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AN APPRAISAL OF DRAINAGE CONDITIONS ALONG SELECTED AREAS AND ROADWAYS IN SOKOTO METROPOLIS

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ABSTRACT

Poor drainage systems form part of major threats to urban environments in Nigeria. Most of streets within the urban and rural settlement are faced with the challenges such as lack of drainages or properly designed drainages to evacuate storm water from the surface-course of our roads Sokoto is one the cities that are growing at a high rate in terms of infrastructural development, which involves construction and concretization of the city land surface. This, as a result of poor drainage systems, leads to flooding and other environmental problems such as roadway pavement failure. This research, however, is limited to evaluating the quality of drainage systems along the streets of Sokoto Metropolitan, and rating of these drainages in four (4) rating categories; excellent, good, fair, and poor. It was carried out through visitation to various streets along the study area. In the process, drainages were observed by the nature of construction, materials used for the construction, and whether or not there is proper maintenance of those drainages. On that basis, the study revealed that the drainage systems in Sokoto metropolis are faced with problems such as; lack of good design, lack of provision of drainages in many streets and roads, blockages of the existing ones, disposal of solid waste materials in gutters which results in over flooding.

Keywords: Poor drainage; Storm water; Periodic maintenance; Visual assessment; Rating.

INTRODUCTION

Sokoto is a city growing at an average level regarding infrastructural development that involves the construction of both buildings and roads. This urbanization is leading to increasing in storm water volumes. The removal of storm water from streets and highway pavement and central areas requires a well-designed rain water collection system. A typical urban storm water collection system consists of streets constructed with curbs, gutters, inlets, and road side ditches; underground storm sewers; and open outfall channels such as stream and rivers receiving runoff. (Zain and Abbas, 2012)

The waters of the natural channels usually empty into artificial channels. In essence, all the materials constitute a nuisance as loads of the natural drainage systems empties into the artificial drainage systems. The performance of these functions depends primarily on both the competence and capability of the overland flow (Jimoh, 2008). Urban environments are faced with major challenges of improper drainage systems which result in the flooding of many cities in Nigeria, particularly the overcrowded areas that experience rainfalls which over whelms the capacity of the drainage systems (David et al., 2014). The system must be properly designed, built and maintained

to properly collect water, avoid disruption of the roads transportation function, maintain safe travel condition and sustain infrastructure. Poor drainage can direct water back into the road and keep it from draining away. Too much water remaining on the surface, base, and subgrade combined with traffic action will cause potholes, cracks and pavement failure. (Urbonas, 1993)

According to Walker, (2000), even on roads built with all the proper drainage elements, neglecting periodic maintenance is likely to result in flooding, washouts, and potholes. Regular annual evaluation of drainage systems is an important part of maintaining and managing roadways. (Zain, 2012)

Many areas and streets in Sokoto lack proper and adequate drainage systems that can drain the increasing storm water volume due to the rapid urbanization of the city causing flooding of the streets and roadways in many areas of the metropolis. This paralyzes traffic mobility, and damage private and public properties.

The state of drainage systems in Sokoto has received little or no attention regarding research. This study aims at assessing the drainage systems in some selected areas within Sokoto metropolis. To achieve this demand the study shall focus on:

- Conducting a visual assessment of the existing drainage systems in the chosen areas,
- Taking the account of the number of drainages within the selected areas, and
- Defining specific problems encountered and rating these drainage systems.

The research is a preliminary one but a step forward to create the awareness of local officials for the importance of appraising these drainage systems so as to plan for periodic maintenance, construction of more systems and improvement programs.

DRAINAGE SYSTEMS

Types of drainage systems

There is two types of drainage system, the surface drainage system in which water is collected and disposed of. The water is first gathered in the longitudinal drains, generally, in the side drains and then disposed of at the nearest stream, valley or water course. Cross drainage structures like culverts and small bridges may be necessary for the disposal of the surface water from the road side drains. The other type is the Sub-Surface Drainage system. This involves the movement of water in the pores of the ground soil mass. Changes in the moisture content of sub-grade are caused by fluctuation in the ground water table, seepage flow, percolation of rain water, movement of capillary water and even water vapor. In sub-surface drainage highways, it is attempted to keep the variation of moisture in sub grade soil to a minimum level. However, only gravitational water is drained by usual drainage system (Jimoh, 2008).

Design of Drainage system

For drainages to serve the main purpose of their constructions, there must be a proper design that will take into account the necessities. The following are to be considered while designing and constructing drainage as an open channel;

(i) It shall be designed and built in a manner that can take care of storm during 2-year and contain 10-year storm.

(ii) Design calculations shall consider a Manning's factor "n" of 0.03, 0.05, and 0.045 for analysis of erosive velocity, vegetated channels, and for rip-rap lined channels respectively

(iii) The minimum longitudinal slope for grass lining should not be less than 1.0%, and less than that, the lining shall be of concrete.

(iv) When the concrete lining is used, the depth shall be at least 110% of the ten-year storm depth (Hanover, 2011).

Two additional considerations for the design of drainages are the geometry of gutter and the slope made by the street to the horizontal. Curbs are used in most urban streets and gutter sections. The shape is chosen for functional, cost, or aesthetic reasons and does not dramatically affect the hydraulic capacity. Swales are used along with some semi-urban streets, and roadside ditches are common along some rural streets. Cross-sectional geometry, longitudinal slopes and swale/ditch roughness values are very much important in determining the hydraulic capacity of the drainage (Mannual, 2006).

Some communities suffer from drainage problems not because they have no drains, but because the existing drainage system has collapsed, become blocked, or are otherwise in need of repairs and rehabilitation. Much more will find that the nearest convenient point of discharge for a new drainage system is an existing primary drainage pipe or canal that needs attention if it is to function properly. Collapse and blockage are the principal types of drainage failure. Each of these can have several causes.

Brief Description of the Study Area

This research effort is based largely on Sokoto, the capital city of Sokoto State, north-western Nigeria, situated about 483 km/300 miles northwest of Abuja, the capital, Nigeria. It is located at latitude $13^0$04'N and longitude $5^0$15'E. The population is over 400,000 people (Census, 2006). The city lies on a traditional caravan route that leads northward across the Sahara With an average annual temperature of 28.3° C (82.9° F), it is one of the world's hottest cities. Sokoto lies along the Sokoto (Kebbi) River just east of the latter's junction with the Rima River. The activities of the inhabitants of the study area range from farming through transportation and a host of other numerous professionals, which demands good road network for ease of transportation. These road networks are being confronted with problems caused by poor drainage channel systems.

The Local Government Areas of Sokoto State includes Binji, Bodinga, Dange Shuni, Gada, Goronyo, Gudu, Gwadabawa, Illela, Isa, Kware, Kebbe, Rabah, Sabon Birni, Shagari, Silame, Sokoto North, Sokoto South, Tambuwal, Tangaza, Tureta, Wamakko. Wurno, and Yabo. (Sokoto State Government, 2013)

Figure 1: Map showing Sokoto and Environs (SOURCE: Google Map, 2013)

The area of study has been divided into three sites based on the Local Government Areas within the metropolis. These are Sokoto North, Sokoto South and part of Wamakko Local Government Areas. The numbers of major and minor streets observed are contained in table 1.

Table 1: Study Sites and their major and minor streets inspected

Site No.	Place Name	No. of Major Streets	No. of Minor Streets	Total No. of Streets
1	Sokoto North L. G. A.	10	10	20
2	Sokoto South L. G. A.	7	13	20
3	Wamakko L. G. A.	7	13	20

SOURCE: Author's Field Survey (2013)

MATERIALS AND METHODS

To achieve the objectives of this research, several field visits have been conducted along some major and minor roadways within the metropolis to visually observe the operating conditions of the existing roadway drainage systems. The inspection process was accompanied by representative photographs to aid in the evaluation process. The field visits were conducted during normal weather conditions as well as during the intense rain events, as Sokoto is known for its heavy winter and extreme rainfall events, though not for a long period, compared to other cities of Nigeria. The existing drainage systems in the visited sites were rated based on the rating system developed by Walker et al, (2000). This rating system consists of four (4) rating categories:

excellent, good, fair, and poor. The rating is based on the general condition, typical defects, and the recommended improvements as illustrated in table 2.

Table 2: Drainage System Rating

RATING	CONDITION	IMPROVEMENT
Excellent	Wide adequate ditches or like-new curbs, gutters, and storm sewer system. All culverts clean and sound. Overall, pavement and shoulder have an adequate crown, ditching or storm sewer on the majority of the section.	No improvement Necessary
Good	May need localized cleaning of ditches, storm sewer, and culverts, minor repairs to curbs, inlets, and culverts. No drainage-related pavement damage. Minimal crown on the pavement. Some areas need shoulder slope improvement.	Minor or localized repairs
Fair	Ditching improvement or cleaning needed up to 50% of ditches. Pavement distress from localized flooding or pounding indicates improvements are required in some storm sewer, inlets or ditching. Some culverts need cleaning and minor repairs. No pavement crown. Shoulders create secondary ditch. Frequent ponding	Several improvements necessary
Poor	Significant ditching improvements needed on more than 50% of the roadway. Frequent localized flooding or erosion with pavement distress or failure. Significant improvement in the storm sewer, curb or inlets and major culvert replacement or improvement needed.	Significant improvement in drainage required

SOURCE: (Walker et al., 2000)

RESULTS AND DISCUSSION

Drainage Rating

During the research, several streets and roadways within the selected three sites were inspected. The inventory of the drainage systems along these roads and their conditions are presented in tables 3, 4, and 5.

Table 3: Streets Inspected in Site 1

S/N	STREET NAME	STREET TYPE	DRAINAGE COMPOSITION	RATE
1	Sultan Abubakar	Major	Double sided ditch	Good
2	Mudagel	Major	Double sided ditch	Good
3	Tudunwada	Major	None	Poor
4	Modibbo Adama	Major	Double sided ditch	Good
5	Maniru	Major	Double sided ditch	Good
6	Lamido Adamawa	Major	Single sided ditch	Fair
7	Rima Radio	Minor	Single sided ditch	Fair
8	Lokoja	Minor	Single sided ditch	Fair
9	Banchi	Major	Double sided ditch	Good
10	Zaria	Major	Double sided ditch	Good
11	Waziri Abba	Minor	Single sided ditch	Fair
12	Shuni	Minor	None	Poor
13	Ali Akilu	Major	None	Poor
14	Tafawa Balewa	Minor	None	Poor
15	Goronyo	Minor	None	Poor
16	Barkh	Minor	None	Poor
17	Abdullahi Kure	Minor	None	Poor
18	Kano	Major	None	Poor
19	Alhassan Drive	Minor	None	Poor
20	Sultan Ibrahim Dasuki	Minor	None	Poor

SOURCE: Author's Field Survey (2013)

Table 4: Streets Inspected in Site 2

S/N	STREET NAME	STREET TYPE	DRAINAGE COMPOSITION	RATE
1	Ahmadu Bello	Major	Double sided ditch	Good
2	Abdullahi Fodio	Major	Double sided ditch	Good
3	Aliyu Jedo	Major	Double sided ditch	Good
4	Emir Yahaya	Major	Double sided ditch	Fair
5	Garba Muhammad	Major	Double sided ditch	Good
6	Bodinga	Minor	Single sided ditch	Fair
7	Central Market	Minor	None	Poor
8	Furniture Factory	Minor	None	Poor
9	Gobir	Minor	None	Poor
10	Kamba	Minor	Single sided ditch	Fair
11	Kilgori	Minor	None	Poor
12	Kantin Daji	Minor	None	Poor
13	Lanzu	Minor	None	Poor
14	Maitama	Minor	None	Poor
15	Tafida	Minor	None	Poor
16	Ubandoma	Minor	None	Poor
17	Waziri	Minor	None	Poor
18	Garba Muhammad	Major	Double sided ditch	Good
19	Maiduguri	Major	None	Poor
20	Kashim Ibrahim	Minor	None	Poor

SOURCE: Author's Field Survey (2013)

Table 5: Streets Inspected in Site 3

S/N	STREET NAME	STREET TYPE	DRAINAGE COMPOSITION	RATE
1	Maiduguri	Major	None	Poor
2	Ludge	Minor	None	Poor
3	Garba Nadama	Minor	None	Poor
4	Clapperton	Minor	None	Poor
5	Kware	Minor	None	Poor
6	Sahabi Dange	Minor	None	Poor
7	Achida	Minor	None	Poor
8	Wurno	Minor	None	Poor
9	Sokoto Polytechnic	Minor	Double sided ditch	poor
10	Kalambaina	Major	None	Poor
11	Nasarawa-Arkilla	Major	Single sided ditch	Fair
12	Lailata	Minor	None	Poor
13	Layout	Minor	None	Poor
14	NDLEA	Minor	Single sided ditch	Fair
15	Sokot-Binji	Major	None	Poor
16	Bado	Minor	None	Poor
17	Garba Duba	Major	None	Poor
18	Gwiwa Low-cost	Minor	Double sided ditch	Good
19	Kaduna	Major	Double sided ditch	Good
20	Al-Sudais	Major	None	Poor

SOURCE: Author's Field Survey (2013)

Problems Associated with the Drainages Inspected

Critically examining the drainage system in Sokoto metropolis, particular problems have been observed to be related to poor drainage system within the three sites under study. These ranges from; narrowly constructed, poorly designed, poor connectivity, disposal of waste materials, vegetation growth within the channels, and drainages not present at all along some streets.

This may have a visible link with the flooding of some parts of the town and environs. It is observed that wherever there are development and urbanization, there is a need for an increase of infrastructures. Going by the rate of urbanization in Sokoto, especially in the areas of housing, road construction and concretization of land surfaces which play a significant role in surface runoff volume, drainage facility of high quality should be provided to commensurate with these levels of development. Figure 2 shows the grading of the drainages inspected along the selected streets.

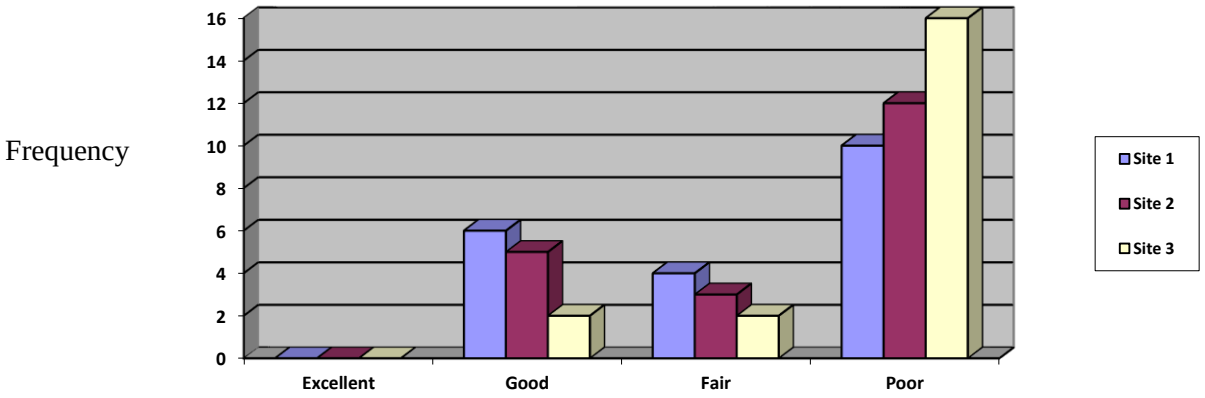

Figure 2: Grading of the drainages along the selected streets in the three sites

As stated by Okoro and Hassan (2009) that histogram is a way of presenting data so that differences among frequencies readily stand out by using figures having heights proportional to the frequencies in each category. The results from the field have been presented the figure above. The information reveals that most of the drainages in Sokoto metropolis are in bad condition. This is owing to particular problems as mentioned above. These problems are depicted in 1, 2, 3, 4 and 5. The plates show only a few of the observed problems as it is impossible to show all the noted problems in this paper.

Plate 1: Kerbs Falling into Drainage (Site 2)

Plate 2: Drainage without Outlet (Site 3)

Plate 3: Drainage Blocked and Filled up (Site 3)

Plate 4: Vegetation Growth in Drainages (Site 3)

Plate 5: Road Constructed without Drainage (Site 1)

CONCLUSION

This study considered the working conditions of drainages along some major areas and streets in Sokoto metropolis. It was observed that most of the streets were constructed without storm water drainages and that most of the existing drainages were not properly constructed, while others are not in good condition due to poor maintenance. It can be seen from the figures above that almost 65% to 70% of the existing drainages in the three sites are in a bad condition. The major problem associated with the drainage system in Sokoto, from the observation, is a lack of urban drainage system in the entire city where the drainages from both major and minor streets will drain into.

RECOMMENDATIONS

The whole town should be surveyed, and urban drainage system is constructed across the city to channel all the storm water systems to the existing rivers in the city. The drainages to build should be well designed and properly constructed, wide enough to take all the storm water within the streets. There should also be the routine maintenance of the existing drainages within the city.

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