AN INVESTIGATION ON HYDROLOGICAL FAILURE IN CULVERTS AT AJEGUNLE-EGBEJILA ROAD AND COCA-COLA ROAD, ILORIN

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Abstract

Hydrological failure in culverts at coca-cola and Ajegunle-egbejila roads in Ilorin, Kwara State was investigated. Reconnaissance Survey and questionnaire methods were used to carry out the investigations. Questionnaires were administered to the residents in the affected areas where the failure of culverts occurred. Oral interview was also used to acquire information on likely causes of culvert failure from the site engineers and other qualified engineers. Rainfall data was also collected from Nigeria Meteorological Agency Ilorin, Kwara state over a period of ten years. Outcome of the investigation revealed that most failure in culverts occur as a result of blockage by accumulated debris, inadequate flow capacity and erosion of embankment. This situation often leads to lead to loss of life and properties, damage crops, and great danger to motorists and other road users. To avoid failure in culverts, it was recommended that adequate designed measures should be ensured before construction and up-stream and down-stream of culvert should permit equal discharge of flow of water.

Key words: Hydrological failure, Culvert, Reconnaissance Survey, Flood

1. Introduction

A culvert is a tunnel structure embedded under roadway or railway to provide cross drainage or which convey water to the other side of the embankment. (Nikora, 2013). A culvert is a cutting under or beside a road which allows water to drain, rather than overtopping and making road conditions hazardous. Culvert is meant to allow water to pass below the ground level so, it should not stay on engineering structure, This may cause flooding or seeping into the pavement causing pot-holes, edge break and crack which are damages (Nikora, 2013). A culvert is a closed conduit used to convey surface water through a roadway embankment or away from the highway right-of-way and it encloses a flowing body of water usually from one side of a road to the otherside

(Braudrick and Grant, 2001). Culvert is any structure under the roadway, usually for drainage, with a clear opening of 20ft (6m) or less measured along the centre of the road way between inside of head walls. Culverts are usually covered with embankment and are composed of structural materials around the entire perimeter, although some are supported on spread footings with concrete riprap channel serving as the bottom of the culvert. For economy and hydraulic, engineer should design culvert to operate with the inlet submerge during flood flows, if conditions permit (Braudrick and Grant, 2001). Hydrological failure is the study of science dealing with the occurrence, circulation, distribution, and properties of water which causes damage or breakdown to structure (Boyd *et al*., 2002). Culvert can be built from a various type of materials depending on the size configurations, concrete, metal and plastics are all common materials. According to Adebara, 2017 and Flaherty, 1986, culvert can be classified as flexible and rigid culvert Culvert can also be classified into two functional types; fluvial culvert and runoff culvert. The fluvial culvert is required where the road crosses a stream/river channel to allow water to pass downstream. Types of culverts are; Pipe culverts, Arch culverts, Box culverts and Slab culverts

2. Factors Affecting the Efficiency of Culvert Design

According to Flaherty, 1987 different factors are to be considered are as follows.

The depth of water pond: For a given design, the depth of the pond formed at the entrance is a function of the size and shape of the culverts. Conversely, the manner in which flow takes place in the culvert is affected by the head of water available at the inlet.

Types of entrance: If the culvert has poorly designed entrance, then considerable turbulence will occur at the inlet and energy will be dissipated which would otherwise be available for moving the water through the culvert.

The roughness of interior walls**:** Rough textured culverts which run full will discharge less water than a smooth one also running full, since much of the energy head is used up in overcoming the resistance to flow.

Basic culverts characteristics**:** The length of the culvert dictates whether or not the type of entrance and roughness of the interior walls are major or minor feature of the hydraulic design if the culvert is properly designed, it adequately drain road grades. The structural and hydraulic design of culverts is substantially different from that of the bridges as are the construction, maintenance, repair and replacement procedures. Culverts are usually designed to operate at peak

flows with a submerged inlet to improve hydraulic efficiency. The effects of pounding and flow on appurtenant structures, embankment and abutting properties are important considerations in the design of culverts (Rigby and Barthelmess, 2011). Structural: culverts are buried in soil and are designed to support the dead load of soil over the culverts as well as live load of traffic.

Either the live load or the dead load may be the most significant load element, depending on the type of culvert, type and thickness of the cover and amount of live load. However, live loads on culverts are generally not as significant as dead load unless the cover is shallow.

Maintenance: Routine maintenance for culverts primarily involves the removal of obstructions and repairs of erosion and scour. Other defects from weathering loads and age will occur and require routine maintenance.

Traffic Safety**:** A significant safety of many culverts as compared to bridges is the elimination of a construction in the road way. Culvert can economically be extended so that the standard roadway cross section can be carried over the culvert.

Construction**:** One of the most significant factors is that culverts are constructed in and through the roadway embankment. The trench width, bedding, composition and amount of fill over the culvert are important factors that influence the ability of the culvert to carry the design load. Thus the construction techniques and quality control of workmanship are critical to the ultimate serviceability and life expectancy of culvert.

Durability: Durability of materials is a significant problem in culverts and other drainage structures. In hostile environments, corrosion and abrasion can cause deterioration of all commonly available culvert materials.

There is a wide variety of maintenance problems associated with culverts (Flaherty, 1986 and culvert repair practices manual, 1995). The problems may be classified into serviceability and strength related criteria as follows.

Serviceability related problems:

Scour and erosion of embankments

Poor design / Inadequate flow capacity

Corrosion and deterioration of concrete and masonry culverts

Inadequate length

Sedimentation and blockage by debris

Strength Related Problems:

Undermining and loss of structural support

Stress cracking of culvert

Over deflection and shape deformation of flexible culvert

Loss of invert of culverts due to corrosion or abrasion

3. Investigation Methods

Reconnaissance Survey

Reinforced concrete culverts located along Coca-cola road and Ajegunle-Egbejila road in Ilorin, Kwara state were visited. Ajegunle-Egbejila road is a single carriageway which is still under construction by the state government. The stage of construction is earth work. The length of the road is 600m with a width of 8m. Coca-cola road is a single carriageway with asphaltic lying; the length of the road is 500m with a width of 8.2m. The drainage facilities are adequate and run through the length of the road of the study area. It was discovered that some of the culverts failed due to blockage by accumulated debris, poor design, penetration of water into the sub-base of the foundation and excessive rainfall.

Data Collection

A total of two hundred (150) structured questionnaires were administered to the Respondent (residents, traders and road users) within the vicinity of the studied area, i.e. Ajegunle-Egbejila road and Coca-Cola road, Ilorin. Information on hydrological failure of culverts was gathered in order to know the history of the failed culverts, causes of failure of the culverts, the risk people are exposed to due to various effect and possible solutions. One hundred (100) copies were properly responded and returned to the researcher. Rainfall data for a period of 2007 to 2016 was collected from Nigeria Meteorological Agency(NIMA) Ilorin, Kwara state. The analysis of the rainfall data was carried out using the frequency analytical method with a database software called Rainbow and Microsoft Excel specially designed to carry out frequency analyses to observe the effect of excessive rainfall (Flood) in the study area. Ajegunle-Egbejila road is a single carriageway under construction by the state government. The stage of construction is earth work. The length of the road is about 600m and width of 8m. The drainage facilities are not adequately run through the length of the road. 24 numbers of slab culverts and 9 numbers of ring culvert was observed to be functioning as presented in Table1.

Table1. Culverts locations and conditions at Ajegunle-Egbejila road, Ilorin.

Types of culvert	**No**	**Size**	**Location**	**Remark**
Pipe	**_____**	**_____**		**Non**
Box	**_____**	**_____**		**Non**
Slab culvert	**24**	**600x3000**		**Good**
Ring culvert	**9**	**600x3000**		**Good**

Table 2: Culverts locations and conditions at coca-cola road

Types of culvert	No	Size	Location	Remark
Pipe	-----	-----	-----	Non
Box	1		Beside captain cook	Good
Slab culvert	23		Coca-cola route	Good
Ring culvert	-----	-----	-----	Non

Coca-cola road is a single carriageway with asphaltic lying; the length of the road is about 500m and the width of 8.2m. The drainage facilities are adequate and run through the length of the road. 23 numbers of slab culverts and 1 number of box culvert were observed to be functioning as presented in Table 2. The on-going construction of the bridge of 2000x3000 box culverts formally in existence collapsed. It was observed that Ajegunle-Egbejila road and coca-cola road, Ilorin was constructed below the road profile which results to overtopping of the cross culverts causing inadequate flow capacity and blockage by accumulated debris. There was no adequate drainage run through the length of the road at Ajegunle-Egbejila compared to coca-cola road experiencing adequate drainage run through the length of the road. These gives rise to the construction Ajegunle-Egbejila and coca-cola bridge as shown in plate 1 – 6.

Plate1.Arrangement of reinforcement bar

Plate 2. The new constructed bridge at Ajegunle-egbejila road.

Plate 3. Dumping of accumulated refuse at coca-cola road, Ilorin.

Plate 4. The collapsed culvert located at coca-cola road, Ilorin

plate 5. the on-going construction of the bridge at coca-cola road.

Plate 6. the on-going construction of bridge at coca-cola road.

4. Data Analysis and Presentation

Rainfall data was collected from Nigeria meteorological agency Ilorin as shown in Table 3. The analysis of data revealed that the average rainfall in Ilorin is higher with rainfall occurring mostly from March to October with September experiencing the maximum rainfalls which result to flooding in the study areas which causes the culvert failure.

Table 3: summary of monthly annual rainfall at Ilorin in the year 2007-2016

Year/ Month	2007 Rainfall (mm)	2008 Rainfall (mm)	2009 Rainfall (mm)	2010 Rainfall (mm)	2011 Rainfall (mm)	2012 Rainfall (mm)	2013 Rainfall (mm)	2014 Rainfall (mm)	2015 Rainfall (mm)	2016 Rainfall (mm)
JAN.	0.0	0.0	11.1	0.0	0.0	0.0	4.8	9.7	0.0	0.0
FEB.	0.0	0.0	1.2	6.7	23.6	22.1	5.5	28.6	38.5	0.0
MARCH	31.6	20.5	17.9	29.4	23.1	4.0	38.4	52.2	43.6	137.6
APRIL	98.9	106.1	223.9	73.5	21.1	138.2	223.4	408.8	3.6	223.0
MAY	285.5	42.3	76.0	95.1	122.8	138.2	121.7	232.3	206.7	618.0
JUNE	158.2	241.0	177.2	89.3	212.9	152.8	148.4	305.2	206.1	242.8
JULY	199.3	318.6	313.4	95.1	93.1	120.7	110.6	332.3	153.5	317.7
AUG.	134.1	226.3	209.1	143.8	203.4	123.4	51.4	225.3	342.0	185.5
SEPT.	241.7	270.3	185.7	267.3	247.5	230.0	266.5	511.7	583.9	529.2
OCT.	152.9	224.5	122.8	148.3	202.4	153.7	308.8	379.4	127.8	139.4
NOV.	0.3	4.8	4.4	11.4	0.0	8.7	0.0	154.0	0.0	24.8
DEC.	6.6	14.0	0.0	0.0	0.0	25.2	6.8	0.0	0.0	37.6
TOTAL	**1309.1**	**1468.4**	**1342.7**	**959.9**	**1149.9**	**1117.0**	**1286.3**	**2639.5**	**1705.7**	**2455.6**

Source: Meteorological department, Airport, Ilorin.

The outcome of the questionnaires analyzed in Figure 1 to 4 shows that poor design are the major cause of hydrological failure in culverts while lack of accessibility is the effect at Ajegunle-Egbejila road, Ilorin.

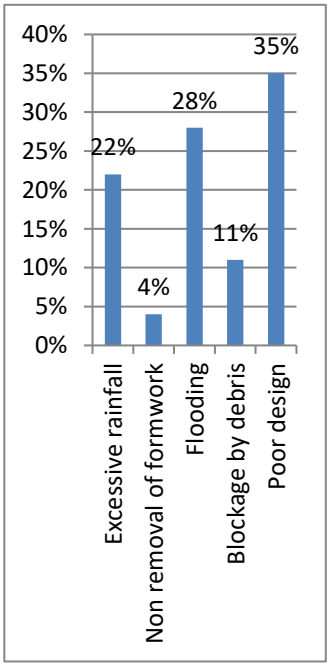

Figure 1: Causes of hydrological failure at Ajegunle-Egbejila road, Ilorin.

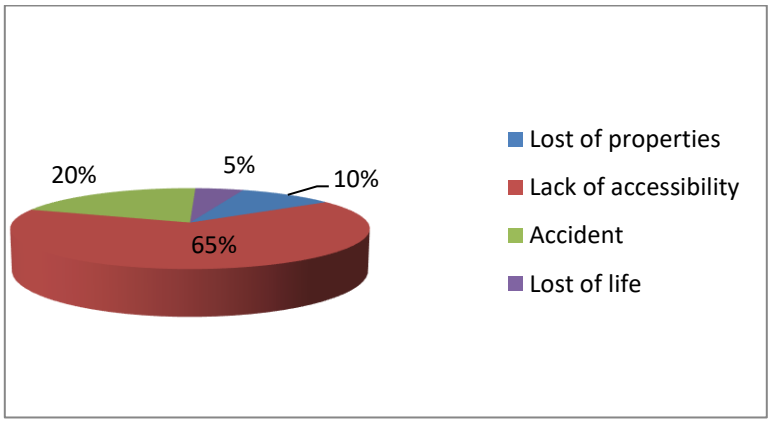

Figure 2: Effect of hydrological failure in Ajegunle-Egbejila road, Ilorin

Moreso, flooding is the major cause of hydrological failure in culverts at coca-cola road, in llorin and lack of accessibility is the major effect.

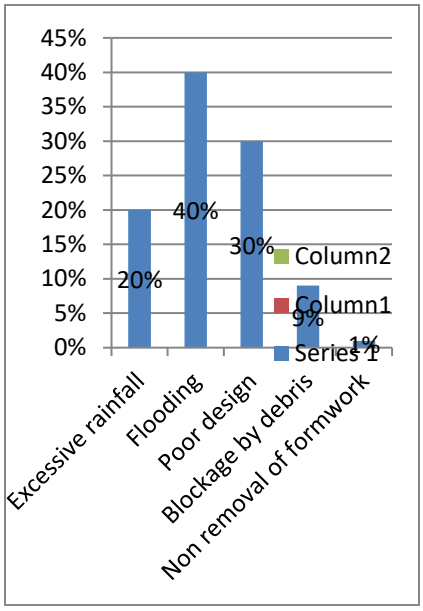

Figure 3: Causes of hydrological failure of culvert in coca-cola road, Ilorin

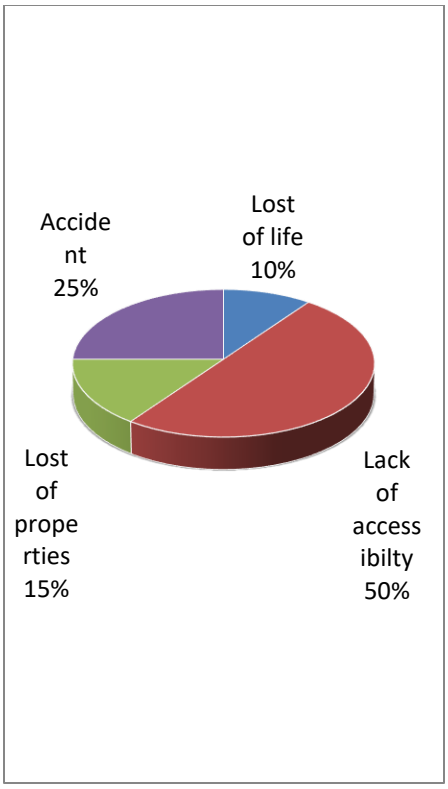

Figure 4: Effect of hydrological failure in coca-cola road, Ilorin

The situation shows that majority of the respondents accept that flooding and poor design was the major causes of failure in culverts in the study area.

5. Conclusion

The causes of hydrological failure of culverts in Ajegunle-Egbejila road and coca-cola road, Ilorin are caused by flooding, excessive rainfall, blockage by accumulated debris, non removal of formwork and poor design. The prominent causes of the failure is as a result of poor design and flooding. The effects of the culverts failure are lack of accessibility, lost of properties, lost of life, and accident while the major effect to the populace is lack of accessibility in both study areas. This brings about to the new construction of bridge in both study area (Plate 2,5). It was concluded that poor design was the main causes of failure of culverts at Ajegunle-Egbejila road and coca-cola road, Ilorin.

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