ISSN 2056-5860

FORMULATION OF NOMOGRAPH FOR INLETS OF ZERO DEPRESSION

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ABSTRACT

The formulation of the nomograph entails the use of the rational formula (Q = 10CIA) where Q is the discharge in m^3 /s, C is the runoff coefficient, I is the intensity in mm/hr and A is the catchments area in m^2. The nomograph relates the basic parameters in the formula $Q = C_W L d^{3/2}$. In other to use the formula $Q = C_W L d^{3/2}$ the following values of coefficient 0.36 – 0.4, 0.47 – 0.64, 0.64 – 0.74 and 0.7 – 1.04 were computed for curb inlets with 0 mm depression respectively. From these values of coefficient, 0.4, 0.58, 0.7 and 0.9 were chosen to formulate the nomograph for the inlets while Q and d values are fixed on logarithmic scale.

Keywords: Nomograph, intensity, duration, inlets, drainage.

INTRODUCTION

A good drainage system consists of inlets (curb and grated), the drains, manholes, catch basins and culverts. Each of these components has to function effectively if the drainage system is to work well. Proper functioning requires adequate design and regular maintenance. Adequate design implies proper sizing, adequate slopes, such that the flood water will be removed from road surfaces quickly enough to eliminate the attendant problems of deterioration and disintegration of the road surfaces and other flood-related problems when flood waters are removed from the road surfaces in a timely fashion.(Anyata et al, 2000). Water is one of the major causes of highway deterioration. once water entered a road pavement, water damage is initially caused by hydraulic pressure; hence the water table must be kept low to prevent the moisture content of the subgrade from increasing hence decreasing the CBR value. The rate of highway failure in Nigeria is alarming and it calls for urgent and decisive action (Osuolale, et al, 2012). There are many causes for road failure but the main cause is the drainage system of roads or material failure against the axial loading. Floodwater serves as a deterrent to free traffic movement and creates unnecessary perils for users of the facility (Ojo, 1997) Uncontrolled water movements may weaken or damage transportation structures and pavement systems. Modern road engineers recognize that the entire serviceability of the highway is greatly dependent upon the adequacy of its drainage system. (O'Flaherty, 1983) Road drainage system provides a route for water to flow from the highway to a suitable discharge point. This route may be at the surface in form of a ditch or underground in form of pipes.

In the hydraulic design of inlets an adequate size must be provided to rapidly remove collected storm water. Survey and measurements made in many Nigerian cities indicate that except for a few towns like Abuja and some parts of Port Harcourt, curb inlets have about the same sizes. Observations also indicate that the bottom invert elevations of curb inlets are often higher than the road level that they are expected to drain. This is caused by either poor construction and/or poor maintenance. Under such circumstances, the storm runoff that is meant for the gutter is not intercepted by the curb inlets. Consequently, flooding of the street occurs.

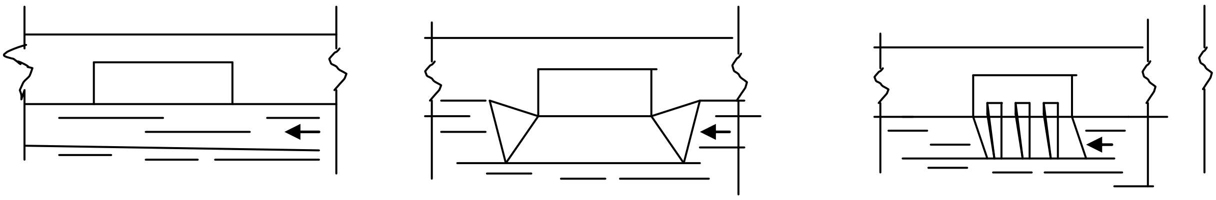
Flooding can also occur when curbs are too high and narrow, the inlet bases will be filled with sand and debris with the result that many storm water intended for the gutters and drains is trapped in between the curb inlet and the road and thus flooding occurs. It is only when substantial flooding of the road has taken place that some flood- water enters through the top (unblocked section) of the curb.

The typical sizes of curb which turn out to be almost the same dimensions in all the cities surveyed were because most highway designers often adopt "standard designs" irrespective of the intensity and / or duration of the rainfall at the locations they are designed for. Omotayo (2001) in Akinro and Olawale (2007) reported that the penetration of moisture from the Gulf of Guinea initiates the rainy season where 80% fall between periods of July and September and that rainfall begins in the month of March and continues to increase appreciably up till June when it reaches its first peak.

The performance of inlets (curb and grated inlets) is of vital importance to both road users, road contractors and the road owners (the Federal and State Ministries of Works and the Local Government Authorities). More money is spent on roads and other road components like drains and inlets than other aspects of construction (infrastructures) in the economy and the average cost per meter road is in the order of hundreds of thousands of naira. Yet despite the importance of some of these vital road components, decisions about their designs are typically made in Nigeria base on experience and "standard designs" with little use of quantitative aids and analysis in decision-making. This paper therefore aims at formulating a nomograph that can be used to select inlet sizes for zero depression.

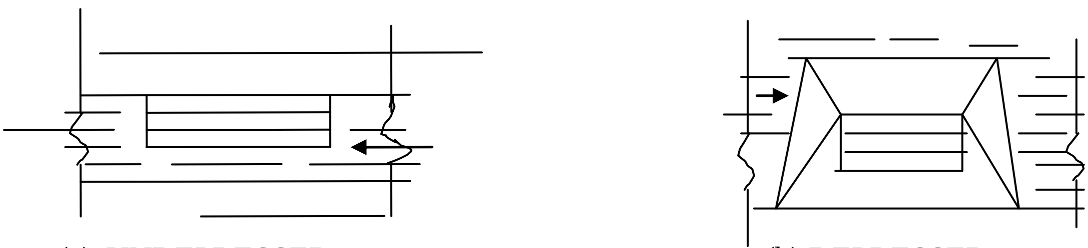
INLETS

An inlet is an opening into storm or combined sewer for entrance of storm water or run off (Mcghee and Steel, 1977) these are generally placed at interceptions to intercept the water flowing in the gutters before it can reach pedestrian cross walks (Babkov, 1985). There are three types of inlets: Curb, grate and combined inlets. (Upadhyay, 2012).



(a) UNDEPRESSED (b) DEPRESSED (c) DEFLECTOR INLET

Figure 1.1: CURB INLETS



(a) UNDEPRESSED (b) DEPRESSED

Figure 1.2: GRATE INLETS

ISSN 2056-5860

LOCATION AND SPACING OF INLETS

The location and spacing of inlets depend on the following factors:

- i. Amount of run off
- ii. Grade profile
- iii. Geometrics of interchanges and intersections
- iv. Width of flow limitations
- v. Inlet capacity

Generally inlets should be at low points in the grade and at intersections to prevent the gutter flow from crossing traffic lanes of the intersecting road. Large amounts of sediments may enter the storm drain system are installed before the upslope drainage area is stabilized or when construction is adjacent to an existing storm drain. In cases of extreme sediment loading, the storm drain itself may clog and lose a major portion of its
Capacity; to avoid these problems it is necessary to prevent sediment from entering the system at the inlets.(CASQA, 2003)

EXISTING SITUATION IN NIGERIAN CITIES

A general consideration of roads in Nigeria exemplifies common problems such as:

- i Lack of maintenance
- ii Improper sizing of inlets and drains
- iii Blockages of inlets and drains
- iv Deposition of sediments along the road surface
- v Flooding of the highway

Inlet sizes vary from 25mm -1500mm in Nigeria cities. Measurements were taken in some Nigeria towns and the following results were discovered. In Akure the inlets comprises of mainly a 150mm diameter passed under a concrete slab. More than 80% of these inlets were blocked with sand. Readings taken in kano indicate a range of 5 – 10cm, height of 14cm and length of 60cm. in port Harcourt readings taken indicate an inlet size of 1500mm x 150mm. The inlets were very clean and not easily blocked by sand deposit.

DESIGN OF INLETS

This involves the hydrologic and hydraulic design. The hydrologic design entails the estimation of the total quantity of storm water that will flow through the opening by using either the rational or the empirical formulae. The quantity depends on the catchment area, ground slope, extent of impervious area, and vegetation growth, rainfall duration, etc. (Punmia et al, 2005). The limited extent of the area involved and the designing principles of the major – minor drainage concepts permits considerable tolerance in the degree of accuracy of runoff calculations such that the rational formulae (Q = CIA) is considered adequate for the minor systems.

FORMULATION AND DEVELOPMENT OF NOMOGRAPH

This entails the use of the rational formulae (Q = 10CIA) where Q is the discharge in m^2/s, C is the run off coefficient, I is the intensity in mm/hr and A is the area of the catchments in m^2.

ISSN 2056-5860

The discharge Q is estimated for an assumed road length of 150m, and given values of s (slope of channel), z (reciprocal of cross slope), n (Manning's coefficient) so that the corresponding depth d of water at the curb can be read from the nomograph for flow in triangular channels. Using the formula $C_W = Q/L\ d^{3/2}$ where L is the length of inlet in meters and C_W is the coefficient of discharge, the following values of coefficient 0.36 – 0.4, 0.47 – 0.64, 0.64 – 0.74 and 0.7 – 1.04 were computed for curb inlets with 0 mm depression respectively. From these coefficient values, 0.4, 0.58, 0.7 and 0.9 were chosen to formulate the nomograph for the inlets. The Q and d values are fixed on logarithmic scale as shown in figure 1. 4 To obtain the pivot line, two different values of Q and d are initially chosen such that the same values of L are obtained.

E.g. when Q = 0.05 m^2/s and d = 0.1065m L = 3.59
When Q = 0.0325 m^2/s and d = 0.080m L = 3.59

Another value of Q and d as chosen as given above to get the same values of L when these values are plotted a straight line is drawn through the points where each pair of values meet to represent the pivot line. To calibrate the pivot line, a unit value of d is taken e.g. d =1and L is computed from the formulae $L = Q/\ 0.4d^{3/2}$ for different values of Q so that when the scale rules is placed on d =1 and the selected values of Q, the point it makes on the pivot line is taken as corresponding to the computed values of L.

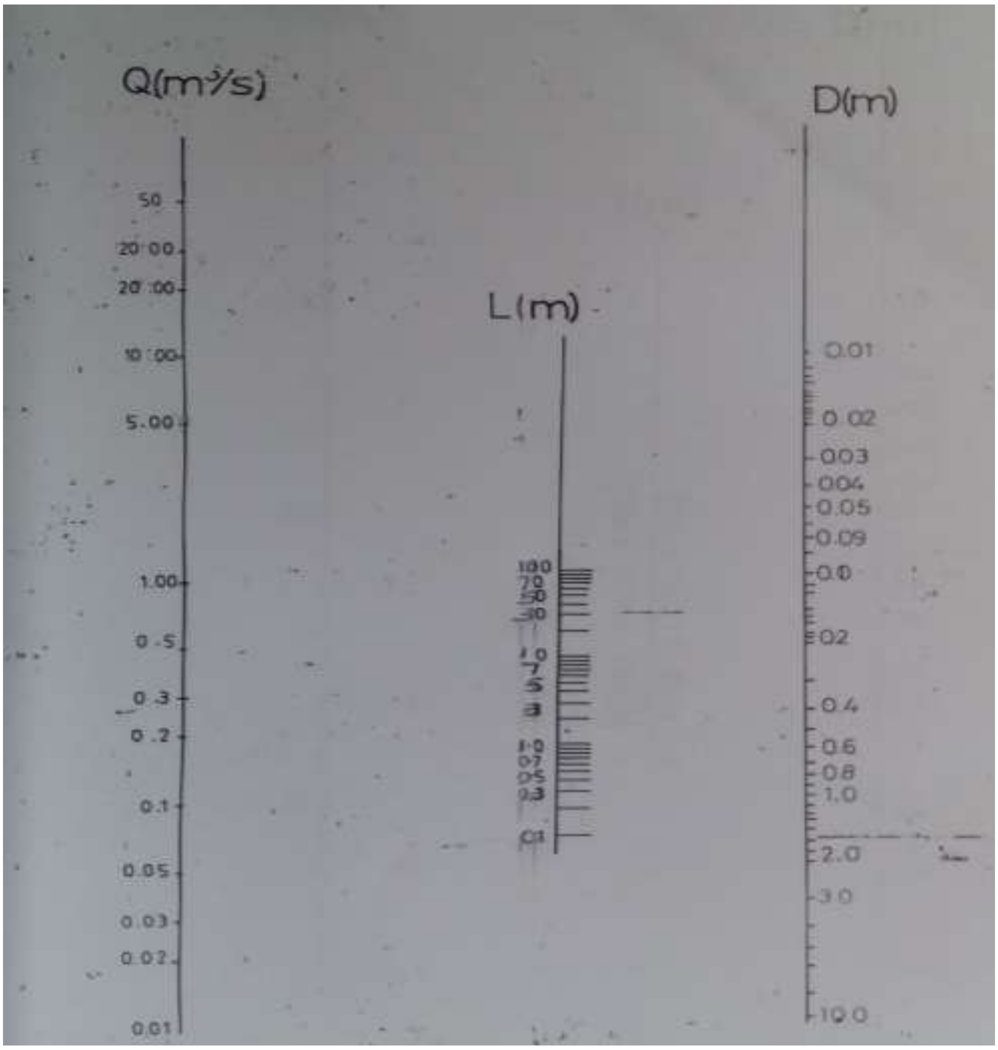


Figure 1. 4: Nomograph for inlets of zero depression.

ISSN 2056-5860

CONCLUSIONS

The formulation of the nomograph entails the use of the rational formula (Q = 10CIA) where Q is the discharge in m^3 /s, C is the runoff coefficient, I is the intensity in mm/hr and A is the catchments area in m^2. The nomograph relates the basic parameters in the formula $Q = C_W L d^{3/2}$ In other to use the formula $Q = C_W L d^{3/2}$ the following values of coefficient 0.36 – 0.4, 0.47 – 0.64, 0.64 – 0.74 and 0.7 – 1.04 were computed for curb inlets with 0 mm depression respectively. From these values of coefficient, 0.4, 0.58, 0.7 and 0.9 were chosen to formulate the nomograph for the inlets while Q and d values are fixed on logarithmic scale. To use the nomograph the values of Q and d must be known. and aligned to obtain the corresponding length of curbs from the L scale

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