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# Bad Drainage and Its Effects on Road Pavement Conditions in Nigeria

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**Abstract**
This paper discusses the various effects of bad drainage on road pavement conditions in Nigeria. A lot of Nigerian roads across the country have inadequate drainage systems and deterioration often begins with the origin of cracks or pot holes on the road pavements either at the edges or along the drive way. This investigation looks into major Nigerian highways like the Lagos-Badagry expressway and municipal roads like the Siluko-Ring Road, Benin, Edo State. Having identified these two roads as case studies, on-site assessment of both roads were scheduled and visited with a view of investigating the possible causes of drainage deterioration and its subsequent effects on road pavement conditions. With the aid of a camera, pictures of the various degrees of drainage deterioration and its consequent effects on road pavement conditions were taken and labeled figures 1 to 11. Based on this investigation, it was discovered that adequate and proper maintenance cultures of drainages needs to be revived and strictly adhered to while carrying out enlightenment campaigns to residents where these drainage channels are situated towards creating an awareness that they need to keep these drainages clean and not use them as refuse dump sites. As a result of this investigation, it was discovered that road pavements needs to be designed and constructed to possess proper cross falls in such a way that they effectively drain off rain water from their surfaces into designated drainages. As such, effective drainage of the road pavement may be achieved by having a road cross fall of 4 - 6 % i.e. 145 – 195 mm fall from centre line on a 2-way cross fall pavement design. Even though many Nigerian roads are of poor conditions due to different reasons, Poor drainage constitutes a majority of those reasons.
**Keywords:** Run-off, Surface Drainage, Sub surface Drainage, Blockage of drains, Moisture content, Water table.

## 1. Introduction

It is well known that the rate of road deterioration increases if the water content of the granular material increases. In rigid pavements (i.e., concrete), temperature gradients across the concrete slab can cause structural defects.Diefenderfer, et al. (2002). Diefenderfer, et al. (2002) presents no less than six adverse effects related to excess water: reduction of shear strength of unbound materials, differential swelling on expansive sub grade soils, movement of unbound fines in flexible pavement base and sub base layers, pumping of fines and durability cracking in rigid pavements, frost-heave and thaw weakening, and stripping of asphalt in flexible pavements. On the positive side, ensuring proper (optimal) water content greatly improves packing of the road during construction, and may also increase its resilience when trafficked, even though this effect is often neglected. It is generally desired to keep the road as close to or less than optimum water content as possible over time as water and road construction do not make for a harmonious couple.Dawson, A.R. (2009).

According to McRobert, J. et al. (2000), Drainage is often described as the central and most important aspect of design, construction and maintenance of any road, including unsealed roads. Drainage of unsealed roads can be of even greater importance because lower quality design and construction standards and marginal materials are generally used, which are more permeable to water. Poor drainage will reduce the life of the pavement and have serious environmental impacts if left unchecked. There are many approaches to reducing erosion of exposed surfaces associated with unsealed roads, such as side drains, cut-off contour banks and batter slopes. Any road will readily concentrate runoff, so there is a need to design and construct roads to allow for frequent and safe discharge.

During the rains, part of the rain water flows on surface and part of it percolates through the soil mass as gravitational water until it reaches the ground water. Some water is retained in the pores of the soil mass and on the surface of soil particles which cannot be drained by normal gravitational methods and this retained water is termed Held water. It is required that the surface water from the carriageway and shoulder should effectively be drained off without allowing it percolate the sub grade. The surface water from adjoining land should also be prevented from entering the roadway. The side drains should have sufficient capacity and longitudinal slopes to carry away all the surface water collected. This improper drainage system causes the failure of road pavements due to many reasons such as increase in moisture content, decrease in strength, mud pumping, formation of waves and corrugations, stripping of bitumen, cutting of edges of pavement and frost action.

 

The aim of this report is to investigate into the possible causes of drainage failures and its corresponding adverse effects on road pavement conditions in Nigeria with the set objective of suggesting remedial recommendations.

## 2. Run-off

Run-off is the quantity/volume of water flowing into the drain from the road pavement after a rainfall. The quantity of water to be drained will depend on a number of variables, i.e. the intensity, duration and frequency of the rainfall, together with the size and type of the area contributing the run-off. As a general rule the shorter the duration of a storm, the higher the intensity of the rainfall. Design is normally based on the rainfall intensity of short intense storms occurring during the months of March to October, (excluding the month of August known as the **August break** which is a short dry season lasting for two to three weeks in August) which usually overload the drainage system more than the less intense rainfall or **Long Dry Season** which is a period spanning from late October to early March with peak dry conditions between early December and late February. The latter may be important; however, where the unpaved area drained is much greater than the paved area. The Tropical Savanna climate exhibits a well marked rainy season and dry season. The tropical wet and dry climate is extensive in area and covers most of Western Nigeria to central Nigeria beginning from the Tropical rainforest climate boundary in southern Nigeria to the central part of Nigeria, where it exerts enormous influence on the region. As such there is availability of high quantity/volume of run-off in these regions whenever there is a storm resulting in high run-off flowing into the drain from the road pavement.

The intensity of rainfall can be determined from rainfall records (Rational method) or by assuming values found to be adequate from experience (empirical approach). The Rational approach to rainfall intensity is applicable where sufficient data in the form of rainfall records, giving frequencies and intensities of storms over a period of at least fifty years are available for a particular location. This approach is beyond the scope of this paper.

An empirical approach to rainfall intensity is based on the premise that for the drainage of paved areas, it is sufficiently accurate to take the following value for rainfall intensity:

(i) Where the time of concentration is less than 10 minutes, assume a rainfall intensity (r) = 38mm/hr

(ii) Where the time of concentration is greater than 10 minutes, assume a rainfall intensity (r) = 25mm/hr.

The time of concentration (tc) is obtained by adding together the time of entry (te) and the time of flow (tf) for a particular length of pipe.

$$Tc = Te + Tf$$

To determine the quantity of run-off to be disposed off, the simplified rational formula is used.

$$Q = \frac{Ap \times r}{360}$$

Where Q = quantity of run-off (cu. metres/sec)

Ap = impermeable area to be drained (hectares)

(1 hectare = 10,000 sq. m)

r = rainfall intensity (mm/hr)

## 3. Types of Drainage Systems

*3.1 Surface Drainage*

In the surface drainage, the surface water from road pavement surfaces is collected and disposed off. The water is first collected in the longitudinal drains, generally in the side drains and then it is disposed off at the nearest stream, valley or water course. Cross drainage structure like culverts and small bridges may be necessary for the disposal of the surface water from the road side drains.

*3.2 Sub Surface Drainage*

In sub surface drainage of road pavements, it is attempted to keep the variation of moisture in sub grade soil to a minimum. Changes in the moisture content of sub grade are caused by fluctuations in ground water table, seepage flow, percolation of rain water, movement of capillary water and even water vapour. However, only gravitational water is drained by usual drainage system.

## 4. Effects of poor drainage on road pavement conditions

On a lot of Nigerian roads across the country having inadequate drainage systems, deterioration often begins with the origin of cracks or pot holes on the road pavements either at the edges (Figure 1) or along the drive way (Figure 2) which differs by their shapes, configuration, amplitude of loading, movement of traffic and rate of deformation.

 

Figure 1. Edge Failure.

Figure 2. Pot Hole.

Initially maintaining adequate water contents in granular road materials is beneficial to road construction but if the water content increases with time, negative effects will most likely emerge. The different effects of water on road pavement conditions which are supplemented with the case studies are given below.

*4.1 Siluko –Ring Road, Benin. Edo State*

The re-construction of Siluko-Ring Road was carried out in 2011 after years of deplorable state due to flooding as a result of failed drainage system. In just a year after re-construction, the drainage conditions of this road are getting damaged by the passage of time. It is observed that on a segment of the road, the Gully is too far from the kerb (Figure 3). The condition remains same throughout the year causing the drain water to flow on the surface of the road before running off through the gully into the drain. The resultant effect of this on the road is a detachment of bituminous pavement layer due to continuous contact of water. In other words, the pavement is seen to have failed due to stripping of bitumen from aggregates resulting to failure on the edges. There is visibly very poor maintenance culture of the road as majority of the Gratings are barely visible due to blockage by

 

debris and vegetation. (Figure 4)

Figure 3. Gully is too far from kerb.

Figure 4. Poor Maintenance – Grating is barely visible.

*4.2 Lagos – Badagry Express Road*

The Lagos-Badagry Expressway is a 60.7 kilometer international Express road linking Nigeria with the neighboring countries of Benin, Ghana and Togo. It was first constructed by the Lagos State government under the administration of Gen. Mobolaji Johnson, the first military administrator of the state from May 1967 to July 1975 during the military regime of General Yakubu Gowon. Since then, the road has suffered massive erosion of infrastructure and abuse of space with people erecting their buildings on the right of way, drainage canals being converted to welder's workshops and culvert outlets blocked with refuse dumps (Figure 5 and Figure 6).

The Lagos-Badagry Expressway as a transnational highway leading in and out of Nigeria should provide easy passage for nationals of other West African countries that share common boundaries with Nigeria, but rather

 

than provide easy passage, it offers a nightmare to land transportation. Foreign nationals from these countries, oftentimes arrive Nigeria through Lagos using the approved land entry points, a showcase of Nigeria to the outside world. Since the Lagos-Badagry Expressway is a major international gateway into Nigeria, its road infrastructure ordinarily should be solidly built and maintained. Ironically, this road is riddled with deep potholes, which cause frequent accidents leading to loss of lives and property. Apart from constituting a death trap, the Lagos-Badagry Expressway which is a federal road is poorly maintained, as physically noticed in the numerous failed side drains overtaken with vegetation (Figure 7) and totally blocked underground drainage network (Figure 8). Entirely all the Gratings on the existing bridges along the length of this road has been blocked by dirt, weed and silt sand accumulation over time (Figure 9) due to lack of maintenance thereby causing water to be retained on the surface of these bridges each time it rains. As a result of this surface retainment of water, the bituminous pavement layer becomes weak thereby resulting in a detachment of bituminous pavement layer (stripping of bitumen) (Figure 10).
Furthermore, the gullies on these existing bridges are seen to be so poorly maintained and blocked also by dirt and silt sand accumulation over time resulting in drain water to be retained on the pavement surface around the gullies each time it rains thereby causing failure on the edges of the pavement around the gullies (Figure 11)

Figure 5. Drainage canal converted to welder's workshop.

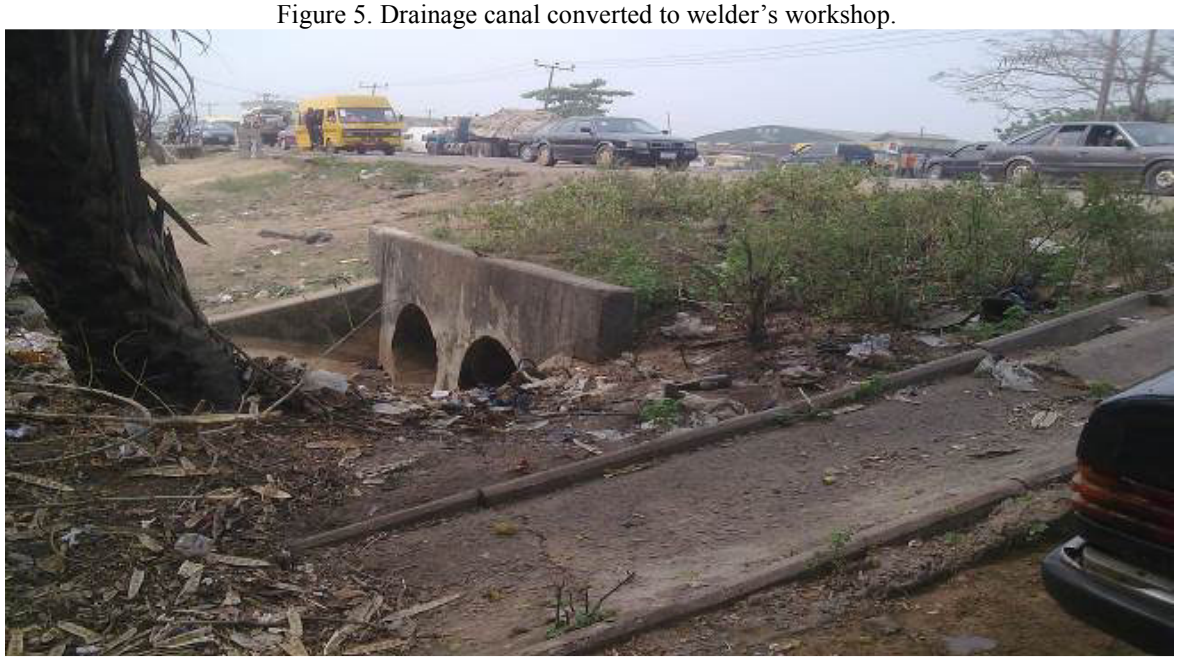

Figure 6. Culvert discharge points blocked with refuse dumps.

 

Figure 7. Failed Side drains overtaken with vegetation.

Figure 8. Poor Maintenance – Totally blocked underground drainage network.

 

Figure 9. Poor Maintenance – Grating blocked with dirt, weed and Silt sand accumulation over time.

Figure 10. Detachment of bituminous pavement layer (stripping of bitumen).

 

Figure 11. Poor Maintenance – Failure on edge of the pavement around gully.

The present state of the Lagos-Badagry Expressway, needless to say, portrays Nigeria as a country without maintenance culture.

**5. Result and Discussion**

*(a). Poor maintenance*

When erected structures and facilities such as drainages and road pavements are poorly maintained, their service lifespan is drastically reduced. From the investigations conducted, figures 5,8,9,10,11 and 12 presents proof of this reduction in service lifespan and it is evident in the deterioration of drainages and subsequent road pavement conditions which are visibly noticed in the form of edge failures of road pavements, pot holes along the drive way of road pavements, stripping of bitumen off the surface of road pavements and blockage of drainage channels such as culverts and underground drainage networks. Also these poor maintenance culture results in gullies and gratings being blocked with dirt weed, silt sand accumulation over time and in the growth of vegetation inside and around the side drains which has resulted into total failure of the side drains structures.

To check these very poor conditions of drainages and road pavements, there is need to properly maintain them by empowering the Local government councils under which these drainage channels are located so that they would be able to perform routine cleaning of dirt, weed and Silt sand accumulation over time that is visibly seen to have blocked these drainages (including underground drainage networks) gullies and gratings.

*(b). Poorly executed construction jobs*

Poorly executed construction jobs are another factor which contributes to poor drainage and road pavement conditions in Nigeria. Some project contractors and consultants do not adhere strictly to construction job blueprints and the resultant effect of this negligence is poorly executed jobs as was noticed on the Siluko –Ring Road, (Benin. Edo State). From the investigation conducted, it is noticed and as shown in figure 4 that the gully is too far from kerb thus creating room for run-off flowing from the walkway onto the road pavement before entering into the gully. This condition is the same through out the year thus resulting in stripping of the bituminous layer of the road pavement in the areas bounding the gully. The resultant long term effect of this condition if not checked will be a total collapse or failure of the gully facility.

To prevent this condition from occurring, it is highly advised that engineers handling construction jobs should executed them with strict adherence to the blueprints of that exact job.

*(c). Negative attitude of residents*

The attitude of residents in communities under which these drainage channels are constructed and located goes along way to determining the service lifespan of these drainage structures. From the investigation conducted and as captioned in figures 6 and 7 which clearly shows that residents have converted a culvert into refuse dump site while also converting the land bounding the culverts discharge point into a welder's workshop. This results in blockage of these drains and its subsequent failures which in turn does negatively affect conditions of the road pavement found in these communities.

There is very urgent need for government agencies and concerned bodies to organize sensitization programs

 

towards enlightening residents on the need to keep drainages located in their communities clean and not use them as refuse dump sites or craftsman's workshops. In situations where these residents refuse to heed environmental sensitizations and warnings, enactment of laws to punish offenders with very strong enforcement machinery should be put in place.

*(d). Non compliance to existing master plan of town*

Deviation from the original master plan by prospective town developers also results in the deterioration of drainages and its subsequent adverse effect on road pavement conditions. A lot of houses built today in Nigeria are erected on natural drainage channels/courses which are often first sand filled by land developers before erecting their structures. From the investigation conducted on the Lagos – Badagry express road and as shown in figure 6, it is noticed that the land bounding the culverts discharge point has been converted into a welder's workshop while residential houses and locked up shops have been erected. The Lagos – Badagry express road was constructed in May 1967 to July 1975 at a time when one can conveniently say that population explosion had not grown up to points where these culverts are located. So with population explosion growth and negligence from the relevant government agencies in charge of town planning and development, land developers started erecting structures on the natural drainage channels/courses thus resulting in reduced drainage life span and total collapse of the constructed drainage structures and facilities.

To check this ugly development, relevant government agencies in charge of town planning and development such as the Ministries of housing and urban development should wake up to their responsibilities of ensuring that ONLY government approved structures inline with town planning master plan are erected on government approved lands and not on natural drainage channels/courses. Also the immediate communities in which these natural drainage channels/courses are located should act as watch dogs towards preventing land speculators and developers from selling and buying lands which are known to be natural drainage channels/courses.

## 6. Conclusion

Drainage is an important feature in determining the ability of any given road pavement to withstand the effects of traffic and environment. Poor drainage conditions on road pavement are of adverse effects and causes failures in different ways. Proper and well maintained drainage systems provided to road pavements will increase their life span but improper and not well maintained drainage systems causes' failure of road pavements at its early age thereby drastically reducing their service lifespan.

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