMPLES AND LABORATORY TESTS

Just after the recession of floodwater, Mr. Sadek and Mr. Rezaul Hoq who worked as Research Associates in this project, visited the damaged sections of the Dudkumar and Dharala embankments and collected soil samples from the area. A total of 40 (forty) samples were collected from the area of which 9 (nine) were from the floodplains near failed section of Dudkumar embankment at Berubari and 31 (thirty one) from the floodplain near failed section of Dharala embankment at Panchgachia Union. These included 3 (three) samples from the original soil near the breach of Dharala embankment and 4 (four) samples from the original soil near the breach of Dudkumar embankment. The rest were from the recent deposits due to flood. These samples were collected from locations selected at random along the riverbank. No attempt was made to measure the aerial expansion, distribution or pattern of the sediments deposited.

Mechanical sieving and hydrometer analysis were performed on the collected soil samples to determine their gradation. US standard sieves #4, #8, #16, #30, #40, #50, #80, #100 and #200 and a power driven sieve shaker were used for mechanical sieving. Hydrometer analysis was performed using a 151H ASTM hydrometer. ASTM-D422-63 test procedure was followed. Sodium Hexameta Phosphate was used as dispersing agent and necessary corrections, e.g., temperature, dispersing agent, meniscus and immersion corrections were applied in the calculations. Specific gravity determination was carried out for each sample that required hydrometer analysis and the respective specific gravity was used in the calculation of grain diameter and percent finer.

RESULTS AND DISCUSSION

The specific gravity values of the collected soils are summarized in Table 1. The average specific gravity of the sediments of Dharala river are 2.703 and that of the Dudkumar river sediments are 2.766. As seen from Table 1, there is no significant variation in the specific gravity of samples collected from different aerial locations near the breached sections of embankments.

Table 1: Variation in specific gravity of the collected soil samples

	Dharala		Dudkumar	
	Original soil from the bank	Soil deposited in 1998 flood	Original soil from the bank	Soil deposited in 1998 flood
No. of samples*	3	21	2	6
Maximum	2.739	2.769	2.695	3.021
Minimum	2.680	2.652	2.624	2.709
Average	2.714	2.703	2.660	2.766
Standard deviation	0.031	0.032	0.050	0.125

* Specific gravity determinations were done for samples that needed hydrometer analysis.

Figure 3 compares the grain size distribution of samples collected from near the breached sections on the left bank of Dharala River. A wide range of grain sizes was found to be deposited at different locations within a small area near the failed sections of the embankments. The average curve is also shown on the same figure. The average curve was obtained by taking mean of the percentage finer values corresponding to any diameter for all the samples. Figure 4 shows similar curves for samples from Dudkumar riverbank. However, the gradation of samples from Dudkumar riverbank is less varied compared to those from the Dharala riverbank.

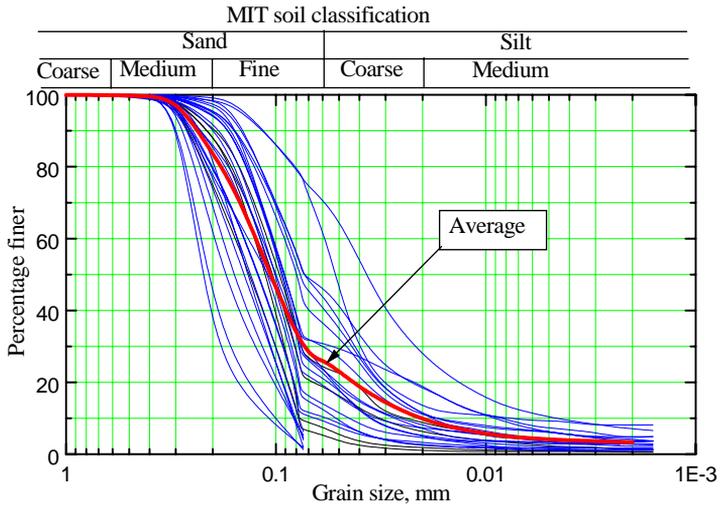


Figure 3: Grain size distribution of soil samples collected from deposits along Dharala riverbank

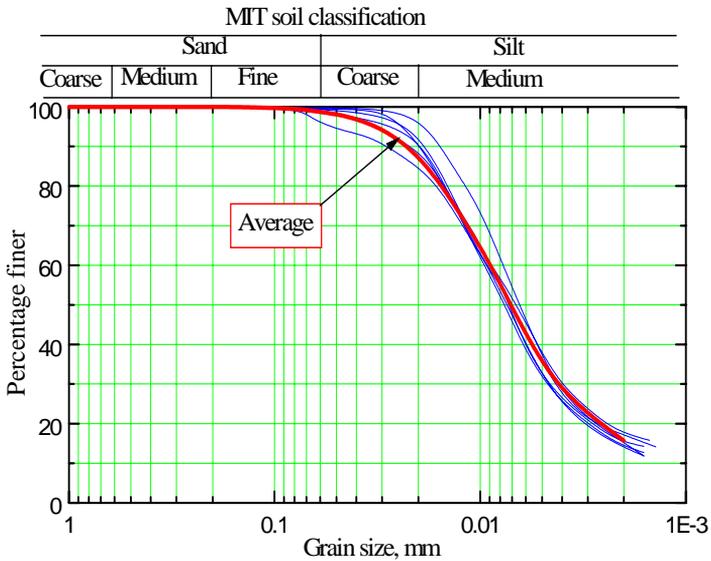


Figure 4: Grain size distribution of soil samples collected from deposits along Dudkumar riverbank

The gradation curves for samples from original soil from the banks are also compared with those from the flood deposits in Figs.5 and 6 for samples from Dharala and Dudkumar riverbanks, respectively. Figure 5 shows that the 1998 flood deposits were relatively coarser than the Dharala bank soil and relatively finer for the Dudkumar riverbank soil. These figures suggest that the deposited sediments originated not from the erosion of the bank near the breach but possibly from upstream locations.

In Figs. 7 and 8, selected diameters d_{10} , d_{30} , d_{50} and d_{60} obtained from individual grain size distribution curves are plotted to show their range of variation. In these figures horizontal scale do not represent any quantity. Here d_{10} means the diameter such that ten percent of the grains are finer than that size and so on. The d_{10} , d_{30} , d_{50} and d_{60} values at different locations are spaced apart along the horizontal axis for clarity. Table 2 shows the mean and standard deviation of these diameters for all samples.

Table 2: Variation in grain diameters of the samples collected from Dharala and Dudkumar riverbanks.

Diameter	Dharala			Dudkumar		
	Mean	Standard deviation	Values from avg. curve	Mean	Standard deviation	Values from avg. curve
d_{10} , mm	0.047	0.0314	0.020	--	--	--
d_{30} , mm	0.084	0.0366	0.073	0.004	2.957×10^{-4}	0.004
d_{50} , mm	0.113	0.04156	0.106	0.007	4.588×10^{-4}	0.009
d_{60} , mm	0.128	0.04481	0.125	0.009	6.276×10^{-4}	0.012

CONCLUSIONS

Soil samples collected from different aerial locations near the breached sections of Dharala and Dudkumar river embankments during the 1998 flood showed that there are considerable variations in grain size distributions of the sediments deposited at different location on the natural levees. Also the grain size distribution of the soil samples collected from just beneath the 1998 deposition, which probably resulted from depositions prior to embankment construction, were found to be very much different from the recent deposits. So, it is suggested that laboratory model studies on flood plane sedimentation and calibration of relevant models be carried out taking into consideration this wide range of distributions of grain sizes.

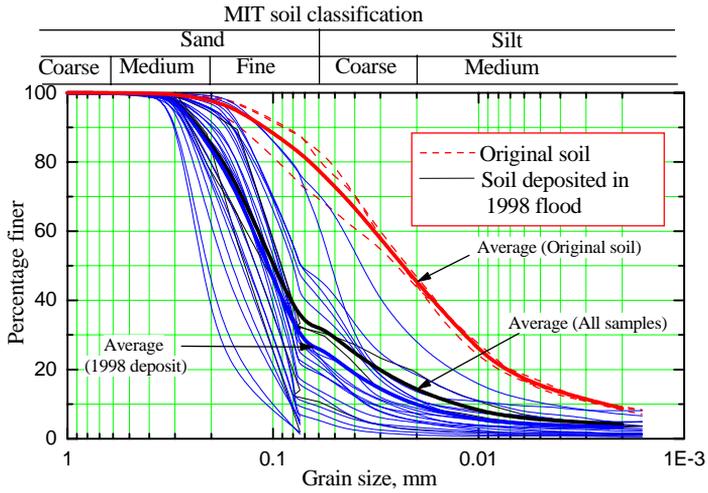


Figure 5: Comparison of grain size distribution of deposited soil due to embankment failure with original soil along Dharala riverbank

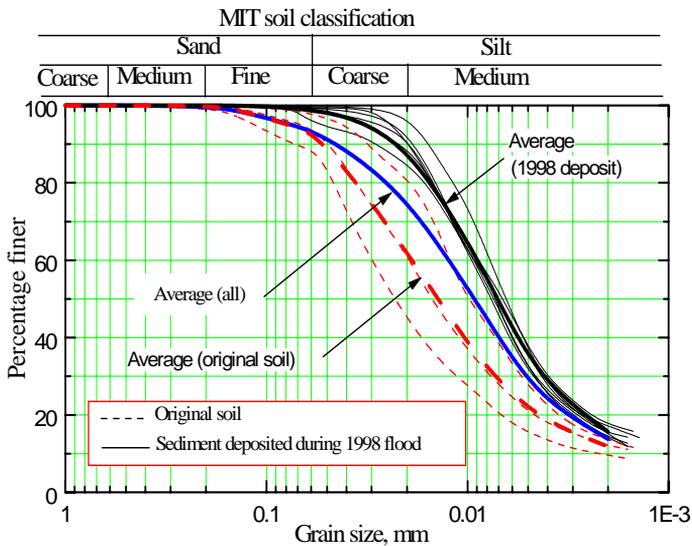


Figure 6: Comparison of grain size distribution of deposited soil due to embankment failure with original soil along Dudkumar riverbank

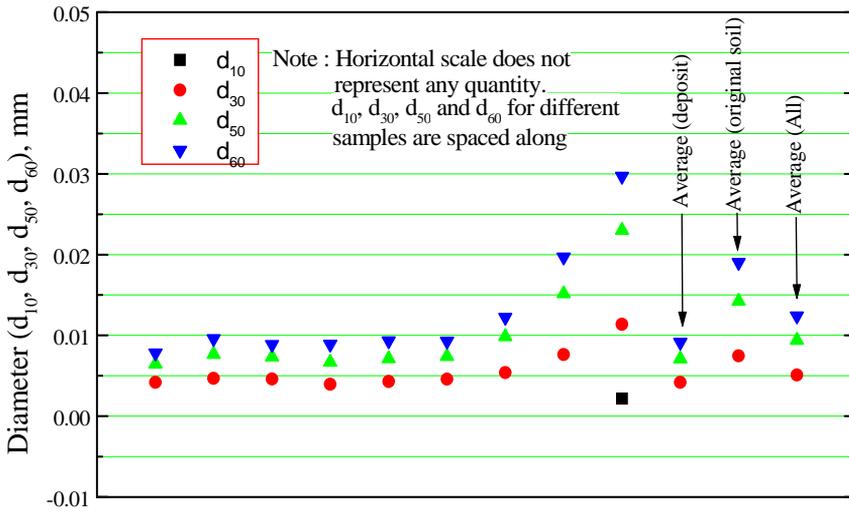


Figure 7: Variation of d_{10} , d_{30} , d_{50} and d_{60} of different sediment samples deposited along Dharala riverbank

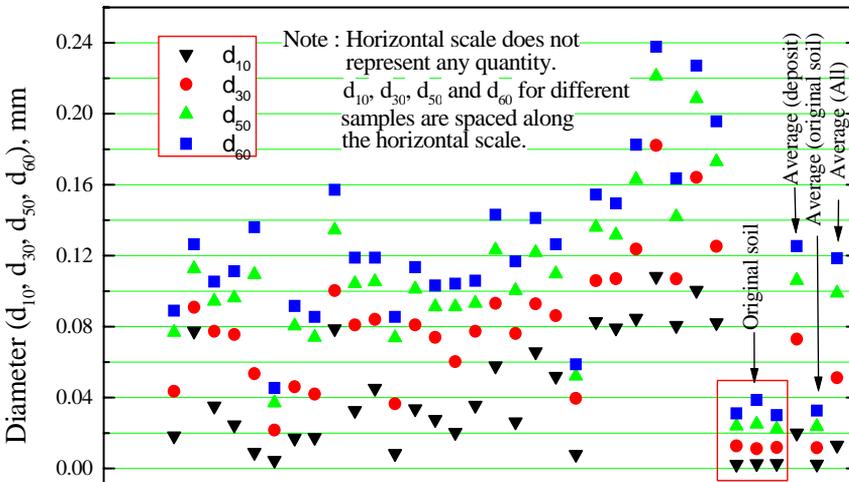


Figure 8: Variation of d_{10} , d_{30} , d_{50} and d_{60} of different sediment samples deposited along Dudkumar riverbank

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