HYDRAULIC DESIGN OF DEUL-UTTARA BRIDGE

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A Thesis Submitted to the Department of Civil Engineering, Daffodil International University in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Civil Engineering

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DECLARATION

This is to certify that the following student worked on the project and thesis titled "**Hydraulic Design of Deul-Uttara Bridge**" under my direct supervision in the laboratories of the department of Civil Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science. On January 2023, the work was presented.

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ABSTRACT

In a bridge design hydraulic consideration is important and integral part of bridge construction. This study deals with the hydraulic design of Deul-Uttara bridge which requires understanding of water resource engineering, hydraulic data, and empirical formula for its analysis and design. A topographical survey was conducted to survey the water line, the bank line, and the location of the bridge. Hydraulic data such as water level, discharge, and velocity were obtained from BWDB, from which design discharge with 100-year return period, scour depth, and linear waterway were estimated. This study recommends 190 meters as the length of the bridge and the depth of the foundation will be 6 meters below the river bed. This is the essential information required to create a bridge.

Keywords: Hydraulic design, Topographical survey, Design discharge, Scour depth, Linear waterway, Depth of foundation, Bridge length.

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LIST OF ABBREVIATIONS

BBA	Bangladesh Bridge Authority
RHD	Roads and Highways Department
LGED	Local Government Engineering Department
LGI	Local Government Initiative
CRI	Climate Risk Index
USAID	United States Agency for International Development
IPCC	Intergovernmental Panel on Climate Change
WMO	World Meteorological Organization
UNEP	United Nations Environment Programme
IPCC	Intergovernmental Panel on Climate Change
PIARC	Permanent International Association for Road Congresses
NASA	National Aeronautics and Space Administration
MERRA	Modern-Era Retrospective analysis for Research and Applications
WL	Water Level
BWDB	Bangladesh Water Development Board
AUTOCAD	Computer-Aided Design and Drafting
HFL	Highest Flood Level
EPZ	Export of Export Processing Zone
HES-RAS	Hydrologic Engineering Center River Analysis System
WSPRO	A Water Surface Profile Computation Model

Chapter 1

Introduction

1.1 General

The bridge is a connecting structure that brings together two sides of the river, or parts of two different regions that are not connected. The bridge is a structure that facilitates a communication path for conveying road traffic or other moving cargo over a river, stream, channel, road, or railroad. The bridge is essential for people, goods, and transportation to get from one place to another. Services that are no longer available can be completed with the help of bridges. The bridge is essential in linking people, commodities, and transportation. With the aid of bridges, it is easy to provide services that are no longer available. The bridge is a significant engineering achievement. It is an art of uniqueness. The history of large bridges is barely a century old, and although it may not be evident at first glance, many of the styles in use now can be traced back to the nineteenth century. In ancient Indian – the period of Ramayana construction of the bridge was well known. Even today, the portion of the sea where the bridge was built is popularly known as "Setu Samudra." Classification of the bridge. As per Ramayana by C. Rajjgopala Chari, so Nala, the son of Viswakarma, was the first bridge engineer who successfully constructed the great causeway which shone across the sea like a milky way in the sky. Indians, Greek, and Romans developed the primitive suspension bridge. It consisted of a single rope with a traveling basket suspended from it. (What is bridge in civil engineering:- Classification of bridge, Components, Parts)

Different Components of Bridge

Typically, long bridges will have the following components:

I. Deck
II. Abutment
III. Pile
IV. Pier
V. Girder

To provide an overview of these components, concise descriptions of each are provided below:

I. **Deck**

A bridge's deck is essential for passing vehicles, commodities, people, etc. from one side to the other.

II. **Abutment**

Abutments are the supports located at the extremities of a bridge.

III. **Pile**

The pile is an integral part of bridges held up by piers. When the top layer of soil is loose, a foundation on piles is often needed. How deep a pile goes depends on how deep the soil is. Usually, a pile is driven into the hard soil layer to a certain depth to find the layer that will keep the building stable.

IV. **Pier**

The compression component that stays above the pile and provides structural stability is the pier. Typically, a pier supports a bridge at intermediate positions.
Piers have two primary purposes:

- Transferring vertical loads from the superstructure to the foundation
- Bridges that can withstand the horizontal forces pressing on them

The pier is the compression component that stays above the pile and provides structural support for the building. Generally speaking, a pier offers a bridge at intermediate sites.

V. **Girder (Box or I-joist)**

On the bridge, girders are utilized similarly to the beam. Either an I-joist or a Box may be used. They were given this name due to their form. I-joist girders are widely used in the construction of bridges. Box girders may be precast or cast in situ, and they are commonly in a prestressing condition.

Types of Bridge

Here are the different kinds of bridges.

1. Truss Bridge
2. Arch Bridges
3. Suspension Bridges
4. Cable-Stayed Bridges
5. Slab Bridges
6. Box Girder Bridges

✓ Truss Bridge

To construct a truss bridge components are comprising of steel with just tension and compression forces. No moment of bending is permitted in this construction. The most stable shape for a truss is a triangle.

✓ Arch Bridges

Most of the time, the arch bridge is under pressure. uses an aerodynamic system that is strong against twisting.

✓ Suspension Bridges

Suspension bridges usually require long spans, which might be supplied as an option. The engineer has the option of constructing a long span using a cable.
The following are the fundamental structural components of a suspension bridge:

♦ Stiffening Girder/ Trusses

Longitudinal structures support and distribute the weight of vehicles.Ensure that the structure's aerodynamic stability is maintained.

♦ Main Cables

A hanger rope supports the weight of principal cables by connecting them to girders. The loads are transferred from the girder to the main cables through these hanger ropes. These primary cables are designed to transfer these loads to the primary towers.

- **Main Towers**

  These intermediate vertical structures support the principal cables and transmit the bridge's total weight to the foundation.

- ✓ **Cable-Stayed Bridges**

  It's a lot like the suspension bridge in a lot of ways. But there are a few differences between cable-stayed bridges and suspension bridges. In this situation, the majority of the vertical loads on the girder are sustained by the bridge. The objective of the stay cables is to provide the girder with central support and to aid in its extension.

- ✓ **Slab Bridges**

  It is the most prevalent bridge type. Use wherever the spread is short.

- ✓ **Box Girder Bridges**

  It is a box-type girder as opposed to a typical I-girder, and it can endure a greater amount of torsion. This form of bridge consists of an upper deck, a vertical web, and a bottom slab. Box girder bridges can be subdivided into three basic categories:

  - Single-cell box
  - Multicell box
  - Box with struts supporting a cantilever deck. (What is a Bridge? Main Parts & Types of Bridges, n.d.)

1.1.1 Benefits of bridges

Bridges are emblematic of a country's infrastructure. Bridges are used for the transportation of both raw materials and finished commodities. You may transport them to factories, warehouses, suppliers, distributors, stores, etc. Bridges can also be used to get from one place to another. The acquisition of products and services is another economic effect of bridges. There is a great association between the presence of good money and the presence of genuine commodities that is facilitated by bridges. One location provides commodities, whereas another pays well for those items. Here, there is a transfer of authority. Thus, a connection is formed between workers and investors. The raw materials are transported to industrial zones most efficiently. When a bridge is constructed, there may be initial inconveniences, but afterward, it can be utilized by large vehicles, resulting in fewer accidents, traffic jams, and pollution. Even in the event of the passage of an ambulance, bridges serve a vital purpose. The routes of bridges vary. This facilitates timely arrival. When large trucks can move more quickly, commodities will be delivered more quickly. Therefore, fewer decaying materials will be given. Frozen items can be delivered faster while retaining their freshness.

As discussed previously, bridges play a crucial function in traffic regulation; they are highly successful in rerouting traffic to different parts of the city and aid in reducing peak-hour road congestion. Otherwise, the subsequent traffic congestion and traffic bottlenecks would squander your valuable time.

1.1.2 Disadvantages

There are also negative effects on bridges. It is essential to construct bridges, but it is also crucial not to drastically disrupt the surrounding natural ecosystems, as this can hurt the local environment. Unfortunately, most local governments pay little attention to local ecosystems, which has a direct impact on their environment. While the primary function of structural systems is to facilitate transit, the route is littered with numerous examples. As a result, regions surrounding bridges, overhangs, and passes frequently feature little mounds. Consequently, areas in and around these bridges are frequently impacted, affecting the local flora and fauna. In addition, increased traffic over the bridges frequently results in chemical and air pollution, making life more difficult for nearby residents. Unavoidably, to build and install a bridge, several trees must be chopped down, which often results in a loss of green area. Consequently, several governments have mandated that construction contractors preserve a sizeable green area either beneath the bridge or nearby. Insofar as natural habitats are concerned, governments have limited power to compel businesses to create nearby green space. Flora and animals often rely on the local natural environment for their existence, and reproducing the same is either impossible or highly challenging. This has led to the extinction of several plant and animal species. (Construction Bridge, n.d.)

1.2 Background

The river Turag flows into the Buriganga from the north. The Buriganga is a major river in Bangladesh. The Turag originates from the Bangshi River, which flows from the Jamuna. It flows through Gazipur before merging with the Buriganga in Mirpur, Dhaka District. The Bangladesh government planned to construct a bridge over the river Turag at Deul.

There were previously three bridges located at Birulia, Amin Bazar, and Ashulia over the same river. This bridge will be constructed on the Mirpur Uttara Road, which will be connecting Deul and Uttara.

Figure 1.2.1 Deul-Uttara Proposed Bridge Site

The Government of Bangladesh planned this bridge. Different agencies are responsible for bridge construction and maintenance. The Bangladesh Bridge Authority (BBA) is the autonomous government agency responsible for the building and maintenance of bridge. According to the Bangladesh Bridge Authority Act of 2016, the implementation and maintenance of bridges of 1500 meters or more, toll roads, flyovers, expressways, tunnels, causeways, ring roads, etc. are the duty of the Bangladesh Bridge Authority. (Bangladesh Bridge Authority, n.d.) The Roads and Highways Department (RHD) is in charge of the construction and maintenance of Bangladesh's primary road and bridge network. The Local Government Engineering Department (LGED) is construct bridges under 1500 m and also creating, maintaining, and managing local infrastructure for transport, commerce, and small-scale water resources by guaranteeing LGI compliance.

Constructing this bridge will give these following benefits-

I. Due to this bridge, the Birulia Bridge can accommodate less traffic. Due to traffic congestion on Birulia Road and adjacent routes, students and other individuals suffer and spend a great deal of time. This issue may be resolved with this bridge.
II. It will reduce the pressure on the existing bridge.
III. Additionally, more than 150 enterprises are located here since this bridge will facilitate export and import facilities, and transportation costs would dwell. Bangladesh is a primarily an agricultural nation. The farmer cultivates vegetables and crops and delivers them to the metropolis of Dhaka. Due to traffic congestion, they sometimes encountered difficulty and damage. This difficulty may also be resolved by constructing this bridge.
IV. Currently, the residents of this region lack access to basic amenities. This area is presently undeveloped and underdeveloped. In addition to inadequate transit communication, they ship their vegetables and harvests to Dhaka.

The Bangladeshi government has already planned a bridge to link these roads. Proper hydraulic design is as vital as structural design. Mainly it helps to transport and structure parts. No one can build a new bridge with piers and abutments in a river until they can show through calculations or modeling that the backwater won't cause or make a lot worse flooding of land and property upstream. This is becoming increasingly important as people want to build on river flood plains, which are already prone to flooding because they are near rivers. At places where a bridge already exists, and there is much flooding, an analysis may be needed to figure out how much of the flooding is caused by the bridge and how much is caused by other things, like there being too much floodwater for the river channel to handle. If the analysis shows that the bridge is the problem, this may be enough reason to build a new bridge. Knowing that a bridge blocks a lot of water flow and causes much flooding and if you know how to bridge hydraulics work, you might be able to design improvements to help fix the problem. In addition to the shape and size of the river channel, the body, spacing, and orientation of the bridge piers and abutments will affect how water flows through the bridge and how likely it is that the river bed will be eroded. Even well-designed bridges can fail, and bridges that aren't made to handle water well are even more likely to fail and fall. How can a good design be made without understanding how bridges work?

1.3 Objectives

Based on the given background, the primary objectives of the study are:

- ❖ Topographic survey will be conducted around bridge location
- ❖ Hydraulic data will be collected from relevant organization
- ❖ Hydraulic design will be done for 100-year life time.

Scope of Study

The scope of the study includes field survey, hydraulic data collection and hydraulic design. Hydraulic design is done here.

Chapter 2

Literature Review

In this chapter mainly focused on different hydraulic parameters using for different method.

2.1 Determination of Design Discharge

2.1.1 Methods

The maximum discharge through which a bridge crossing a natural stream must pass may be determined using one of the following procedures:

- By using one of the empirical equations appropriate to the location
- By using a rational technique using the rainfall and other features of the area
- From the stream's hydraulic parameters, such as its cross-section area and slope,
- From any accessible records of the flood discharges recorded a previous time.

It is best to use all or at least two of the above methods to figure out the flood discharge. These procedures are described in detail below. (VICTOR, 1973)

2.1.2 Empirical Formula

Formal empirical formulas for flood discharge from a catchment are presented:

$$Q = CA^n$$

Where,

Q = maximum flood discharge in m^3/s
A = catchment area in km^2
C = constant based on the kind and location of the catchment
n = constant
Ryve's formula, expressed by the equation, is a common empirical formula of the sort described above

$$Q = CA^{2/3}$$

(Ryves, 1884)

The value of C varies from 6.5 near the coast to 21 in very steep hilly regions. These empirical formulas are oversimplified and heavily reliant on the proper value of C. A credible value for C in any given location can only be established by a meticulous statistical study of a huge volume of observed flood and catchment data. Even such a value is invalid for just other areas. Consequently, the dependability of empirical formulas of this sort is rather restricted. (VICTOR, 1973)

2.1.3 Rational Formula

The size, shape, slope, permeability, and initial wetness of the catchment, as well as the intensity, distribution, and duration of the precipitation, must all be considered in a flood discharge estimate. The hydrological treatises include several complex formulae. The standard formula is:

$$Q = AI_0\lambda$$

Where,

Q = maximum flood discharge in m^3/s
A = catchment area in km^2
I_0 = Peak rainfall intensity in millimeters per hour
λ = a function dependent on the features of the catchment for calculating peak runoff.
$= 0.045Pf\left(\frac{2}{t_c+1}\right)$
t_c = concentration time in hours
$= \left(0.88\frac{L^3}{H}\right)^{0.385}$
L = Distance in kilometers from the crucial point to the bridge location
H = elevation difference between the critical point and the bridge location, in meters
P = percentage coefficient of runoff for the features of the catchment
f = a factor to adjust for the variance in rainfall intensity I throughout the catchment area.

Table 2.1.3.1 Value of P in Rational Formula

Surface	P
Steep bare rock, and also city pavements	0.90
Rock, steep but with thick vegetation	0.80
Plateaus, lightly covered	0.70
Clayey soils, stiff and bare	0.60
Clayey soils, lightly covered	0.50
Loam, lightly cultivated	0.40
Loam, lightly cultivated	0.30
Sandy soil, light growth	0.20
Sandy soil, heavy brush	0.10

Table 2.1.3.2 Value of Factor f in Rational Formula

Area km^2	f
0	1.000
10	0.950
20	0.900
30	0.875
40	0.845
50	0.820
60	0.800
70	0.775
80	0.760
90	0.745
100	0.730
150	0.675
200	0.645
300	0.625
400	0.620
2000	0.600

Using this procedure, the Survey of India's topographical maps may be used to determine the values of A, L, and H. The Department of Meteorology must provide I_0. Assessing the value of P requires much judgment and expertise. Any inaccuracy in the latter will reduce the accuracy of the outcome of the hard computations required by this approach. (VICTOR, 1973)

2.1.4 Area Velocity Method

The most precise way for determining flood discharge is likely the area-velocity method based on the hydraulic characteristics of the stream. Using Manning's formula or an equivalent method, the flood velocity of a stream is calculated. The Manning formula is applied here. The most precise way for determining flood discharge is likely the area-velocity method based on the hydraulic characteristics of the stream. Using Manning's formula or an equivalent method, the flood velocity of a stream is calculated. The Manning formula is applied here. The Q value is derived from

$$Q = AV$$

Where,

Q = maximum flood discharge in m^3/s

A = catchment area in km^2

V = velocity of flow m/s

$$= \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

n = coefficient of roughness

S = slope of a stream

R = hydraulic mean radius in meters

$$= \frac{\text{wetted area in } m^2}{\text{wetted perimeter in meters}}$$

The scaled cross-section of the stream at the site, which shows flood levels, is used to figure out the wetted area and wetted perimeter. S, which shows how steep the stream is, is a hard number to look at. The standard way to figure out slope is to compare the bed levels at two cross-sections that are a long way apart. This could give wrong results because it's hard to call a certain level in a cross-section "bed level." The author thought it was important to figure out the slope of the stream based on low water levels or water levels at any given time at the proposed site, as well as at a section upstream and a section downstream of the proposed site. How well this method works depends on how well the flood level is predicted. In this case, the right way to look at the data will require a lot of judgment and experience. On railway cross drainage works, the maximum flood mark is usually shown when a train track is close to where a bridge is. If a new road is being built in a sparsely populated or undeveloped area, the investigation engineer must figure out the highest flood level based on the information given by older residents and what he sees on the banks, on tree trunks, etc. (VICTOR, 1973)

Table 2.1.4.1 Roughness Coefficient n in Manning's Formula for Natural Streams

Surface	Perfect	Good	Fair	Bad
Clean straight banks, no rifts or deep pools	0.025	0.028	0.030	0.033
Same as (1), but some weeds and stone	0.030	0.033	0.035	0.040
Winding, some pools, and shoals, clean	0.035	0.040	0.045	0.050
Same as (3), more ineffective slope and sections	0.040	0.045	0.050	0.055
Same as (3), some weeds and stone	0.033	0.035	0.040	0.045
Same as (4), stony sections	0.045	0.050	0.055	0.060
Sluggish river reaches, rather weedy	0.050	0.060	0.070	0.080
Highly weedy reaches	0.075	0.100	0.125	0.150

2.2 Method of finding extreme Flood discharge

2.2.1 Chow's Formula

Chow has demonstrated that the general equation of hydrologic frequency analysis may be used to represent the majority of frequency distribution functions pertinent to hydrologic investigations.

$$x_T = \bar{x} + K\sigma_{n-1}$$

Where,

x_T = value of the variate X of a random hydrologic series with a return period T

$\bar{x}$ = mean of the variate

σ_{n-1} = standard deviation of the variate,

$= \sqrt{\frac{\sum(x-\bar{x})^2}{N-1}}$

K = frequency factor which depends upon the return period, T

2.2.2 Gumbel's extreme-value distribution method

Gumbel's extreme value distribution is one of the few often used frequency distribution functions for forecasting extreme flood values.

K = frequency factor which depends upon the return period

$= \frac{y_T - \bar{y}_n}{S_n}$

T = return period frequency

y_T = reduced variate, a function of T and is given by

$= -\left[\ln.\ln\frac{T}{T-1}\right]$

Table 2.2.2.1 Reduce Mean $\bar{y}_n$ in Gumbel's Extreme Value Distribution

N	0	1	2	3	4	5	6	7	8	9
10	0.4952	0.4996	0.5035	0.5070	0.5100	0.5128	0.5157	0.5181	0.5202	0.5220
20	0.5236	0.5252	0.5268	0.5283	0.5296	0.5309	0.5320	0.5332	0.5343	0.5353
30	0.5362	0.5371	0.5380	0.5388	0.5396	0.5402	0.5410	0.5418	0.5424	0.5430
40	0.5436	0.5442	0.5448	0.5453	0.5458	0.5463	0.5468	0.5473	0.5477	0.5481
50	0.5485	0.5489	0.5493	0.5497	0.5501	0.5504	0.5508	0.5511	0.5515	0.5518
60	0.5521	0.5524	0.5527	0.5530	0.5533	0.5535	0.5538	0.5540	0.5543	0.5545
70	0.5548	0.5550	0.5552	0.5555	0.5557	0.5559	0.5561	0.5563	0.5565	0.5567
80	0.5569	0.5570	0.5572	0.5574	0.5576	0.5578	0.5580	0.5581	0.5583	0.5585
90	0.5586	0.5587	0.5589	0.5591	0.5592	0.5593	0.5595	0.5596	0.5598	0.5599
100	0.5600									

Table 2.2.2.2 Reduce Standard Deviation S_n in Gumbel's Extreme Value Distribution

N	0	1	2	3	4	5	6	7	8	9
10	0.9496	0.9676	0.9833	0.9971	1.0095	1.0206	1.0316	1.0411	1.0493	1.0565
20	1.0628	1.0696	1.0754	1.0811	1.0864	1.0915	1.0961	1.1004	1.1047	1.1086
30	1.1124	1.1159	1.1193	1.1226	1.1255	1.1285	1.1313	1.1339	1.1363	1.1388
40	1.1413	1.1436	1.1458	1.1480	1.1499	1.1519	1.1538	1.1557	1.1574	1.1590
50	1.1607	1.1623	1.1638	1.1658	1.1667	1.1681	1.1696	1.1708	1.1721	1.1734
60	1.1747	1.1759	1.1770	1.1782	1.1793	1.1803	1.1814	1.1824	1.1834	1.1844
70	1.1854	1.1863	1.1873	1.1881	1.1890	1.1898	1.1906	1.1915	1.1923	1.1930
80	1.1938	1.1945	1.1953	1.1959	1.1967	1.1973	1.1980	1.1987	1.1994	1.2001
90	1.2007	1.2013	1.2020	1.2026	1.2032	1.2038	1.2044	1.2049	1.2055	1.2060
100	1.2065									

(Onni Suhaiza Selaman, 2007)

2.2.3 Design Discharge

The size, shape, slope, permeability, and initial wetness of the catchment, as well as the intensity, distribution, and duration of the precipitation, must all be considered in a flood discharge estimate. The hydrological treatises include several complex formulas. The goal of preparing for the passage of the most extreme flood that might occur at a given place is not desirable from an economic standpoint. It may be enough to construct culverts for a once-every-20-years flood and bridges for a once-every-100-years flood and to guarantee that rarer floods pass without causing undue damage to the structure. (VICTOR, 1973)

2.2.4 Linear Waterway

Where the watercourse to be crossed is an artificial channel for irrigation or navigation or when the banks are sufficiently demarcated for natural streams, the linear waterway should be the whole width of the watercourse.

For large alluvial streams with undefined banks, the required linear waterway should be determined using Lacey's formula given in Equation

$$L = C\sqrt{Q}$$

Where

L = the linear waterway in meters
Q = the designed maximum discharge in m^3/s
C = a constant, usually taken as 4.8 for regime channels, but may vary from 4.5 to 6.3 according to local conditions.

The linear waterway should not be narrowed below the regime condition. If a decrease is implemented, it is important to pay close attention to the affluence and the speed of the water beneath the bridge. Deeper foundations would be needed if the waterway were narrowed, as higher velocities and scour depths would be required. Therefore, the cost of digging deeper foundations will cancel out any savings from a shorter linear waterway.

2.2.5 Afflux

Afflux is when water rises above the flood level because a bridge cuts off the flow of water.

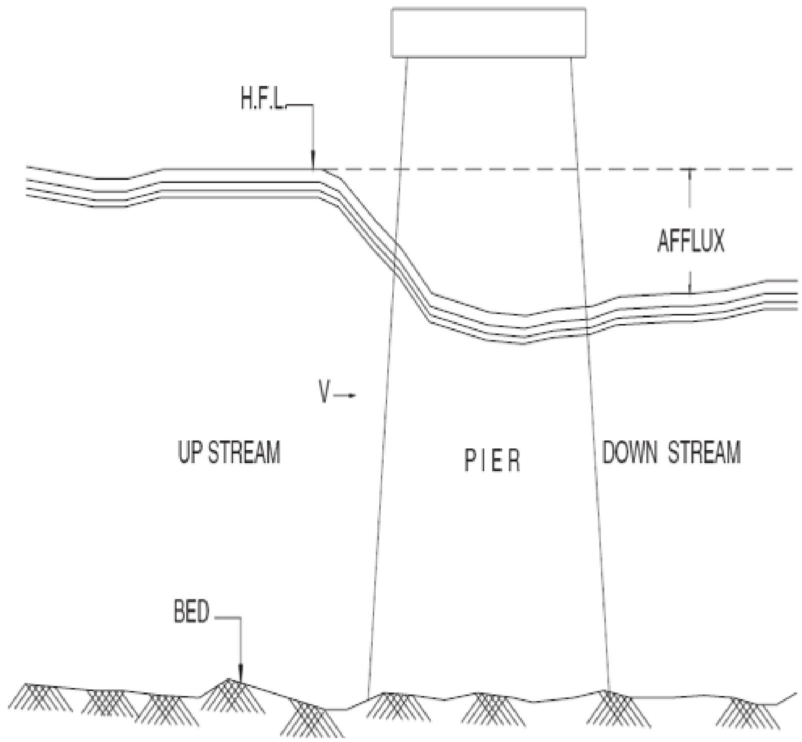


Figure 2.2.3.1 Afflux

(JCG MEDIA GROUP, n.d.)

It can be computed from Equation

$$x = \frac{V^2}{2g}\left[\frac{L^2}{c^2 L_1^2} - 1\right]$$

where

x = afflux
v = velocity of normal flow in the stream
g = acceleration due to gravity
L = width of stream at HFL
L_1= linear waterway under the bridge
c = coefficient of discharge through the bridge, taken as 0.7 for sharp entry and 0.9 for bell mouthed entry.

The amount of afflux should be kept to a minimum and not exceed 300 mm. The speed under the bridge should not go faster than what is safe for the bed material. (VICTOR, 1973)

Typical values of safe velocities are as below:

Loose clay or fine sand	up to 0.5	m/s
Coarse sand	0.5 to 1.0	m/s
Fine gravel, sandy or stiff clay	1.0 to 1.5	m/s
Coarse gravel, rocky soil	1.5 to 2.5	m/s
Boulders, rock	2.5 to 5.0	m/s

2.2.6 Vertical Clearance above HFL

Between the HFL and the lowest point of the superstructure on high-level bridges, there should be a vertical clearance. This is needed to make up for any mistakes that might be made when estimating the HFL and the design discharge. It also lets debris on the water pass under the bridge without hurting the bridge's structure. Between the HFL and the lowest point of the superstructure on high-level bridges, there should be a vertical clearance. This is needed to make up for any mistakes that might be made when estimating the HFL and the design discharge. It also lets debris on the water pass under the bridge without hurting the bridge's structure. It is therefore logical to provide higher values of clearance for greater discharges as in **Table 2.2.6.1**

Table 2.2.6.1 Minimum Vertical Clearance

Discharge m^3 per second	**Minimum Vertical Clearance mm**
Below 0.3	150
0.3 to 3.0	450
3.1 to 30.0	600
31 to 300	900
301 to 3000	1200
Over 3000	1500

For arched bridges, the area under the intrados' crown shall not be less than one-tenth of the water's maximum depth plus one-third of the rise of the intrados' crown. For structures provided with metallic bearings, the clearance between the base of the bearings and the highest flood level taking afflux into account is not to be less than 500 mm. For irrigation channels, the vertical clearance may be relaxed at the discretion of the engineer-in-charge. (VICTOR, 1973)

2.2.7 Scour Depth

Erosion of the stream bed happens as a flood discharge moves through. The noses and curves of the piers don't help matters. To the extent practicable, a comparison of the maximum scour depth to nearby structures should be made. Additional scour may occur if the projected discharge is higher than the flood discharge for which the scour was recorded, and increased velocity owing to flow obstruction from the bridge's structure must also be accounted for in the observed values.

If the above method can't be used, a formula can be used to figure out the normal depth of scour for natural streams in alluvial beds.

$$d = 0.473 \left(\frac{Q}{f}\right)^{0.33}$$

where

d = normal depth of scour from bed level for regime conditions in a stable channel in meters

Q = designed discharge in m^3 per second

F = Lacey's silt factor for a representative sample of the bed material. as in **Table 2.2.7.1**

Table 2.2.7.1 Lacey's Silt Factor

Type of bed material	Size of particles mm	Silt factor f
Very fine silt	0.05	0.4
Fine silt	0.12	0.6
Medium silt	0.23	0.8
Standard silt	0.32	1.0
Medium sand	0.50	1.2
Coarse sand	0.73	1.5
Heavy sand	1.29	2.0
Coarse gravel	0	9.0

The maximum depth of scour D is to be taken as below

1.in a straight reach	1.27d
2. at a moderate bend	1.50d
3. at a severe bend	1.75d
4. at a right-angled bend	2.00d
5. at noses of piers	2.00d
6. at upstream noses of guide banks	2.75d

The minimum depth of foundations below HFL is kept at 1.33 D for erodible strata. (VICTOR, 1973)

2.2.8 Width of Carriageway

How wide the road needs to be will depend on how often and how much traffic is expected to use the bridge. The width of a carriageway is measured by how many traffic lanes it has. Each traffic lane is the width needed to fit one train of Class A vehicles.

All bridges must have at least two lanes, except for those on very small village roads. For one lane, the road must be at least meters wide. At least 3.0 meters must be left between each additional lane. But for two-lane traffic, it would be better to have a carriageway that is 7.5 meters wide instead of 6.8 meters wide. The roads on bridges must have two, four, or multiples of two lanes. Accidents will be more likely to happen on three-lane bridges, so they shouldn't be built.

In urban areas, it may be necessary to have separate bike paths in addition to the carriageway. Also, footpaths might need to be added. These things should be taken care of in the design. (VICTOR, 1973)

Chapter 3

Data Collection

3.1 Topographic Survey and Approach Alignment

In July of 2022, a first survey of the Deul Bridge Project region was conducted. On both banks of the Turag River, the potential bridge placement locations and approach alignments were investigated. The available region maps and pertinent data were collected and analyzed.

After determining the potential site of the bridge, the comprehensive survey for constructing the approach road and bridge was conducted. On both ends of the planned bridge, several alignments were explored. Mirpur Road has been elevated; however, it still has to be lifted a little further. Alternatively, the road at Amin Model Town traverses a low-lying region that will need substantial filling. This layout necessitates a bend near to the bridge's commencement.

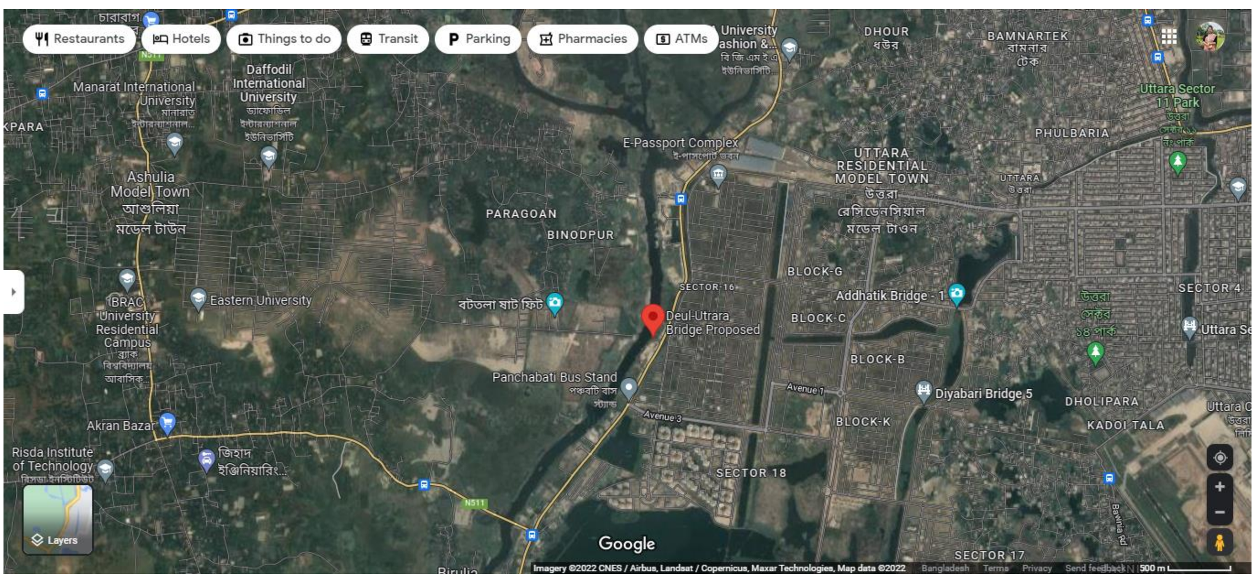


Figure 3.1.1 Bridge Proposed Area

In light of the aforementioned, this alignment was abandoned in favor of one that would provide a smaller challenge in terms of land acquisition, would reduce the expense of road embankment construction, and would permit the supply of a curve sufficiently far from the bridge's terminus, making it more acceptable for the safe passage of vehicle traffic. Following the alignment, it was determined that a full topographic survey would be conducted.

Along the route of the road, a topographical study was conducted. 500m were investigated. The location of all features, including road distance from station center, road width, water line, river area, and high and low land is documented.

With a scale of 1:1 (1 paper unit = 1 drawing unit), a topographic map of the approach and bridge area has been created. Deviation point, woodland, distance, minimum distance, river area, water line, Mirpur Road, homestead, Uttara Road, Birulia Bridge, Amin Model Town Road, and other roads are shown. Field inspections are conducted to ensure that all features are accurately shown on the map and that any modifications are made as required.

3.2 Hydrographic Data

The survey was conducted from July 29, 2022. The purpose of this survey was to locate the water lines and obtain bathymetry required for the Physical Model Study. Measurements taken include river survey, Mirpur-Uttara Road, showing water lines, river area, and bank material samples. A copy of the Hydrographic Survey is enclosed with this. The hydrographic survey covered 500 m in the upstream and 500 m in the downstream direction from the proposed bridge site near the Mirpur-Road as shown in the **Figure 3.2.1**

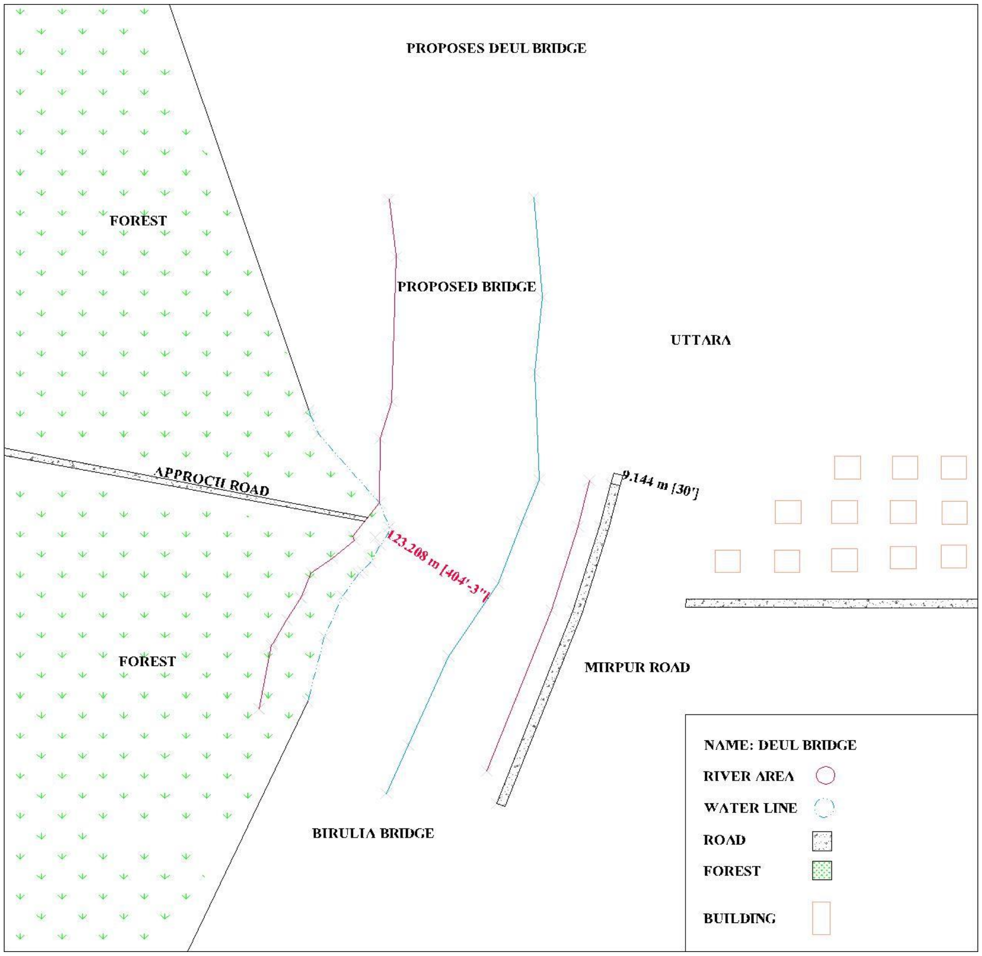


Figure 3.2.1 Index Map

Initially, the basic layout of the location was examined. Then, select the essential area for bridge construction. Following the selection of a region, choose a location in close proximity to it for the station's installation. This location was much higher than its surroundings. Consequently, reflectors were not visible in every direction from the station. Then we began accumulating points at each 50-meter interval along the north side of the station. Thus, the northern region lost about 10 points. On the southern side of the station, after measuring 50-meter along the riverbank, 10 to 11 points were obtained. After gathering all of the data on the eastern side, we crossed the river by boat and began collecting data on the western bank. It was quite difficult to collect data on the west side of the river. Due to the extensive number of beds established along the river's banks. The mattresses prevented us from seeing the station's reflection, despite its elevated location. The length of the reflector was increased by connecting it to a long bamboo. After then, the station's tail reflector became apparent. According to the monsoon season, the water from the river's bank seeped into the cultivated land in certain locations, and the river's circle seemed to be rather big. Therefore, in order to determine the precise extent of the river, we gathered riverbank data by boat. After collecting data from both sides of the river, we've gathered information on the Baribad-to-Mirpur-and-Gabtoli-connecting Mirpur Road abutting the river's eastern bank. According to this survey, the length of the bridge is 123.208 meters.

Few images from our topographical surveying

3.3 Hydrology

3.3.1 Climate

The project region has a subtropical climate with three distinct seasons: the dry season from March to the end of May, the monsoon season from June to the middle of October, and the cool season from October to February. During the dry season, temperatures are high, humidity is low, and there are few stormy rainy days. During the monsoon, the sky is frequently overcast for several days. In the dry season, when clouds are present and it rains frequently, the temperature is slightly lower, but the humidity rises. The cool season is pleasant, and it does not rain frequently.

Based on when it rains, a year can be split into three seasons: spring, which lasts from March to May, monsoon, which lasts from June to October, and dry, which lasts from November to February.

Rising global temperatures are disrupting weather patterns and upsetting the natural balance, posing a number of hazards to people and all other forms of life on Earth. Temperature increases may exacerbate heat-related illnesses and make it more difficult to work and move. When temperatures are higher, it is simpler to ignite and spread wildfires. Currently, the effects of climate change include:

- Extreme droughts
- Cause water shortages
- Severe fires
- Rising sea levels
- Flooding
- Melting of polar ice
- Destructive storms
- Biodiversity decline. (Climate Change, n.d.)

To evaluate the susceptibility of a bridge to climate change, additional elements are recognized as having to be taken into account. These major implications can include:

I. Temperature fluctuations would result in the expansion and contraction of the bridge's superstructure, resulting in thermally induced strains that might lead to its deterioration.
II. The rising sea level may cause erosion and a decrease in bridge clearance.
III. Increased wind speed as a result of a more intense storm may pose a hazard to towering bridges in particular.

IV. Permafrost melting owing to warmer temperatures, greater precipitation, and rising sea levels causes more soil to be transported away from surrounding pillars.

V. More intense precipitation and the lack of plants that protect slopes as a result of climate change may render slopes unstable and raise the possibility of a landslide. Landslides may cause bridge instability and failure.

VI. Similar to slope collapse and landslides, melting permafrost may cause rock slopes to become unstable and increase the amount of material that flows. And rising temperatures might increase the likelihood of snow avalanches. All of these may destroy bridges

VII. Due to rising and falling water levels caused by climate change, the soil on which the bridge is constructed may become unstable and sink. For instance, when water levels are lower and the earth is no longer entirely saturated with water, the bridge might compress the soil.

VIII. When the water level rises as a result of global warming, the bridge exerts less pressure on the land below (just like we are less heavy when standing in a pool with water reaching our neck compared to a pool with water reaching our waist). With less pressure, an earthquake may shake the ground more readily.

IX. Additional loads on piles that may cause them to become overstressed may potentially cause damage to bridges. This may occur, for instance, when the reverse of the pool example occurs: as the water level lowers due to climate change, the pile gets heavier and must support greater weight.

X. Additional loads on piles that may cause them to become overstressed may potentially cause damage to bridges. This may occur, for instance, when the reverse of the pool example occurs: as the water level lowers due to climate change, the pile gets heavier and must support greater weight.

XI. As climate change causes winds to blow more quickly in certain locations, the frequency and height of high waves also increase. Extreme waves may also cause damage to bridges, particularly the piers and abutments. The abutment is the bridge's connection to the ground.

XII. If climate change causes greater precipitation, the drainage system's importance increases, but it may also be overloaded.

XIII. Some bridges are paired with control sluice gates, increasing load. These sluices may be used, for instance, to manage the quantity of irrigation water or to prevent flooding. With high water levels, the sluice gates and therefore the abutments, piles, or piers are subjected to increased pressure.

Due to climate change, bridges have seen a number of calamities. Here is an example:

In recent years, particular investigations on the susceptibility of bridges to climate change have highlighted the necessity to design and modify bridges with this variable in mind. (Olmos, June 15, 2020)

We saw deadly floods in Europe, record-breaking floods in China, as well as severe winter storms and temperatures in the United States in 2021. However, countries with higher living standards have more resources to deal with the unavoidable consequences of climate change. A developing country does not. Bangladesh is one of the ten countries most affected by climate disaster, according to figures and rankings from the German Watch Climate Risk Index and the Notre Dame Global Adaptation Initiative. Coastal communities and island nations confront some of the worst climate crisis-related risks as a result of rising sea levels. Bangladesh, which ranks eighth on the German watch company's Climate Risk Index (CRI) for cumulative risk from 2000 to 2019, has been battling the effects of climate change for decades, much like the Philippines. The country saw 185 severe weather occurrences over this time, resulting in losses of $3.72 billion (€3.5 billion). These challenges have an almost universal impact on the country. A 2018 USAID study found that 143 million Bangladeshis, or 89% of the population, reside in areas that are "very" or "very highly" vulnerable to climate change. By 2050, when 75% of Bangladesh would be under water, it is predicted that Bangladesh will lose 11% of its land to rising sea levels. One in seven people in Bangladesh may be forced to flee as a consequence of this.. (10 of the countries most affected by climate change, 4 July 2022)

The World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), which founded the Intergovernmental Panel on Climate Change (IPCC) in 1988, found that the intensity of precipitation, specifically the proportion of total precipitation that falls during heavy storms, has grown and would probably continue to increase in the future. According to the existing research, there is a tendency toward a rise in strong daily rainfall events in many locations, including those where the average rainfall is predicted to decrease. In the latter cases, the decrease in precipitation is often due to fewer wet days rather than a decrease in the intensity of rainfall when it does occur. The IPCC also noted that bridges are among the infrastructure most at risk from climate change and that more heavy precipitation may increase the risk of flooding. The World Road Association's conclusions and its own are in agreement (PIARC). Together with road managers from thirteen states and five continents, they came to the conclusion that rising river flows due to increased precipitation intensity and frequency might result in severe scouring of bridge pier foundations and abutments.

Flowchart that aids in providing a clear picture of how climate change affects bridges.

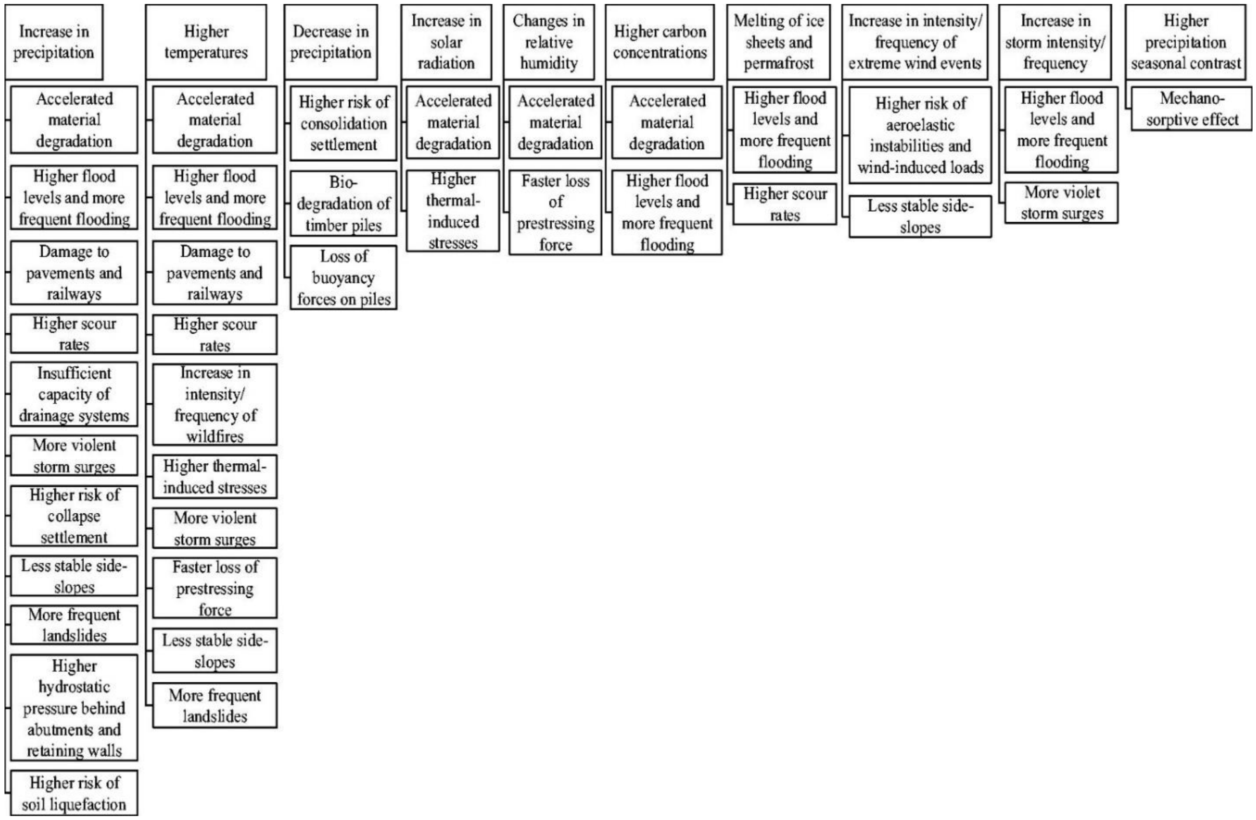


Figure 3.3.1.1 Climate Change risks on bridges, examples

(Amro Nasr, 2019)

To construct a bridge, it is necessary to know the local weather and environment. For the bridge to be durable and long-lasting, it must be constructed with climatic knowledge in mind. The river's water level increases as a result of significant rainfall, threatening the bridge. Bridge construction requires extensive knowledge of river erosion, floods, droughts, and wildfires. Before constructing the bridge, comprehensive climatic information must be obtained to prevent these effects. Here we have the average precipitation, humidity, wind speed, and temperature for our project which we get from NASA's Project MERRA-2. We will elaborate upon these statistics.

Rainfall

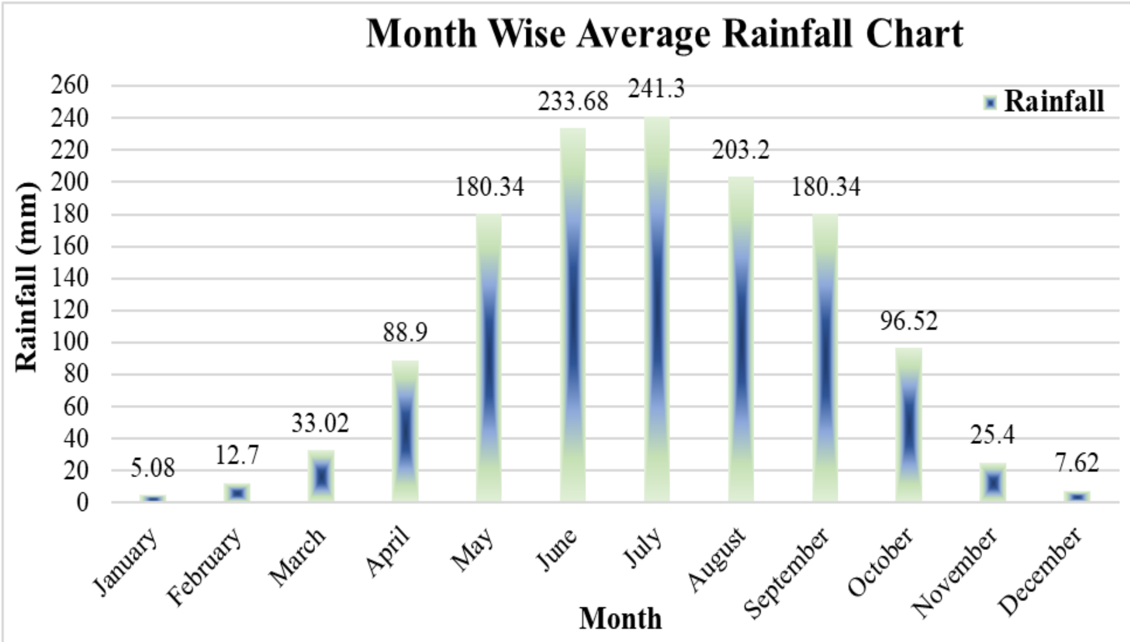


Figure 3.3.1.2 Month Wise Average Rainfall

(Weather spark, n.d.)

All forms of water that reach the surface of the earth from the atmosphere are referred to as precipitation. The most frequent types of precipitation include rain, snow, hail, frost, and dew. Precipitation must meet four requirements in order to develop, including the presence of water vapor in the atmosphere. For, condensation of water vapor to occur, there must be sufficient nuclei present, favorable weather conditions, and the condensation product must reach the ground. Winter westerly depressions, early summer nor 'wester thunderstorms, and summer monsoon rains are the three primary precipitation sources.

For the Deul-Uttara bridge, the average monthly precipitation in the Shahjalal Airport area of Uttara close to the Savar-Ashulia region has been used. July has the maximum precipitation at 241.3 mm, while January has the lowest at 5.08 mm.

If rainfall is abundant, the quantity of precipitation will grow. Thus, the water level will rise. This is detrimental to the bridge. Again, the volume of water will decrease if precipitation is reduced. Likewise, this will result in harm. If it does not rain for an extended period, the river will be completely dry. Perhaps after twenty or thirty years, it will become apparent that there is no water under the bridge. To safely cross the river on the bridge, it is essential to carefully consider the river's past route. How the river behaves over the long term, as well as how it may behave throughout the bridge's lifespan, must be thoroughly researched. Rainfall in our region is still typical.

Humidity

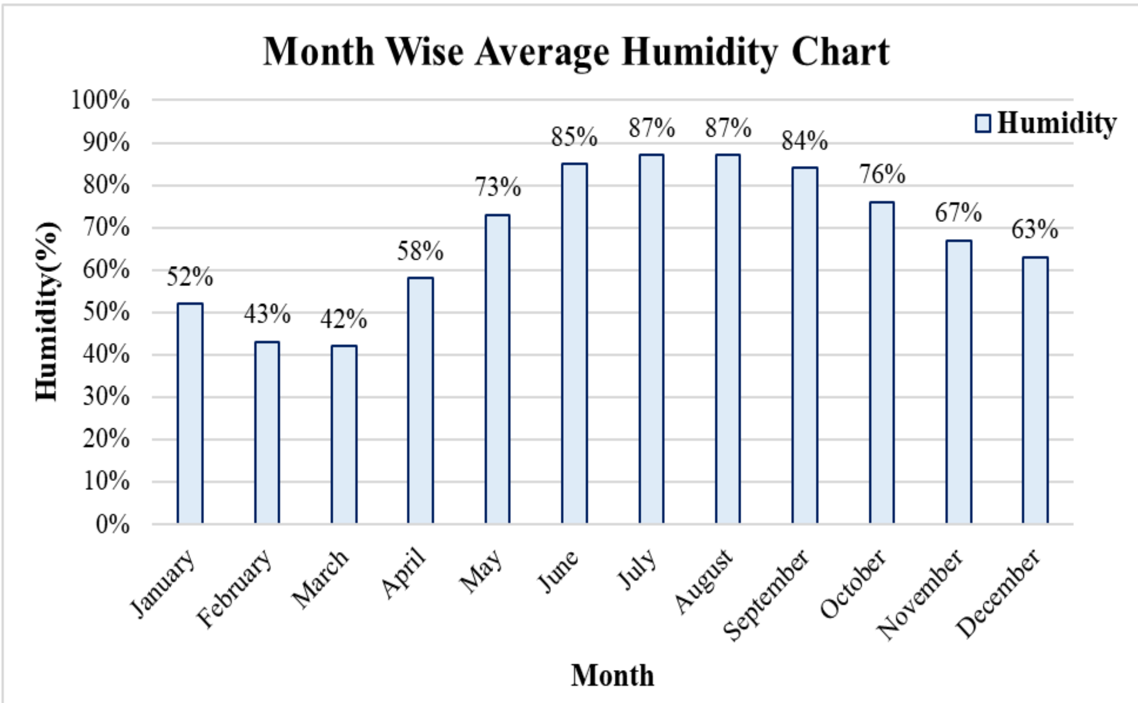


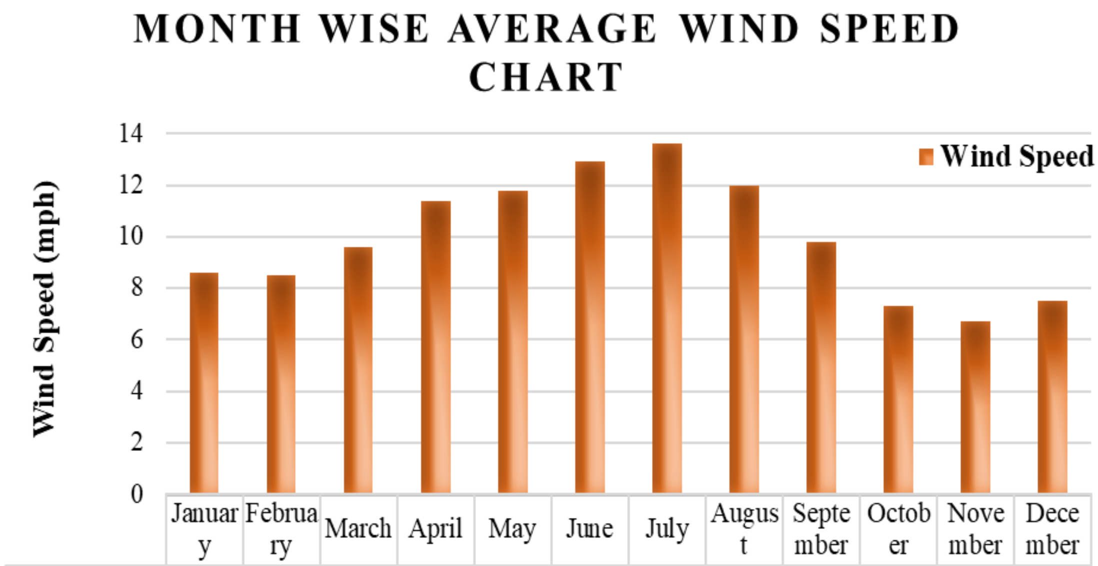
Figure 3.3.1.3 Month Wise Average Humidity

(Wanderlog, n.d.)

The wettest season of the year is the monsoon season when humidity levels are at their height (June to October). The Southwest monsoon, which originates over the Indian Ocean and transports warm, humid, and unstable air, is responsible for precipitation. In the majority of the western United States, March and April are the least humid months. March is the month in which Dinajpur has the lowest average relative humidity (57%). January through March are the driest months in the eastern regions. In March in Brahmanbaria, the lowest monthly average of 58.5% was recorded. From June through September, the relative humidity is more than 80 percent everywhere. (BANGLAPEDIA, n.d.)

The graph indicates that March humidity levels are 42%, and July and August humidity levels are 87%.

Wind Speed



	January	February	March	April	May	June	July	August	September	October	November	December
Wind Speed	8.6	8.5	9.6	11.4	11.8	12.9	13.6	12	9.8	7.3	6.7	7.5

Figure 3.3.1.4 Month Wise Average Wind Speed

(Wanderlog, n.d.)

The rate of evaporation increases with increasing wind speed up to a certain threshold, after which further increases in wind speed have no impact. Wind velocity and direction are the only two variables that may be used to determine its characteristics. Wind velocity is essential since it may affect water loss and precipitation occurrences. From November to February, the majority of the wind comes from the north. From March to May, southerly and south-southwesterly winds prevail. From June through September, the wind blows from the south, southeast, and east.

According to the graph, July's average speed is 13.6 mph, while November's average speed is 6.7 mph.

The bridge's structure may be affected by an increase in wind speed. The bridge can collapse if the wind is extremely severe or if any construction errors were made. It is questionable if the bridge will withstand an earthquake. Therefore, the bridge's construction should be designed with wind velocity in mind.

Temperature

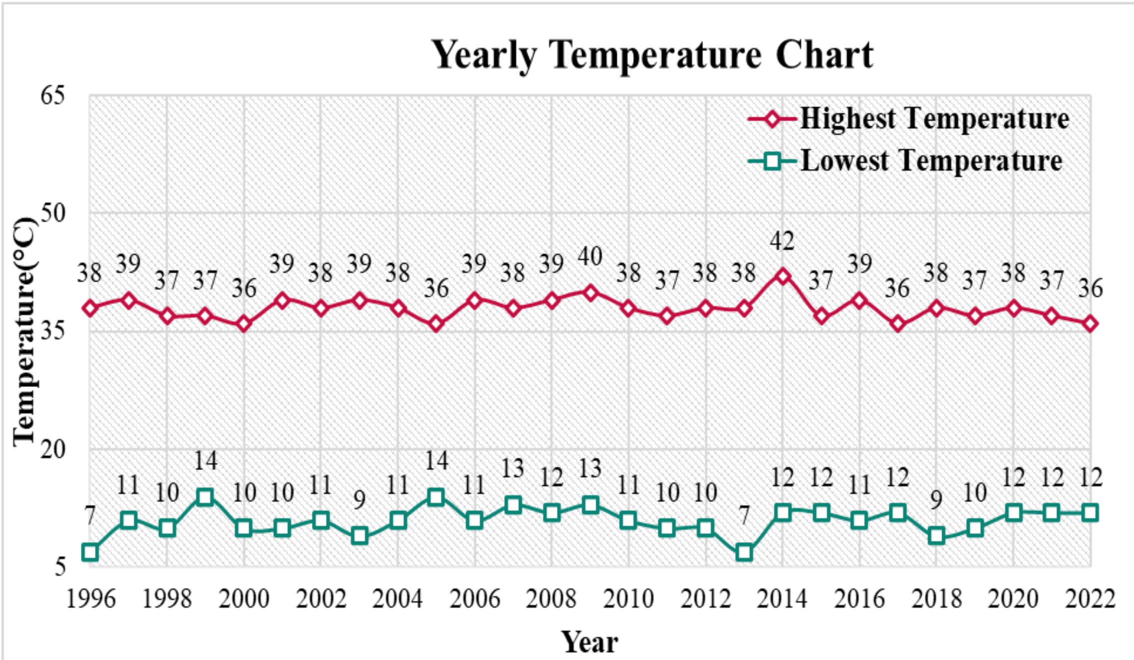


Figure 3.3.1.5 Yearly Temperature Chart

(Weather Spark, n.d.)

From 1996 until 2022, the graph above displays the highest and lowest temperatures. Temperature raises and lowers on an annual basis. 2014 was the warmest year in the last 27 years. 1996 and 2013 mark the record low. April 2014 was the month with the greatest temperature among the maximums. The minimums are in May 2000, June 2005, April-May 2017, and April-June 2022 among the maximums. The temperature was 36°C. 14° C was recorded in December 1999 and February 2005. December 1996 and June 2013 were the two lowest years. 7°C was the temperature that day.

The water level is correlated with temperature. The water level will decline due to severe temperatures. When the water level drops, the scour rate increases. When the water level decreases as a result of climate change, the pile grows heavier and must support greater weight, resulting in pile collapse. Snow avalanches may be triggered by higher temperatures. Metal, concrete, and asphalt expand when exposed to heat. As a result, it bends or cracks, which may result in accidents. The temperature in Bangladesh and the project area is not too high or too low. Not too low and not too high, which is good for a bridge. And there is no chance that those problems will happen.

Evaporation is the process by which a liquid transform into a gas at a free surface below its boiling point as a result of the passage of heat energy. The pace and type of precipitation, evaporation, and snowmelt are influenced by temperature. The rate of evaporation increases as the water temperature rises. Extreme temperatures, precipitation, and relative humidity make it difficult to construct a bridge. Many bridges are constructed using timber in addition to concrete and steel. Climate change is perceptible to them. Additionally, the use of plastic in bridge building carries with it this danger. Bridge maintenance has long been concerned about flooding. In most cases, sea level rise, excessive temperatures, and excessive precipitation are the primary causes of floods. Floodwaters that rise over the bridge may impede traffic, and if they remain there for an extended period, they can create a variety of bridge problems. Consequently, if the bridge is made of concrete, the concrete may arise, and if it is made of wood, the card may weaken and woodworms may attack it. Increasing temperatures will cause ice to melt, water levels to rise, and water currents to increase. This will change the scour rate. The water level will rise due to significant precipitation. This will enhance the water's current.

Rangpur, located at a distance of 40 km west of Kurigram, is the nearest station with temperature and humidity records. The mean daily temperature varies from a lowest of 18°C in January to a highest of 29°C in August. A maximum of 42°C was recorded in May and a minimum 4°C in January. The largest variation in daily temperature is about 4°C, which generally occurs in March and smallest variation is about 1.5°C in August. Relative humidity usually reaches the highest of 88% in the warm month of August and decreases to 62% at the end of cold season in March. During a day the relative humidity is highest just before sunrise and lowest just before sunset.

3.3.2 Analysis of Discharge and Water Level

The Turag originates from the Bangshi River, a major tributary of the Dhaleshwari River, runs through Gazipur and converges with the Buriganga near Mirpur, Dhaka District. (Turag River, n.d.) The river is considered steady because, throughout the years, it has stayed almost unchanged. The available water level data of the Turag at Mirpur (Station No. 302) were used to calculate the water level for the selected return time. BWDB was able to provide WL data for the years 1981 to 2014. (Processing and Flood Forecasting Circle Bangladesh Water Development Board, n.d.) After data collection, they were validated for consistency and put properly for future statistical analysis. Tabular representations of Turag's annual maximum water level are shown. (BRTC, 1999)

Choice of Return Period

Based on basic design standards for water-control structures, such as highway culverts, bridges, embankments, and dams, it has been proposed that the return time for highway bridges on the principal system range from 50 to 100 years. One hundred years was chosen as the design return time because Turag is a steady river. (BRTC, 1999)

Determination of Design Discharge

The duration of available WL was 34 years; frequency analysis was deemed adequate for establishing 100-year discharge and water level values. The BWDB (Bangladesh water development board) provides us this **Table 3.3.2.1**

Table 3.3.2.1 Annual Maximum Water Level of Turag River at Mirpur

Year	Water Level (m)	Year	Water Level (m)
1981	5.75	1998	7.97
1982	5.37	1999	6.30
1983	5.99	2000	6.12
1984	6.59	2001	5.46
1985	5.75	2002	6.10
1986	5.39	2003	2.16
1987	7.26	2004	7.29
1988	8.35	2005	6.00
1989	5.38	2006	5.69
1990	5.45	2007	6.62
1991	6.01	2008	6.10
1992	4.65	2009	5.37
1993	6.03	2010	5.36
1994	5.20	2011	5.70
1995	6.37	2012	5.20
1996	6.17	2013	5.18
1997	5.80	2014	6.00

3.4 River Morphology

Turag is a calm river. As a result, its course has not changed. The river has been flowing in the same direction since creation. The river erosion is very low here. Cross-section of River (Cross section ID-6) for the years 2005, 2010 and 2014 has been superimposed to examine (**Figure 3.4.1**) river bed change. The graph illustrates how bed level varies with distance from the left bank. Between 2005 and 2014, there was a big change in the bed level (**Figure 3.4.1**). Between 2010 and 2014, this river has again demonstrated its stability. Observing this figure leads us to the conclusion that the river of Turag is stable and not eroding. (Sazzad Hossain, 2019)

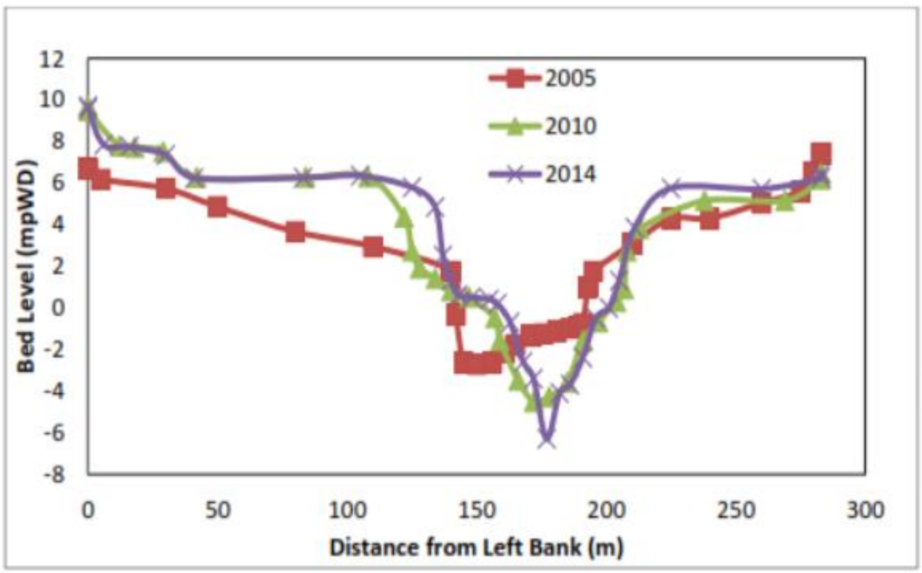


Figure 3.4.1 Supper imposed river cross sections of Turag River at cross section ID 6

3.5 Selection of Bridge Location

In the planning and design of a bridge, the selection of a suitable location is a vital consideration. A poorly situated bridge is subject to deterioration and a variety of other issues. A bridge's location is thus just as important as its features. When choosing a good bridge site, a number of factors, including environmental and geological concerns, hydrology and hydraulics, preliminary engineering, and highway alignment, must be taken into account.

If we choose a terrible location, the resulting costs and circumstances will be intolerable. Bridges can be the most expensive components of a road, and it can be difficult to secure funds to repair or replace them. Therefore, it is essential to choose the ideal place from the start. (Bridge Design Location Considerations, n.d.)

Residents who live on the west side of the Turag have a great interest in finding a solution to this site to build another bridge. Currently there are three bridges over the Turag River connecting Dhaka city with Savar Upazila. And they are (listed from south to north)

1. **Amin Bazar Bridge:** This bridge firstly made link between Dhaka and Savar; then with whole South and East district of Bangladesh. It is also known as gate of capital Dhaka for South and East district of Bangladesh. The length of the bridge is 234 meters. This bridge connecting Dhaka city's Gabtoli point along with Dhaka-Aricha Highway. (Amin Bazar Bridge, n.d.)

2. **Birulia Bridge:** Which provides access to Savar via Mirpur Road. Specially connecting Birulia union with Uttara and Mirpur.

3. **Ashulia Bridge:** Construction of 190-meter long Ashulia Bridge is connecting Ashulia Savar-EPZ Road over River Turag under Dhaka Road Division. Bangladesh Bridge Authority (BBA) has begun the construction of this bridge to reduce traffic congestion in and around the Dhaka-Ashulia area, as well as to improve road connection in the northern portion of Dhaka, connecting significant commercial, industrial, and business centers in Dhaka.

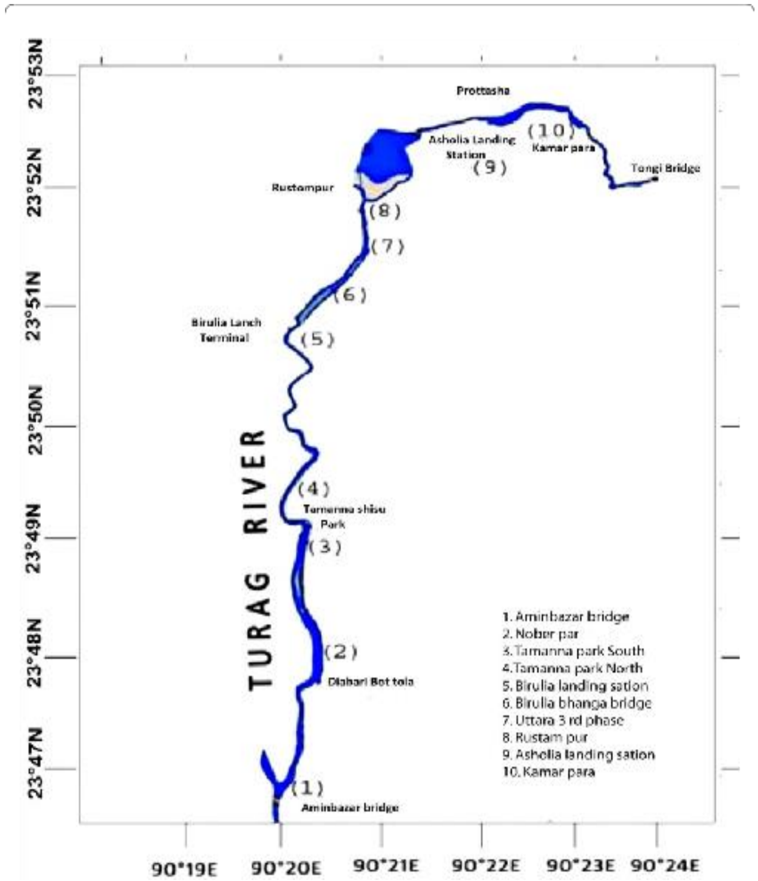


Figure 3.5.1 Map of Turag River

(Naser Ahmed Bhouiyan, April 2016)

Despite the presence of three bridges between "Gabtoli" and "Ashulia," there is a 5.3-mile gap between the "Birulia" Bridges and the "Ashulia Access Road" bridge. Social and economic circumstances necessitate the construction of a bridge in the region between Birulia and Ashulia.

Reducing travel expenses, rerouting heavy traffic, and transferring people and commodities across the river more effectively will have a favorable economic impact on the region. (Wimmer, 2015)

3.5.1 Preliminary Engineering

This section contains the work performed prior to and during site visits. Preparation for site investigation include gathering maps, geologic and hydrologic reports, and photographs. On the other hand, site works includes site investigation, site survey, and geotechnical investigation.

A collection of aerial photos from several years may be used to assess the stability of streams. While unstable streams may show in different places on several photos captured over time, stable streams will always appear in the same general region. To find out who owns the private property where the bridge would be situated, county plats and other landownership maps should be examined. Landowner consent must be obtained prior to performing site surveys and investigations.

3.5.2 Site Working

Work on the site consists of site assessment, site surveys, and geotechnical investigations. Because the abutment placements and sites are governed by the roadway, railroads, and lined ditches or canals, simple site investigations are sufficient for some locations. These locations are typically previously disturbed and have few environmental concerns. Still, the engineer must walk upstream and downstream to look for signs of floating debris, ice damage, and earlier flooding.

The following are some of the questions that should be asked:

- What time of year have the floods occurred?
- How high did the water get?
- Did the water stay in the stream or jump the banks?

Deltas, alluvial fans, aggravating or degrading parts, steep curves, multithreaded channels, sloughs, wetlands, and floodplains are some examples of dynamic sections and trouble spots that should be studied during field reconnaissance of the stream.

3.5.3 Site Surveys

After completing site surveys with a total station or other traditional methods, a topographic map should be created. Both the total station and traditional surveying methods have their advantages and disadvantages. To learn more about how to perform a survey using either technique, see a surveying reference book.

For optimal results, a survey sample size of at

- Proposed centerline and edges of the roadway
- Significant slope variations in the channel, stream centerline, and water's edge
- Tops and bottoms of banks
- Floodplains and islands
- Locations of drift, ice damage, and heights of areas impacted by drifting debris and ice
- Utilities
- Trails
- Bedrock outcroppings; and
- Plenty of elevation data for a detailed map.

3.5.4 Hydrology and Hydraulics

It is important to do a good hydrologic and hydraulic analysis. Because the stream flow or high flood level wasn't figured out or wasn't figured out right, a lot of buildings have been washed away or damaged by floating debris.

- **Hydrology**

A hydrologist who is knowledgeable with the local conditions and stream flows should do the hydrology calculations. In order to reach a reasonable conclusion, the findings from different approaches should be compared because discharge calculations are not an exact science and the results might vary greatly depending on the method.

- **Hydraulics**

People who live in the area or have lived there for a long time should be asked about flooding in the past. Peak flows happen at different times in different places. Southeast Alaska floods, for example, when it rains more than 3 inches per day in the fall. In the Midwest and West, flooding occurs during spring runoff and sometimes after rain in the summer. The Mid-Atlantic may flood when hurricanes generate storms, while the Northeast can flood when it rains on snow. It should be known when and why the peak flows are in the area of the bridge, and these things should be taken into account in the design.

In conducting a hydraulic analysis, the following steps should be performed:

1. Create a topographic map of the area and stream cross-sections based on data gathered during the site survey.
2. Put the results of your hydrologic study into your computer model.
3. Back calculate a Manning's n for the stream, if discharge measurements were taken.
4. Use either HEC-RAS or WSPRO to perform hydraulic analysis.
5. Compare results to field observations made during a site examination.

Important for hydraulic analysis is the validation of results. According to the proverb, "garbage in, garbage out." Scour should be taken into account while confirming velocity and streambed strata. Every project that crosses a stream should include a scour analysis.

3.5.5 Geomorphological Concern

The location of bridges depends heavily on the geomorphology of the watershed and channel. Designers may better understand the processes and challenges that develop when bridges cross a variety of watershed areas by using fundamental geomorphological concepts. These processes vary by location within the watershed and along the crossing place's reach. The channels are quite active. Depending on the position of the channel within the watershed, the type of disturbance, and the channel types along the stream, they respond to changes in the watershed by propagating the changes upstream and downstream, respectively.

3.5.6 Alignment

The shortest and cheapest constructions are horizontal alignments built perpendicular to the stream. Due to limited stopping sight distances and turning radius, perpendicular crossings may necessitate sharp turns, which might provide safety concerns on the approaches. In order for large trucks to turn without damaging the bridge railings, the bridge may need to be extended if it is not located on a very straight stretch of road. With the necessary horizontal bends or straight approaches for the road's design speed, a suitable horizontal alignment should provide enough sight distance. The ideal bridge approach would enable incoming traffic to be seen by approaching cars.

Alignments that are vertical are also important. Water will drain off slightly sloping bridges, however on sagging bridges, water will collect and debris will build up. Maintenance and safety concerns will occur from debris and gravel on the bridge surface. If the bridge is unable to drain water, the water might freeze and provide a safety risk, or it could hasten corrosion or the destruction of the bridge.

Flare ditches on the approaches to the highway will aid in reducing pollution by filtering runoff via plants before it joins the stream. By building a drainage system, it is feasible to increase the bridge's toughness and safety by topping the road to drain water before it reaches the bridge. Less effective alignments are acceptable when circumstances are governed by large trees, banks, animal habitat, or strong stream sinuosity. It is not recommended to straighten stream channels or change channel alignments; instead, thorough hydraulic and geomorphological assessments are required.(James Scott Groenier, 2007)

Chapter 4

Data analysis

4.1 Design Discharge and Water Level

BWDB data are utilized to calculate scour depth, linear waterway, and design discharge. Various formulas, such as Lacey's theory, Chow's formula and Gumbel's method, are applied. This chapter will obtain all of the numerical information required for hydraulic design.

Before beginning hydraulic design, the design discharge must be determined. Determine the 100-year design discharge using the Gumbel's method. From BWDB, only the water level has been obtained for the past 34 years; the discharge has not been managed to obtain. Using Gumbel's method, determine the water level over the next 100 years. From the **Table 3.3.2.1** construct this graph.

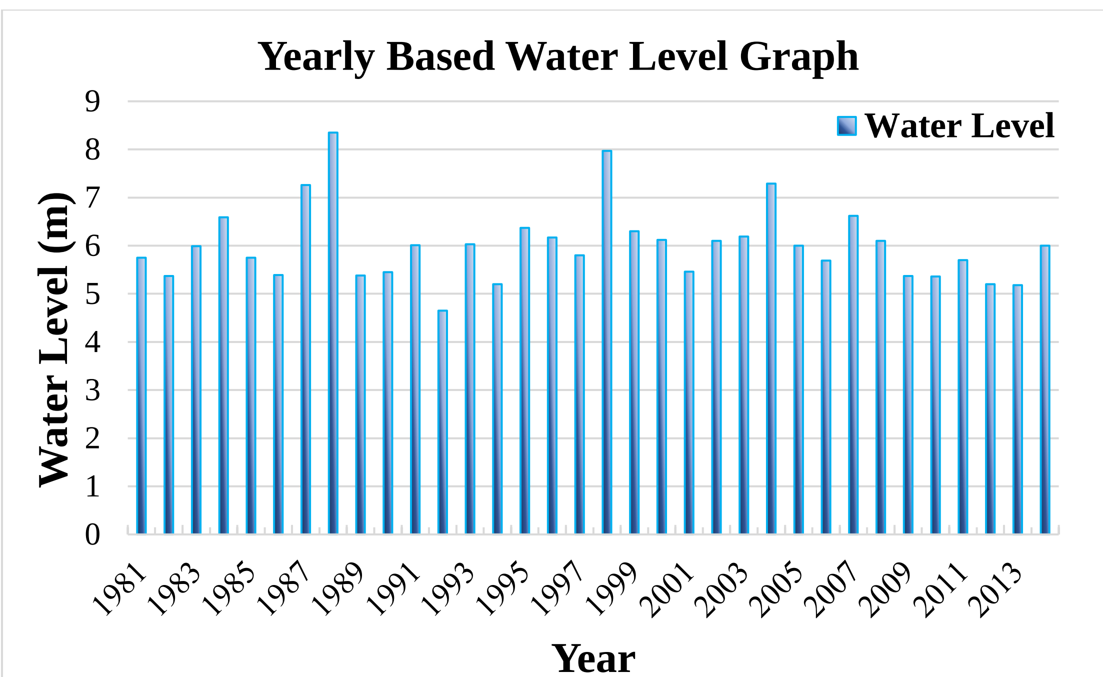


Figure 4.1.1 Yearly Based Water Level Graph

The water level values are arranged in descending order and the plotting position recurrence interval T, for each discharge is obtained as

$$T_P = \frac{N+1}{m} = \frac{34+1}{m}$$

where

m = order number

The statistics $\bar{x}$ and σ_{n-1} for the series are next calculated and are shown in Table. Using these the water level x_T for some chosen recurrence interval is calculated by using Gumbel's formulae.

Table 4.1.1 Calculation of T_P for Observed Data

Order Number m	Water level (m)	T_P (Years)	Order Number m	Water level (m)	T_P (Years)
1	8.35	35	18	5.99	1.94
2	7.97	17.50	19	5.8	1.84
3	7.29	11.67	20	5.75	1.75
4	7.26	8.75	21	5.75	1.67
5	6.62	7.00	22	5.7	1.59
6	6.59	5.83	23	5.69	1.52
7	6.37	5.00	24	5.46	1.46
8	6.3	4.38	25	5.45	1.40
9	6.19	3.89	26	5.39	1.35
10	6.17	3.50	27	5.38	1.30
11	6.12	3.18	28	5.37	1.25
12	6.1	2.92	29	5.37	1.21
13	6.1	2.69	30	5.36	1.17
14	6.03	2.50	31	5.2	1.13
15	6.01	2.33	32	5.2	1.09
16	6	2.19	33	5.18	1.06
17	6	2.06	34	4.65	1.03

Sample calculation to obtain discharge for certain return period:

Number of data, N = 34 years

Mean, $\bar{x}$ = 6.005 m

Standard deviation, σ_{n-1} = 0.786 m

From **Table 3.3.2.1** and **Table 4.1.1**, for N = 34, $\bar{y}_n$ = 0.5396 and S_n = 1.1255

Choosing T = 5 years, by Eqn.

y_T = - $\left[ln.\,ln\,\frac{5}{5-1}\right]$ = 1.500

K = $\frac{1.500-0.5396}{1.1255}$ = 0.853

x_T = 6.005 + 0.853 × 0.786

= 6.675

Table 4.1.2 Calculation of x_T for Observed Data

T	y_T	K	x_T
2	0.367	-0.154	5.884
5	1.500	0.853	6.675
10	2.250	1.520	7.200
20	2.970	2.160	7.702
40	3.676	2.787	8.196
60	4.086	3.151	8.482
80	4.376	3.408	8.684
90	4.494	3.514	8.767
110	4.696	3.693	8.908
120	4.783	3.771	8.969

Use this table to plot a graph, and use it to figure water level for 100-year return period.

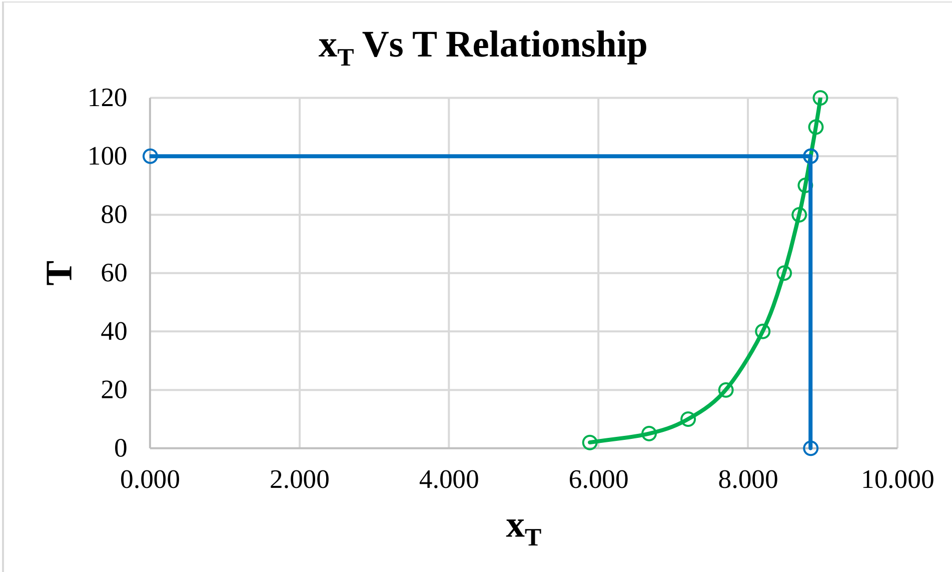


Figure 4.1.2 x_T vs T Relationship

By extrapolation of the theoretical x_T vs T relation from **Figure 4.1.2**

At T = 100 years,

Water level for 100-years return period

x_T = 8.837 m

Now, this water level is used to calculate the design discharge. Received the discharge for a specific water level. Using these data, the design discharge for the 100-year return period can be determined. To determine the design discharge, simple geometric processes are applied.

From BWDB,

Q = 1468 m^3/s
V = 0.74 m/s

WL = 8.17 m

From Survey Map,

L_1 = 123.208 m

WL_{100} = 8.837 m

Design discharge for 100 years, Q_{100} = 1587.848 m^3/s

4.2 Linear Waterway

Equation's Lacey's formula should be used to estimate the necessary linear canal for big alluvial streams with ill-defined banks.

$$L = C\sqrt{Q}$$
$$= 4.75\sqrt{1587.848}$$
$$= 189.28 \text{ m}$$

4.3 Scour Depth

Sieve Analysis is the process for determining the amount of particles of varying sizes present in a soil sample. In order to calculate the scour depth, you will also need the silt factor. As a result, a sieve analysis table and a PSD curve were created in order to calculate the silt factor. Gather some of the soil from the river bed for the sieve analysis. For the sieve analysis, 1000 g of soil was used. After finishing the laboratory procedure, collect all of the necessary data for the sieve analysis. Create a PSD Curve using the percent finer and particle size data provided from the sieve analysis **Table 4.3.1**

Table 4.3.1 Sieve Analysis

Sieve No	Opening (mm)	Sieve Wt. (gm)	Sieve + Soil Wt. (gm)	Wt. of soil retained (gm)	Percent retained	Cumulative percent retained	Percent finer
4	4.75	500.22	500.22	0	0	0	100
8	2.36	292.68	292.68	0	0	0	100
16	1.18	288.28	288.28	0	0	0	100
30	0.6	294.29	294.9	0.61	0.061	0.061	99.939
50	0.297	294.05	368.1	74.05	7.407	7.468	92.532
100	0.149	249.49	1049.14	799.65	79.983	87.450	12.550
Pan	0	298.57	424.04	125.47	12.550	100	0
Total				**999.78**			

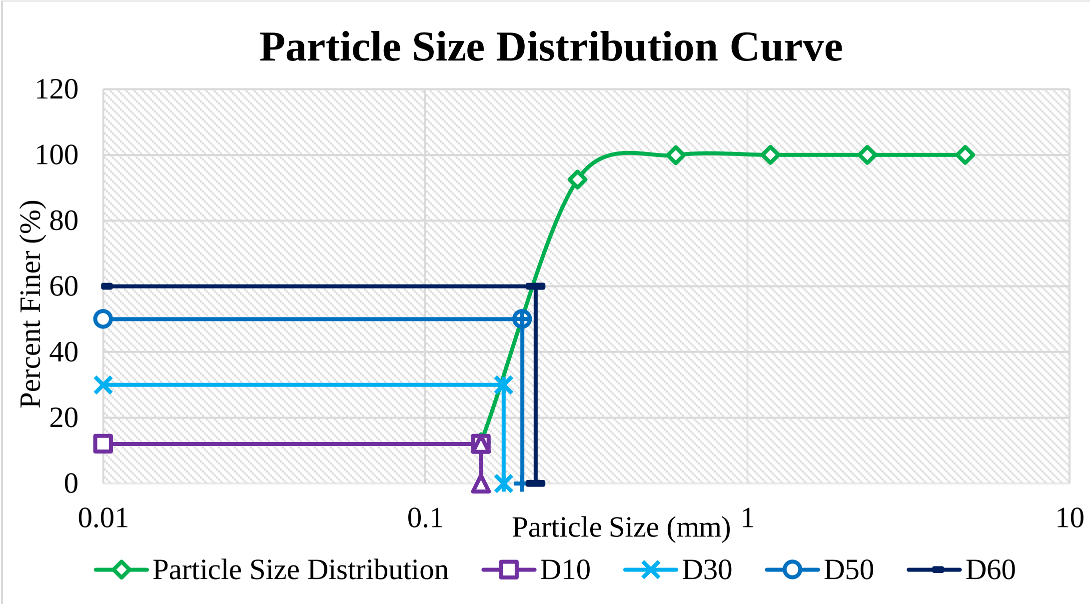


Figure 4.3.1 Particle Size Distribution Curve

To compute Water Bearing Soil Layer, MIT classification of soil particle proportions is required.

MIT soil classification:

Table 4.3.2 MIT Classification

Silt/Clay	< 0.06 mm
Fine Sand	0.06-0.20 mm
Medium Sand	0.20-0.60 mm
Coarse Sand	0.60-2.00 mm
Fine Gravel	>2.00 mm

For the PSD curve,

Below 0.06 mm, no particles are visible. So, this graph does not include any clay or silt. At 0.06-0.20 mm, a little quantity of fine sand may be seen.

Fine Sand = 51%

Medium sand is visible at 0.20-0.60 mm.

Medium Sand = 100-51 = 49%

0.60-2.00 mm is Coarse sand. There are no visible particles present. Consequently, Coarse Sand = 0%

This graph has no fine gravel above the value of 2.00 mm.

Table 4.3.3 Soil Type

Soil Type	Percentage (%)
Fine Sand	51
Medium Sand	49
Course Sand	0

(Jamal, 2017)

Fineness Modulus:

F.M = $\frac{Cumulative\ Percent\ Retained\ of\ Sieve\ \#4\ to\ \#100}{100}$

$= \frac{0+0+0+0.061+7.468+87.450}{100}$

= 0.950

Silt Factor = $1.76\sqrt{D_{50}}$

$= 1.76\sqrt{0.200}$

= 0.787

From, Lacey's Silt Factor **Table 2.2.7.1**

f = 0.8

which is medium silt.

For natural streams in alluvial beds, the normal scour depth can be estimated using an equation.

d = $0.473\left(\frac{Q}{f}\right)^{0.33}$

$= 0.473\left(\frac{1587.837}{0.8}\right)^{0.33}$

= 5.796 m

4.4 Afflux

For determine afflux need linear waterway, velocity and width of stream at HFL. Linear waterway, velocity already has. Now need to find out width of stream.

Discharge for 100-year return period is 1587.837 m^3/s.

$A = \frac{1587.837}{0.74} = 2145.74\ m^2$

River is most of time trapezoidal. By normal geometry process,

Depth of stream at HFL, D = 8.837 m

Width of stream at HFL, L = 171.43 m

Where,

C = constant as per shape

= 0.7, for sharp entry

= 0.9, for bell mouth

V = Velocity of normal flow in the stream =0.74 m/s

L_1= linear water way =189.28 m

L = Width of stream at HFL=171.43 m

Now,

$$x = \frac{V^2}{2g}\left[\frac{L^2}{c^2L_1^2} - 1\right]$$

$$= \frac{0.74^2}{2*9.81} \times \left(\frac{171.43^2}{0.9^2*189.28^2}-1\right)$$

$$= 0.000796\ m$$

4.5 Bridge Length

From hydraulic consideration, the total length of the bridge has been found to be 189.28 m. This length is considered for 100-year return period. At HFL, the width of the stream measured 172.764 m.

4.6 Navigational Consideration

The Turag River has little navigational traffic. A clearance of 1.2 m has been kept above the HFL of 8.837 meters (100-year return period). This clearance is obtained from the upper **Table 2.2.6.1.** It is navigable by boat all year round. Boats and small bulk carriers are sailed here. Bulker ships typically have a height of 7.9 meters. (Banglar Arjan, n.d.) There bridge height would be 9.1 meters.

Chapter 5

Conclusion

5.1 Conclusion

In bridge design hydraulic parameters plays very important role. Based on hydraulic data linear water way for the bridge, length of the span, scour depth and related river training including bridge abutments design has to be done. This study was limited to hydraulic design only without the superstructure design. The proposed bridge site at Deul-Uttara crossing over the river Turag. The following observations are found considering the field survey and data collected from other sources.

- Topographic survey has been conducted 500 m upstream and 500 m downstream from the proposed bridge location by using the total station. Details of this survey may be seen in **Figure 3.2.1**. During the survey water level, bank level, road level (Dhaka city flood embankment). From the survey it has been found water width is 123 m and bank to bank distance was 130 m. During survey it has also been seen 3 more bridges over the river Turag. From **Figure 3.2.1** bridge site location is recommended based on minimum width of the river which is 123 m.

- The Bangladesh Water Development Board (BWDB) provided statistics on discharge, velocity, and water level during a 34-year period.

- Design discharge with a 100-year return period has been calculated using Gumbel's method which is 1588 m^3/s. Based on design discharge linear waterway, scour depth, clearance between HFL and bottom of the bridge deck have been calculated. These values are 190 m, 5.8 m (from the river bed) and 9.1 m respectively. From these findings the proposed bridge length may be consider 190 m and the depth of pier foundation may be considered 5.8 m below the river bed. From the hydraulic data and local investigation bank line of river Turag is more or less stable as such proposed bridge location is justified. Since in other bridges constructed over the river Turag required no river training works except the bridge abutments, river training works for the proposed bridge may not be recommended.

5.2 Further Recommendations

The present study was conducted with many limitations. Based on these limitations following recommendations may be made:

- During field survey water depth, velocity and cross section could not be measured. In future, direct measurement of these parameters will give better results.
- Calculation of scour depth may be predicted using more empirical equations to compare the results obtained using Lacey's equation.

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