

ROAD SURFACE DRAINAGE AT HAT-BAZAAR OF RURAL AREA: A CASE STUDY

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ABSTRACT

The average annual rainfall in Bangladesh varies from 1429 to 4338 millimeters (BMD, 2014). During rainy season, this water causes serious water logging on roadways due to improper drainage system & local road dwellers behavior. Without proper drainage of water, it creates hazardous impact on daily activities of rural as well as urban area people. Pahartali is a Local Hat-Bazaar of Raozan upazilla on Chittagong- kaptai road. During rainy season, this bazaar becomes water logged for long time due to absence of proper drainage system and drainage maintenance system, which cause nuisance for consumers and sellers.

The present study includes a field investigation on a selected hat-bazaar area related to water-logging as well as to find out a probable solution for water logged area. In this regard, a suitable solution may be providing a permeable pavement along the both side of the pavement along with proper drainage system so that a sustainable & effective drainage system can be achieved. The overall benefits of permeable pavements may include; improved storm water drainage, improved skid resistance, reduction of mud spray to drivers and pedestrians as well as a potential for noise reduction. This techniques can be used for local hat-bazaar area of Bangladesh which are usually suffered from water logging during rainy season.

Key Words: Hat-Bazaar; permeable pavement; drainage system; water logging; CRMB (Crumb Rubber Modified Bitumen)

INTRODUCTION

Due to rapid modernization of human life, rapid growth of population, Bangladesh generates numerous economic places on roadside such as Hat-Bazaar. A Bazaar is a permanent enclosed merchandizing area, market place or streets of shop where goods and services are exchanged or sold. In each and every rural area of Bangladesh, there are some bazaars whether shaded or open where rural people fulfil their daily essentials.

Hat-Bazaar area has been facing extensive water logging problem during monsoon period due to poor drainage system & drainage maintenance system. Water logging provides many problems for traffic & road users and sometimes the whole transportation system become useless. Road development is independent compare to other mode of transportation. Without road transportation, other transportation system will become functionless. Only a well-defined & well developed road network can serve a country and its population properly. Water logging is one of the problem which is responsible for the damage of road & sudden break down of smooth as well as comfort transportation system, causing local water logging, spreading diseases, environmental problem, economic degradation & many more. That's why the study of water logging problem at Hat-Bazaar area is too much necessary.

Permeable Pavement (CDT, 2016) is an alternate solution that can be used with proper drainage system to overcome this problem. Pahartali Bazaar is situated on Chittagong-Kaptai road which is a regional highway (Medium volume road). For laboratory investigation & to make a comparison between normal bitumen & CRMB M30-10 have been used for permeable pavement. CRMB M30-10 is a modified binder that a mixture of 10% (by wt. of bitumen) waste crumb rubber (passes through #30 sieve) with bitumen. To determine stability, flow & Optimum Bitumen Content (OBC) Marshall

method of mix design has been used (AASHTO 2350). Also OBC has been calculated by Equation [1] (Kadiyali, 2003).

$$\text{OBC} = \text{Bitumen content at (max. stability + max. density + avg. air void + 80\% VFA)/4} \dots (1)$$

Moreover, to determine moisture susceptibility, Indirect Tensile Test have been conducted in the laboratory. And hence Tensile Strength Tensile Strength Ratio (LS-297) have been calculated by Equation [2] and Equation [3] respectively.

$$\text{ITS} = \frac{(2000 * P)}{(\pi * h * d)} \dots (2)$$

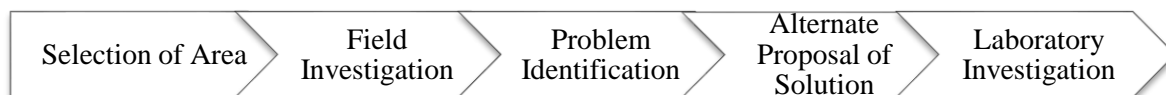
$$\text{TSR} = \frac{\text{ITS(wet)}}{\text{ITS(dry)}} * 100\% \dots (3)$$

The purpose of this paper is to provide a guidance for road concerning officials and other relevant organizations regarding proper road surface drainage. This paper also describes the causes of road surface drainage problem and its remedial measures at rural-hat bazaar area. In this era of drainage problems the following objectives have been selected for the present study.

- To ascertain the causes of water logging on selected hat bazaar area.
- To find out the suitability of permeable pavement.

METHODOLOGY

Water logging has been creating enormous problems due to improper drainage system. It impacts on local dwellers with respect to economic and normal activities. To overcome this problem, a sustainable and effective solution have to be implemented. The aim of this study is to find out a solution for water logging problems at Hat- Bazaar areas. The total investigation has been done by the following ways.



Selection of Area

There are many Hat-Bazaar areas in Chittagong. Out of these, Pahartali Bazaar is being selected for the present study as it is situated very near to Chittagong University of Engineering and Technology (CUET) and it has been facing water logging problem almost throughout the year.

Field Investigation

From field investigation, we have identified some problems regarding water logging; during the monsoon period, with very little amount of rain the roads of Pahartali bazaar become water logged and road surface is heavily damaged which has been shown in Figure 1

The logged water cause serious traffic problem on the road has been represented in Figure 2.

Field investigation includes the study of the present scenario, the causes of water logging is,

- The Pahartali Bazaar becomes water logged during and after rainfall due to non-availability of adequate camber, proper drainage system, disposal system and maintenance system is shown in Figure 1.
- The adequate cross slope does not exist due to the blockage of the drain that was provided for the carry out of excess water has been represented in Figure 2.
- The drain which lay alongside of the road is severely blocked due to the solid waste thrown by local dwellers & due to soil siltation which has been shown in Figure 3.
- The road become very narrow due to the wastage are dumped on the road is shown in Figure 3.



Fig. 1: Damaged & Water Logged Areas at Pahartali, Raozan, Chittagong.



Fig. 2: Traffic problem & Blockage of drainage at Pahartali, Raozan, Chittagong.



Fig. 3: Dumped waste and Soil siltation on road side.

Alternate Proposal of Solution

From field investigation and problem identification data, this study realize that water logging problem has to be removed by using a sustainable solution. The excess water is to be drained by using elevated road surface along with a proper drainage system. In addition, to accelerate the water drainage, a permeable pavement which is a new technique can be implemented within the roadway pavement on both side.

Laboratory Investigation

To implement permeable pavement, laboratory investigation is needed to determine its feasibility. Laboratory Investigation includes selection of aggregate, selection of binder and the selection of design method.

Selection of Aggregates

The aggregates used in the permeable pavement consists of crushed angular stone with maximum size not exceeding 19 mm which has been shown in Table 1 according to AASHTO-2350.

Table 1: Aggregate gradation for permeable pavement (AASHTO- 2350)

Sieve Size, mm	Percentage Passing %
19	100
12.5	85 – 100
9.5	55 – 75
4.75	10 – 25
2.36	5 – 10
0.075	2 – 4

Selection of Binder

Permeable pavement consists of a high percentage of interconnected air voids. Because of high amount of air voids, aging resistance of the binder becomes crucial. Void content in asphalt mix determines the rate of aging by controlling oxygen access to the binder. Aging makes bituminous materials harder and more brittle, thus increasing risk of pavement failure, such as raveling and cracking. Crumb Rubber Modified Bitumen (CRMB) has been shown to have the ability to improve the rutting resistance, resilience modulus and fatigue cracking resistance of asphaltic mixes. CRMB is produced by mixing normal bitumen (80/100) with reclaimed crumb rubber (Palit, 2001).

To compare Marshall Stability, flow, OBC value and water sensitivity in addition to CRMB, normal bitumen also used in this investigation.

Selection of Design Method

This laboratory investigation has been carried out on the basis of Marshall Mix Design. (Kadiyali, 2003).

EXPERIMENTAL RESULTS & DISCUSSION

To investigate the properties of aggregate & binder, physical characteristics have been tested in the transportation laboratory, Department of Civil Engineering, CUET. The physical properties of aggregate & binder have been represented in Table 2 & Table 3 respectively.

Table 2: Physical Characteristics of Aggregate

Serial No.	Desirable Property of Aggregates	Name of the Experiment	Result	Permissible Value Specified by IRC (for bituminous surface course)
1	Specific Gravity	Specific Gravity	2.67	2.5 to 3.2
2	Toughness	Aggregate Impact Value	10.73%	< 30%
3	Shape of Aggregates	Flakiness Index	14.35%	< 15% and should not exceed 25%
		Elongation Index	13.56%	< 15 %
4	Hardness	Abrasion loss	26.38%	< 40 %
5	Water Absorption	Water Absorption	0.54%	should not exceed 1%

Table 3: Comparison of binder properties between Normal bitumen & CRMB

Type of Test	Normal Bitumen	Modified Bitumen(M30-10)CRMB
Penetration Value(mm)	99	74
Ductility (cm)	100	45
Softening Point (°C)	46	56
Flash Point (°C)	302	248
Fire Point (°C)	318	266
Loss on Heating	0.25%	0.31%
Specific gravity	1.019	1.03

From Table 2, it has been found that the values obtained are matched with the recommended value of Indian Road Congress (Kiran, 2014).

Performance Test

To determine stability, flow & OBC of the bituminous mixes Marshall Method has been used for heavy duty road. The Marshall parameters have been found out for varying content of binder. The experimental results of Marshall Mixes have been presented in Table 4 & OBC has been calculated according to Equation [1].

Table 4: Comparison of Marshall Parameters between Normal bitumen & CRMB

% Bitumen	Marshall parameters for Normal Bitumen					Marshall parameters for CRMB				
	Stability (KN)	Flow (mm)	Density (gm/cm ³)	Air Void %	VFA %	Stability (KN)	Flow (mm)	Density (gm/cm ³)	Air Void %	VFA %
4%	6.14	3.62	2.20	10.43	45.28	7.22	2.08	2.23	10.16	46.0
4.5%	6.21	3	2.23	10.17	49.14	8.65	2.75	2.25	10.15	49.20
5%	6.64	3.7	2.21	10.05	51.90	6.64	2.83	2.24	10.02	51.99
5.5%	5.50	2.8	2.19	9.98	54.28	5.79	3	2.21	9.64	55.23
6%	3.90	2.6	2.18	9.41	57.85	5.6	3.95	2.19	9.50	57.60

From Table 4, it has been found that CRMB bituminous mixes has shown higher stability than normal bitumen. OBC values for CRMB mixes & for normal bituminous mixes have been found 4.6% and 4.8% respectively. Therefore, respective OBC has been used for water sensitivity test and the results have been presented in table 5. It is seen from Table 5 that CRMB shows more tensile strength than normal bitumen.

Table 5: Results of Indirect Tensile Strength Ratio

Type of Bitumen	No. of Blows	Tensile Strength at Dry Condition (KPa)	Tensile Strength at Wet Condition (KPa)	Tensile Strength Ratio %
CRMB	75	238.9	186.4	78.10
Normal	75	212.8	138.32	65.45

As CRMB bituminous mixes show higher performance in terms of stability and water sensitivity than normal bituminous mixes, permeable pavement can be constructed by using CRMB binder. A typical cross section of a road pavement along with permeable pavement and surface drainage system has been proposed and depicted in Figure 4.

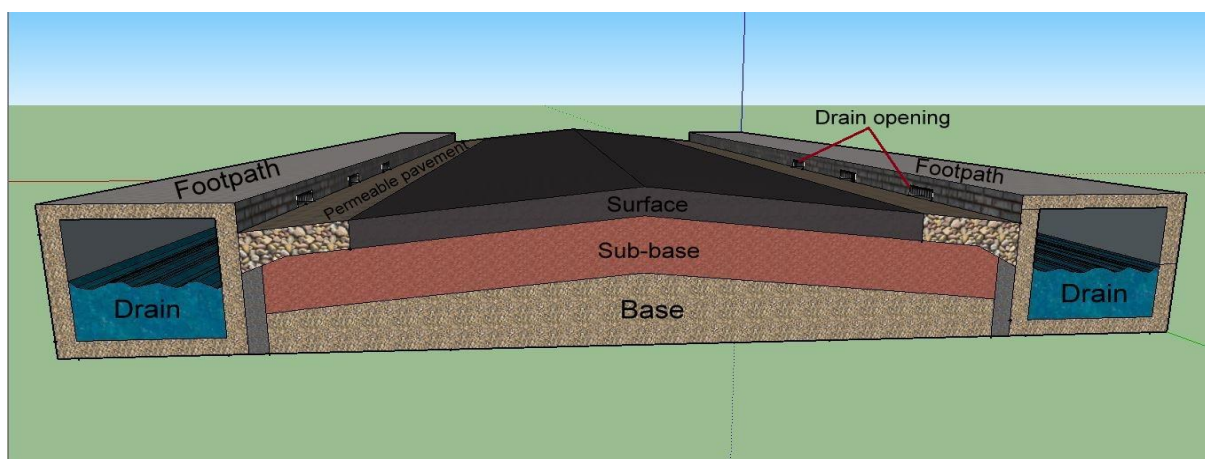


Fig. 4: Proposed cross-section of a road pavement along with permeable pavement & surface drainage system

CONCLUSION

Hat-Bazaar is the center of local activity. During rainy season, this Bazaar become water logged due to improper drainage system & drainage maintenance system. So, the water logging becomes a threat to the local dwellers for social as well as economic activities. Due to lack of awareness of local people, waste such as polythene, domestic waste etc. is thrown to the drain, creating clogging of drainage system. It's a serious matter that require immediate attention & available solution. So a proper drainage system along with proper drainage maintenance system is a crying need for bazaar as well as for other water logged areas. Nothing can be implemented properly if the solid waste management has not been done properly. To imitate these problems, drainage management system have to be handled carefully. The road surface must be elevated from the drain so as to drain out of water swiftly. Permeable Pavement can be used on both side of the roadways to accelerate the drainage capacity. So a proper drainage system along with permeable pavement can be a better solution to remove water logging from Hat-Bazaar areas to establish a healthy & economic environment.

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