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Effect of Flood On Water Profile in Different Cross Sections of Vishwamitri River Using HEC-RAS

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Abstract — *A flood is a high stage in river at which the river outflows its banks and inundates the adjoining area. The present study considers the case of Vishwamitri River flowing through the Vadodara City. The river section is of meandering type with thick vegetation at the riverbed and riverbanks. During 2005, a flood of nearly 805 cumecs passed through the river which resulted in overbank flows. So it is necessary to remodel and reshape the channel to suitable cross-section. This paper focuses on suggesting a new section other than natural section using HEC-RAS. The river reach covers 15.2 km from NH-48 crossing to well beyond Atladra Bridge with 152 cross-sections along the reach. The natural and suggested sections are derived. After determining the maximum flood carrying capacity of each section, the return period corresponding to the maximum flood is known. The maximum discharge of suggested section is used to analyze the bridges located along the reach of natural and suggested sections.*

Keywords- *Flood, Vishwamitri River, HEC-RAS, Water Surface Elevations, Bridges*

I. INTRODUCTION

Floods occur in rivers when the flow rate exceeds the capacity of the river channel, particularly at bends or meanders in the waterway. Floods often cause damage if they are in the natural flood plains of rivers. The damages caused by floods in terms of loss of life, property and economic loss due to disruption of economic activity are well known. The hydrograph of extreme flood and stages corresponding to flood peaks provide valuable data for purposes of hydrologic design. The most important and widely used parameter of flood hydrograph is the flood peak. At a given location in a stream, flood peaks vary from year to year and their magnitude constitutes a hydrologic series which enables one to assign a frequency to a given flood peak value. In the design of all hydraulic structures the peak flow that can be expected with an assigned frequency, say 1 in 100 years is of prime importance to adequately proportion the structure to accommodate its effect. This study takes into account the case of Vishwamitri River which is narrow followed by sharp meandering loops. The present study focuses on analyzing new section which is superior than the existing section in terms of flood carrying capacity and performs well even in worst flood conditions. The software used for such analysis is computer programme HEC-RAS developed by Hydrologic Engineering Center.

II. OBJECTIVES

The objectives of the study are the following:

1. To derive natural and suggested section and carry out graphical comparison of both sections.
2. Comparison of water surface elevations of both sections at a discharge of 805 cumecs.
3. To determine the maximum flood carrying capacity of the natural and suggested section.
4. To analyze the natural and constricted sections for flood during various return periods found out.
5. Comparison of water surface elevations of both sections by considering the maximum discharge of suggested section.
6. To identify the critical cross sections at bridges, located along the reach of natural and suggested sections that are affected by the maximum flood conditions.

III. TOOLS USED

The HEC-RAS model is a one-dimensional steady and unsteady flow hydraulic model, which is mainly used to determine the open channel flow analysis and flood plain area. The results of model can be used for the analysis of regional flood management and flood safety research, which is used to evaluate flood and the damage degree of regional scope. HEC-RAS includes capabilities for calculating bank full discharge and for designing geomorphologically stable channels. HEC-RAS simulation provides information like water depth, flow velocity and a temporal variation of the flood. Specific locations where water begins to overflow can be identified. HEC-RAS can simulate a single river, dendritic drainage system or looping river network system.

IV. STUDY AREA

The Vishwamitri River is a seasonal river which flows east to west between the Mahi and Narmada rivers in Gujarat. It originates in the Pavagadh hills. The Vishwamitri River flows west through the city of Vadodara and joins the Dhadhar River and Khanpur River before emptying into the Gulf of Khambhat. Its total length is 70.40 km; its form is generally narrow, deeply incised and meandering. The river substantially dries up in summer, leaving only a small stream of water. The Vishwamitri River enters the Vadodara City at NH-48 crossing and flows throughout the city upto Atladra Bridge. About 25km of river stretch passes through the Vadodara city and bisects the city. The study has been conducted on the river reach which lies between NH-48 crossing to well beyond Atladra Bridge as shown in Fig. 1 below. There are 152 cross sections along the reach, located at an interval of 100m each, which are taken into consideration for study. The cross section starts from the station 15200 and ends to station 100. There are 7 bridges located along the reach.

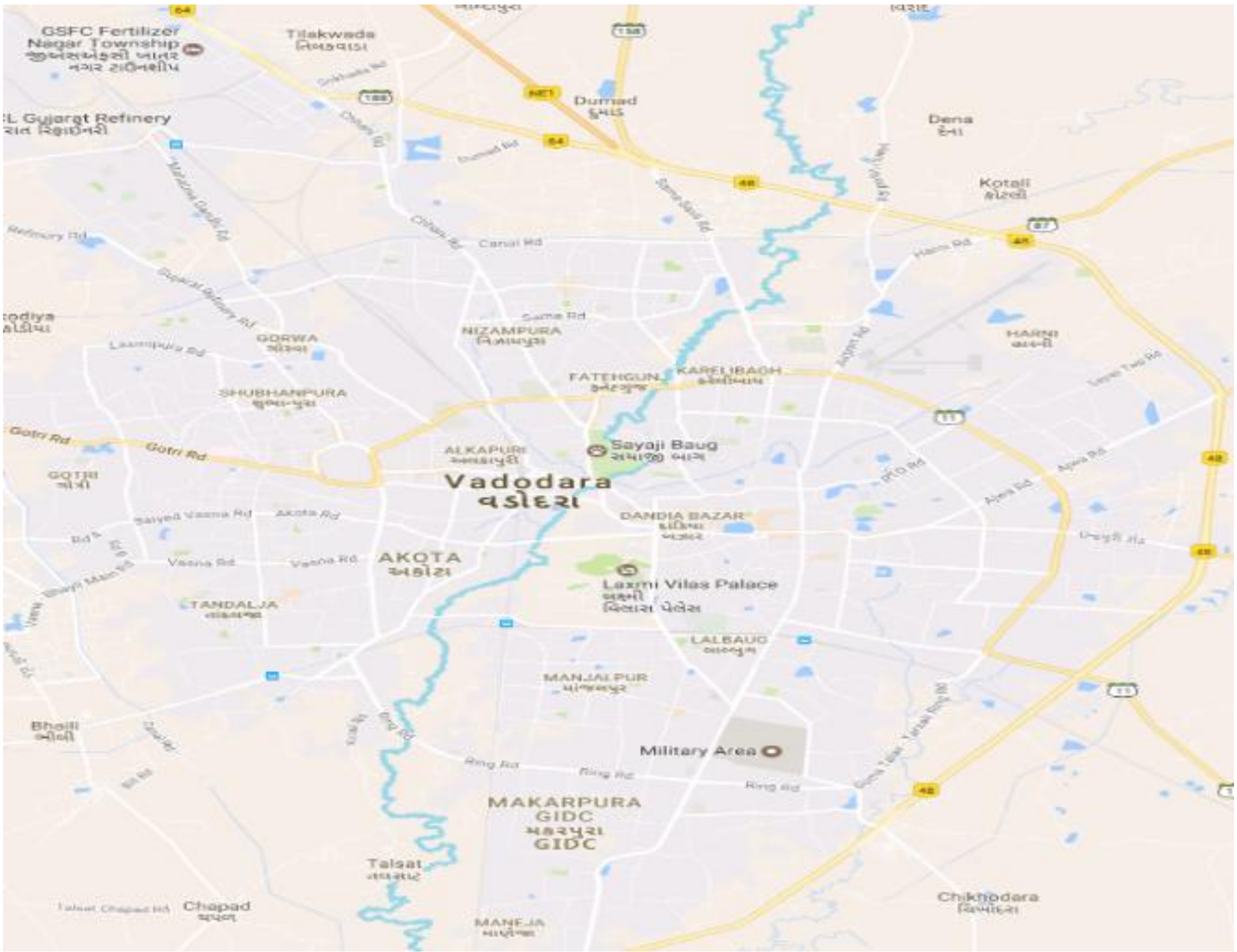


Figure 1. Street map of Vishwamitri River

V. DATA USED

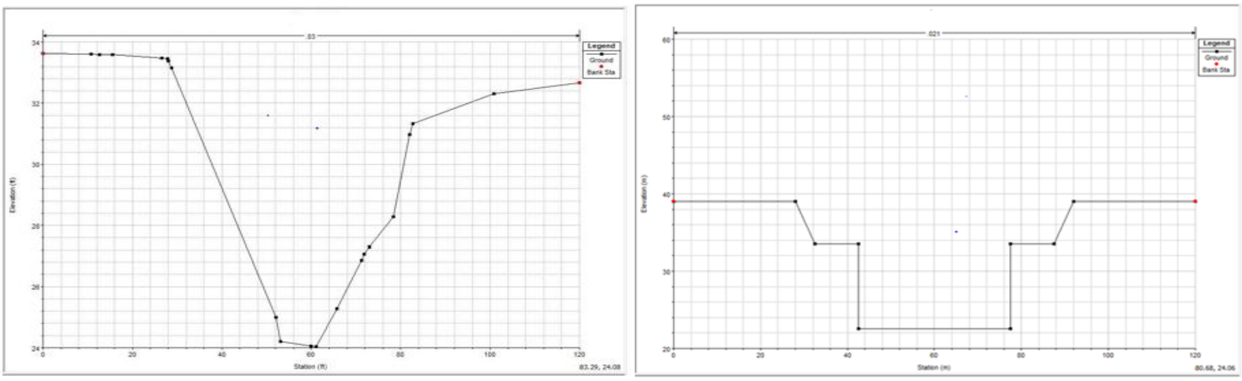
The data that is being used for the present study consists of geometric data of cross section and bridge, steady flow data, and flood data. The geometric data of the cross section includes station-elevation data, downstream reach lengths, Manning’s n values, main channel bank stations, and contraction and expansion coefficients. The geometric data for the bridge includes distance from upstream deck width, Upstream/Downstream Embankment side slope, and Pier data. Steady flow data include number of profiles, flow rate, and boundary conditions The flood data of the past 18 years is used for flood frequency analysis.

VI. METHODOLOGY

The project starts by creating a river system schematic. Then geometric data of the cross sections is entered to derive the natural and suggested river reach. The suggested river reach will be rectangular in geometry. A graphical comparison of the natural and rectangular cross section is made. The discharge of 805 cumecs is taken as inflow and water surface elevations for the natural and rectangular sections are found out by carrying out steady flow analysis. A comparison of the water surface elevations at natural and rectangular cross sections at 805 cumecs is made. Different flow rates are entered and steady flow analysis is carried out to know the maximum flood carrying capacity of both sections. Flood frequency analysis is carried out using Gumbel's Method to obtain the flood peaks at various return periods. The maximum discharges of the natural and rectangular sections are compared with these flood peaks to know the return period of that flood for both the sections. The maximum discharge of the rectangular section is taken as inflow and steady flow analysis is carried out to obtain the water surface elevations. Then a comparison of the bank stations and water surface elevations of the rectangular channel is made. The water surface elevations at critical cross sections of various bridges located along the natural and rectangular sections are found out.

VII. RESULTS

The natural and rectangular sections are derived by entering the cross section data as shown in Fig. 2 below



Natural Cross Section Rectangular Cross Section

Figure 2. Natural and Rectangular Cross Sections

A graphical comparison of the natural and rectangular sections is made as shown in Fig. 3 below.

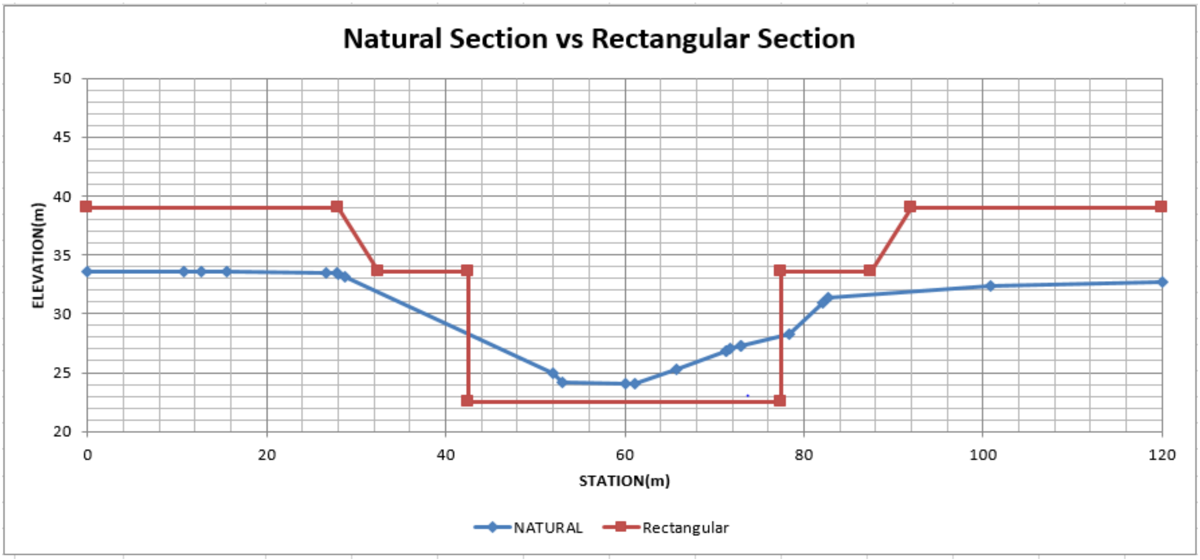
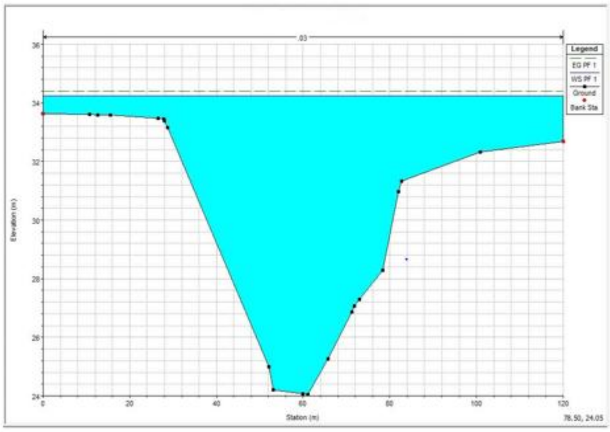
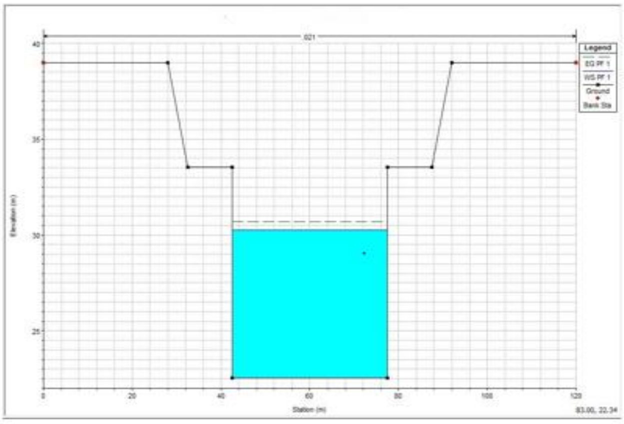


Figure 3. Natural and Rectangular Section Comparison

Simulations are carried out at a discharge of 805 cumecs for natural and rectangular sections by performing steady flow analysis as shown in Fig. 4 below.

Natural Section　　　Rectangular Section

Figure 4. Effect of 805 cumecs Flood on Natural & Rectangular Sections

The comparison of the water surface elevations of natural and rectangular sections at a discharge of 805 cumecs is made as shown in Fig. 5 below.

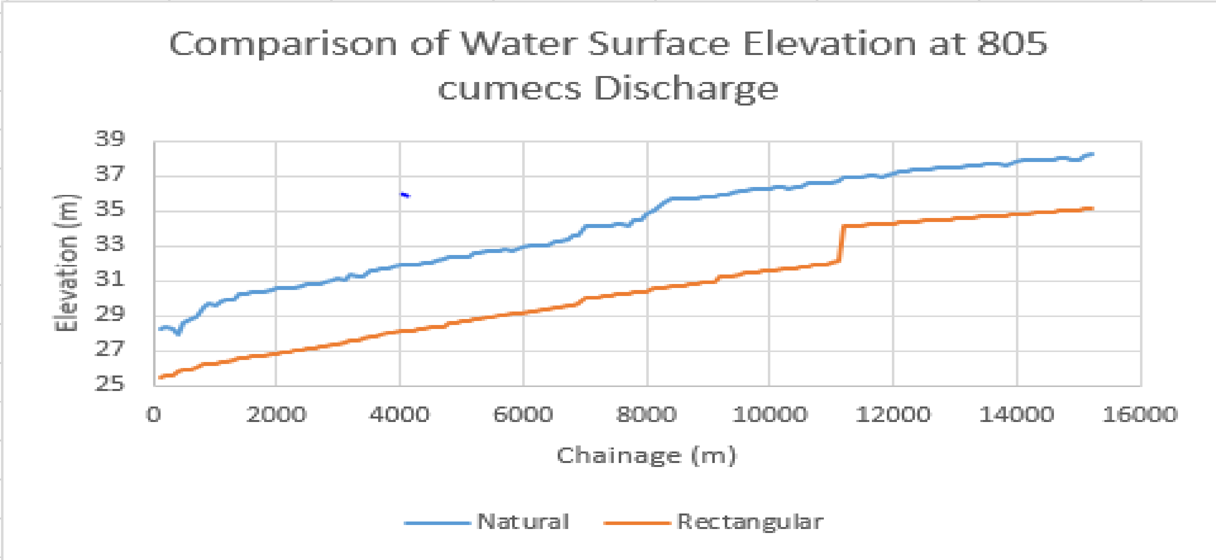


Figure 5. Water Surface Elevation Comparison at 805 cumecs Discharge

The maximum flood carrying capacity of the natural and rectangular sections is determined by performing steady flow analysis at different flow rates. The resulting flood carrying capacity for the natural section is 25 cumecs and rectangular section is 970 cumecs.
Flood peaks for various return periods are determined by using Gumbel's Method as shown in table below.

Table 1. Flood Peaks for various Return periods

Return Period (years)	Flood (cumecs)
10	657
15	753
20	825
25	873
30	916
35	952
40	981

Thus from above table, it is observed that rectangular section can carry a flood of 40 year return period.
Now the discharge of 970 cumecs is taken as inflow, which is the maximum discharge for rectangular section, and water surface elevations are found out. Then a comparison of the bank stations of rectangular section and water surface elevations is made as shown in Fig. 6 below.

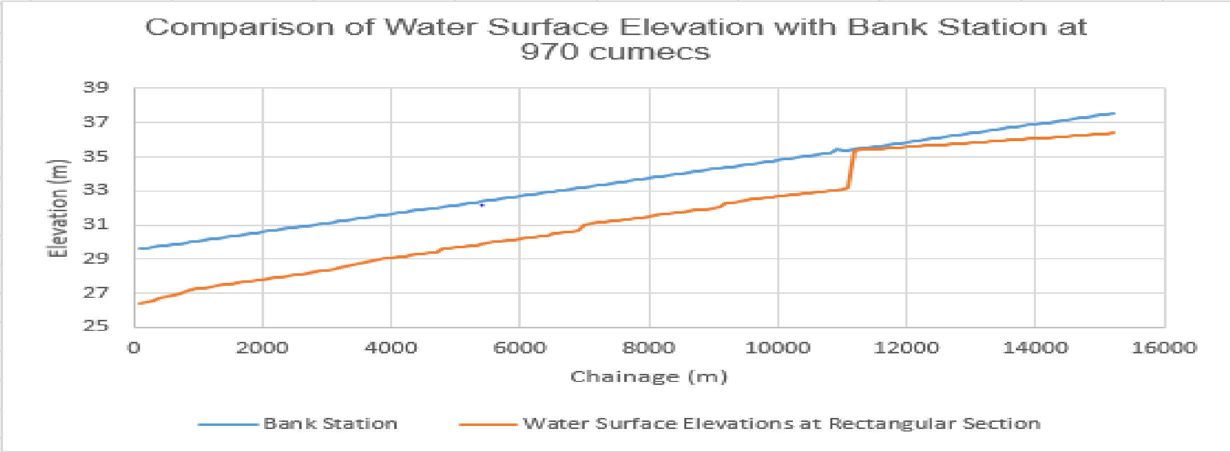


Figure 6. Water Surface Elevation and Bank Station Comparison

The water surface elevations at various bridge sections located along the natural and constricted sections are found out, considering the maximum discharge of rectangular section. The comparison of the water surface elevations and bottom of bridge for natural and rectangular sections is shown in Fig. 7 below.

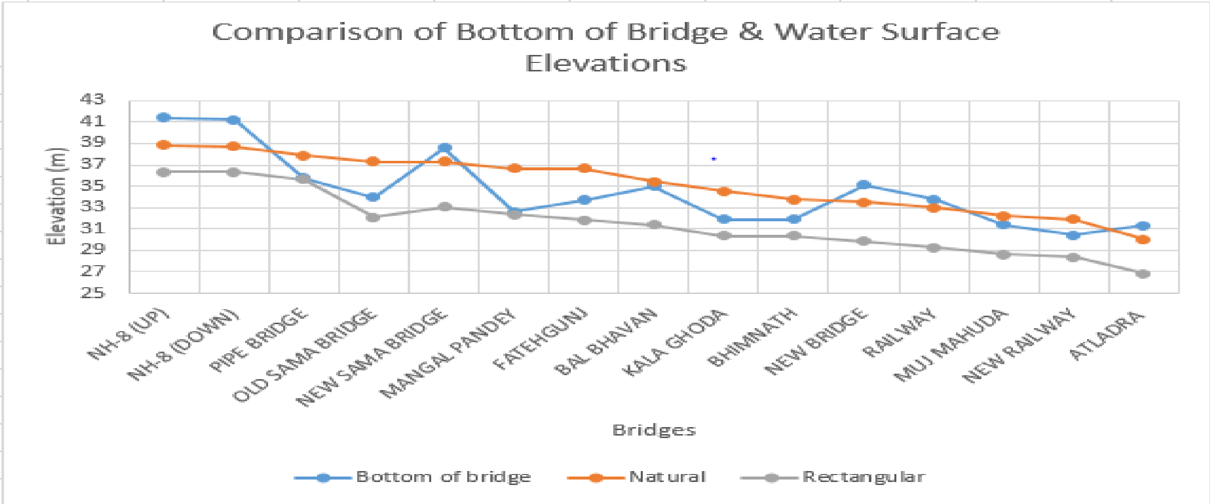


Figure 7. Comparison of Water Surface Elevation & Bottom of Bridge

VIII. CONCLUSIONS

It can be concluded that rectangular section requires adequate amount of dredging and filling whenever the need for modification arises. At 805 cumecs discharge, overflow takes place at natural section while rectangular section remains safe. The water surface elevations of the natural section are much higher than rectangular section at 805 cumecs discharge. The maximum flood carrying capacity of rectangular section is 970 cumecs which is far higher than natural section. Rectangular section can carry a flood of 40 year return period which is higher than natural section. The comparison of the bank stations and water surface elevations of rectangular section shows that overflow does not occur at any of the cross section of rectangular channel reach. From the comparison of water surface elevation & bottom of bridge, it is observed that 9 bridges located along the natural section are overtopped, while none of the bridges along rectangular section are overtopped.

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