Simulation of HEC-RAS model on Prediction of Flood for Lower Tapi River Basin, Surat

[1]VipinkumarG Yadav, [2]Darshan Mehta, [3]Sahita Waikhom
[1]Assistant Professor, Civil Engineering Department, G.E.C, Rajkot
[2]Assistant Professor, Civil Engineering Department, S.S.A.S.I.T, Surat
[3]Associate Professor, Civil Engineering Department, Dr.S.&S.S.G.E.C, Surat

Abstract—**Floods are natural disaster; they cause the losses and damages to lives, properties and the nature. The main objective of this study is to integrate science of meteorology, hydrology and hydraulics by using an appropriate and effective method in flood management. 1-D Hydrodynamic model is used to evaluate geomorphic effectiveness of floods on lower Tapi river basin. In this present study, geometry of lower Tapi River, flood plain of Surat City and past observed flood data have been used to develop 1-D integrated hydrodynamic model of the lower Tapi River, India. After collecting the entire data using 1-D hydrodynamic model to simulate the flood of year 1968, 1998, 2006, 2012 and 2013. As Surat city has faced many floods since long back. Major flood event occurred in the year 1883, 1884, 1942, 1944, 1945, 1949, 1959, 1968, 1978, 1979, 1990, 1994, 1998, 2002, 2006, 2007, 2012 and 2013. The carrying capacity of river is approximately about 4.5 lakhs cusecs (12753 cumecs) at present. The river network and cross sections for the present study were extracted from the field surveyed contour map of the river Tapi River. In this, stability of a segment of lower reach of Tapi river approximately 6 km length between Weir cum causeway and Sardar Bridge is evaluated for its carrying capacity and geomorphic effectiveness. The study reach consists of 24 cross-sections. The model is used to evaluate steady flow analysis, flood conveyance performance and uniform flow analysis. The study area selected is highly affected by the flood and it is necessary to develop flood reduction plan for the study area which will helps to control a big disaster in future. The recommendations are done based on this study either to increase height of the retaining wall or construct a retaining wall at certain sections along study reach. The present study also recommends improving carrying capacity of Tapi river so that it will minimize the flood in surrounding area of Surat City.**

Index Terms —**Cross-sections, Floods, HEC-RAS, River.**

I. INTRODUCTION

Water is essential part of life and it is basic need of any human being in their life. River isthe main source of water and it's been need to construct dam and other structure on river tocollect needful water for population of nation. With the acceleration of urban development inrecent decades, some engineering concepts regarding water control have been changing.Sanitary problems reflect on the population health, constant flooding and the deterioration ofa rich and diverse environment in many regions. The transformation of a rural environment inan urban area increases the sanitary problems endangering future generations.

Mostly in river flood is problem from which economy and culture of city to be distracted so it is necessary to analyze the flood on river and forecast the flooding condition on river. Flood inundation is the process in which we have to inundate or analyze flood in particular region of river so it is easy to prevent future flood condition and also precaution against hazardous condition. Tapi River mostly flood occur due to upstream raining and therefore it is necessary to forecast flood on Tapi.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.

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, for this purpose we have selected my study reach from Weir cum causeway to Sardar Bridge in which there are 24 cross-sections and length of study reach is 6km.

OBJECTIVE OF STUDY

The objective of study is to analyze the stability of a segment of lower Tapi river reach between Weir cum causeway and Sardar Bridge (6km) by evaluating its capacity in response to discharge and slopes.

Following are the objectives of study:

1. To compute the different cross-sections using HEC-RAS and past flood data.
2. To determine adequacy of existing section to carry flood magnitude.

3. To recommend measures to assure safe flood conveyance for the study reach by increasing height of retaining wall, proposing new bunds or retaining wall.
4. Identifying critical section for the spread of water in the study area.

II. STUDY AREA

The Surat city, being coastal city, had been seen susceptible to major floods and undergone with huge damage in the past. Flood occurs at Surat city frequently due to sudden release of water from Ukai dam in river Tapi. The region of Tapi river mostly affected by flood and many big hazardous situation are occurred so this area to be chosen for the flood analysis. Study of flood is very much needed because of many times flood is occurred in this region. At the time of floods in river Tapi, Surat city and surrounding regions are most affected. The Surat city and villages around it are a part of flood drainage of Tapi River. From year 1882 to 2006, eight flood events are recorded in August, while sixteen in September.

The study reach, located between Weircum causeway and Sardar Bridge, approximately 6km long with 24 cross sections, is shown in Fig. 1. 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.

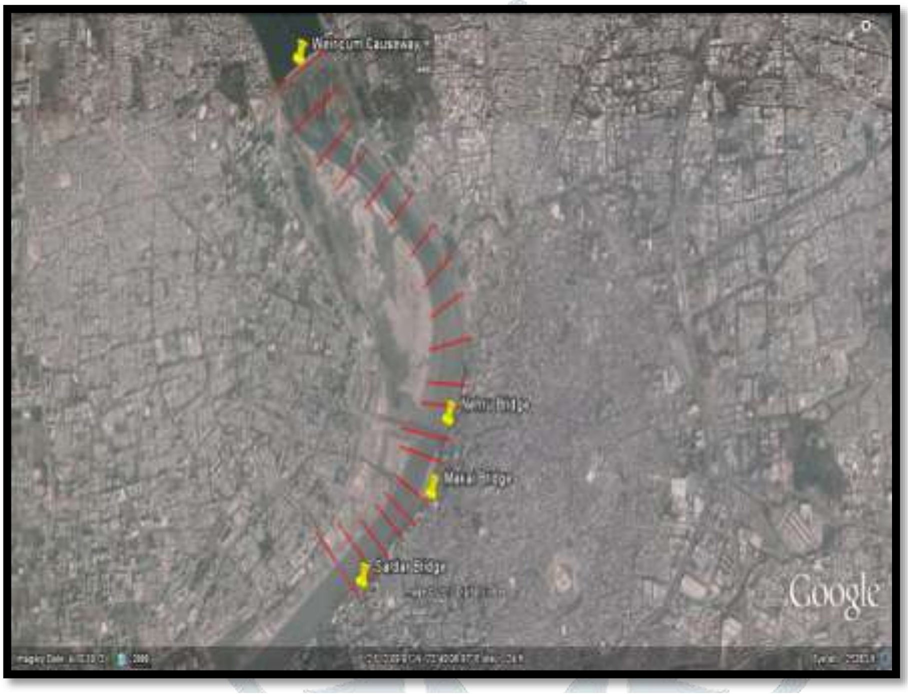

Figure 1 - Study Area with Cross-sectional details

Figure shows the study area from Weir cum Causeway to Sardar Bridge. Following are the details of study area:

- Total numbers of cross sections are 24(CS-1 to CS-24).
- River reach length is 6kms i.e. 6000meters.
- Red line indicates cross-section in river reach.
- Average interval between cross-section to cross section is 250 meters,
- Upstream: Weir cum causeway Downstream: Sardar Bridge.

Figure 2 - Weir Cum causway

Figure 3 - Study Area

Figure 4 - Sardar Bridge

Figure 5 - Left Side Bank of Study Reach

III. HEC-RAS SOFTWARE

Originally designed in 1995, the United States Army Corps of Engineers HydrologicEngineering Center's River Analysis System (HEC-RAS) is "software that allows you to perform one-dimensional steady and unsteady flow river hydraulics calculations, sediment transport-mobile bed modelling, and water temperature analysis." The program solves the mass conservation and momentum conservation equations with an implicit linearized system of equations using Preissmann's second order box finite difference scheme. In a cross-section, the overbank and channel are assumed to have the same water surface, though the overbank volume and conveyance are separate from the channel volume and conveyance in the implementation of the conservation of mass and momentum equations. The simultaneous systems of equations generated for each time step are solved to develop specifically for steady or unsteady river hydraulics.Many people or we can say most of people in slum are going on daily basis wages as they don't have any other source of income, and what has been see in movies seems to be a bitter dramatically truth that 60% of the ladies over there have the same complaint that their husband or family member does not do anything else than alcoholic consumption. Therefore, how much income comes into their houses are 40 % only, in which they run their houses. There are much more Government properties available, railway tracks and water supply system are the examples of few objects involved. Due to unavailability of sanitation facilities they answer nature's call on rail tracks, since there is no wastage disposal facility the wastage is thrown in open space.

IV. HEC-RAS INPUT PARAMETER

HEC-RAS uses a number of input parameters for hydraulic analysis of the 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) as shown in Fig. 6. HEC-RAS subdivides the cross sections in this manner, because of differences in hydraulic parameters.

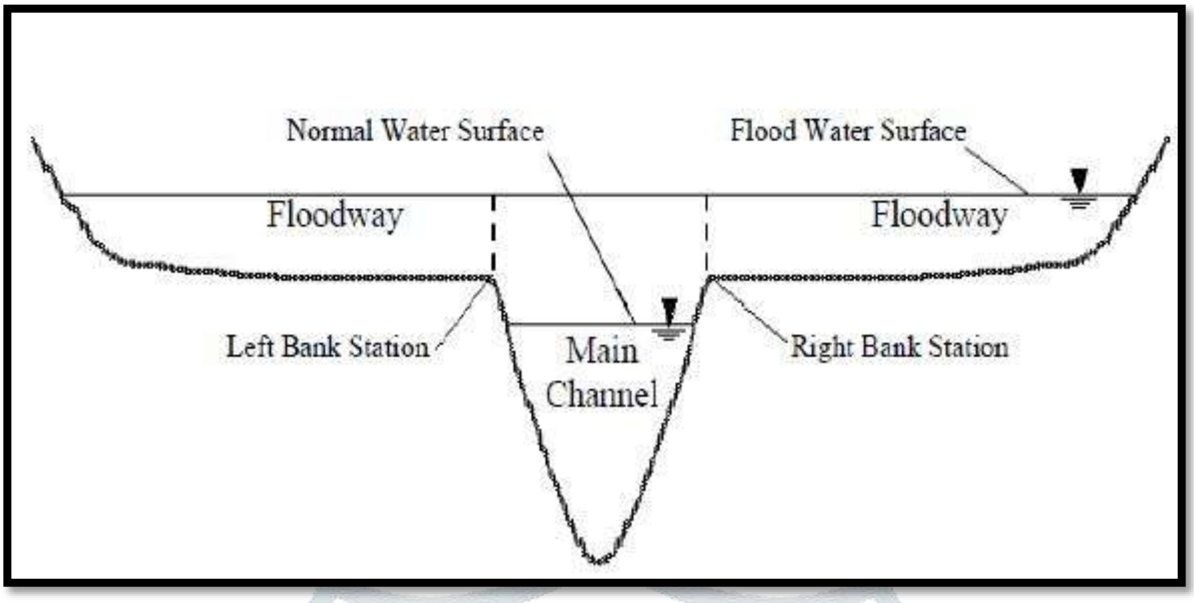

Figure 6 - Schematic daigram of stream channel

- **Data Requirements**

The function of the HEC-RAS program is to determine water surface elevations at all locations of interest. The data needed to perform these computations are separated into geometric data and steady flow data (boundary conditions).

- **Geometric Data**

The basic geometric data consists of establishing how the various river reaches are connected (River System Schematic); cross section data; reach lengths; energy loss coefficients (friction losses, contraction and expansion losses); and stream junction information. Surat Municipal Corporation (SMC) has provided the geometric data of the reach for present study as contour map in Auto CAD (.dwg file) format. The study reach is about 1080m long and has very mild slope. The effect of meandering has been neglected as there is no reasonable curvature seen in study reach by providing expansion and contraction coefficient as 0.3 and 0.1 respectively. Total 24 cross-sections at various important locations on the river have been used. The detailed configuration of study reach was respectivelycollected from Surat Municipal Corporation (SMC) and Surat Irrigation Circle (SIC), Govt. of Gujarat, India in the hard map format.

- **Cross sectional Data**

Boundary geometry for the analysis of flow in natural streams is specified in terms of ground surface profiles (cross sections) and the measured distances between them (reach lengths). Cross sections should be perpendicular to the anticipated flow lines and extend across the entire flood plain. Cross sections are requires at locations where changes occur in discharge, slope, shape or roughness; at locations where levees begin or end and at bridges or control structures such as weirs. Each cross section is identified by a Reach and River Station label. The cross section is described by entering the station and elevations (x-y data) from left to right, with respect to looking in the downstream direction.

- **Reach Length**

The reach length (distance between cross sections) should be measured along the anticipated path of the center of mass of the left and right over bank and the center of the channel (these distances may be curved).

V. HYDRAULIC REGIME

For evaluation of flood performance, past flood data collected from the SIC, Surat and also 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, 2002, 2006, 2007 and 2013. The summary of the floods is given in the 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

VI. METHODOLOGY

The input data require for 1-D analysis for carrying capacity of study reach, data collected from Surat Municipal Corporation are entered in HEC-RAS software. The study reach consists of 24 cross sections. The details like station number, elevation, Manning's roughness coefficient were entered in geometric data window of HEC-RAS software. After entering geometric data the necessary steady flow data can be entered. Steady flow data consists of number of profiles to be computed, flow data and the river system boundary conditions. To access the carrying capacity of particular section using hydraulic design function and uniform flow condition, input discharge of specific year in the software. Additionally, discharge can be changed at any location within the river system. Discharge must be entered for all profiles. A boundary condition must be established at the most downstream cross section for a subcritical flow profile and at the most upstream cross section for a supercritical flow profile. Based on this input data HEC RAS will compute section. The computed section is sufficient to carry input discharge if F.S.L is within the bank heights. If computed section is insufficient to carry input discharge software will develop levees on that bank which is overtopped by the input discharge. The above procedure is repeated for all the 24 sections.

Following are the steps for designing the river section:

Step 1: Create a new HEC-RAS project

Step 2: Create a new river and reach in the geometry editor window with steady flow analysis (Fig. 7)

River Name: Tapi

Reach Name: Weir cum causeway

Step 3: Enter Geometric Data

Step 4: After adding all data we get Geometric cross section (Fig. 7) in HEC RAS which issame as that collected from Surat Municipal Corporation.

Step 5: Enter the Manning's value for upstream Reach. In our project, value of n is taken as "0.022". The value of 'n' can be taken according to bed material of the river reach. **(K.Subramanyam, 2006).**

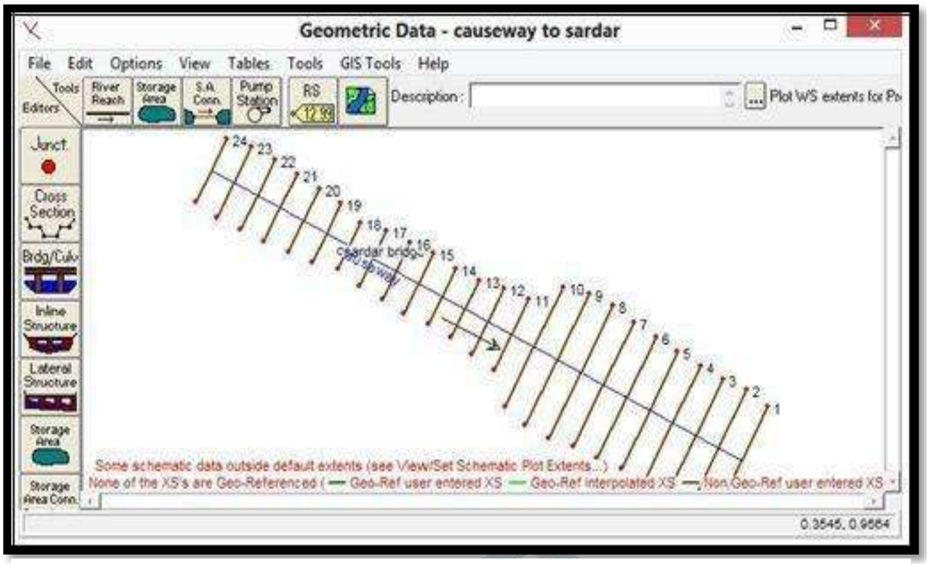

Figure 7 - Tapi River reach with Geometric Data

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 of:

- the number of profiles
- the flow data
- 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 past flood discharge of specific year to a selected section. Repeat this procedure for 24 sections.

Step 10: In the same window, after entering flood discharge of specific year click on computeicon.

Step 11: 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 banks and software will develop levees on that bank which is overtopped by the input discharge.

Step 12: Repeat steps 8 to steps 10 for all cross sections of study reach i.e. 24 cross sections.

VII. RESULT ANALYSIS

Data Analysis is the key tool in understanding the behavior of the river cross-sections under the effect of various flood events. After collecting all data of study reach, input all data for designing of river reach section in uniform flow and simulation is carried out using HEC-RAS and past flood event. In this study sufficiency of existing sections are accessed using two major flood events of historical floods. The section were classified as highly critical (where depth of water above existing bank is more than 0.7m), moderately critical (where depth of water above existing bank is between 0.4 to 0.7m) and critical (where depth of water above existing bank is up to 0.4m).The study of behavior of river cross-sections under various flood discharges along with tidal condition is carried out. The carrying capacity of study reach section is accessed for flood events.

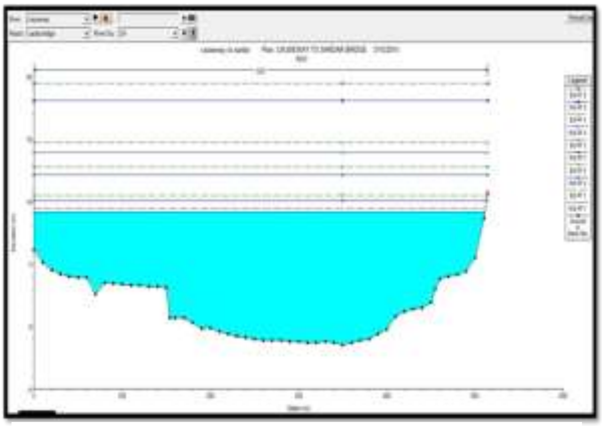

Figure 8 - Detail of Computed Section CS-1

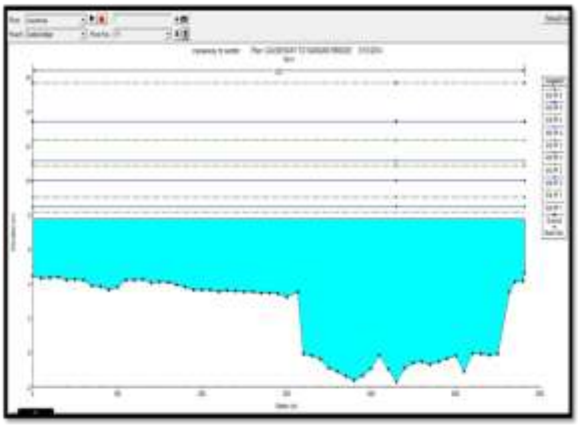

Figure 9 - Detail of Computed Section CS-11

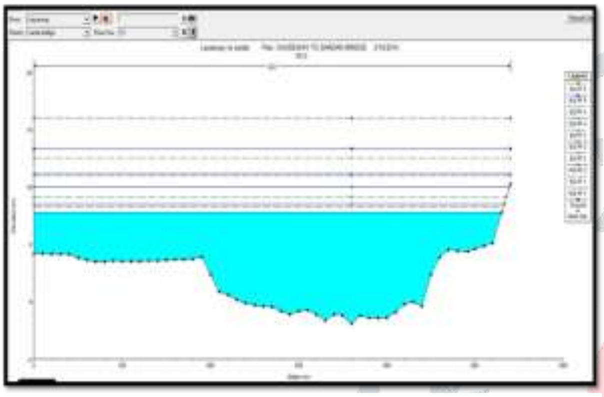

Figure 10 - Detail of Computed Section CS-12

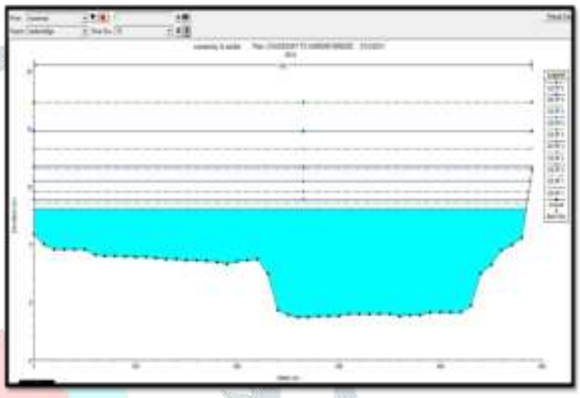

Figure 11- Detail of Computed Section CS-15

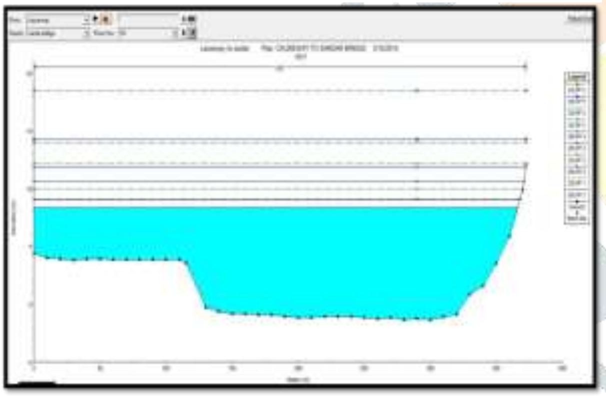

Figure 12 - Detail of Computed Section CS-18

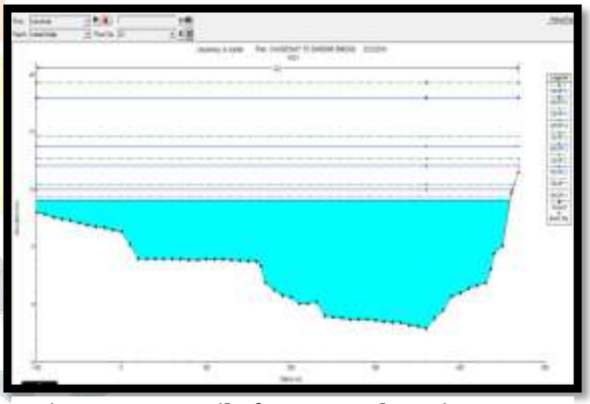

Figure 13 - Detail of Computed Section CS-22

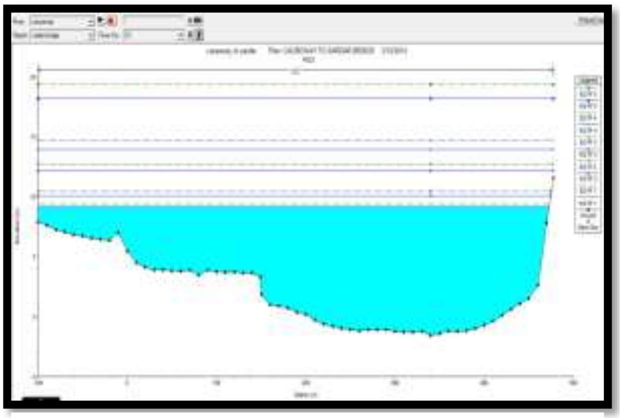

Figure 14 - Detail of Computed Section CS-23

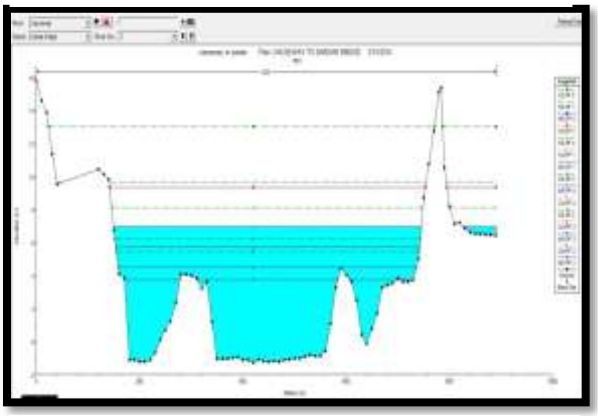

Figure 15 - Detail of Computed Section CS-24

- At Cross-section 11 for flow of 3.35, 4.62, 6.73, 9.10 and 15.6 lakhs cusec the cross-section is not sufficient to carry flow.

- At Cross-section 1, for flow of 3.35, 4.62, 6.73 lakhs cusecs the cross-section is sufficient to carry flow but when the flow is of 9.10 and 15.60 lakhs cusecs, the section is not capable of carrying the flow
- At Cross-section 12, for flow of 3.35, 4.62, 6.73 lakhs cusec the cross-section is sufficient to carry flow but when the flow is of 9.10 and 15.6 lakhs cusec, the section is not capable of carrying the flow.
- At Cross-section 15, for flow of 3.35, 4.62, 6.73 lakhs cusec the cross-section is sufficient to carry flow but when the flow is of 9.10 and 15.6 lakhs cusec, the section is not capable of carrying the flow.
- At Cross-section 18, for flow of 3.35, 4.62, 6.73 lakhs cusec the cross-section is sufficient to carry flow but when the flow is of 9.10 and 15.6 lakhs cusec, the section is not capable of carrying the flow.
- At Cross-section 22, for flow of 3.35, 4.62 lakhs cusec the cross-section is sufficient to carry flow but when the flow is of 9.10, 6.73 and 15.6 lakhs cusec, the section is not capable of carrying the flow
- At Cross-section 23, for flow of 3.35, 4.62 lakhs cusec the cross-section is sufficient to carry flow but when the flow is of 9.10, 6.73 and 15.6 lakhs cusec, the section is not capable of carrying the flow.
- At Cross-section 24, for flow of 3.35, 4.62 lakhs cusec the cross-section is sufficient to carry flow but when the flow is of 9.10, 6.73 and 15.6 lakhs cusec, the section is not capable of carrying the flow.

Conclusion & 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.
- 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
- It is strongly recommended that the sections, which water overtops over the existing embankment or retaining wall need to be raised.
- Due to urbanization, some natural drainage is blocked by constructions such as Airport and Shipyard. If such constructions are must to be build up then alternate routes must be provided for natural drainages to flow.
- It is strongly recommended that the width of the river in no case be encroached as already sections are sensitive to high floods, encroachment will result in flooding of study region.

Acknowledgment

Authors are thankful to Principal and Director, Shree Swami Atmanand Saraswati Institute of Technology, Surat. Authors are also thankful to Principal, Government Engineering College, Rajkot. The authors are also grateful to Surat Municipal Corporation for providing data as well as information regarding flood occurred in Surat City.

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