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# Study of the Specific Energy of a Storm Water Drain in Guwahati Metropolitan City

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Abstract: Theminor drainage schemes of Guwahati Metropolitan city 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 paper 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 specific energy and specific energy curves were computed and certain conclusions were drawn.

Keywords: Storm water drain, Specific Energy.

## 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 was 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.

#### **2.2 Calculation of Elevations**

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

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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]

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

V= Velocity of flow

R= Hydraulic radius

 $S_b = Bed slope$ 

n= Roughness coefficient or rugosity coefficient

The roughness coefficient mainly depends on surface roughness and factors like vegetation cover, crosssectional 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:

$$Q = AV$$

where Q= Discharge through the section A= Area of the section V= Velocity of flow through the section [1], [2], [4]

## 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][8]

#### 3.3 Calculation of Reduced Level

The reduced level of the different sections was calculated and noted down in a tabular format. [7][8]

#### 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.

It was observed that the peak discharge of the channel is 19.886 cumec.[7][8]

## **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. It was observed that the peak discharge through the channel was 19.309 cumec.[7][8]

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#### 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]

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

where E = Specific energy

d = depth of flow

- q = discharge per unit width
- g = acceleration due to gravity

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

#### 3.6.2 Specific Energy Curve

The total energy can be expressed as mentioned above as:

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

This equation gives the variation of specific energy (E) with the depth of flow (h). Hence for a given discharge Q, for different value of depth of flow, the corresponding values of E may be obtained. Then a graph between specific energy (along X-axis) and depth of flow, h (along Y-axis) may be plotted.



Figure 3: A general specific energy curve

The specific energy of the various sections, taking five sections at a time were plotted and are shown below.



Figure 4: Specific energy curve for sections 1-5



Figure 5: Specific energy curve for sections 6-10



Figure 6: Specific energy curve for sections 11-15



Figure 7: Specific energy curve for sections 16-20



Figure 8: Specific energy curve for sections 21-25

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Figure 11: Specific energy curve for sections 36-40











Figure 14: Specific energy curve for sections 56-60



Figure 15: Specific energy curve for sections 61-65



Figure 16: Specific energy curve for sections 66-70

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Figure 17: Specific energy curve for sections 71-75

### 4. Conclusion

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 study the specific energy of the various sections of 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.[7][8]
- 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. [7][8]
- The minimum specific energy in terms of critical depth was found to be 1.71 kg-m/kg.[7][8]

From the study, it can be observed that, the various specific energy curves obtained resemble the general specific energy curve. Hence the study can be concluded as progressing in the right direction. The variations observed in the curves are mainly due to the variations in the depths of the storm drain and the non-uniformity in the sizes of the sections of the drain.

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