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APPLICATION OF 1-D HEC-RAS MODEL IN DESIGN OF CHANNELS

Darshan J. Mehta*
Asst. Prof., CED, S.S.A.S.I.T, Surat

Mr. Manthan Ramani
U.G, Student, CED, S.S.A.S.I.T, Surat

Mr. Maulik Joshi
U.G, Student, CED, S.S.A.S.I.T, Surat

Abstract— ***Flood occurs at Surat city frequently due to sudden release of water from Ukai dam in river Tapi. At the time of floods in river Tapi, Surat city and surrounding regions are most affected. The city has faced many floods since long back. Major flood event occurred in the year 1883, 1884, 1942,1944,1945,1949, 1959, 1968, 1994, 1998, 2002, 2006, 2007 and 2012. The carrying capacity of river is approximately about 4.5 lakhs cusecs (12753 cumecs) at present. In this, stability of a segment of lower reach approximately 6 km length of Tapi river between Weir cum causeway and Sardar bridge is evaluated for its carrying capacity and stability in response to discharge and slopes using HEC-RAS software for past flood data. The study reach consists of 24 cross-sections. The hydraulics model, HEC-RAS is employed to evaluate flood conveyance performance and also uniform flow computation is carried out. In the present study existing storm drains are not only marked but based on the HEC-RAS water surface elevation computation for various flood discharges, need of flood gates on the storm drains are also assessed. The recommendations are done based on this study either to increase height of bank or construct a retaining wall at certain sections along the study reach. The present study also recommends installations of flood gates on all the storm drain outlets which are without flood gates. The width of river in no case be encroached as sections are sensitive high floods.***

Keywords— Flood, HEC-RAS, Storm Drains, Tapi River, Uniform flow computation

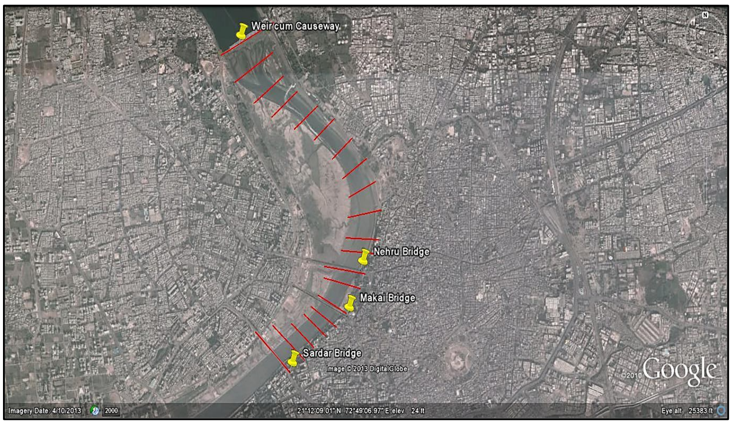
I. INTRODUCTION

Indian rivers, in general, and the Tapi river, in particular, are vulnerable to high-magnitude floods at interval of several years to decades. Geomorphic effects of floods depend upon magnitude, frequency, flood power, duration of effective flow and channel geometry. With rapid advancement in computer technology and research in numerical techniques, various 1-D hydrodynamic models, based on hydraulic routing, have been developed in the past for flood forecasting and inundation mapping. The discharge (past flood data) and river stage (stations and elevations) were chosen as the variables in practical application of flood warning. In this study, one dimensional hydrodynamic model using HEC-RAS (4.1) has been developed using geometric and past flood data of the lower Tapi River. The developed model has been utilized to simulate the flood of year 1968, 1998, 2006, 2012 and 2013 for uniform flow computation. At present, there is an urgent requirement of a hydrodynamic model which should be able to predict the flood levels in the lower part of the Tapi River for flood forecasting and protection measures in and around the Surat city. As we know that there were floods in river Tapi, Surat city and surrounding regions are most affected. Thus in this present paper I have selected study reach from Weir cum causeway to Sardar Bridge in which there are 24 cross-sections and length of study reach is 6km.

II. OBJECTIVES

The objectives of the study are:

- To compute the different cross-sections using HEC-RAS software and past flood events
- To determine adequacy of existing section to carry flood of various magnitude.
- To recommended measures to assure safe flood conveyance for the study reach by increasing height of retaining wall, proposing new bunds or embankment at the particular cross-sections.



III. STUDY AREA

The study reach, located between Weircum causeway and Sardar Bridge, approximately 6km long with 24 cross sections. Surat, being coastal city, had been susceptible to major floods and undergone huge damages in the past. The river reach selected for present study is extremely important as 80% of total population of Surat is settled on the either side of the bank. Major business centers for diamond industries, textile industries and industrial area of Hazira are within 1km radius of the study reach. Fig. 1 shows the study area with cross-sections details. Total no. of cross sections is 24. Total distance of Study reach is 6km (6000m). Distance between cross-sections to cross-sections is 250m. Red line indicates cross-sections. Upstream reach is Weir cum causeway and downstream reach is Sardar Bridge.

IV. OVERVIEW OF HEC-RAS SOFTWARE

HEC-RAS is an integrated system of software for one-dimensional water surface profile computations and is designed for interactive use in multi-tasking, multiuser network environment. HEC-RAS (Hydrologic Engineering Center River Analysis System) was developed by U.S. Army Corp of Engineers in 1995 which is a part of the Institute for Water Resources (IWR), U.S. Army Corps of Engineers. HEC-RAS is “software that allows you to perform 1-D steady and unsteady flow river hydraulics calculations, sediment transport capacity, uniform flow computations and water temperature analysis. The latest HEC-RAS version is available free-of-charge under a public domain license from the website of the U.S. Army Corps of Engineers. The current version (4.1) was released in January 2010.

V. HEC-RAS INPUT PARAMETERS

HEC-RAS uses a number of input parameters for hydrodynamic analysis of the river stream channel geometry and water flow. These parameters are used to establish a series of cross-sections along the stream. In each cross-section, the locations of the stream banks are identified and used to divide into segments of left floodway (overbank), main channel and right floodway (overbank). The function of HEC-RAS is to determine water surface elevations at all location of interest. Following are the data required for carrying out 1-D hydrodynamic modelling using HEC-RAS:

- Detailed cross-sections of Tapi river (Geometric Data)
- Manning ‘n’ value
- Map of Study area
- Past flood Events
- R.L of both banks i.e. Left side and Right side bank of the Study reach

VI. FLOOD CONVEYANCE PERFORMANCE

For evaluation of flood performance, past flood data are collected from Flood Cell, Surat were used. The flood frequency analysis results were based on data which coincides with the upstream limit of the project reach. Major flood events took place in the year 1883, 1884, 1942, 1944, 1945, 1949, 1959, 1968, 1994, 1998, 2006, 2007, 2012 and 2013. The summary of flood is given in Table. 1.

Table 1- Flood History of Surat City

Sr. No	Year	Discharge (cumecs)	Discharge (lacs cusecs)
1	1882	2095.5	7.40
2	1883	2845.8	10.05
3	1884	23956	8.46
4	1944	33527	11.84
5	1945	28996	10.24
6	1949	23843	8.42
7	1959	36642	12.94
8	1968	44174	15.60
9	1998	19057	6.73
10	2006	25768	9.10
11	2012	9508.04	3.35
12	2013	12146	4.62

VII. METHODOLOGY

Following are the steps are required for uniform flow computations:
Step 1: Create a new HEC-RAS project.
Step 2: Create a new river and reach in the geometry editor window.
River Name: Tapi
Reach Name: Weir cum causeway to Sardar Bridge

Step 3: Enter the geometric data i.e. station and elevation data.

Step 4: After adding all data we get geometric cross-section in HEC-RAS software which is same as that collected from Surat Municipal Corporation.

Step 5: Enter the Manning's value for upstream reach. In this paper, value of **'n'** is taken as 0.022. The value of 'n' can be taken according to bed material of the river reach.

Step 6: Enter steady flow data for different flood peak discharge.

Once the geometric data is entered, the necessary flow data can be entered subsequently. Steady flow data consists:

- the number of profiles
- the flow data
- and the river system boundary conditions

Step 7: Open Run windows. Click on Hydraulic design function and select, uniform flow.

Step 8: In Hydraulic Design, Uniform flow window input the peak flood discharge of specific year to a selected section. Repeat this procedure for 24 sections.

Step 9: In the same window, after entering the peak flood discharge click on compute icon

Step 10: For a particular section selected in Step 9**,** following detail may appear:

- If section is sufficient, F.S.L is within the bank heights i.e. section under consideration is sufficient for input discharge.
- If section is not sufficient, F.S.L is above the bank and software will develop levees on that bank which is overtopped by the input discharge.

Step 11: Repeat step 8 to step 10 for all cross sections of study reach i.e. 24 cross-sections.

VIII. FINDINGS AND DISCUSSION

In this paper sufficiency of existing sections are accessed using the major flood events of historical floods. The sections are classified as highly critical (where the depth of water above existing bank is more than 0.7m), moderately critical (where the depth of water above existing bank is between 0.4m to 0.7m) and critical (where the depth of water above existing bank is up to 0.4m). Figure presents computed section using HEC-RAS software and past flood events. Figure shows the graph between Station (Chainage in m) and Elevation (Bed level in m).

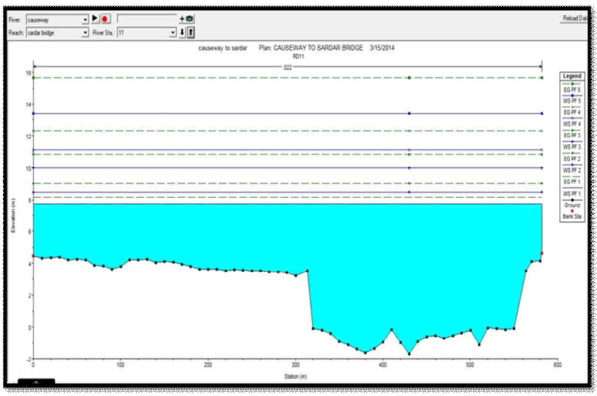


Fig. 2 Computed Section CS-11

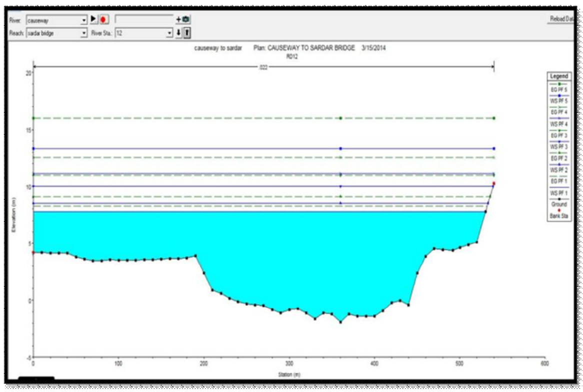
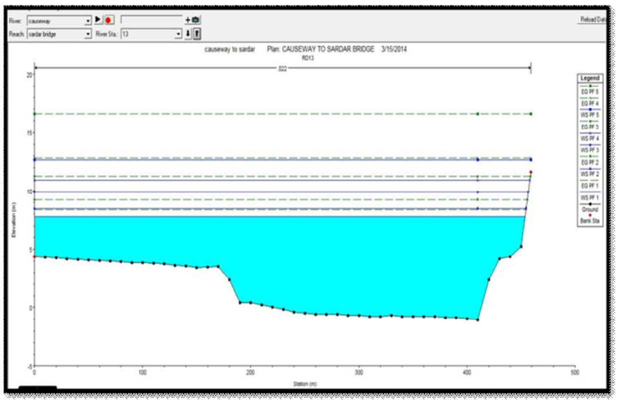
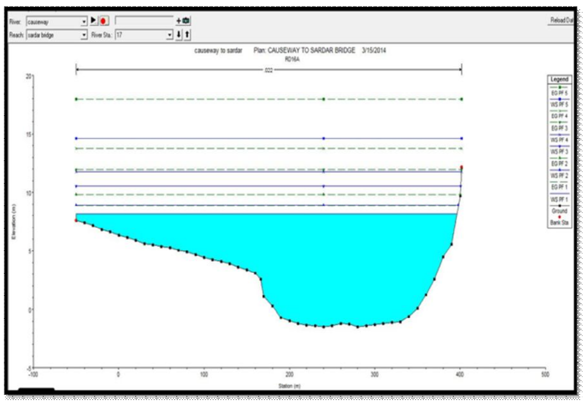


Fig. 3 Computed Section CS-12





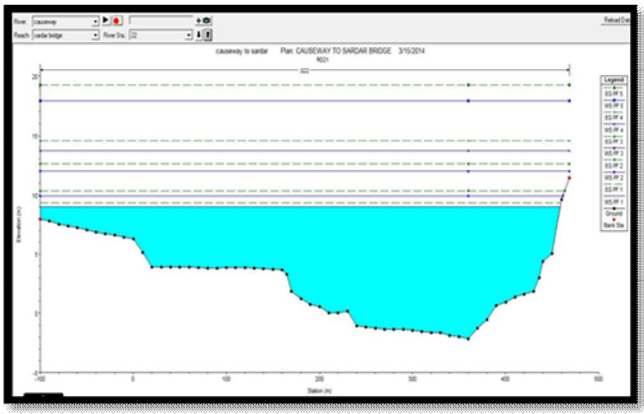
The flow in the channel as, 3.35 lakh cusecs, 4.62 lakh cusecs, 6.73 lakh cusecs, 9.10 lakh cusecs and 15.6 lakh cusecs has been considered for uniform flow analysis. When these values are given as input at all the 24 cross-sections the output obtained is as shown in Fig. 2 to Fig. 7 respectively.

The Finding of above study is summarized as below:

1. At cross-section 24, for flow of 3.35 and 4.62 lakhs cusecs the cross-section is sufficient to carry flow but when the flow is of 9.10, 6.73 and 15.6 lakhs cusecs, the section is not capable of carrying the flow.
2. At cross-section 22, for flow of 3.35 and 4.62 lakhs cusecs the cross-section is sufficient to carry flow but when the flow is of 9.10, 6.73 and 15.6 lakhs cusecs, the section is not capable of carrying the flow.
3. At cross-section 17, for flow of 3.35, 4.62, 6.73 and 9.10 lakhs cusecs the cross-section is sufficient to carry flow but when the flow is of 15.6 lakhs cusecs, the section is not capable of carrying the flow.

Fig. 4 Computed Section CS-13

Fig. 5 Computed Section CS-17



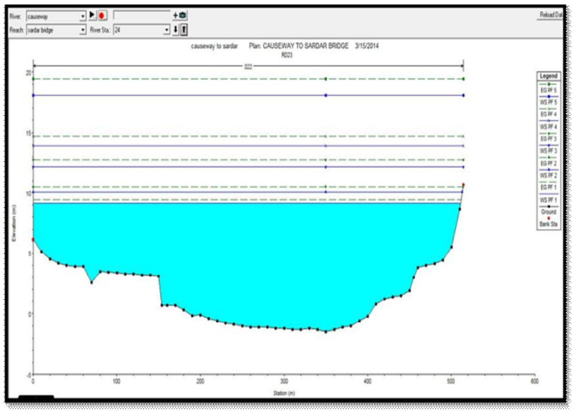


Fig. 6 Computed Section CS-22

Fig. 7 Computed Section CS-24

4. At cross-section 13, for flow of 3.35, 4.62, 6.73 and 9.10 lakhs cusecs the cross-section is sufficient to carry flow but when the flow is of 15.6 lakhs cusecs, the section is not capable of carrying the flow.
5. At cross-section 12, for flow of 3.35, 4.62 and 6.73 lakhs cusecs the cross-section is sufficient to carry flow but when the flow is of 9.10 and 15.6 lakhs cusecs, the section is not capable of carrying the flow.
6. At cross-section 11, for flow of 3.35 and 4.62 lakhs cusecs the cross-sections is sufficient to carry flow but when the flow is of 6.73, 9.10 and 15.6 lakhs cusecs the cross-section is not sufficient to carry flow.

By using this analysis, one can easily predict the possible effects of flood in the surrounding area of study reach and accordingly preventive measure can be taken up in the form of bank protection like levees, bunds, by raising the level of retaining wall, stone pitches and embankment. In this paper, the present study is used to check sufficiency of all the cross-sections from Weir cum causeway to Sardar Bridge to carry specific magnitude of flood.

IX. CONCLUSION AND RECOMMENDATIONS

- The study area is highly affected by the flood and it is necessary to develop flood reduction plan for the study area which helps to control big disaster in future.
- As the slope of river increases, the velocity of water also increases and hence the discharge carrying capacity of river also increases.
- The width of bank of study reach has reduced considerably from 1080m to 900m only as a result of encroachment on the bank.
- By considering the past flood events, it is strongly recommended to improve the carrying capacity of Tapi river, so that it will minimize the flood in surrounding area of Surat city.
- From the analysis of flood event 2006, it shows that West zone and South West zone is highly flood prone while East zone is least. About 90-95% Surat city was under water in hazardous 2006 flood event.
- It is strongly recommended that the sections, which water overtops over the existing embankment or retaining wall need to be raised.

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