Chezy's Resistance Factor Variations in Different Bangladeshi Rivers Using the Bazin Formula for Measuring Discharge

Ahanaf Tahmid[1], Md. Hasanur Rahman[2], Khan Abid Ahsan[3]

[1]*Undergraduate Student, Department of Civil Engineering, AUST, Bangladesh (170103160@aust.edu)*
[2]*Undergraduate Student, Department of Civil Engineering, AUST, Bangladesh (170103153@aust.edu)*
[3]*Lecturer, Department of Civil Engineering, AUST, Bangladesh (nabil117@aust.edu)*
Corresponding Author: 170103160@aust.edu

Abstract

The coefficient of roughness is one of the most important specific constraints of hydrology and hydraulics. Several researchers proposed multiple methods for observing the coefficient of roughness. In calculating standard depth in the open channels, the Chezy's coefficient for resistance of flow plays an important role. When using the Chezy's relationship for the calculation of the normal depth, the main unknown parameter is Chezy's coefficient. The assessment of the Chezy's resistance coefficient has no explicit and full relationship. In this study, Chezy's resistance factor is used to regulate the restricting characteristics of various streams in Bangladesh, showing that stream release greatly influences the restricting characteristics. Bazin suggested a formula considering Chezy's coefficient to be a function of hydraulic radius but not of slope where another function is coefficient of roughness whose values were proposed by Bazin depending on the type of channels. After determining and comparing, Chezy's roughness coefficient by Bazin for different types of channels, it is seen that the "Earth Channels in Perfect, Ordinary and Rough Condition" shows a wide variation with the actual one which is demonstrated on the discharge of the streams. Bazin formula of determining the Chezy's coefficient is not applicable for Bangladeshi rivers.

Keywords: *Bazin formula; Chezy's coefficient; Hydraulics & hydrology; Roughness coefficient; Rivers.*

1. Introduction

Hydraulics may be described as the sector of water technology (at rest or in motion). Mechanics of fluids can be characterized as fluid mechanics [1]. Rough and sloped beds have been a hydraulic problem with flow resistance. As a result of viscosity propulsion or pressure on wet surfaces, the resistance to flow in open channels occurs [2]. Different kinds of barriers and roughness on the beds and sides of ribs enhance roughness, induce water loss, delay the flow and increase the surface of the river. The flow resistance coefficient is recognized as the major factor in natural waterway simulation modes, the coefficient being determined according to speed, depth and roughness of the bed. Discharge coefficient is defined as the ratio of the mass flow rate at the end of the channel to the theory. The discharge coefficient in a hydraulic and hydrological system can be determined in several ways.

The stream is not defined in nature, but due to the reciprocal interaction between the stream and the bed it is sensitive to changes in mark geometry and parameters. The stream's defense is a result of grain aggressiveness alone, and a single viciousness concern for all deliveries is thought to be adequate to show the stream's protection. The essence of the problem is that the bed design alters with changes in stream conditions, making it difficult to determine the water resistance of waterways. In actuality, the rivers of Bangladesh are alluvial. The three powerful streams and their feeding systems are distinguished between stream complexity and difficulty, residue and channel structure. Survey data are also highly essential in the field of platforms, stream preparation, flood-control operations, tidal wavering enlistment due to upgrades, weathering, dams and other pressures driven constructions and points and crossing into stream channels and identification and real presence of the stream. Today, Bangladesh's rivers are alluvial. The three powerful streams and their feeding systems differ in the complexity and difficulty of the stream, the residue and the channel geometry. That is why river discharge measuring is an important factor. But it is difficult to measure in actuality. So, roughness parameter is an important factor to measure discharge depending on other parameters. Chezy's coefficient is one of them. Sometimes, actual parameters like velocity and discharge cannot be found easily. That is why Bazin formula [3] is used to determine Chezy's coefficient. But it seems a lot of variation with the actual one. And it seems not justified formula for Bangladeshi rivers. In present time and near future Bazin formula should not be used to determine the Chezy's coefficient.

The formula of Chezy, which is considered the first single flow formula on which Manning stretched its shape. Chezy's formula is an empirical formula which refers to water discharge as a proportionate measure of the channel and water pitch surfaces [2]. The Chezy factor likewise grows as the flow speed in the channel rises. Chezy's formula measures the performance or efficiency of the flow. The first standardized flow formula was developed, the famous Chezy formula, by French engineer Antoine Chezy in 1769, which typically is as follows:

$$V = C\sqrt{RS} \tag{1}$$

Where, S is the slope of the energy axis, R is the hydraulic radius, V is the mean velocity and C is a flow resistance metric known as Chezy's coefficient.

Two statements can be used to extract Chezy's formula mathematically. Chezy's first statement is as follows: "In turbulent flow the force of resistance per unit wetted area varies as the square of the mean velocity". The second statement is the fundamental theory of uniform flow, which Brahms asserted first in 1754 [4, 5]. It states that, when the gravity force causes flow, the effective portion must equate to the total resistance force in a uniform flow. It says that the efficient part can equal the overall resistance force of a uniform flow while the gravitational force induces flow. There have been several efforts to evaluate the coefficient value of Chezy. One of them is the Bazin formula. In 1855 and 1862 H. Darey began and then Bazin performed a wide range of open channel flow tests. In 1865, Bazin presented the results [6]. In 1897 Bazin eventually suggested a formulation based on cumulative data [3]. In 1897, H. Bazin suggested the French hydraulic formula that regarded Chezy's coefficient as a hydraulic radius but not as a sloping. This formulation is expressed in English units:
Where, 'm' is a roughness coefficient whose values are shown in table 1 as suggested by Bazin.

$$C = \frac{157.6}{1 + \frac{m}{\sqrt{R}}} \tag{2}$$

Table 1. Proposed values of Bazin's m [7]

Description of channel	Denoted by	Bazin's m
Very smooth cement of loaned wood	m_1	0.11
Unplanned wood, concrete, or brick	m_2	0.21
Ashlar, rubble masonry, or poor brickwork	m_3	0.83
Earth channels in perfect condition	m_4	1.54
Earth channels in ordinary condition	m_5	2.36
Earth channels in rough condition	m_6	3.17

2. Methodology

In this research paper, the roughness characteristic of the streams is calculated by Chezy's resistance factor. The selected rivers and stations of Bangladesh are shown in table 2. The data of the steams of different rivers of Bangladesh were collected from BWDB (Bangladesh Water Development Board) and the Chezy's coefficient of actual values determined by the equation is given below:
Chezy's resistance factor:

$$C = \frac{Q}{AR^{\frac{1}{2}}S^{\frac{1}{2}}} \tag{3}$$

Where, A= cross-sectional area of the station (m^2), R= hydraulic radius (m), Q= discharge of the station (m^3/s), S= slope of the energy axis and g= acceleration due to gravity (= 9.81 m/s^2). Also, assumptions of observation data from the BWDB, most of which between from 0.000014 to 0.00008 [8], have set water slopes of the rivers.

Table 2. Chosen Rivers and Stations of Bangladesh

River Name	Station
Gumati-Burinadi	SW110
Surma-Meghna	SW267
Old Brahmaputra	SW230.1
Surma-Meghna	SW266
Gumati-Burinadi	SW114
Kushiyara	SW173
Sangu	SW247
Turag	SW301

In equation (2), the hydraulic radius of different stations (Data gathered from BWDB) for different Bazin's m were put and Chezy's coefficient was found.

Table 3. Values of the Roughness Coefficient Chezy's C (Actual) and Chezy's C (Bazin) for the streams under consideration

River Name	River Code	Chezy's C	Bazin's C					
			m_1	m_2	m_3	m_4	m_5	m_6
Gumati-Burinadi	SW110	61.842	145.338	135.737	96.298	72.256	56.084	45.930
Surma-Meghna	SW267	36.037	152.276	147.739	124.704	105.811	90.054	78.506
Old Brahmaputra	SW230.1	14.074	151.590	146.512	121.313	101.351	85.167	73.563
Surma-Meghna	SW266	44.189	152.484	148.113	125.763	107.233	91.639	80.128
Gumati-Burinadi	SW114	42.289	147.151	138.786	102.620	79.035	62.456	51.736
Kushiyara	SW173	41.149	153.329	149.643	130.232	113.389	98.653	87.429
Sangu	SW247	38.761	150.231	144.107	115.029	93.439	76.793	65.301
Turag	SW301	41.576	152.025	147.289	123.446	104.140	88.208	76.628

The statistical data variation is showed here for a month and other months data are similar as respective.

3. Analysis of Results

Figure 1(a-h) are shown a plot of Chezy's coefficient by equation 2 (for different Bazin's m) and equation 3 vs discharge of the streams by using the data's collected from BWDB.

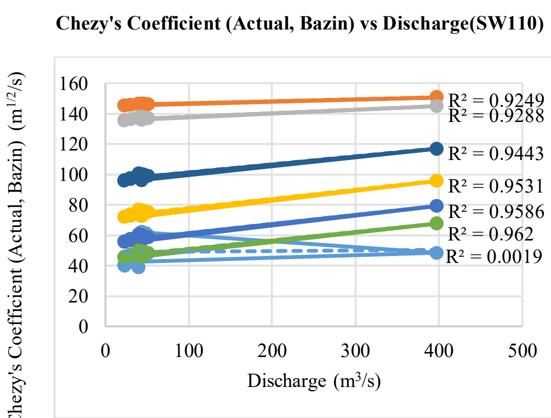

Figure 1 (a): SW110

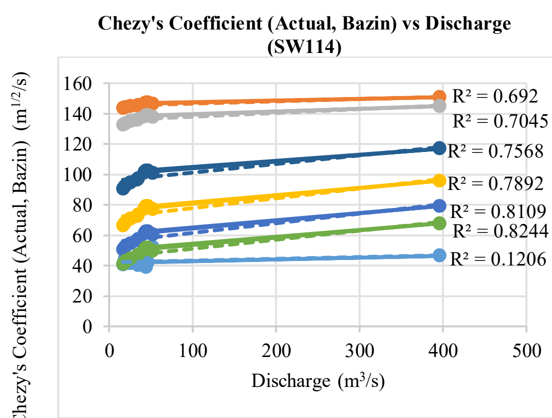

Figure 1 (b): SW114

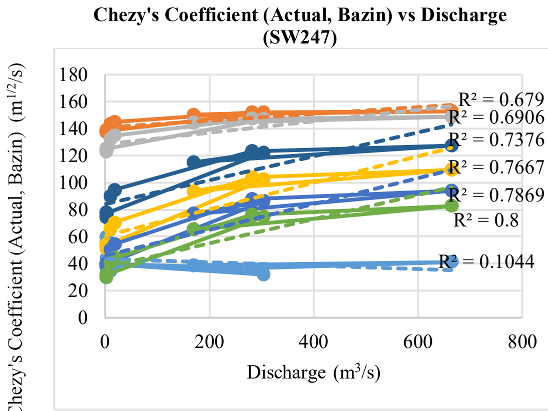

Figure 1 (c): SW247

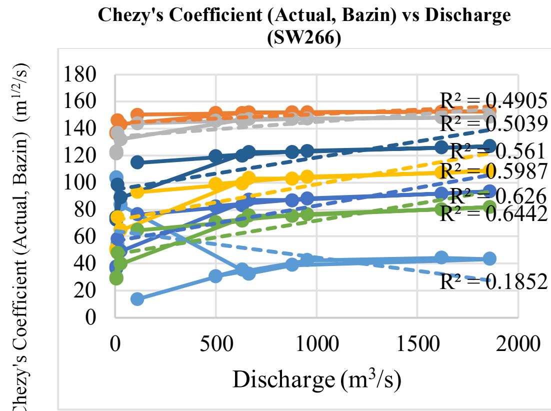

Figure 1 (d): SW266

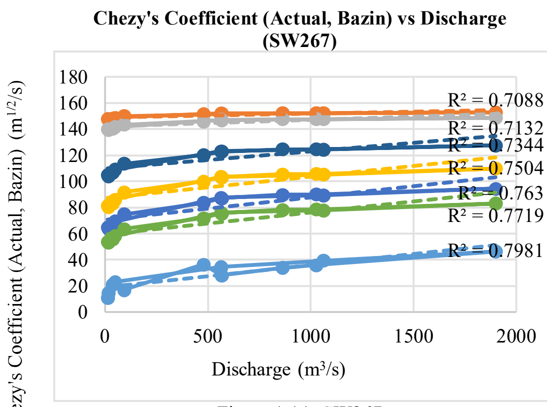

Figure 1 (e): SW267

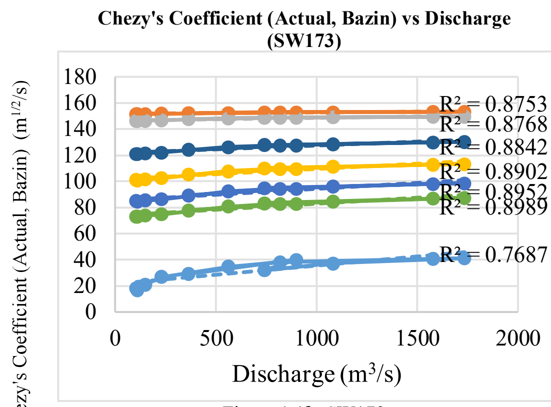

Figure 1 (f): SW173

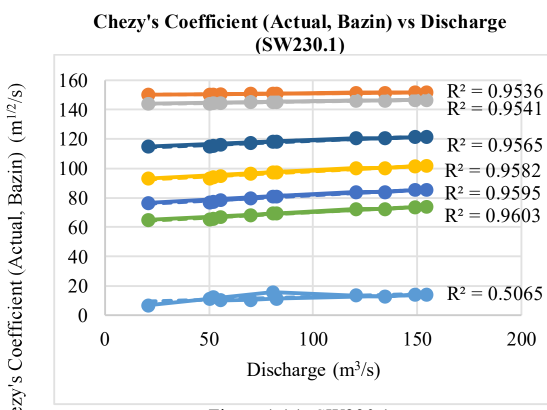

Figure 1 (g): SW230.1

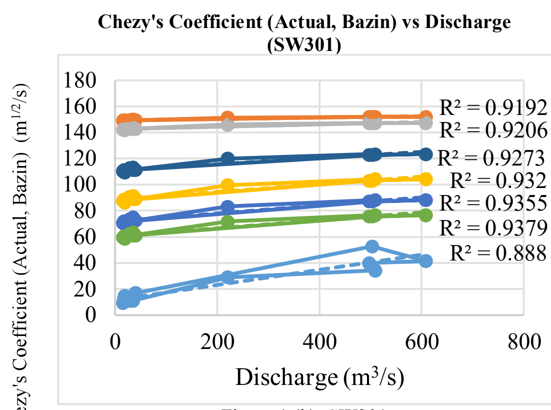

Figure 1 (h): SW301

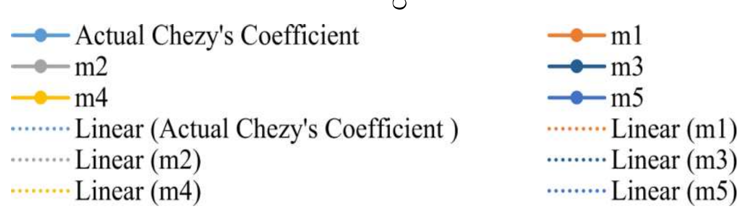

Figure: Figure 1(a-h). Chezy's coefficient (Actual,Bazin) vs Discharge

From figure 1 (a-h), it is observable that Bazin formula is function of only hydraulic radius and roughness coefficient, m but the actual formula from Chezy is function of parameters- discharge and slope. Bazin formula contains no terms of kinematic viscosity [9]. This difference is also affected the variation between finding the exact coefficient. Some of the stations of rivers gave closer R^2 as Figure 1(e, f, h). Roughness coefficient is missing in the equation 3. So, it gave less R^2 for linear analysis for all the rivers.

4. Conclusion and Recommendation

For determining Chezy's C and comparisons, most of the works have been done for flows of section wise channel types like rectangular, triangular etc. but not for open channels. The objective of the research found that Chezy's coefficient which was found from equation 3 shows a wide variation with the Bazin formula for all types of channels descripted in table 1 for all the selected rivers of Bangladesh. Though Earth Channels in rough Condition with the value of m=3.17 gave closer value to the actual one but it also shows a wide difference between the magnitude of Chezy's coefficient for the rivers. So, it can be concluded that the Bazin formula may not be applicable to determine the Chezy's coefficient for Bangladeshi rivers. The outcome of the study cannot be compared with other works as Bazin formula was invented a long time ago and no other recent works related to it in Bangladesh and any other country. So, it is the first comparison for Bangladeshi rivers. For more accuracy, this analysis can be done with more data and rivers of Bangladesh.

Reference:

Standard Test Method for Open-Channel Flow Measurement of Water with Thin-Plate. vol. 92, no. Reapproved, pp. 1–8, 2001.

Muhtar, B. and Albayati, M.M.A., (2016). Bed Resistance Investigation for Manning ' s and Chezy ' s Coefficients. vol. 2, no. 6, pp. 263–274, doi: 10.13140/RG.2.2.18412.87681.

Bazin, H. (1897). A new formula for the calculation of discharge in open channels. vol. 14.

Henderson, F.M. (1966) "Open Channel Flowo Title," *MacMillan Co.*

Brahms, A. *Elements of Dam and Hydraulic Engineering*. Aurich, Germany.

Darey, H. and Bazin, H. (1865). Experimental research on flow of water in open channels. vol. 1.

Chow, V.T. (1959) *Open-channel hydraulics*. Blackburn Press: McGraw-Hill civil engineering series.

Halim, M.A. (2010). Roughness Characteristics of Alluvial Rivers of Bangladesgh. *AUST J. Sci. Technol.*, vol. 2, no. 2, pp. 1–11.

Achour, B. (2015). Chezy's Resistance Coefficient in a Rectangular Channel. *J. Sci. Res. Reports*, vol. 7, no. 5, pp. 338–347, doi: 10.9734/jsrr/2015/18385.