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# The Study of the Hydraulic Properties of a Storm Water Drain in Guwahati Metropolitan City

## Swapnaneel Roy<sup>1</sup>, Nilotpal Sharma<sup>2</sup>, Mayuri Deka<sup>3</sup>

<sup>1</sup>8<sup>th</sup> Semester, Civil Engineering Department, Royal School of Engineering and Technology, Royal Group of Institutions, Betkuchi, Guwahati-35, Assam *royswapnaneel9[at]gmail.com* 

<sup>2</sup>8th Semester, Civil Engineering Department, Royal School of Engineering and Technology, Royal Group of Institutions, Betkuchi, Guwahati-35, Assam *nilotpalsarma39[at]yahoo.in* 

<sup>3</sup>Assistant Professor, Civil Engineering Department, Royal School of Engineering and Technology, Royal Group of Institutions, Betkuchi, Guwahati-35, Assam mayurideka53[at]gmail.com

Abstract: Guwahati city does not have a comprehensive drainage system in most parts of the city except the small areas where the Guwahati Metropolitan Development Authority has implemented some minor drainage schemes. These minor drainage schemes along with the existing natural drainage channels are not sufficient to handle the amount of discharge of storm water flow during the monsoon season mainly due to unplanned development process, encroachment and other factors such as pollution of water, etc. This often leads to frequent rain water floods which causes flooding of road, residential and commercial establishments and hence causes great damage and disturbances to the general public. This study aims at studying the relatively recent constructed storm water drain from Betkuchi to Lokhora alongside of the National Highway 37. A span of 1 km of the drain was scrutinized and the allowable discharge and other hydraulic characteristics were computed. A comparison was made with the actual rainfall discharge and certain conclusions were drawn.

Keywords: Storm water drain, Rainfall Discharge

## 1. Introduction

The scope of this paper was to take into study a recently developed storm water drain from Betkuchi to Lalungaon, in the Guwahati Metropolitan city; and to make certain conclusions about the discharge and other hydraulic characteristics of the drain.

A storm water drain in Guwahati city was taken into consideration. A span of 1 kilometre of the drain was scrutinised, starting from the front of Royal Group of Institutions to near the GEMS National Public School. The dimensions of the storm water drain were measured at specific intervals and the design discharge and other hydraulic characteristics were calculated. The design discharge was compared to the rainfall discharge over a period of 10 years and certain conclusions were drawn.



Figure 1: The storm water drain under study

The study area, which is the 1km span of the storm water drain from Betkuchi to Lalungaon can be seen in the map as given below.



Figure 2: Map showing the location of the study area

## 2. Methodology

#### 2.1 Site Selection

The first and the foremost thing for starting the project work were to select a suitable site for the project work to be done. So the site for the project work was selected depending on traffic conditions, convenience to carry out survey work and measurement of dimensions of the storm water drain. The survey of the storm water drain was carried out for a length of 1 km length starting from Royal Group of Institutions, Betkuchi to GEMS National Public School, Lalungaon. 2<sup>nd</sup> International Seminar On "Utilization of Non-Conventional Energy Sources for Sustainable Development of Rural Areas ISNCESR'16

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#### 2.2 Calculation of Elevations

The instrument used in the calculation of elevations was Compact Dumpy Level.

At first we placed the instrument in such a position from where the maximum number of observations could be taken. The instrument was placed on a tripod stand. The legs of the tripod stand was stretched at suitable height and the two legs of the tripod stand were fixed while the other one was moved in and out until the spirit bubble was at the center. Leveling was done with the help of spirit bubble by the movement of the foot screws of the instrument inward or outward and once the spirit bubble is in the mid portion or center the foot screws were tightened and the instrument was fixed.

After leveling the eye piece adjustment was done by rotating the focusing screw clockwise or anticlockwise until the cross hair can be seen clearly.

After doing all the adjustments, the staff readings were taken. The staff readings were taken at an interval of 10 meters.

The staff readings were recorded in a tabular format and the elevations (or the reduced levels) of the sections were calculated by Height of Instrument method.

#### 2.3 Measurement of dimensions of the storm drain

At each section, the width, overall depth and the wetted depth was measured using a bamboo and a 5m steel tape. The observations were noted in a tabular format and the wetted perimeter and the area of flow was calculated.

#### 2.4 Calculation of velocity of flow

The velocity of flow was calculated using two formulas given by Manning and Chezy.

#### 2.4.1 Manning's Formula

Irish engineer Robert Manning (1891) gave a formula for velocity of flow in open channel. [1], [2], [4]

$$V = \frac{1}{n} R^{2/3} S_b$$

V= Velocity of flow

R= Hydraulic radius

S<sub>b</sub>= Bed slope

n= Roughness coefficient or rugosity coefficient

The roughness coefficient mainly depends on surface roughness and factors like vegetation cover, cross-sectional irregularity, channel silting, scouring, obstruction and stage or depth of flow.

#### 2.4.2 Chezy's formula

A formula for calculation of velocity of flow was given for uniform flow in open channels by the French Engineer Antoine Chezy (1769). [1], [2], [4]

$$V = C \sqrt{RS_b}$$

V= Velocity of flow C= Chezy's coefficient

R= Hydraulic radius

 $S_b = Bed slope$ 

The value of Chezy's coefficient 'C' can be calculated by the Ganguillet-Kutter formula as follows:

$$C = \frac{\frac{23 + \frac{0.00155}{S_b} + \frac{1}{n}}{1 + \left(23 + \frac{0.00155}{S_b}\right) \frac{n}{\sqrt{R}}}$$

Where n= Roughness or rugosity coefficient R= Hydraulic radius =  $\frac{Area \ of \ flow}{wetted \ Perimeter}$ 

S<sub>b</sub>= Bed slope [1], [2], [4]

#### 2.5 Calculation of discharge:

After the calculation of velocity of flow was done, the discharge for each section was calculated. The discharges were noted in a tabular form and the maximum discharge was noted.

The discharge was calculated by the following formula: Q=AVwhere Q= Discharge through the section

A= Area of the section

V= Velocity of flow through the section [1], [2], [4]

#### 2.6 Calculation of rainfall discharge:

The rainfall discharge was calculated using the rainfall data for a period of 10 years. The rainfall runoff was calculated using the rational method for determination of runoff. In the rational method, the basic equation which co-relates runoff and rainfall is as follows:

Q=CIA

where Q is the flood flow in hectare-metre per hour (or cubic metre per hour); I is the intensity of rainfall in metres per hour; A is area of the drainage basin in hectares (or square metres); and C is a runoff coefficient. [3]

## 3. Results and Discussions

#### 3.1 Data Considered

The catchment area, coefficient of runoff and Manning's rugosity coefficient have been considered from the Conceptual Detail Project Report (DPR) for Implementation of Pilot Project, [5], [6] and are given as follows:

- Catchment Area = 22.9 hectares
- Coefficient of runoff = 0.4
- Manning's rugosity coefficient = 0.015
- Bed slope,  $S_b = 1$  in 3000

#### **3.2 Measurement of Dimensions**

The dimensions of the rectangular channel were measured at intervals of 10m and were noted in a tabular format. [7]

#### 3.3 Calculation of Reduced Level

The reduced level of the different sections was calculated and noted down in a tabular format. The variation of the RL along the various sections were put in a graphical format as shown. [7] 2<sup>nd</sup> International Seminar On "Utilization of Non-Conventional Energy Sources for Sustainable Development of Rural Areas ISNCESR'16





Figure 3: Variation of RL along different sections

#### 3.4 Calculation of Velocity of flow and Discharge

## **3.4.1** Calculation of velocity and discharge by Manning's Formula

The velocity of flow was calculated using Manning's formula as mentioned in the previous chapters.

The discharge was calculated by multiplying with the area of the section.

The findings were noted in a tabular format and the obtained data can be represented in a graphical format as show below. [7]. It was observed that the peak discharge of the channel is 19.886 cumec.



Figure 4: Variation of discharge using Manning's formula

## **3.4.2** Calculation of Velocity and Discharge using Chezy's Formula

The velocity of flow was calculated using Chezy's formula as mentioned in the previous chapters.

The discharge was calculated by multiplying with the area of the section.

The findings were noted in a tabular format and the graphical representation of the same can be seen below. [7] It was observed that the peak discharge through the channel was 19.309 cumec.



Figure 5: Variation of discharge using Chezy's formula

#### **3.5 Calculation of Rainfall Discharge**

The peak rainfall discharge was calculated using the Rational method for determination of runoff. [3]

The rainfall intensity was considered according to the Project report on "The Improvement of Drainage system in Guwahati city (Lokhra to Betkuchi)". The rainfall data for 11 years from 1990 to 2000, was taken into consideration and from the intensity-duration curves and the calculated intensity for the 11 years, the maximum intensity was taken as 70 mm/hour which occurred in the year 1999. [5], [6]

Therefore the intensity of rainfall, I can be taken as 70 mm/hour.

Now, the peak rainfall discharge can be given by, O = CIA

$$= CIA = 0.4 \text{ x} \frac{(70 \text{ x} 10^{-3})}{3600} \text{ x } 22.9 \text{ x } 10^4$$

= 1.781 cumec

Hence, the rainfall discharge through the channel is 1.781 cumec. [6]

#### 3.6 Calculation of other Hydraulic properties

#### 3.6.1 Specific Energy

Specific energy of a flowing liquid is defined as energy per unit weight of the liquid with respect to the bottom of the channel. [1], [2], [4]

$$\mathbf{E} = d + \frac{q^2}{2g \, d^2} = \mathbf{E}_{\mathbf{p}} + \mathbf{E}_{\mathbf{k}}$$

where E = Specific energy

d = depth of flow

q = discharge per unit width

g =acceleration due to gravity

The specific energy at each 10m interval was calculated and noted in a tabular format and the graphical representation of the same can be seen below. [7]

It was observed that the minimum specific energy for the channel was 1.376 kg-m/kg.



Figure 5: Variation of specific energy along different sections

#### 3.6.2 Critical depth

Critical depth is defined as that depth of flow of water at which the specific energy is minimum. This is denoted by ' $h_c$ '. [1], [2], [4]. Minimum specific energy was achieved at section number 22, and the depth of flow at that section was 1.140m.

Hence the critical depth can be given as  $h_c = 1.140$ m.

#### 3.6.3 Critical Velocity

The velocity of flow at critical depth is known as critical velocity. It is denoted by  $V_c$ . [1], [2], [4] The mathematical expression for critical velocity is given by the following equation:

$$V_c = \sqrt{g \times h_c}$$

where  $V_c$  = critical velocity g = acceleration due to gravity  $h_c$  = critical depth

In this study, it was found that critical depth  $h_c$  is 1.140m. Hence critical velocity can be given by:

$$V_c = \sqrt{9.81 \times 1.140} = 3.344$$
 m/sec.

Hence the critical velocity for the channel is 3.344 m/sec.

#### 3.6.4 Minimum specific energy in terms of critical depth

Theoretically, minimum specific energy can be given by:  $E_{\min} = \frac{ah_c}{2}$ 

Hence, 
$$E_{\min} = \frac{3 \times 1.140}{2} = 1.71 \text{ kg-m/kg}.$$

Therefore, theoretical minimum specific energy is found to be 1.71 kg-m/kg.

## 4. Conclusion

#### 4.1 General

This project aims at studying the relatively recently constructed storm water drain from Betkuchi to Lokhra alongside of the National Highway 37. In this project, an effort has been made to compare the actual discharge that is taking place in the storm water drain with the rainfall discharge through the drain.

• The discharge in the storm water drain according to Manning's formula was found out be 19.886 cumec and by Chezy's formula was found to be 19.309 cumec. It can

be observed that the discharge by Manning's formula is slightly greater than that by Chezy's formula.

- The rainfall discharge was found to be 1.781 cumec.
- The minimum specific energy of the flow through the drain was found to be 1.376 kg-m/kg. The critical depth for the minimum specific energy was 1.140 m and the critical velocity was 3.344 m/sec.
- The minimum specific energy in terms of critical depth was found to be 1.71 kg-m/kg.

It was seen that, the discharge carried by the drain is significantly higher than the rainfall discharge in the area. But, as several factors such as sewage from the residential and industrial establishments, rainfall water flowing down from the nearby hilly areas etc. which also add to the net discharge through the drain, were not taken into consideration, hence the results cannot be taken to be completely accurate. Hence the storm water drain cannot be considered to be safe.

Also, variation in the theoretical and practical values of specific energy was seen which was mainly because of the non-uniformity of the channel under study.

#### 4.2 Future Scope

From this study, it can be concluded that the storm water drain under scrutiny is not safe for the future years. With the increasing population the sewage will significantly increase. Also, due to adverse effects of global warming, the rainfall may also rise, which may also result in flash floods. This discharge will not be accommodated by the present storm water drain. Also, high levels of pollution were observed in the present condition of the drain. This may lead to blockage of the drain in future and hence hamper its functionality. Certain improvements such as lining of the drain using suitable lining material, making the channel uniform throughout the length of the drain, providing suitable measures to avoid pollution etc. can be made for better functioning of the drain. Further studies need to be conducted so as to make the storm water drain more efficient and better suited to meet the future demands.

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## **Author Profile**



**Swapnaneel Roy** is pursuing B.E. in Civil Engineering Department from Royal School of Engineering and Technology, Royal Group of Institutions, Guwahati, Assam, India.



**Nilotpal Sarma** is pursuing B.E. in Civil Engineering Department from Royal School of Engineering and Technology, Royal Group of Institutions, Guwahati, Assam, India.



**Mayuri Deka** is working as an Assistant Professor in Civil Engineering Department from Royal School of Engineering and Technology, Royal Group of Institutions, Guwahati, Assam, India.