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Drainage Network / Storm Water Design For Unilorin

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***Abstract*—Overland flow through the surface is usually channeled to either a surface drain or underground surface drain. In this study, the analysis and design for storm water drainage in other to channel over land surface flow into drainage network on Olu Daramola road, university of Ilorin Nigeria so as to prevent overland flooding. 2.15 m^3/s discharge was used in the analysis while AutoCAD and Hy8 were the tools used for the design. A trapezoidal drain was designed with a dimension of 800 mm depth and a width of 250 mm using rational method. The HY8 gave an output of the elevations and water profile of the drain including the culvert.**

Keywords—Culvert, Discharge, Drainage, Hydraulic

I. INTRODUCTION

Drainage network is the pathway in which storm water or runoff follows a flow path before getting to a receiving water body. Storm water drainage system is design to collect and convey runoff generated within a catchment area during and after rainfall event for safe discharge into a receiving watercourse. The magnitude of peak flows that have to be accommodated depends on the intensity of rainfall, topography and soil type and land use of the catchment. The collection and proper disposal of storm water and surface runoff is essential for any environment as it stabilizes the state of wellbeing of occupants in that vicinity reduces soil erosion for extensive agricultural productivity and therefore enhance quality of life.

In the urban environment, storm water drainage systems are provided to convey runoff from developments in a safe, convenient, and environmentally conscious manner. Inherent in this philosophy is the analysis of rainfall events (storms) that result in both “minor” and “major” storm water flows [1]. The minor system sometimes referred to as the “Convenience’’ consists of the components that have been historically considered as part of the “Storm drainage system”. These components includes curbs, gutters, ditches, inlets, access holes, pipes and other conduits, open channels, pump detention basins, water quality control facilities. The minor system is normally designed to carry runoff from 10- year frequency storm events. The major system provides overland relief for storm water flows exceeding the capacity of the minor system. This usually occurs during more infrequent storm events, such as the 25-, 50-, and 100 year storm. The major system is composed of pathways that are provided knowingly or unknowingly for the runoff to natural or manmade receiving channels such as streams, creeks, rivers, and lake. The major system normally uses a 100 year event as the check storm.

One of the major problems associated with new urban development is the increased volumes and rates of storm water runoff generated within previously natural watersheds. Runoff volume is increased when natural previous land surfaces are covered by such impervious structures as buildings, roadways, and parking lots and when natural depressions are removed, which serve as storage areas for surface runoff in their natural state. The rate of runoff including peak flow rates is significantly increased when structural drainage systems such as storm sewers and ditches which greatly reduced the time of concentration of runoff are constructed [3]. In this design, the “minor” storm flow was channeled through the open surface drains while the “major” storm water was drained using the underground storm water drain. All storm drain designs is be based on an engineering analysis which takes into consideration runoff rates, pipe flow capacity, hydraulic grade line, soil characteristics, pipe strength, potential construction problems, and potential runoff treatment issues [5]. This research tends to focus on the comparison in the use of both Autocard and HY8 software in the design of a storm water and drainage for the study area.

II. METHODOLOGY

A. *The Study Area*

The study area is OluDaramola road situated in the University of Ilorin, Kwara state (longitude 80 28'and latitude 40 39'). The location of the area is as shown in the figure 1 below.

B. *DESIGN METHODOLOGY*

Data collection: Relevant data like the topographical map and the rainfall intensity- duration-
Frequency chart for Ilorin were used.

Fig 1. OluDaramola road in University of Ilorin, Kwara State

Analysis: Manual calculation, the use of software such as AutoCAD and Hy8 for the design was made use of.

Hydrological Design: The catchment flow rate was determined using the rational method which is stated as $Q = CIA/360$. ....Eqn(i)
Where, C is the Coefficient of runoff which represents the fraction of rainfall converted to runoff [4]. Appropriate values for coefficient of runoff are shown in the table1.0. I is the Rainfall intensity which is expressed as the average rainfall intensity in mm/hr for a selected reoccurrence frequency and for duration equal to the time of concentration of the watershed [4]. And A is the Area of watershed, in hectares.
The Time of concentration was obtained using kirpich formulae $T_c = 0.0078 \times (L^{0.77}/s)^{0.385}$
…Eqn(ii)
Where: Tc= time of concentration in mins. L = length of water shed area (ft). S = Slope of water shadewhich was obtained using the slope formulae. A Design return period of 10 years was used in this analysis.

Hydraulic design: Appropriate sections were computed using design formulas obtained from the table 2 below. This values are based on the assumption that b=2y, where y is the flow depth and b is the bottom width.

Table1. Runoff Coefficients for Rational Method [2].

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

Hydraulic design: Appropriate sections were computed using design formulas obtained from the table 2 below. This values are based on the assumption that b=2y, where y is the flow depth and b is the bottom width.

Table 2: – Hydraulic Sections Values (assuming flow depth y = 2* width (b)).

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 3: Different Values of Mannings Roughness Coefficient **n**.

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

Design of a Trapezoidal open drain for the road using the peak flow. Using manning equation:

Q = A* 1/n * (R) 2/3 * (S) 1/2

Where, Q = 2.15m3/s (flow from olu Daramola road).

From table 2.0 A = y2$\sqrt{3}$, and R = 0.5y, and n = 0.013

Q * 0.013 = y2$\sqrt{3}$* (0.5y) 2/3 * (0.025)1/2

From the above eqn. flow depth (y) = 0.5m

Base = 0.25m.

Therefore, the flow dimension is 500mm depth and a base of 250mm, adding a freeboard of 300mm, given an actual dimension of 800mm depth as in fig 2.0.

The drain shown in figure 2 is a typical crosssection of

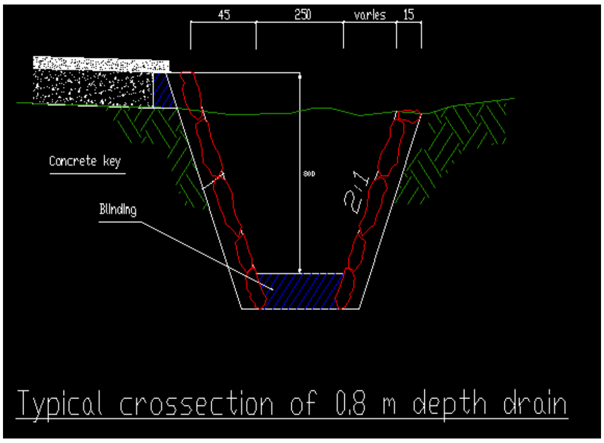

Fig 2. A cross sectional view of the proposed open channel (Stone pitched drain) using Autocad

a stone pitched drain with a depth of 0.8m which is determined through the use of manning equation. It is a lined drain which can easily be constructed by the use of readily available materials such as Stones and mortar (Fine sand and cement) while the base of light blinding.

A typical culvert of a cross sectional diameter of 600mm having a head wall shown in Figure 3. This

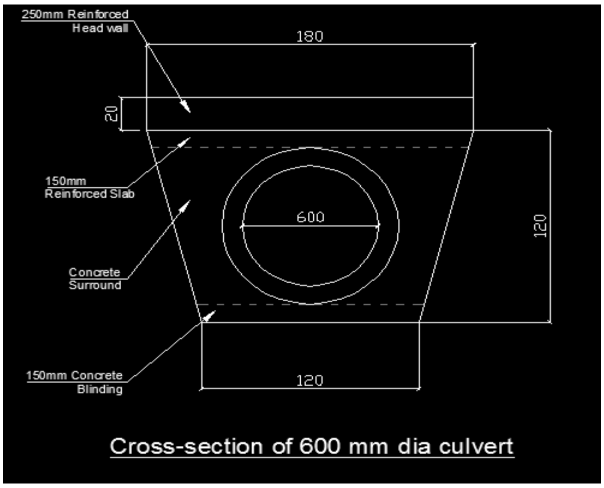

Fig 3. A cross Showing a cross section of a designed culvert using AutoCad

are mainly fixed on areas that requires passage so as to have an easy assess in the area. It is made using reinforced concrete for its construction.

A full section of a road shown in figure 4 consists of

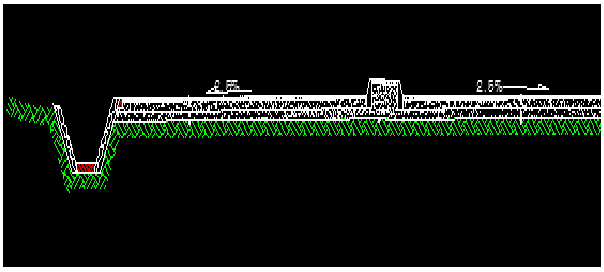

Fig 4. Shows a full section of the road with its drainage using AutoCAD

both the road layers and the drainage at the side of the road. A slope of about 2.5% is needed on the road to enable surface water drainage into the drain.

Using HY8 software in the design of culvert crossing and the trapezoidal channel we have the summary of results.

Table 5: Culvert Crossing

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)
0.00	0.00	1000.00	0.00	0.0
7.59	7.59	1001.00	1.00	0.74
15.19	15.19	1001.44	1.44	1.09
22.78	22.78	1001.78	1.78	1.38
30.37	30.37	1002.10	2.10	1.66
37.97	37.97	1002.41	2.41	1.94
45.56	45.56	1002.70	2.70	2.22
53.15	53.15	1002.97	2.97	2.53
55.00	55.00	1003.03	3.03	2.60
68.34	68.34	1003.47	3.47	3.19
75.93	75.93	1003.72	3.72	3.55

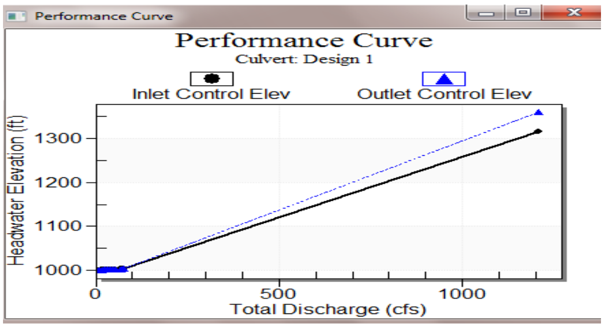

Fig 5. Performance Curve ectional view of the proposed open channel (Stone pitched drain) using Autocad

A culvert crossing as shown in table 5 contains both the elevation and the graph of the plot of the headwater elevation and discharge is seen on performance curve shown in figure 5.

Table 6: Water Surface Profile

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Out let Control Depth(ft)
0.00	0.00	1000.00	0.00	0.0
7.59	7.59	1001.00	1.00	0.74
15.19	15.19	1001.44	1.44	1.09
22.78	22.78	1001.78	1.78	1.38
30.37	30.37	1002.10	2.10	1.66
37.97	37.97	1002.41	2.41	1.94
45.56	45.56	1002.70	2.70	2.22
53.15	53.15	1002.97	2.97	2.53
55.00	55.00	1003.03	3.03	2.60
68.34	68.34	1003.47	3.47	3.19
75.93	75.93	1003.72	3.72	3.55

The water surface profile contain the headwater elevation at each rate of discharge and also the inlet and outlet control

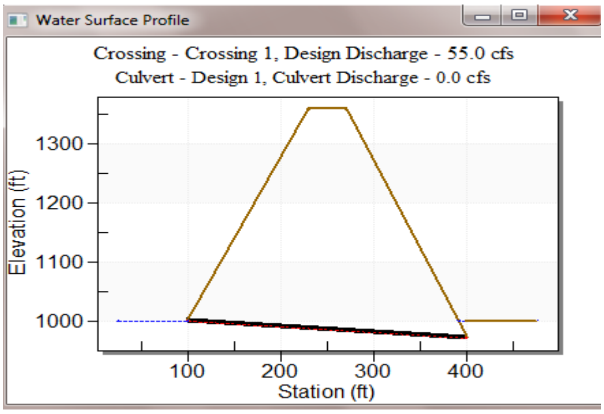

Fig 6. Water Surface Profile chart

in the design of the culvert, A chart showing the culvert crossing surface profile is seen on figure 6.

IV. CONCLUSION

Through both tools used in the design of storm water and drainage. It was noted that the Autocad software could do more of the schematic design showing the 2D diagram of the drain while that of the HY8 software does the analysis as well as a chart to display its result. A section of the trapezoidal drainage designed to carry a flow of 2.18m^3/s has the dimension 800mm depth and 250 mm width. This design also shows the importance of rational formula in the design and analysis of overland and channel flow. Flow velocities and discharge obtained from the stage-discharge curves indicates that there will not be overflow which can lead to flooding.

In the analysis and schematic representation of storm water drainages for communities both the use of AutoCAD and HY8 is very much relevant. Therefore recommended for use in the design of storm water drainage in the University of Ilorin.

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