International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 03 Issue: 06 | June -2019 ISSN: 2590-1892

MATHEMATICAL MODEL EVALUATING FLOOD PROTECTION WORKS OF DIFFERENT KHADS IN JASWAN PRAGPUR CONSTITUENCY, H.P.

Arun Kumar[1], Rushikesh Ingale[2] , Shreya Atram[3], Niraj Bongirwar[4], Khushi Gill[5]

[1]Scientist B Central Water and Power Research Statio, Pune
[2]BE Student, Civil Department of D Y Patil College of Engineering, Pune
[3]BE Student, Civil Department of D Y Patil College of Engineering, Pune
[4]BE Student, Civil Department of D Y Patil College of Engineering, Pune

[5]BE Student, Civil Department of D Y Patil College of Engineering, Pune

---***---

Abstract - The River area are the main region where the large community settles and carries out the farming activities. So as to safeguard the property along the river bank the river bank protection work is required. In this study the detailed research work is carried in order to study the river flow pattern, the river profile so as to determine the measures to be taken to provide river bank protection. Riverbank erosion is due to the flood occurring during the rainy season has progressively been affecting more and more people as population is increasing over the time near the Beas River in Himachal Pradesh. As there are fourteen different Khads/ Tributaries and they are interconnected with physical phenomenon, riverbank erosion and flood has unique consequences over the affected people and farming activities. The major impact is on the farming along the sloping areas along bank and also to villages and towns nearby the river bank. HEC-RAS Hydraulic Engineering Centre River analysis system is the software which is used for controlling flood. So the mathematical model is used to evaluate the flood level in the river for 25 and 50 year return flood period so as per the different river bank protection work can be provided.

Key Words**:** HEC-RAS, Highest flood level (HFL), Khads, manning's coefficient (n), Synthetic Unit hydrograph.

1. INTRODUCTION

The hilly region rivers are with steep slopes and the cross section of river is also different at various locations depending on the geographical and geological features of the terrain. The rise in the water level is also sudden due various factors which cause the flood to occur leading to environmental and public damages. It also leads to the bank erosion which causes damage to the public property, vegetation along the river bank. The Beas River is located in the Pargpur Constituency of Kangra district in Himachal Pradesh. The river bank is been facing the problem of bank erosion constantly, due to which the property along the river bank is being getting damaged. Therefore there is need to provide bank protection work so as to safeguard the bank from getting eroded. The mathematical model (HEC-RAS) is used to determine the flood pattern of river so as to provide the protection for bank respectively.

1.1 The Study Area

The Beas River is a River in North India. The river rises in the Himalayas and flows for some 470 kilometers to Sutlaj River in Indian state of Punjab. Its drainage basin is 20,303 square kilometer large. It is located in the Mandi plain and its average discharge is 499.2 cumecs. The hilly region rivers are with steep slopes and the cross section of river is also different at various locations depending on the geographical and geological features of the terrain. The water of the Beas River is allocated to India under the terms of the Indus water treaty between India and Pakistan. The study area falls under Kangra district and Pragpur constituency. The soil of Pragpur constituency is loamy, clay and sandy. The soil is very fertile for agriculture crops. The water retaining capacity is moderate. The geographical area of the constituency is 6876 Ha, agriculture land is 1795 Ha, barren land is 943 Ha and uncultivated is 943 Ha. The constituency has a total of 15 panchayats with a population of 34116, as the area is with settlement of people and various activities are carried out so the banks of the river should be protected as to safeguard the property

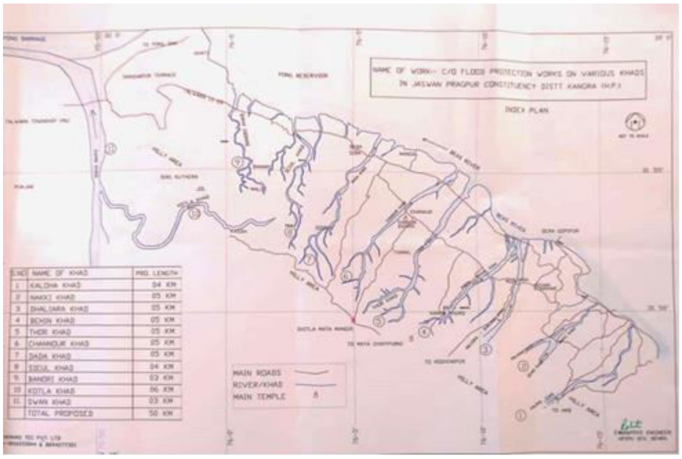

Figure 1: Index Plan of Beas River and tributaries

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 03 Issue: 06 | June -2019 ISSN: 2590-1892

2. METHODOLOGY

The research is conducted through HEC-RAS one dimensional approach. Data was retrieved from government in the form of topographic maps, catchment area, rainfall data (annual data), highest flood level (HFL), Manning's coefficient, 25 years maximum intensity of rainfall, RLs of various points and river flow pattern. This hydrographical and catchment data is based on khads present in particular area. The nature of riverbed and the flow of river water is analyze and evaluate. The rainfall data is also used for the analysis of flood frequency of the area. By using maximum rainfall data discharge is computed. This computation includes peak discharge, runoff coefficient, rainfall intensity and catchment area. The input data required for 1 D analysis is introduced in HEC-RAS software. The study reach consists of 14 Khads. The details like station number, elevation, Manning's roughness coefficient are entered in geometric data window of HEC-RAS software. After entering geometric data the necessary steady flow can be entered. Steady flow data consists of no. profiles to be complete, flow data and river system boundary condition. 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 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 HECRAS will compute section. The computed section is sufficient to carry input discharge if FSL is within the bank heights. If computed section is insufficient to carry input discharge then software will develop levees on that bank which is over topped by the input discharge. The above procedure is repeated for all the khads.

3. HEC- RAS

HEC-RAS is a computer program which simulates water flow through natural and man-made channels. It is one – dimensional model developed by the US department of defense, arms corps of engineers in order to manage the rivers, harbors and other public works under their jurisdiction .it has found wide acceptance by many others since its public release in 1995. HEC-RAS is equipped to model a network of channels, a dendritic system or a single river reach. Certain simplification must be made in order to model some complex flow situations using HEC-RAS one dimensional approach. It is capable of modeling subcritical, supercritical and mixed flow region flow along with the effects of bridges, culverts, weirs and structures.

4. HYDROLOFICAL ANALYSIS

Based on the hydrological and catchment area data of River Beas and other tributaries/ khads, the flood frequency analysis was carried out to determine the peak flood discharge for 25 year and 50 year return period flood. Two approaches were made to determine the flood frequency;

i) Rational Method and Gumbel's method of flood frequency analysis.
ii) Synthetic Unit Hydrograph Method.

Rational Method and Gumbel's method of flood frequency analysis is used to determine the flood peak or discharge for the Khads having area less than 25 km^2 , Synthetic Unit Hydrograph Method is used to determine the peak flow/ discharge of the Khads having area more than 25 km^2. For study purpose the Bannori Khad is taken out of the different tributaries and the Rational Method, Gumbel's method of flood frequency is used to determine the discharge for 25 and 50 year return flood period.

As per the rainfall intensity given from January 1991 to December 2017 (Annexure A) the discharge is computed and is tabulated in Table 1.

Sr no	Tributary Name	Catchment Area, km^2	Discharge, m^3/s (25 yr return period)	Discharge, m^3/s (50 yr return period)
1	Bannori Khad	17.66	292.16	314.54

Table 1: Discharge of 25 and 50 year return period flood

5. RESULT AND DISCUSSION

A) Geometrical data

Banoori Khad:

The geometrical data of the River/Khads consisting of the cross section at different stations along the alignment were introduced in the model so as to obtain the cross section. The structures like bridges across the Khad are also introduced in the model so as to analyze the flow pattern in the river. The Figure 2 shows the output of the model for corresponding geometric data of River Banoori.

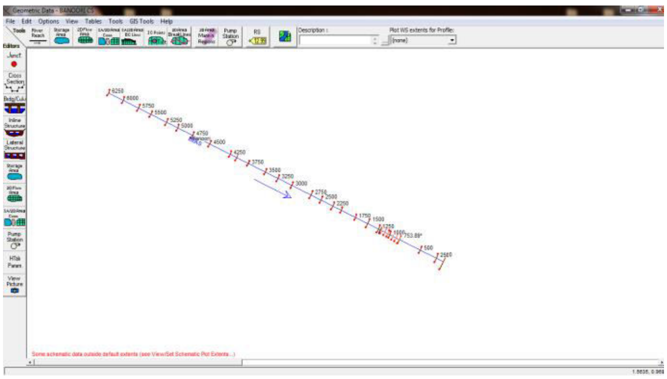

Figure 2: Banoori Khad geometic profile

B) Steady flow Data

The intensity of flood for 25yr and 50yr return period are determined using the rational method and gumbel's method of flood distribution. The corresponding discharge along with the known water surface level was substituted in the model. The calculated discharge as per the intensity of rainfall is being shown in the Table1.

C) Run the Model

The model is been run for Sub critical flow and is computed for the discharge for 25yr and 50yr return period. The profile output tables showing the discharge, computed HFL, velocity of flow of water are being displayed. The results are for 25 yr flood return period, as displayed in form of Table 2 as shown.

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Vel Chnl (m/s)
Banoori	6250	25 yr FF	292.16	609.91	612.07	4.08
Banoori	6000	25 yr FF	292.16	601.11	603.52	4.42
Banoori	5750	25 yr FF	292.16	590.60	593.09	4.37
Banoori	5500	25 yr FF	292.16	581.00	583.46	4.44
Banoori	5250	25 yr FF	292.16	570.18	572.52	3.88
Banoori	5000	25 yr FF	292.16	560.36	562.93	4.34
Banoori	4750	25 yr FF	292.16	551.10	553.58	4.22
Banoori	4500	25 yr FF	292.16	542.29	544.80	4.53
Banoori	4250	25 yr FF	292.16	532.12	534.49	4.21
Banoori	4000	25 yr FF	292.16	523.89	526.15	4.14
Banoori	3750	25 yr FF	292.16	517.99	520.21	3.12
Banoori	3500	25 yr FF	292.16	513.38	516.01	3.84
Banoori	3250	25 yr FF	292.16	508.84	510.88	3.86
Banoori	3000	25 yr FF	292.16	503.76	506.33	4.75
Banoori	2750	25 yr FF	292.16	496.25	498.51	4.00
Banoori	2500	25 yr FF	292.16	490.82	493.07	3.91
Banoori	2250	25 yr FF	292.16	483.39	485.45	3.96
Banoori	2000	25 yr FF	292.16	475.91	477.56	3.97
Banoori	1750	25 yr FF	292.16	468.42	470.55	4.25
Banoori	1500	25 yr FF	292.16	461.11	462.49	3.53
Banoori	1250	25 yr FF	292.16	455.39	458.94	2.45
Banoori	1210		Bridge			
Banoori	1179.07*	25 yr FF	292.16	454.00	456.40	4.18
Banoori	1108.14*	25 yr FF	292.16	452.61	454.79	4.03
Banoori	1037.21*	25 yr FF	292.16	451.22	453.10	3.86
Banoori	1000	25 yr FF	292.16	450.49	452.20	3.75
Banoori	917.96*	25 yr FF	292.16	448.72	450.28	3.61
Banoori	835.93*	25 yr FF	292.16	446.95	448.37	3.48
Banoori	753.89*	25 yr FF	292.16	445.17	446.53	3.14
Banoori	750	25 yr FF	292.16	445.09	446.57	2.81
Banoori	500	25 yr FF	292.16	439.70	441.49	3.49
Banoori	250	25 yr FF	292.16	430.82	432.33	3.22
Banoori	0	25 yr FF	292.16	423.80	424.61	2.59

Table 2 : Mathematical model output

D) Validating/ Proving the model

The maximum output discharge in the River Banoori for the corresponding observed High Flood Levels (HFL) was not available. However, the observed HFL were supplied by the authorities and were compared with the computed HFL from the model at the various bridges across the Banoori River. The comparison is presented in Table 3.

Sr no.	River/ Khad	Bridge at RD m	Water level RL, m (CWPRS, PUNE)	Water level RL, m (HEC-RAS)	Difference m
1.	Banoori Khad	1210	452.77	453.49	-0.72

Table 3: Comparison of water levels obtained from model and that observed water level

It is been seen that the computed water level from the mathematical model is nearly matching with the observed HFL. It is also noted that the discharge given by the authorities were computed on basis of empirical formula and on the observation of water marks left by the water on the bridge piers, the correlation of these data with the mathematical model results are not appropriate. However, by varying the manning's value 'n' from 0.030 to 0.045 for Banoori Khad the water levels computed are tried to match with the observed water level by varying the manning's 'n' value and thus the model is been validated.

The hydraulic parameters required for the design of flood protection works extracted from the mathematical model are given in Table 4.

		25 yr return flood period	25 yr return flood period	25 yr return flood period
Sr no.	Name of Khad	Average depth of flow, m	Average velocity of flow, m/s	Average discharge intensity, $m^3/s/m$
1	Banoori Khad	1.29	3.9	5.03

Table 4: Hydraulic parameters of river Banoori for flood of 25 return period discharges

E) Flood protection measures

Based on different hydraulic parameters extracted from the 1-D mathematical model (HEC-RAS), following flood protection measures in the form of embankments or direct bank protection works can be designed and provided. These embankments/banks are proposed to be protected with regular stone crated protection works in the form of dressed sloping bank, launching apron, toe wall on river side.

6. CONCLUSIONS

The study is attempted to apply the HEC-RAS model to compute the Water surface profile through steady flow analysis. The output from the mathematical model is computed with the observed data to analyze the water level in the river for 25 year return flood period. The parameters required for the design of the flood protection work are extracted from the model.

The findings from this study are used to provide bank protection in form of embankments, launching apron to safeguard the nearby vicinity along the bank of the Banoori River. The HEC-RAS (Hydraulic Engineering Centre River Analysis System) can be used to predict the flood conditions and suitable measures to control the flood.

ACKNOWLEDGEMENT

The authors acknowledge the Head of Department of Civil Engineering, D Y Patil College of Engineering, Pune and also we wish to express our deep sense of gratitude to Central Water and Power Research Station (CWPRS), Khadakwasla, Pune, for providing us with this work.

ANNEXURE A

Max-Daily in Month Rainfall Data (in mm) Site:- Dehra Distt Kangra (HP)

Year/Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec.
1991	0.0	33.8	19.2	17.6	17.6	68.8	71.5	72.0	73.7	0.0	0.0	25.7
1992	18.0	21.1	21.1	2.9	32.0	31.6	29.6	55.4	77.1	0.0	0.0	24.5
1993	22.3	17.5	45.2	12.0	9.5	47.0	90.5	41.0	41.3	0.0	11.2	0.0
1994	6.4	33.0	0.0	16.8	14.6	20.0	50.4	64.4	36.1	0.0	0.0	9.2
1995	48.0	16.0	16.8	8.0	0.0	4.8	36.0	112.8	47.1	0.0	0.0	4.1
1996	36.2	20.0	15.4	5.9	40.3	14.4	63.4	63.8	45.3	0.0	0.0	9.8
1997	64.8	14.0	61.0	68.8	18.4	34.4	68.8	76.8	70.4	16.8	25.6	32.8
1998	0.0	7.2	32.8	9.6	17.6	64.0	73.6	48.5	78.6	37.8	0.0	12.3
1999	40.2	12.3	3.2	0.0	13.3	42.6	65.9	64.5	39.0	0.0	4.7	5.1
2000	3.2	37.8	15.4	5.9	10.7	68.3	45.9	40.3	20.2	0.0	2.1	0.0
2001	17.8	0.0	20.0	16.2	6.6	10.0	20.2	16.4	6.8	0.0	4.5	2.9
2002	2.5	8.5	15.5	12.5	4.5	5.5	7.2	17.8	28.7	5.2	0.0	6.0
2003	3.2	4.3	3.5	6.3	1.7	8.0	13.8	13.8	14.0	0.0	3.5	3.9
2004	0.5	82.0	13.5	2.0	2.0	75.5	51.0	57.6	42.0	14.5	0.5	12.5
2005	4.0	47.2	19.2	7.4	13.4	85.4	57.4	40.5	25.3	0.0	2.6	0.0
2006	11.0	0.0	11.3	0.0	9.2	6.8	18.3	21.2	32.0	4.7	3.2	4.7
2007	0.0	52.4	22.0	12.2	8.2	55.2	85.3	45.5	12.2	4.2	0.0	0.0
2008	0.0	7.2	32.8	9.6	17.6	61.5	101.6	45.6	39.6	6.0	0.0	24.5
2009	2.0	28.0	29.2	31.5	19.6	25.5	134.0	47.6	79.6	7.6	8.4	0.0
2010	2.8	17.9	0.0	0.7	35.0	48.3	55.7	37.1	130.9	28.4	12.6	33.2
2011	0.0	14.5	11.0	2.5	17.0	40.5	92.0	83.0	22.0	0.5	0.0	4.0
2012	57.0	13.0	5.2	25.6	0.5	5.6	77.0	64.0	71.0	0.0	2.0	15.5
2013	0.4	65.6	10.8	1.6	1.6	60.4	40.8	54.5	33.6	11.6	0.4	10.0
2014	0.0	25.6	21.6	24.0	27.6	19.6	46.0	90.4	50.4	14.4	0.0	64.4
2015	25.2	26.0	95.6	14.4	23.6	19.6	48.8	46.8	23.6	18.0	1.2	15.2
2016	35.0	18.0	16.0	10.0	0.0	6.0	41.0	80.0	27.0	0.0	0.0	10.0
2017	14.3	12.8	11.7	12.0	9.5	27.0	70.6	41.0	41.3	0.0	11.2	0.0
Max Daily in a Month	64.8	82.0	95.6	68.8	40.3	85.4	134.0	112.8	130.9	37.8	25.6	64.4

Sources:- Department of Agriculture (H.P.)

A) Maximum Rainfall Intensity From January 1991 to December 2017

REFERENCES

1. River bank erosion and mitigation strategies in Vietnam, Gerrit J. Klaassen, Krystian W. Pilarczyk, Dinh Cong San (Southern Institute of Water Resources Research, Center for River Training & Natural Disaster Prevention, Ho Chi Minh City, Vietnam)
2. River bank protection measures in the Brahmaputra-Jamuna River: Bangladesh Experience, Maminul Haque Sarker (jakia_cegis@yahoo.com), and Md. Ruknul Ferdaous (Center for Environmental and Geographic Information Services (CEGIS), Dhaka, Bangladesh)
3. Application of two-dimensional hydraulic modeling in riverine systems using HEC-RAS, Abdulaziz Saeed Alzharani, University of Dayton.
4. Design of a Bank Protection System on River Brahmaputra at Jamuguri, Dr. Sujit Kumar Dash, Dr. S. Dutta1, Dr. S. Sreedeep and Prof. G. V. Rao.
5. Flood Control and Prediction of Flood Using HEC-RAS – A Review, Sania Modak , Prashant Nagarnaik.
6. Dynamic flood routing and unsteady flow modelling: A Case Study of upper KRISHNA RIVER, Doiphode Sanjay L, Oak Ravindra A.
7. Flood Estimation report for western Himalayas- Zone 7
8. Handbook for flood protection, anti-erosion and river training works by Central Water Commission (CWC), 2012.