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Assessment of Flood Damage to Roads in and around Dhaka City and Remedial Measures

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Abstract

The devastating flood of 1998 has caused considerable damages to the road pavements in and around Dhaka City. After the recession of floodwater, a major investment is usually necessary for rehabilitating the road network. An assessment of the volume and extent of damage is needed for framing the corresponding fiscal policy. In this study, assessment of the damages to the roads in and around Dhaka city has been made and investigations into the road material characteristics have carried out. A field survey has been undertaken which includes manual measurement, field interview and photographic evidence. Material samples have also been collected from the damaged road sites. Photographs have been analyzed in the studio and materials have been tested for important engineering characteristics. From the study, it has been found that flow of large vehicles during flooding period has a significant influence on the extent of damage. Also, the pavements that have been in good condition before the flooding have experienced less or almost no damage. It has also been found that for a number of pavements, design parameters and proper specifications have not been followed.

INTRODUCTION

The devastating 1998 Flood inundated a significant portion of road network in and around Dhaka City. It has generally been observed that considerable damages have been incurred in all the inundated roads. Right after the recession of the floodwater, a major investment would be necessary for rehabilitating the

road network. An assessment of the volume of damage is urgently needed for framing the corresponding fiscal policy. It is again necessary to investigate the reasons for such wide scale damage to the road pavements. In the long-term basis, it is also important to investigate whether any changes in the pavement design criteria and material specifications should be made in view of the frequent inundation of roads by flood.

The major objectives of the present research study were: (i) To assess the flood damage to roadway pavements; (ii) To record the inundation characteristics of major roadway corridors of Dhaka City; (iii) To measure characteristics of in-situ road materials, and to compare the characteristics with those of the standard specifications; and (iv) To suggest remedial measures for future construction and design processes.

METHODOLOGY

For this study, major roads of Dhaka City were identified. Physical visits to those roads were made and questionnaire surveys were carried out at the road sites to record the inundation conditions. Right after the recession of the flood, photographs of selected sections of each major road were taken for assessing the scale of damage. Simultaneously, material specimens were collected from each section of the road. The photographs were analyzed in the studio and the materials were tested in BUET laboratories. The extent of damage was assessed by analyzing the photographs. Efforts were made to identify the reasons of wide scale damages to roads by the flood. Also, results of material tests were compared with the standard specifications to see whether those were followed during construction.

FIELD SURVEY

Field survey is an effective way of gathering information regarding flood damage to roads. When this research work started, the floodwater from Dhaka City roads had already receded. Therefore, alongside photography and visual observation interview of roadside residents and retailers were taken regarding the inundation characteristics of the roads (Hossain et al., 1999). In-situ materials from road surface layers were also collected for laboratory tests. Twelve major roads/corridors of Dhaka City and its suburbs were identified for carrying out the filed survey. These were Shantinagar Road, Khilgaon-Taltala Road, Shahid Suhrawardy Avenue, Pragati Sarani, Dhaka-Aricha Highway, Sayadabad–Jatrabari Road, Demra Road, Basabo Corridor, Mirpur Darussalam Road,

Satmasjid Road, Jatrabari-Postogola Road and Dhaka–Mawa Road. Apart from visual observation, photographs and interview, road materials samples were also collected from surface as well as base or subbase layers, where surface layer was washed out.

Visual Observation

After arriving at the road site, general observation of the road surface was made. As the floodwater had already receded by that time, efforts were made to find the mark of the maximum flood water level on the roadside structures i.e., curb, footpath, electric/telephone pole, walls, etc. Where found, the approximate floodwater height from the road surface was measured with scale/tape. Also, the general condition of the pavement was observed and recorded. The maximum pond depth created by flood damage was also measured in each 100m section of the road.

Interviews

Roadside residents and retailers are the best witnesses of the flood and hence the best source of information regarding the duration and extent of flooding. After confirming their knowledge the road under consideration, such people were asked about the flood duration in days. If at least three estimates of the flood duration from three different persons matched, then it was recorded as the flood duration for that portion of the road.

Photographs

Photographs can be used as the hard evidence of flood damage. In the present study, photographs of the flood-damaged roads were taken for use in assessing the damage. One snap is taken in each 100m portion of the road. In order to be able to determine the approximate scale of the photo, two bright markers (bright colored cloth in this case) were included in each photo.

Sample collection

The final task of field survey at each site was to collect material sample from roads. From each road site more than one sample consisting of approximately 5-7 kg of asphalt concrete from the wearing course were collected. In cases where wearing coarse was fully washed away, material samples from base/sub-base coarse were collected. A mild steel pavement cutter along with a heavy-duty hammer was used for this purpose.

LABORATORY TESTS

Laboratory tests were performed on the samples collected from the road site. The objective of the laboratory tests was to know the field material characteristics relevant to the design for the asphalt concrete pavement. The main material characteristics used in the design process were: percentage of bitumen, aggregate types, grading and strength. Asphalt content of the wearing course was found by extracting the asphalt with tri-chloroethylyne in accordance with ASTM 2172 (ASTM, 1992). The aggregate type (whether stone chips or shingles) was noted by observing the asphalt free aggregates. Then sieve analysis was performed on the aggregate samples to know the gradation. Aggregate Impact Value (AIV) test was performed (BS, 1985) to determine the strength of the aggregate used in base/sub-base coarse.

ANALYSIS OF PHOTOGRAPHS

In order to be able to observe the photographs in a magnified scale, slides were developed. All the required linear measurements regarding the extent of damage were taken from the projected views of the slides. Thus, it was possible to minimize the magnitude or error in distance measurements. Most of the photographs represented little over one thousand square foot of pavement surface area. Therefore, the extent of pavement damage was estimated as a percentage of damaged pavements per one thousand sq.ft. of pavement area. A typical damage assessment and flooding characteristics for Pragati Sarani Road has been presented in Table 1. The same in summary form for all other roads under the present study has been presented in Table 2. From Table 1 it can be observed that even a low height flooding (3 inch to 6 inches) for duration of five to ten days caused damages upto 95% of the pavement area in case of Progati Sarani. The damage assessment listed in Table 2 also reveals that flood duration and flooding height have no definite correlation with the extent and severity of damage. Again, from Table 2 it can be observed that DIT road to Khilgaon Chowdhurypaara road section was damaged only about twenty five percent with no severe pond/ditch type of damage, although flood duration here was twenty days with a maximum flood height of one foot (30.48 cm). For similar types of flood duration and flooding height, the road section from Chowdhurypaara to Taltala market have not experienced any visible damage. However, it has been reported by the roadside residents that the road is resurfaced just before the flooding season. Similarly, Dhaka-Mawa section of the Dhaka-Khulna highway incurred insignificant damage although flooding duration was fifteen days with a maximum height of two to three feet (61 cm). From field interviews, it has been

revealed that the road was in good condition before flooding and was resurfaced only recently.

Table 1: Assessment of flood-damage and flooding condition of Progati Sarani

Section No.	Location	Damage condition	Flooding information
1	In front of U.S. Embassy	• Severe damage • Up to 5.0 inches deep ditches • 20 % in 1000 sq. ft • Uniform crack	• Water logging • Flood height: 6.0 inches • Duration 10 days
2	Progati Smarani (Shahjadpur)	• Ditch like a pond • Up to 15.0 inches deep • 80 % in 1000 sq. ft	• Water logging • Flood height: 3.0 inches • Duration 5 days
3	400 ft south from Progati Smarani	• 10 inches deep ditches • Great damage • Uniform interval • Large extend of ditches • 85 % in 1000 sq. ft	• Water logging • Flood height: 3.0 inches • Duration 5 days
4	North Badda (in front of Hossain Market)	• Great damage • 6.0 inches deep ditches • Crack • 80 % in 1000 sq. ft	• Water logging • Flood height: 3.0 inches • Duration 10 days
5	Middle Badda	• 15 inches deep ditches • Pond type ditch in large extent • 95 % in 1000 sq. ft	• Water logging • Flood height: 4.0 inches • Duration 10 days
6	Middle Badda (Bus Stand)	• 15 inches deep ditches • Pond type ditch in large extent • 95 % in 1000 sq. ft	• Water logging • Flood height: 4.0 inches • Duration 5 days
7	Middle Badda (Bus Stand)	• Pond in road ! • 15.0 inches deep ditch in 1000 sq. ft area • 95 % in 1000 sq. ft	• Water logging • Flood height: 4.0 inches • Duration 10 days
8	Middle Badda	• Pond in road • 15.0 inches deep ditch in 1000 sq. ft area • 95 % in 1000 sq. ft	• Water logging • Flood height: 3.0 inches • Duration 10 days
9	Merul Badda	• 15 inches deep ditches • Very bad condition • 85 % damage in 1000 sq. ft	• Water logging • Flood height: 3.0 inches • Duration 10 days
10	North of Rampura Bridge	• 15 inches deep ditches • Very bad condition • 85 % damage in 1000 sq. ft	• Water logging • Flood height: 3.0 inches • Duration 10 days

Table 2: Summary of assessment of flood damage to roads

Road/Corridor	% Pavement area damaged per 1000 sq. ft.	Depth of ditch/ pond, if any	Inundation characteristics
Shantinagar Road	25-50	4"-6"	Flood water high 1'-1.5' flood duration 25-40 days
DIT Road to Khilgaon Chowdhury Para	25-30	-	Flood water height = 1 ft Flood duration 20 days
Chowdhury para to Taltala Market	No damage, Good condition, Road repaired just before flood	-	Flood water height = 1 ft Flood duration 20 days
Shahid Suhrawardy Avenue	10-20	3"-5"	Flooding height = 3"-7" Flood duration = 10-20 days
Pragati Sarani	The pavement is almost fully damaged	6"-15"	Flooding height = 3"-4" Flood duration = 5-10 days
Dhaka – Aricha Highways	Technical to Amin Bazar portion is fully damaged	6"-8"	Flooding height = 0.5'-1.0' Flood duration = 10-20 days
Amin Bazar to Hemayetput Portion	30-60	2"-3"	Flood height 1'-4' Flood duration 15-20 days
Sayadabad to Jatrabari	30-70	4"-8"	Flood height = 3"-4" Flood duration = 5-15 days
Basabo corridor	20-40	4"-6"	Flood height = 1'-3' Flood duration 20-25 days
Mirpur Darussalam Road	40-90	3"-4"	Flood height = 1 ft Flood duration = 15-20 days
Satmasjid Road Mohammadpur Bus Stand to Physical College Portion	40	2"	Flood height = 2"-3" Flood duration = 5 days
Jatrabari – Postogola	50-100	4"-6"	Flood height = 1'-3' Flood duration = 15 days
Dhaka – Mawa	Insignificant damage		Flood height = 2'-3' Flood duration = 15 days

The critical loading condition on the pavement is resulted from heavy-duty trucks and large buses (TRL, 1993; BRRL 1987). Therefore, it is expected that during flooding the flow of these large vehicles would have multiplying damaging effect on the pavement structure. From a recent study (Hossain et al., 1999a) it has been revealed that among the national highways Dhaka-Mawa corridor of Dhaka-Khulna highway carries lowest percentage of large vehicles.

While the percentage of heavy vehicles on this road is in the range of 5%-6%, the same on the other national highways varies in the range of 12%-25% with the maximum percentage of trucks on Dhaka-Aricha highway. Also, within the city area the less damaged (Table 2) roads like DIT road to Chowdhurypara and Chowdhurypara to Taltala do not include the three major truck routes as identified by a recent study (Chowdhury et al., 1991). So, it appears that flow of large vehicles during flooding period has a significant influence on the extent of damage. Generally, the flooded road with higher percentage of truck traffic experienced greater damage.

ANALYSIS OF RESULTS

Material characteristics of Dhaka–Aricha highway have been investigated through laboratory tests. Tests have been performed on four different pavement samples collected from four different sections of the highway. The percentage of bitumen content found in the wearing course mix is given in Table 3. While optimum bitumen content for most of the asphalt concrete mixes lies between 5.5% to 6.5% (RHD, 1994), from Table 3 it can be observed that three out of four samples contained either very low or very high percentage of bitumen. This lower or higher amount of bitumen content might be a major reason for lower stability of the mixes.

Table 3: Percentage bitumen content in the paving mixture sample

Road	Sample No.	Sample layer	Inundation period (Days)	% bitumen content
Dhaka - Aricha highway (Gabtali-Aminbazar section)	1	Surface layer	5	9.7
	2	Surface layer	20	8.2
	3	Surface layer	10	5.4
	4	Surface layer	15	3.7

From bitumen extraction it has been found that two out of four aggregates samples are shingles and rest two are stone chips. The gradation curves of all the four aggregate samples along with the suggested (RHD, 1994) gradation range have been plotted in Figure 1. It is suggested (RHD, 1994) that aggregates used should consist of chipping with a maximum size 8 to 14 mm. Thus, from Fig. 1 it can be observed that none of the samples, especially the coarser portion of the aggregate, are within the specified range. The results of AIV tests on base/sub-base aggregates are presented in Table 4. Aggregate gradation has a significant influence on the overall stability and strength of the asphalt concrete mix. From

Table 4 it can be observed that AIV values for three out of four samples are significantly higher than the specified maximum value of 25 (TRL, 1993).

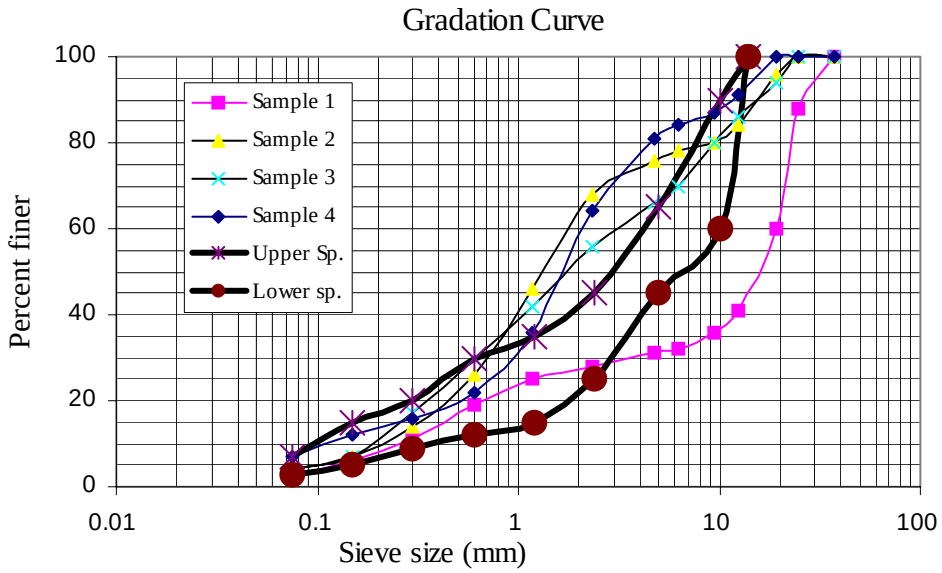

Figure 1: Comparison of aggregate sample gradation with the suggested (RHD, 1994) gradation range

Table 4: Aggregates impact values of aggregates samples collected from base/subbase layer

Road	Sample No	Sample layer	Inundation period (Days)	AIV value
Dhaka – Aricha highway (Gabtali-Aminbazar section)	1	Base/Subbase	20	34
	2	Base/Subbase	5	23
	3	Base/Subbase	10	34
	4	Base/Subbase	15	32

CONCLUSIONS

Assessment of flood damage reveals that even a low height flooding (3 inch to 6 inches) for duration of five to ten days caused wide scale damages to pavements. It proves that flood duration and flooding height have no definite correlation with the extent and severity of damage. However, it has been revealed that flow of

large vehicles during flooding period has a significant influence on the extent of damage. Generally, the flooded road with higher percentage of truck traffic experienced greater damage. Also, the pavements that were in good shape before the flooding experienced less or almost no damage.

While optimum bitumen content for most of the asphalt concrete mixes should be between 5.5% and 6.5%, it has been observed that most of the wearing course samples contained either too low or too high percentage of bitumen. This lower or higher amount of bitumen content might be a major reason for lower stability of the mixes. It has also been revealed that in selecting the gradation and type of coarse aggregate used in the wearing course, proper specifications have not been followed.

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