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Development of a Drainage System Network in Kurutie Environs

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ABSTRACT: *Due to the flooding in Kurutie environs, the development of a drainage system network in the Kurutie environs has been has been proposed. The development encompassed water drainage in order to channel the overflowing water around the Kurutie environs into drainage, thereby making the prevention of overland flooding possible. A 2.15 m3/s discharge was used in the evaluations. While AutoCAD and Hy8 were the tools used for the development. A trapezoidal drain was designed with a dimension of 800mm or 0.8m depth and a width of 250mm or 0.25m utilizing rational method together with a culvert of 600mm or 0.6m respectively. The HY8 gave an output of the elevations and water profile of the drain, including the culvert. It is recommended that this design should be utilized in the development of the drainage in the Kurutie community.*

Keywords*: Development, Drainage, System, Network, Environs*

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I. INTRODUCTION

Drought together with flooding reoccurs, and it affects the lives of millions of people globally. This happens as a result of variations in climate [1]. Drainage is a huge precedence city service doubled with the related challenges which are rousingly fit the concept as a result of blistering urbanization together with worldwide climate impactful variation. Practically, a channel that geometrically reduces the excavation costing together with linning is frequently desiderated. However, the slop, together with the roughness of the designer, aims to reduce the cross sectional area of a particular discharge [2]. Also, it has been proven that the utmost operative cross sectional shape is the wetted perimeter is also reduced [3 – 6].

Globally, there has been an increase in growth in the number of the state of being mortal, together with people severely affected by storms coupled with flooding [7-8]. Precisely, the amount of economic indemnification affects a huge together with an increasing share of these impacts are urban regions in low coupled with average countries like Nigeria, in which floods impacted more than 3million populace in choice urban region around 1983 – 2009 [9]. Poorly urbanized infrastructure design together with blueprints will probably have caused this; but if the reverse is the case, it is evidence of the susceptibility of urban populations to flooding coupled with storms whose constant and ardency is probably to rise in most areas. The increment in the reportage of flooding all over Nigeria in recent years shows that complete transformations need to be put in place in order to manage storms of water. All through the past ten years, flooding has occurred with high increase continuously [10-11]. Recently, the factors attributed to this are the inappropriate development of the functional drainages in the city, thereby resulting in incompetency in managing storms of water and inappropriate drainage maintenance and so on [12].

Consequently, storm drains play an important part in the management of flooding as they do the collection together with the transportation of the overage runoffs to a safe place of disposal. When they are inappropriate and this function cannot be done, flooding emanates, thereby causing damage in homes coupled with streets as a result of the spills from the escaped storm water. Furthermore, the efficient development of storm drains plays an important function in the management of flooding in cities like the emerging city of Kurutie, where the Nigeria Maritime University Take-off Campus is sited [12 -14].

The revelation that the stage of peril, together with susceptibility in urban places of emerging nations, contribute to socioeconomic stress, ageing coupled with inappropriate infrastructure physically [15]. A large portion of urban dwellers are tenants and are not capable of paying for a good flat, thereby end of living where there are no all – weathered roads and no proper drainage systems [16].

Similarly, [11] established that floods are phenomenal and occasionally have calamitous influences on living humans. The effects of flooding are more enunciated in average living places as a result of the increase in the populace, emaciating infrastructure together with the absence of appropriate management and environmental planning, and that many urban poor inhabitants in Nigeria are facing increasing serious flooding challenges [17].

Furthermore, in this work, the development of a drainage system network in the Kurutie environs in order to guide the construction of drainage systems in the Kurutie environs.

II. MATERIALS AND METHODS

STUDY AREA

Fig.1 Aerial View of Kurutie Emerging City

The Kurutie emerging city has low yearly precipitation of 650mm, high evaporation together with constant water deficits. August has the highest rainfall, but the rain concentrates in the months of July, August and September. There are three related seasons in Kurutie, like the rainy, cool and hot seasons respectively. Also, the average monthly temperature is above 20^0C but the day-to-day temperatures vary. Flooding is normally experienced from October to November because of the poor drainage system.

MATERIALS USED

Topographical map of Kurutie emerging city
Rain Intensity –Duration – Frequency Chart for Kurutie environ
Manual Calculations
AutoCAD and Hy8 for Design and other relevant information required.

METHODS

Modeling of the Drainage System

Applicably, the theory of the best or most effective hydraulic section for gutters together with culverts is required to reduce cost when the real construction is to take place [4]. Given, R – minimizing wetted perimeter may be considered as a challenge to maximizing R. Hence, a channel of maximum – R does not give the optimal hydraulic development but also fosters a section of reduced cost. The fundamental equation for the best hydraulic section for trapezoidal or rectangular cross – section is derived as follows, utilizing Fig. 2 [6].

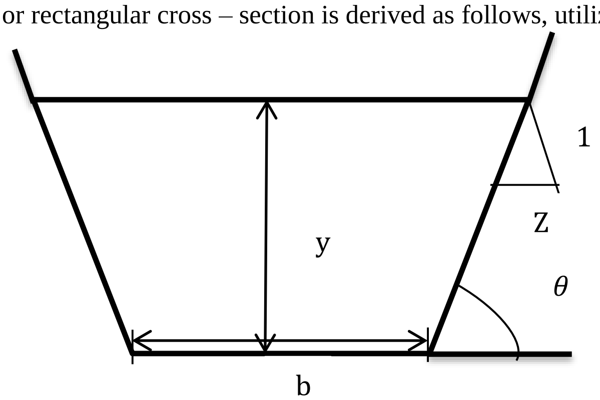

Fig. 2 Depiction of optimal trapezoidal section

The hydraulic radius for the trapezoidal section is expressed as:

$$R = \frac{A}{P} = \frac{by+zy^2}{b+2y(1+z^2)^{\frac{1}{2}}} \quad (1)$$

Also,

$$P = \left(\frac{A}{y} - 2y\right) + 2y\sqrt{1-z^2} \quad (2)$$

Differentiating with y equation 2:

$$\frac{dP}{dy} = \left(\frac{-A}{y^2} - z\right) + 2\sqrt{1+z^2} \quad (3)$$

Where:

y is hydraulic depth (m); R is hydraulic radius (m);A is Cross-sectional area (m^2);z is channel side slope as shown in Fig. 2; b is Bottom width (m) together with P which is the wetted perimeter (m) respectively. P = 0 when $\frac{dP}{dy}$ =0.

From equation 3 taking into consideration when P = 0, A can be derived as:

$$A = y^2\left(2\sqrt{1+z^2} - z\right) \quad (4)$$

Comparing Equation 4 with Equation 1 b can be derived as:

$$b = 2y\left(\sqrt{z^2+1} - z\right) \quad (5)$$

Putting 'b' into Equation 1 $R_{max.,}$ which is the effective maximum hydraulic radius, can be expressed as:

$$R_{max} = \frac{y}{2} \quad (6)$$

Chezy-Manning's equation for uniform flow in channel section maybe expressed as:

$$Q_p = \frac{1}{n} A R^{\frac{2}{3}} S_0^{\frac{1}{2}} \quad (7)$$

Where: n =Manning's Roughness Coefficient, S_0 = normal channel slop and Q_p = peak discharge or in some cases it can be taken as flow rate.

Equations 5, 6 together with 7 will give depth of flow which is expressed as:

$$y = \left\{\frac{1.587 n Q_p}{2\left(\sqrt{1+z^2} - z\right) S_0^{1/2}}\right\}^{3/8} \quad (8)$$

The equations 5 coupled with 8 give the development of the hydraulic and Equations 9, 10, 11 and 12 provide the hydrological runoff computing concept [18].

The catchment flow rate was gotten utilizing rational method which is expressed as:

$$Q = \frac{CIA}{360} \quad (9)$$

Where: I = the rainfall intensity (mm/hr) for selected reoccurrence frequency together with the period or duration that is equated to the concentration time of the watershed.

A = area of the watershed (hectres).

Utilizing Kirpick Expression is given as:

$$T_c = 0.078x \left(\frac{0.77L}{S}\right) 0.385 \quad (10)$$

Where:

T_c is time of concentration (min.); L is length of watershed area (ft); S is the slop of the shade achieved utilizing the slope equation. The development return time of ten years was utilized for the appraisal.

Table 1: hydraulic section values on the assumption that flow depth y = 2* width (b); **Table 2**: runoff coefficients for Rational Methods; **Table 3**: Different Values of Mannings Roughness Coefficient and **Table 4**: Catchment Characteristics, Hydrograph Parameters and Results respectively

Table 1: Hydraulic Sections Values

Cross Section	**Area (A)**	**Wetted Perimeter (p)**	**Top Width (T)**	**Hydraulic depth (D)**
Trapezoid	$y^2\sqrt{3}$	$2y\sqrt{3}$	$\frac{4y\sqrt{3}}{3}$	$\frac{3y}{4}$
Rectangle	$2y^2$	$4y$	$2y$	y
Triangle	y^2	$2y\sqrt{2}$	$2y$	$\frac{y}{2}$

Parabola	$\frac{4y^2}{2}\sqrt{2}$	$\frac{8y}{3}\sqrt{2}$	$2y\sqrt{3}$	$\frac{\pi y}{2}$
Semicircle	$\frac{\pi y^2}{2}$	πy	$2y$	$\frac{\pi y}{4}$

Table 2: Runoff Coefficients for Rational Method.

Type of Drainage Area	**Runoff Coefficient ''c''**
Business:	
Downtown Area	0.75 – 0.95
Neighborhood Area	0.550 – 0.70
Residential:	
Single Family Area	0.30 – 0.50
Multi- Unit, Detached	0.40 – 0.60
Multi -Unit, Attached	0.60 – 0.75
Suburban	0.25 – 0.45
Apartment Dwelling Area	0.50 – 0.70
Street:	
Asphaltic	0.70 – 0.95
Concrete	0.80 – 0.95
Brick	0.70 – 0.85
Drives and Walkways	0.70 – 0.85
Roofs	0.70 – 0.95

Table 3: Different Values of Mannings Roughness Coefficient

Type of Channel lining	**Roughness Coefficient, n**
Smooth Concrete	0.012
Smooth asphalt	0.015
Earth	0.020
Rock	0.035
Grass and Brush	0.050
Ductile Iron pipe	0.013
Corrugated steel pipe	0.024
Corrugated plastic pipe	0.024

Table 4: Catchment Characteristics, Hydrograph Parameters and Results

`Estimated Value Catchment Characteristics	
Drainage Area, A (m^2)	184000
Watershed Slope, S (%)	5
Watershed Coefficient, C_t	2.6
Length of main channel, L (m)	635
Length from the main channel outlet to the catchment centroid, Lc (m)	295
Hydrograph parameters	
Storage Coefficient, K (hr)	0.75
Time Interval (hr)	0.25
Lag Time, t_t, (hr)	1.18
Rainfall Excess Duration, D (hr)	0.22
Base Time, T (hr)	`6.45
Study Basin Results	
Weighted Curve Number	73
Time of Concentration, t_c (hr)	1.98

Unit Hydrograph Peak Discharge, q_p (m^3/s)	1.02
100yr, 24hr Storm hydrograph Peak Discharge, Q_p (m^3/s)	2.15

III. RESULTS AND DISCUSSION

RESULTS

After using Equation 7 and taking values of Tables 1 – 4 into consideration to the one that fits the calculations and also the y = 0.5m, base =0.25; Q is given ; freeboard = 0.3m and real dimension is 0.8m. The Figs 3 – 5 are the AUTOCAD depiction of the drainage network.

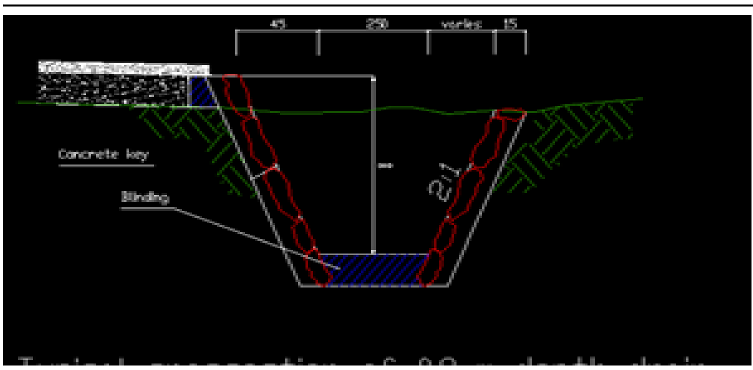

Fig. 3 AUTOCAD Depiction of Cross Sectional View of the Proposed Open Channel in Kurutie Environs.

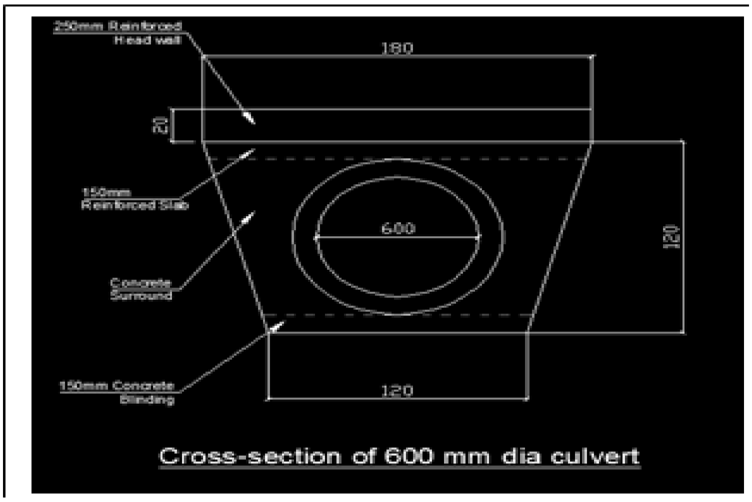

Fig. 4 AUTOCAD Depiction of Cross Section of the Proposed Culvert in Kurutie Environs.

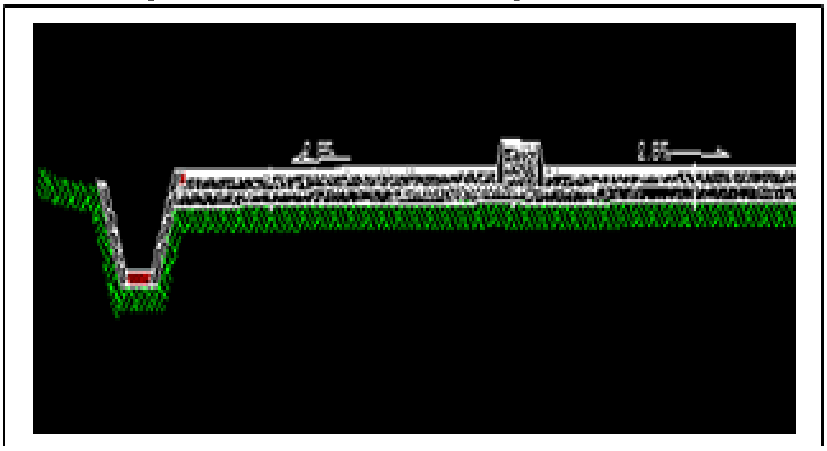

Fig. 5 HY8 Depiction of the Road with its Propose Drainage System Network

DISCUSSION

Fig. 3 is the stone-pitched drain cross - section. It is got via the Manning Expression, and it is a lined drain that can be constructed with ease utilizing the available materials like stones together with the mortar that was got from fine sand and cement and light blinding of the base as well. A culvert of a cross-sectional diameter of 600mm 0r 0.6m having a head wall is depicted in Fig. 4. Finally, the full section is illustrated in Fig. 5 utilizing HY8 Software and a slope of about 2.5% is required on the road to give surface water drainage into the drain.

IV. CONCLUSION

The development of a drainage system network in the Kurutie environs has been done. The development encompassed water drainage in order to channel the overflowing water around the Kurutie environs into drainage, thereby making the prevention of overland flooding possible. A 2.15 m3/s discharge was used in the evaluations. While AutoCAD and Hy8 were the tools used for the development. A trapezoidal drain was designed with a dimension of 800mm or 0.8m depth and a width of 250mm or 0.25m utilizing rational method together with a culvert of 600mm or 0.6m respectively. The HY8 gave an output of the elevations and water profile of the drain, including the culvert. It is recommended that this design should be utilized in the development of the drainage in the Kurutie community.

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