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Discharge Carrying Capacity of River Banks-Validation of model

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Abstract: *Discharge carrying capacity of river in downstream is one of the important factors responsible for flood in urban area. This paper present comparison of discharge carrying capacity of river Tapi calculated by developing programme in Microsoft Excel in aid of visual basic with observed data at various location along river length. Validation of model shows that calculated discharge is close to observed discharge at respective stations. Output of the work helps to warn people about flood likely to occur and rescue plan can be prepared to save human lives and valuable property of low lying area.*

Key Words: Discharge, River bank, Tapi, Flood

I. INTRODUCTION

Flooding constitutes the most prevalent and costly natural disaster in the world [1]. India too has been suffering heavily due to flood. Tapti is one of the large perennial rivers in western India. It is 724 km long originating from Multai in Betul district of Madhya Pradesh. It meets Arabic see near Surat[2]. Total catchment area of the Tapti river basin is 65,145 kms^2 including about 79%, 15%, and 6% in Maharastra, MP, and Gujarat respectively.

Flood inundation models are a major tool for mitigating the effects of flooding. They provide predictions of flood extent and depth that are used in the development of spatially accurate hazard maps. These allow the assessment of risk to life and property in the floodplain, and the prioritisation of either the maintenance of existing flood defences or the construction of new ones[3].

II. SURAT ON TAPI

The city of Surat, located on the western part of India in the state of Gujarat on the River Tapi, is an important historical trade centre and trade link between India and many other countries. The city has one of the highest proposed investments and almost zero percent unemployment. It is one of the fastest growing cities in India. [4]

In the early past, hardly any incident of flood was reported because of no development of surrounding areas. But in last 10 to 15 years developmental activities took place which resulted in construction of roads, buildings and bridges near or across river banks.[5]

In the catchment area of Tapi river the monsoon generally starts during the third week of June and there are occasional heavy rainstorms from the beginning of August to the end of September. The mean annual rainfall in the basin is estimated to be about 758 mm. and the average monsoon rainfall from 1988 to 1998 was 897 mm. The maximum annual rainfall (1168 mm) and the minimum of (257 mm) were recorded in 1944 and 1899. Most of the floods in Tapti occurred during August [6].

III. HISTORY OF FLOOD IN SURAT

In the catchment area of Tapi heavy stormy rainfall when it occurs generally lasts for the period of three days during monsoon. This combined with low banks in the lower catchment of the river in Gujarat results in frequent overflowing of the river causing major floods and damage. In the ninety-four years, from 1876 to 1970, the Tapi crossed the danger level at Hope Bridge in Surat for 19 times, i.e., on an average every five years. However, the floods were not regular. The 1968 flood had been the biggest flood with peak flow of about 15 lakh cubic feet of water per second (Cusecs). The flood in 1970 too was quite big with a peak flow of 13.14 lakh cusecs. To prevent repeated floods in Surat, a major Dam was constructed in 1972 at village of Ukai, which is located about 100 km upstream of Surat. According to the introductory booklet published by the State Government on the Ukai Project describes that the project would provide effective protection against floods to Surat city and other downstream areas. It would be possible to release water from reservoir in advance in a regulated manner, as soon as warning of the approaching flood is received from the upstream areas. This would create adequate space in the reservoir to store floodwaters.

IV. METHODOLOGY

In order to find out discharge carrying capacity of each river cross-section manually by following continuity equation requires velocity at particular section. And in order to find out velocity Manning's equation is used.This procedure for

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ample number of cross sections is very labourious and time consuming. As a replacement of it programme in Microsoft Excel in aid of visual basic has been prepared to determine discharge of various sections. Roughness coefficients represent the resistance to flood flows in channels and flood plains. The results of Manning's formula, an indirect computation of stream flow, have applications in flood-plain management, in flood insurance studies, and in the design of bridges and highways across flood plains.**[7]** When actual stream velocity measurements are not available, the velocity can be calculated using Manning's Equation. Manning's Equation is an open channel flow equation used to find either the depth of flow or the velocity in the channel where the channel roughness, slope, depth, and shape remain constant (Steady Uniform Flow). The depth of flow using Manning's Equation is referred to as the normal depth and the velocity is referred to as the normal velocity. The geometry involved in solving Manning's Equation can be complex and consequently, a direct mathematical solution for some channel shapes is not possible. Instead, a trial and error approach may be necessary. Various design tables are available to assist in these solutions as well as several personal computer programme[8]

:DISCHARGE CARRING CAPACITY AT DIFFERENT R.L.IN Mt.:

N value:	0.0400		Max GL of section:	10.470 m.	
S value:	0.000893	(1 IN 1120.00)			
Design Q :	25768.09	cumec(910000ft³/s)	Min GL of section:	-3.10 m.	
% Q :	25768	cumecs 100			

Sr. No.	R. L. in m	Area in m² A	Perimeter in m P	R= A/P	2/3 R	Velocity in m/s V=1/NxRxS	Discharge in m³/sec Q = A x V	Disch. in %	
1	1.502	842.71	287.81	2.93	2.05	1.53	1288.40	5	%
2	3.047	1292.11	296.23	4.36	2.67	1.99	2576.81	10	%
3	4.100	1612.43	359.76	4.48	2.72	2.03	3274.33	15	%
4	5.830	2651.40	631.71	4.20	2.60	1.94	5153.62	20	%
5	6.460	3052.60	642.89	4.75	2.83	2.11	6442.02	25	%
6	7.017	3410.11	645.08	5.29	3.03	2.27	7730.43	30	%
7	7.537	3745.29	647.12	5.79	3.22	2.41	9018.83	35	%
8	8.028	4062.53	649.05	6.26	3.40	2.54	10307.23	40	%
9	8.495	4364.94	650.88	6.71	3.56	2.66	11595.64	45	%
10	8.942	4655.49	652.88	7.13	3.70	2.77	12884.04	50	%
11	9.375	4937.57	655.56	7.53	3.84	2.87	14172.45	55	%
12	9.792	5210.38	658.14	7.92	3.97	2.97	15460.85	60	%
13	10.194	5475.00	660.64	8.29	4.10	3.06	16749.26	65	%
14	10.581	5729.85	662.34	8.65	4.21	3.15	18037.66	70	%
15	10.948	5972.02	662.34	9.02	4.33	3.24	19326.07	75	%

Fig.:1 – Print Screen showing key for n, S and Q

For finding out discharge carrying capacity of any section, calculated discharge value is selected for respective section. Bed slope (S) is worked out for each section manually and its values for different sections are already put in the programme by Key menu. The box of 'n' 'S' and 'Q' is shown in Fig.1

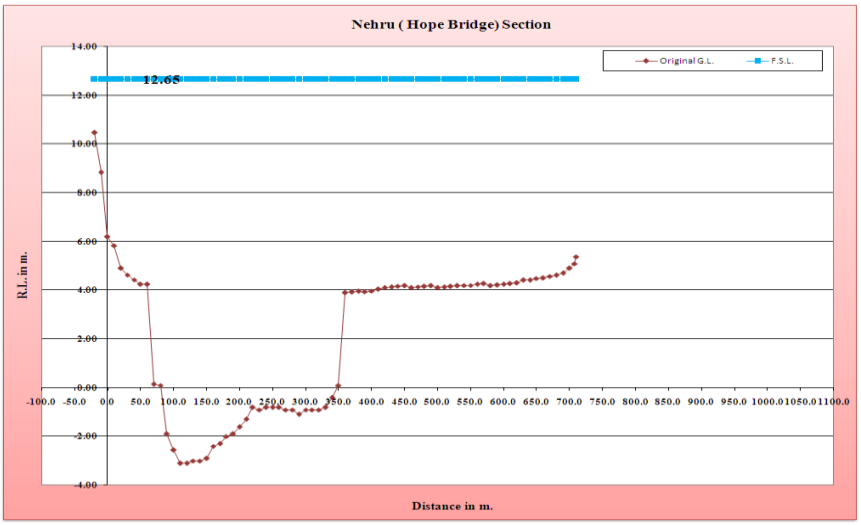

Fig.:2Print Screen Showing Cross-Section of River Tapi near Nehru (Hope) Bridge as Q 25768.09 m^3/s (9.1 Lakh Cusecs)

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For case study a river section near Nehru Bridge is taken and different value of assumed discharge is put. For a value 25768.09 m^3/s (9.1 Lakh Cusecs) is used to see water level at this section. The water level at this section is shown by blue line, which shows water level at 12.65 m .See Fig.2

By taking discharge 25768.09 m^3/s (9.1 Lakh Cusecs) the water level does not touch to the bank height but it is above from lowest bank height.By taking less value than the discharge taken earlier, run the programme and see position of blue line, until it touches to the lowest point of the either bank height.When water level i.e. blue line touches lowest bank height read the value of area A, perimeter P, and hydraulic radius R from the column D, E, and F respectively.The value of velocity is obtained from column 'H ', Manning's equation is used for it.The maximum discharge of the given section is obtained by using continuity equation and in the programme it is seen in column 'I'.Column 'J' gives the percentage discharge that the section can carry at different water level. According to water level i.e. blue line indicates possible discharge the section can carry in the percentage.For the section near Hope Bridge the maximum discharge is found out by running the programme making number of trials. The maximum carrying capacity is found 4530.65 m^3/s (1.6 Lakh Cusecs) and river level 5.51 m., see Fig.3 and Fig.4

:DISCHARGE CARRING CAPACITY AT DIFFERENT R.L.IN Mt.:

N value:	0.0400		Max GL of section:	10.470 m.
S value:	0.000893	(1 IN 1120.00)		
Design Q :	4530.65	cumec(160000ft³/s)	Min GL of section:	-3.10 m.
% Q :	4531	cumecs 100		

Sr. No.	R. L. in m	Area in m² A	Perimeter in m P	R= A/P	2/3 R	Velocity in m/s V=1/NxRxS	Discharge in m³/sec Q = A x V	Disch. in %	
1	-0.522	282.53	254.08	1.11	1.07	0.80	226.53	5	%
2	0.074	438.55	269.65	1.63	1.38	1.03	453.06	10	%
3	0.544	569.92	282.59	2.02	1.60	1.19	679.60	15	%
4	0.930	679.31	284.70	2.39	1.79	1.33	906.13	20	%
5	1.279	778.70	286.59	2.72	1.95	1.45	1132.66	25	%
6	1.600	870.83	288.35	3.02	2.09	1.56	1359.20	30	%
7	1.900	957.38	289.98	3.30	2.22	1.66	1585.73	35	%
8	2.184	1039.45	291.52	3.57	2.33	1.74	1812.26	40	%
9	2.453	1117.81	292.99	3.82	2.44	1.82	2038.79	45	%
10	2.710	1193.02	294.39	4.05	2.54	1.90	2265.33	50	%
11	2.957	1265.54	295.73	4.28	2.64	1.97	2491.86	55	%
12	3.195	1335.70	297.03	4.50	2.72	2.04	2718.39	60	%
13	4.569	1867.06	608.53	3.07	2.11	1.58	2944.92	65	%
14	4.722	1960.36	615.10	3.19	2.17	1.62	3171.46	70	%
15	4.868	2050.54	620.63	3.30	2.22	1.66	3397.99	75	%
16	5.004	2134.65	622.93	3.43	2.27	1.70	3624.52	80	%
17	5.134	2215.69	624.31	3.55	2.33	1.74	3851.05	85	%
18	5.262	2294.98	625.66	3.67	2.38	1.78	4077.59	90	%
19	5.386	2372.66	626.99	3.78	2.43	1.81	4304.12	95	%
20	5.508	2448.83	628.28	3.90	2.48	1.85	4530.65	100	%

Fig.:3,Print Screen showing Discharge 4530.65 m^3/s (1.6 Lakh Cusecs)

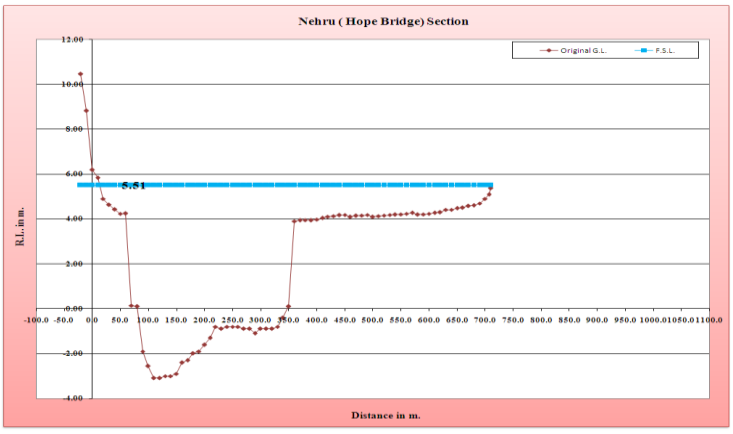

Fig.:4 Print Screen Showing Cross-Section of River Tapi near Nehru Bridge as Q 4530.65 m^3/s (1.6 Lakh Cusecs)

V RESULTS

Repeating above procedure for all 310 sections and changing discharge values which contain water within bank height discharge carrying capacity of each sections worked out and represented by bar chart as shown in fig.5

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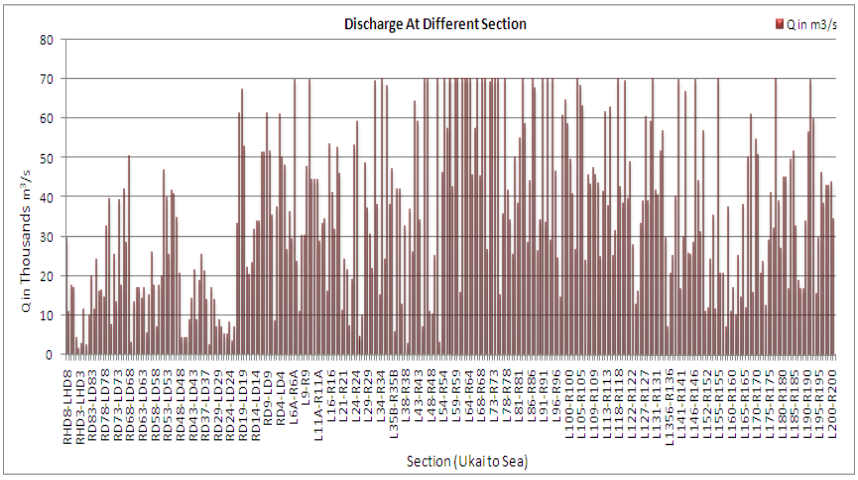

Fig.:5 Discharge carrying capacity of all sections of river Tapi

VI. VALIDATION OF MODEL

Urban flood models simulate the connection between surface and inflow with an internal boundary condition (IBC). The inlets IBC used can vary from model to model and they are not equivalent nor do they provide the same results[9]. (Leandro et al. 2009a); these can be an orifice, a weir, a combination of both[10] or a combination of different control sections depending on the geometry[11] . For validation of the software we plotted graph of time in date versus gauge level in meter and time in date versus discharge in Lakh Cusecs. Both these graphs are plotted combine indicating time (in date) on horizontal axis and gauge level in meter at left vertical axis and discharge in Lakh Cusecs at right vertical axis, the combined graph is shown in Fig.6.

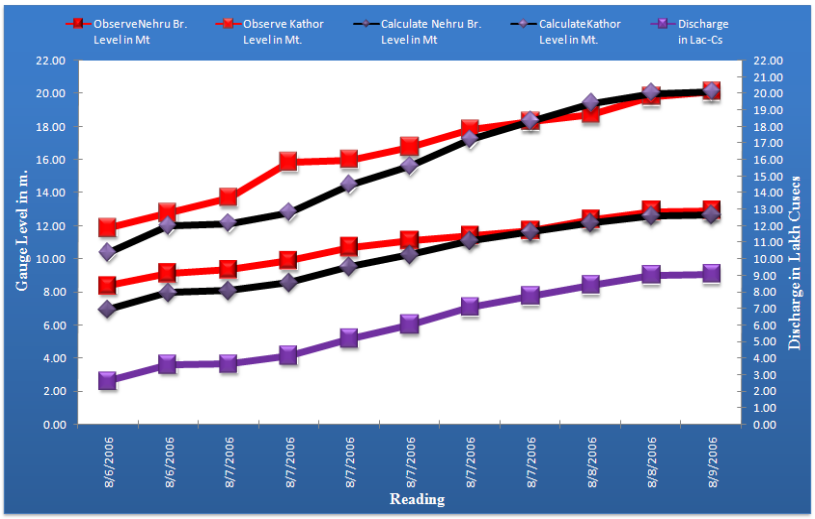

Fig.:6 Comparison of River gauge level @ Nehru Bridge, Kathor

Two river gauges station namely Kathor and Nehru Bridge are considered for validation of the discharge carrying capacity of the river at different section .At Nehru bridge observed river gauge level was 7.0m on date 06/08/2006 and increased up to 12.50 m as per SMC on date 09/08/2006. Our calculations indicate it 8.2 m and 12.65 m for the same period. Same way observed river gauge level at Kathor on date 06/08/2006 was 10.4 m and increased to 20m on date 09/08/2006. We got calculated river gauge level for the same time 12.1 m and 20.19 m respectively. Hence observed river gauge level and calculated river gauge level with help of software at Nehru bridge for lower discharge range 6230 m^3/s (2.20 Lakh Cusecs) to 12175 m^3/s (4.3 Lakh Cusecs) differ by small amount. But when discharge increases from

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this range both the values come closer. Like wise at Kathor for low discharge range the observed and calculated river gauge level are differing, storage of water at Singanpur weir may be the factor responsible for it. For discharge more than 17000 m^3/s (6.0 Lakh Cusecs) both the observed and calculated river gauge level are matching with one another. It implies that software developed for measuring maximum carrying capacity of each section gives reliable results.

VII. CONCLUSION

Software developed in Microsoft Excel for finding out maximum carrying capacity of the river gives very reliable results.The river hydraulic data are very useful for analysis, narrowing of the Tapi river is revealing one. 40 years back it could carry 28310 m^3/s (10 Lakh Cusec) of water. It has been reduced to 9910 m^3/s (3.5 Lakh Cusecs). After the flood of 2006 our analysis shows that the safe carrying capacity of river near Surat is reduced to 4531 m^3/s to 5660 m^3/s (1.60 to 2.0 Lakh Cusecs).

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