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Study of Flood Frequency for Tan River at Station Amba, Gujarat

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ABSTRACT

A flood frequency analysis of Tan river at station Amba, Gujarat was carried out. Tan river is one of the major tributary of the Auranga river basin. Tan river originates in the Sahyadri hill ranges in the Nasik district of Maharashtra state. The present study covers analysis of annual peak flow of Tan river at station Amba. Four statistical methods were used in the study namely, Foster method, Gumbel distribution, Ven Te Chow method and Log Pearson type III distribution methods. From four methods, The Gumbel Distribution may be recommended for practical use.

Keywords : Flood frequency, Skewness, Standard deviation, Recurrence interval.

INTRODUCTION

A flood is an unusual high stage of a river due to runoff from rainfall and/or melting of snow in quantities too great to be confined in the normal water surface elevations of the river or stream, as the result of unusual meteorological combination.

Flood frequency analysis is an analytical technique that involves using observed annual peak flow data to calculate statistical information, such as mean values, standard deviation, skewness and recurrence interval. This statistical data are than used to construct frequency distributions, which are graphs and tables that tell likelihood of various discharge as a function of recurrence interval or exceedance probability.

Floods affect many of the engineering structures such as bridges, embankments, tanks, causeways, levees, reservoirs etc. While designing these structures, proper safeguards must be made for the safe passage of the maximum flood expected. The structure must be sound not only for its own safety but also for the life and property, which might be in danger by its own failure. This is more important in the hydraulic structures in the river valley projects, where large areas may be endangered by the failure of the structures.

STUDY AREA

Amba station of Tan River is chosen as study area for research work. The basin receives most of the rainfall from South-West monsoon during June to September. 95% of annual rainfall occurs during the monsoon season. The maximum, minimum and average annual rainfalls in the basin are 3457 mm, 995 mm and 2160 mm respectively. The Southern part of Gujarat is rich is water resources. Tan River originates in the Sahyadri hill ranges in the Nasik district of Maharashtra state. Amba station has North latitude of 20°35'32" and East longitude of 73°14'07". Catchment area at Amba station is 243.24 sq. km. Tan river is one of major tributary of Auranga river.

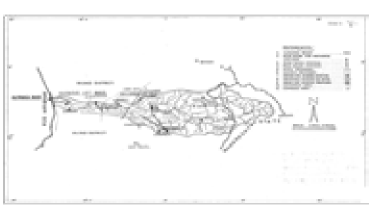

Figure 1: Basin Map

DATA COLLECTION

Annual peak discharge data are 1350.60, 825.60, 824.00, 950.30, 1347.00, 744.00, 1345.30, 922.20, 540.60, 383.18, 534.55, 1350.58, 1112.37, 845.90, 564.67, 1450.00, 485.16, 828.00, 1080.00, and 380.00 cumecs. Data are ranging from 1993 – 2012 and gauging station is at Amba in Tan River. Data are collected from State Water Data Centre.

FLOOD FREQUENCY METHODS

Foster Method:

Foster method requires the determination of the "coefficient of variation" as well as the "coefficient of skew".

Expected peak flow:

$X=\overline{X}+(K \times S)$

$\overline{X}$ is mean of recorded floods, K is a skew curve factor and S is standard deviation

The coefficient of variation $C_V=S/\overline{X}$, and

Standard deviation S= $\sqrt{\frac{\sum \Delta x^3}{n-1}}$

The coefficient of skew $C_S \frac{\sum \Delta x^3}{(n-1)S^3}$

In order to make an allowance for the error due to the length of record, adjustments were suggested by Foster in two types of curves, namely, Type I and Type III.

In Type I curve, adjusted coefficient of skew $\overline{C_S} = C_S\left(1+\frac{6}{n}\right)$

In Type III curve, adjusted coefficient of skew $\overline{C_S} = C_S\left(1+\frac{8.5}{n}\right)$

Gumbel Distribution:

According to the extreme value distribution, the probability of occurrence of a flood peak ≥ Q, is given by

$$P = 1 - e^{-e^{-y}}$$

The reduced variate y is given by y= -0.834-2.303 X_T

Where, X_T=loglog {T/((T-1))}

Expected peak flood is given by,

$QT = \overline{Q} + (K \times S)$

Where, frequency factor $K = \left(\frac{y - \overline{y_n}}{S_n}\right)$

$\overline{yn}$ is reduced mean and S_n is reduced standard deviation

Ven Te Chow Method:
Gumbel's method is modified by Ven Te Chow, in which use was made of frequency factor. The equation was given as below:

$Y_T = a + (b\,X_T)$ Where, $X_T = \log[\log \frac{T}{T-1}]$

a and *b* are the parameters estimated by the method of moments from observed data.

$$\sum Y = n \times a + b \sum X_T$$

$$\sum X_T Y = a \sum X_T + b \sum X_T^2$$

Log – Pearson Type III Distribution:
In this method, expected flood magnitude for the desired recurrence interval is given by,

$\log Q = \bar{y} + (K \times S_y)$

Where,
Q is the expected flood magnitude, $\bar{y}$ is the mean of logarithmic values of the annual floods, K is the frequency factor taken from the table corresponding to the skew coefficient C_s of the logarithmic values of flood and corresponding years of corresponding years of return period and S_y is the standard deviation of the logarithms.

Standard deviation $Sy = \sqrt{\frac{\sum(y-\bar{y})^2}{N-1}}$

Coefficient of skew $C_s = \frac{N\sum(y-\bar{y})^3}{(N-1)(N-2)(S_y^3)}$

RESULTS AND DISCUSSION
The highest measured flow of 1450 cumecs was recorded in year 2008 and lowest measured flow of 380 cumecs was recorded in year 2012 for Tan river at station Amba.

For Foster method, $\overline{X}$ = 893.201, S = 349.043, C_V = 0.391 and C_S = 0.126

For Foster type I, $\overline{C_S}$ is 0.164 and for Foster type III, $\overline{C_S}$ is 0.180

For Gumbel distribution, n = 20, $\overline{yn}$ = 0.5236, S_n = 0.0628, $\overline{Q}$ = 893.201 and *S* = 349.043

For Ven Te Chow method, $\sum y$ = 17864.01, $\sum X_T$ = -11.7918, $\sum Y X_T$ = -13560.4 and $\sum X_T^2$ = 11.213 and from method of moments, a = 474.23 and b = -710.61

For Log Pearson Type III distribution, $\bar{y}$ = 2.92, $\sum(y-\bar{y})^2$ = 0.6546, $\sum(y-\bar{y})^3$ = -0.04564, S_y = 0.1856 and C_s = -0.42

Table 1: Expected Flood Magnitude For Different Methods For Different Return Periods

Return Period (In Years)	Expected Flood Magnitudes (In Cumecs)				
	Foster Type - I Method	Foster Type - III Method	Gumbel Distribution	Ven Te Chow Method	Log Pearson Type - III Distribution
1.25	569.28	597.21	0.41	584.76	581.57
2	879.94	886.22	21.49	844.74	848.40
5	1206.64	1183.60	6322.23	1194.53	1186.86
100	1664.59	1751.85	23556.32	2151.30	1947.60
1000	1798.27	1968.60	36381.55	2863.30	2409.35

CONCLUSION
For flood frequency study, 20 years of annual peak flood readings of Tan river at Amba station was used. For Analysis four methods were used: Foster method, Gumbel distribution, Ven Te Chow method and Log Pearson type III. The highest annual flood peak attained in the Tan river at Amba station was 1450.00 cumecs in 2008. From table the 100 year flood given by Foster method is 1751.85 cumecs, 23556.32 cumecs by Gumbel method, 2151.30 cumecs by Ven Te Chow method and 1947.60 cumecs by Log Pearson type III method. So, Gumbel Distribution gives the most probable maximum flood in the life period of structure. The Gumbel Distribution may be recommended for practical use.

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