

Highway Failure and Their Maintenance: A Study of Rajshahi Metropolitan City, Rajshahi, Bangladesh

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Abstract

Total length of paved road in Rajshahi City is about 186.64 km (2011 census). It shows that about 23% of total road lengths are present in failure condition. This study shows an investigation to compute the flexible pavement's failure types, to define and identify the causes, and select the best maintenance for that failures of flexible pavement within Rajshahi City. There are many types of failures occur on the roads such as different types of cracks, potholes, raveling, water bleeding, corrugation and shoving, depression, and rutting. The possible causes of flexible pavement failures are improper bituminous mixes with poor quality of materials, heavy traffic loads, heavy rainfall, and bad drainage on pavement. The failures are gradually raised due to lack of proper planning, inspection, and treatment. These failures create different types of disadvantages like traffic jam, discomfort to the passengers as well as drivers, increasing vehicle operating, maintenance cost, etc. This study proves that the authorities practice maintenance procedures to repair the failures of pavement which are about 60% similar to the conventional road maintenance procedures. The authorities as Roads and Highway Department and Rajshahi City Corporation are suggested to do maintenance according to the requirements of urgent maintenance and availability of fund which is found in this investigation.

Keywords

Failure; Causes; Investigation; Maintenance

1 Introduction

The development of a country depends upon transportation system and the transportation system should be well developed in roads, railway, waterways, and air ways [1-3]. Developed transportation systems are not only essential for the development of a country but also for reducing the cost of communication [4] and arrival of daily commodities. It is seen that road transportation is the nearest to the people. The road network could serve the remotest villages of the vast country. People depend on roads and highway for the movement of goods, for travel from one place to another, for service, for social and recreational purpose and many other activities necessary to the functioning of our complex society [1]. But roads are not free from failure. If construction of road is done very carefully, the failure of road will be minimized. But, for having mistaken in construction procedure [5] and the defects of used materials, the road surface is failed [6]. So, maintenance of this failed road is needed to be repaired. The maintenance of this failures is required not only to repair but also to increase the life of the road [7], to reduce operating vehicle and maintenance cost, and to keep the road in serviceable condition [8]. Based on

structural and design purpose, road pavements are generally divided into two types as flexible pavement and rigid pavement [9-11]. In Bangladesh, flexible pavement is mostly constructed for having advantages than rigid pavement [6, 7]. Rajshahi is a developing city in Bangladesh where investigation was done. Every year this city needs to construct a greater number of flexible pavements as roads with definite length, available fund, materials, equipment and workers according to the requirements. Most of the roads of this city are constructed and maintained by the Roads and Highway Department (RHD) and Rajshahi City Corporation (RCC) [6]. But deteriorations of flexible pavements occurred every year due to poor quality of construction coupled as well as due to heavy rainfall and bad drainage condition [12-14]. Therefore, it requires more money for road construction [15, 16] as well as for the maintenance. However, the requirements are not satisfied. For this reason, the present study has been taken to investigate the types and causes of pavement's failures, maintenance type and operation adopted by respective authorities.

2 Literature Review

The term pavement ordinarily means the surfacing layer only. But in highway design, it means the total thickness of pavement that includes surface, base, and sub-base [2, 3]. It is a hard crust constructed over the natural soil for the purpose of providing stable and even surface for the vehicles. It is therefore a structure consisting of superimposed layers of materials above the natural soil subgrade whose primary function is to distribute the applied vehicle loads to the subgrade [2]. As different types of failures are mostly occurred in flexible pavement [17-19] so regular maintenances are required for this pavement [3, 4]. Literatures of flexible pavement deterioration are studied to get the idea about types of failures and their maintenance management. The operations as cleaning, cutting, filling, sealing are performed to repair the failures [5, 6]. Routine, periodic and urgent maintenances are used to maintain the failed road according to budget [6]. Flexible pavements are those, which on the whole have low or negligible flexural strength and are rather flexible in their structural action under the loads [20, 21]. The flexible pavements layers reflect the deformation of the lower layers on the surface of the layer. Flexible pavement consists of four components as shown in Figure 1.

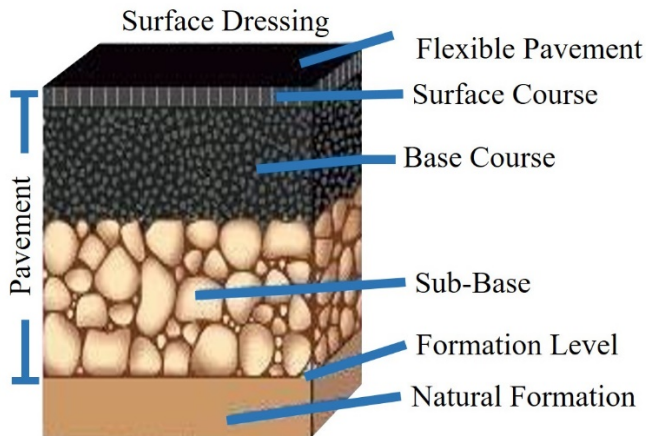


Figure 1 Components of flexible pavements [22]

3 Study Area

Rajshahi City is a metropolitan city with area of 96.68 km² which is located on the north bank of Padma River near the Bangladesh-India border. The historical name of this city is Rampur Boalia and the nickname is Silk City or City of Education. Every year different types of road failures occur in Rajshahi City. Road condition within the Rajshahi City is not good throughout the year due to this failures occurrence. Therefore, different types of problem occur to the road users such as unsafe journey, road accident, loss of lives, etc. The map of Rajshahi City area is shown in Figure 2.



Figure 2 Road network and study area (bold) in Rajshahi City [23]

4 Methodology and Data Collection

Different types of road failures are identified within Rajshahi City which are given as alligator cracking, block cracking, slippage cracking, longitudinal cracking, transverse cracking, potholes, raveling, water bleeding, corrugation and shoving, depression and rutting. The causes of failures and their maintenance procedures are collected by field investigation, information collection from respective authorities as Rajshahi City Corporation and Roads and Highway Department and consideration of public opinion. Field investigation was done in 2018 to 2019 where failures were observed carefully to identify them and to find out the causes of them at each location. Here, public opinion was collected by group discussion with peoples to achieve the idea about the causes of failures. The maintenance of highway is done by following the manners which are given by respective authorities which are routine maintenance, periodic maintenance, and urgent maintenance. Routine maintenance includes a vary frequency of activities which is generally carried out once or more a month. The activities include clearing and grass cutting, cleaning of silted ditches and culverts, and patching. For gravel roads it may include regarding every six months. Periodic maintenance includes activities that can be classified as preventive, resurfacing, overlaying, and pavement reconstruction. Paved road repaving is required to be carried out in about every eight years and for a gravel road re-

graveling is required in about every three years. Urgent maintenance is undertaken for a repair that cannot be foreseen but requires an immediate attention to failures of flexible pavement that block a road, bridges, drainages, etc. Types, locations, causes, maintenance procedure and figures of the identified failures within Rajshahi City are given in the following.

4.1 Alligator cracking

Alligator cracking is a very common failure. It occurred in Dewanpara, Katakhal. It indicates the structural failure that may further deteriorate to a pothole. The causes of this cracking are inadequate structure, poor drainage, etc. Maintenance taken such as carpeting is used for normal alligator cracking, but patching is carried out for effective alligator cracking (Figure 3).



Figure 3 Alligator cracking at Katakhal

4.2 Block cracking

Block cracking is found near khorkhori Bypass area, Talaimari bus stoppage, etc. It allows moisture infiltration and roughness. It is caused by poor construction and unstable base. After carpeting, seal coat is given to repair the cracked surface (Figure 4).



Figure 4 Block cracking at Talaimari

4.3 Slippage cracking

Slippage cracking is found at Railway Station, Vodra. It creates roughness on the road. It is caused by unstable wearing surface and bad drainage. Surface treatment as carpeting and sealing are done for the repair (Figure 5).



Figure 5 Slippage cracking at railway station

4.4 Transverse cracking

Transverse cracking occurs near Kazla, Nowdapara. It allows moisture infiltration and roughness. It is caused by heavy traffic and poor mix design. Surface dressing as carpeting is used to repair this crack (Figure 6).



Figure 6 Transverse cracking at Nowdapara

4.5 Longitudinal cracking

Longitudinal cracking is located near Court area, Laxmipur. It allows moisture infiltration, structural failure. It is caused due to unstable base, poor construction. Surface dressing is used to repair this crack (Figure 7).



Figure 7 Longitudinal cracking at Laxmipur

4.6 Potholes

Pothole is the most common failure that occurs in most places as Talaimari, Vodra, Kazla, Laxmipur, Nowdapara, Court area, Katakhal, and Khorkhori. It creates structural failure and roughness. It is caused by the movement of heavy loaded vehicle and accumulation of rain water. When the depth of the pothole is considerable then cutting, filling, rolling operation is considered for low depth pot hole and number of potholes are more only filling of the premix materials are carried out (Figure 8).



Figure 8 Potholes at Vodra

4.7 Raveling

Raveling is located near Court area, rail station, and Talaimari. It creates loose debris in the pavement, roughness, and loss of skid resistance. It occurs due to the inability of asphalt binder to hold aggregate in place, insufficient compaction and aged asphalt binder. Surface treatment is used to solve this failure (Figure 9).



Figure 9 Raveling at Talaimari

4.8 Water bleeding

Water bleeding is found at Talaimari, Court area, Kazla, and Nowdapara. It reduces skid resistance and structural support. It is caused by poor mix design with more and unsuitable binder. Sanding is applied to repair by spreading coarse sand over the surface. Sanding and surface dressing are carried out to repair this water bleeding (Figure 10).



Figure 10 Water bleeding at court area

4.9 Corrugation and shoving

Corrugation and shoving are found at Talaimari, Katakhal, Vodra, Kazla, and Court area. They create roughness and elevated portion. It occurs due to poor mix design, heavy traffic, unsuitable binder, etc. After cutting the failure portion, the techniques including premix filling, rolling, and sealing are carried out respectively to repair them (Figure 11).



Figure 11 Corrugation and shoving at Kazla

4.10 Depression

Depression is found in Talaimari, Railway Station, Alupotti, and Vodra. It creates depression on roads. It is caused by heavy rainfall and improper drainage system. Depression is repaired by removing the affected portion and replacing it by premix filling (Figure 12).



Figure 12 Depression at Vodra

4.11 Rutting

Rutting occurs near Nowdapara, Katakhal, and Court area. Ruts that are filled with water can cause vehicle hydroplaning. It is caused by heavy truck loads and poor construction procedure. The rutting portion should be milled off and replaced with premix. Finally, sealing is applied on premix for repair (Figure 13).



Figure 13 Rutting at Nowdapara

5 Results and Analysis

Maintenance procedures are taken into action under some maintenance types for the collected different types of failures. This maintenance types were collected from the respective authorities which are shown in the Methodology and Data Collection section.

Table 1 Types of failures, failure presence according to locations, and maintenance types

No	Types of Failures	Failure Presence (Locations)	Maintenance Types
1	Cracks	10	Routine
2	Potholes	8	Urgent
3	Raveling	3	Periodic
4	Water Bleeding	4	Routine
5	Corrugation and Shoving	5	Urgent
6	Depression	4	Urgent
7	Rutting	3	Periodic

Table 1 indicates the maintenance types and the presence of failures according to locations. The chart below (Figure 14) shows the failure presence percentage of each failure types which points out that cracks and potholes are failures with the highest number. The chart shown in Figure 15 represents the used maintenance types in percentage and it is also seen that the most performed maintenance is urgent maintenance. Both charts are based on the data shown in Table 1.

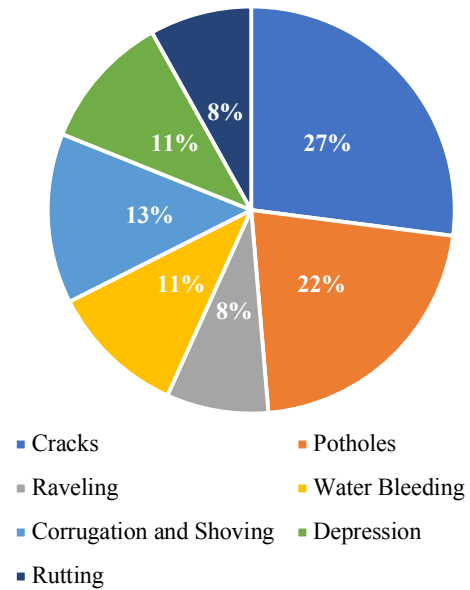


Figure 14 Presence of failures (according to locations)

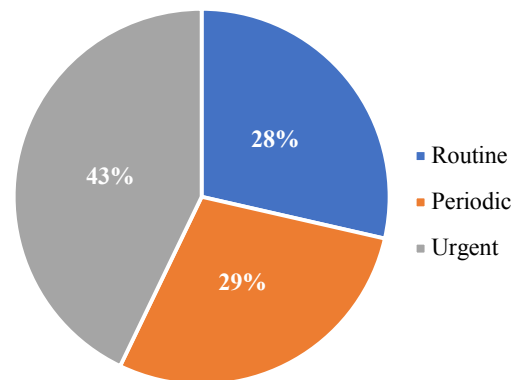


Figure 15 Used maintenance types

6 Conclusions and Recommendations

6.1 Conclusions

The investigation implies that there are different types of failures that occur in Rajshahi City which most of them are surface failures. Major failure is not found within this area. The respective authorities also stated about the presence of this failures and different types of cracks and potholes mostly occur. The causes of bituminous pavement failures that occur in Rajshahi City are poor quality control, weather condition, heavy traffic load, inadequate structural support, and excessive moisture in sub-grade. The investigation shows that urgent maintenance is mostly carried out in Rajshahi City compared to routine and periodic maintenance. Therefore, the quality of the maintenance and standardization of maintenance procedure are not always properly controlled which causes the roads to undergo early and repeated road maintenance.

6.2 Recommendations

The following recommendations are prepared after the completion of investigation, which are: i) the respective authorities should construct the roads and highways with proper planning and designing, required fund, best quality materials, adequate workers, professionals, technical and skilled inspectors and manager to make the roads serviceable according to design years of the roads, ii) after the completion of road construction, skilled inspectors should be appointed to examine the roads every six months to be able to perform a repair if failures occur, and iii) the authorities should operate an action against the road failures by taking proper maintenance procedures using decent materials, machineries and skilled workers and supervisors to establish an effective maintenance.

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