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ESTIMATION OF DESIGN FLOOD BY USING DIFFERENT TECHNIQUES

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ABSTRACT

The design of flood defence structures requires the estimation of flood water situations corresponding to a given probability of exceedance, or return period. In swash flood operation, this estimation is frequently done by statistically analysing the frequency of flood discharge peaks. A flood frequency analysis is a notable idea which helps in avoiding the casualties passed during flood. It aids in chancing out the frequentness of flood, is to come over specific area. In this exploration, statistical approach is used for three fine computing styles as Gumbel's system, Log-Pearson system and Log-Normal system to find the frequency of cataracts at Yamuna River of Okhla Barrage in Delhi. These styles are compared and smallest value of D- indicator by Gumbel's is considered as the most applicable for flood analysis. Mathematical calculation is done to prognosticate the discharge of swash Yamuna with their corresponding return period in which colourful distributions is done to estimate the statistical parameter similar as mean standard divagation measure of friction, measure of skewness. As per CWC report, discharge data for the Yamuna River from 1954 to 2018 is used for flood frequency analysis, and also to estimate flood magnitude for different return ages for gauged catchment of the receptacle is 17950 km2, and the threat assessment calculated for 1000 times return period.

Keywords: Flood Frequency Analysis, D-Index, Gumbel's Method, Log-Pearson Method, Log-Normal Method, Risk Assessment.

I. INTRODUCTION

It is describing the estimation of flood peak at the Hathnikund and Okhla Barrage sites in Yamuna River Basin. The flood peak has been estimated for Hathnikund and Okhla Barrage sites by using the frequency analysis and the empirical formula. Using the design flood values, the risk of failure of structure during various construction periods has been computed and presented in the paper. A comparison of design flood values at both the sites has also been made. A flood is relatively high flow that overtops the natural or artificial banks in any reach of a system.

II. METHODOLOGY

There are three basic approaches to the estimation of design flood: (1) D-Index Test (2) Gumbel Distribution (3) Use of empirical formulae. Application of D-Index Test approach is ruled out in the present case due to the non-availability of the required data. Many empirical formulae have been devised for the purpose of estimating peak flows. These formulae can be safely applied to the areas for which they have been specifically developed. However, these formulae must be used with great prudence, and must never be used unless their origin has been investigated. No particular formula will give precise results for all the sites. This is because of the fact that the magnitude of the flood of a given frequency depends upon several factors but these formulae are developed using a limited number of variables.

III. MODELING AND ANALYSIS

SPECIFICATIONS TABLE:

Subject	Water Resources Engineering
Specific subject area	Flood Frequency Analysis, Risk Assessment
Type of data	Table, figure, text file
How data were	Data is collected in terms of discharge.

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acquired	
Data format	Arbitrary and Homogeneous
Parameters for data collection	As per CWC report, discharge data for the Yamuna River from 1954to 2018 is used for flood frequency analysis, and also to estimate flood magnitude for different return periods for gauged catchment of the basin.
Description of data collection	Discharge data used deluge frequency analysis for Yamuna River as handed by CWC Manual, and conversion of the all- discharge data into the logarithmic series consider both the discharge series with prognosticating the discharge inflow at the Okhla Shower station.
Data source location	Yamuna River (Okhla Barrage)
Data accessibility	With the article.

STUDY AREA-

Yamuna River (Okhla Barrage)

Length - 1376 Km

Basin area - 366223 Km^2

Discharge (avg) - 2950 m3/sec

Country – India

Origin- Yamunotri

DATA COLLECTION AND AVALIBILITY

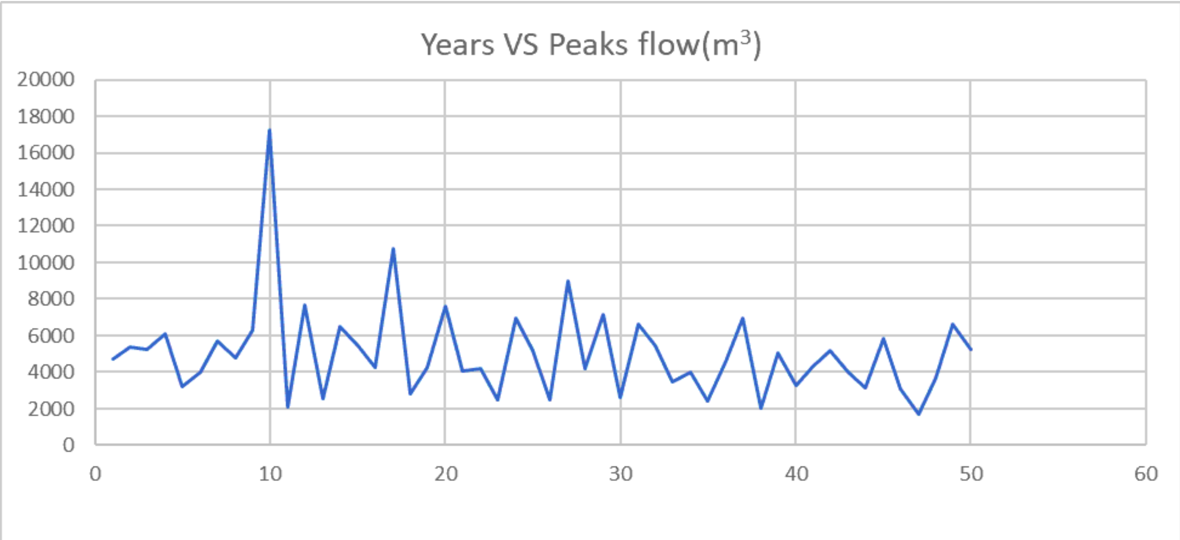

Fig 1: Collected Discharge data

VALUE OF DATA:

For the prediction of peak flow discharge frequency analysis should meet the followingrequirement are:

- Data should be arbitrary
- Data should be homogeneous

CHECK FOR OUTLIERS:

For check for outliers, statistics of the log transformed annual peak discharges are computed:

Mean logarithm - 3.6571

Standard deviation of logs –0.19496

Skewness coefficient - 0.2069 Number of years – 50

CHECK FOR LOW OUTLIERS:

XL= Low outlier threshold

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$\bar{X}$ = Mean of the log transformed series

S= Standard deviation of the log transformed series KN= outliers test K values for 10% significance level

XL= $\bar{X}$ - KN .S

XL= 3.6571 – (2.48×0.19496) = 3.1735992QL = Antilog (3.1735992)

QL = 23.89332664

No value is below this threshold value.

CHECK FOR HIGH OUTLIERS:

XL= $\bar{X}$ + KN * S,

XL= 3.6571 + (2.48*0.19496) =3.70545008QL = Antilog (3.70545008)

QL = 40.66834721

No value is above this threshold value.

STATISTICAL CHARACTERISTICS OF THE FLOW SERIES:

The statistical characteristics of the flow sample of 50 annual maxima have been computed:Mean = 5031.12

Maximum observed peak = 17227

Minimum observed peak = 1723

Variance = 6633618.598

Standard deviation = 2575.581214

Coefficient of Variance = Standard deviation / Mean = 0.5119

PROBABILITY DISTRIBUTION:

According to Hazen formula Discharge data in descending order used to calculate the probability as m= rank, N= total amount of data.

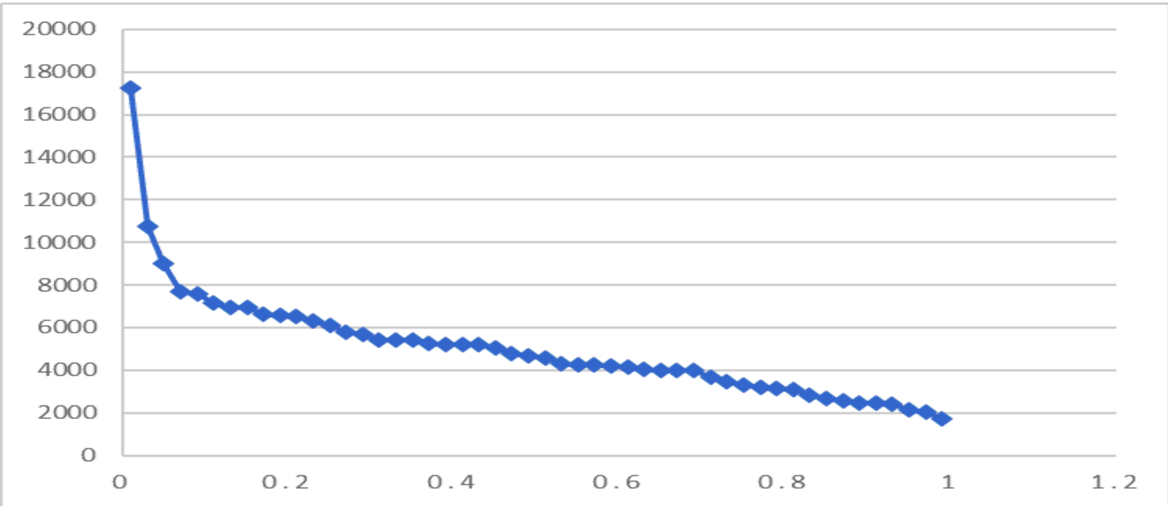

Fig 2: Probability distribution

CHOICE OF FREQUENCY DISTRIBUTION:

LOG NORMAL DISTRIBUTION-

T= Return Period, Cs=Coefficient of skewness, KO= Frequency Factor, Zt =$\bar{Z}$ + K*σ, σ = Standard Deviation, Qt = (Antilog of Zt) Estimated Discharge, $\bar{Z}$ = Mean of the logarithmicseries.

Table No. 1: Data for Log Normal Distribution

T	Cs	Ko	Zt	Qt
2	0	0	3.657	4540.72
10	0	1.282	3.907	8073.56
25	0	1.751	3.999	9965.56

50	0	2.054	4.058	11417.6
100	0	2.326	4.111	12900.4
200	0	2.576	4.159	14432.6
1000	0	3.09	4.26	18178.4

LOG PEARSON TYPE -III

T= Return Period, Cs=Coefficient

of skewness, K= Frequency Factor, Zt = $\bar{Z}$ + K*σ, σ = Standard Deviation, Qt = (Antilog of Zt) Estimated Discharge, $\bar{Z}$ = Mean of the logarithmic series.

Table No. -2: Data for Log Pearson Type-III

T	Cs	K	Zt	Qt
2	0.2069	-0.033	3.6507	4473.95166
10	0.2069	1.301	3.9108	8142.7155
25	0.2069	1.818	4.0116	10269.8499
50	0.2069	2.159	4.078	11968.6674
100	0.2069	2.472	4.1391	13774.27
200	0.2069	2.763	4.1958	15696.479
1000	0.2069	3.38	4.3161	20705.8556

Fig.6 - Log Pearson Type III

GUMBEL EXTREME VALUE DISTRIBUTION-

T= Return period, Y_t = Reduced Variant = - [ln ln T/T-1], K= (Y_t - Yn̄) / Sn, X_t = Estimated Discharge, X = peak flow data.

Table No. -3: Data for Gumbel's Method

T	T/(T-1)	Yt	K	Xt
2	2	0.3665	-0.182	4562.4
10	1.1111	2.2504	1.7019	9414.4
25	1.0417	3.1985	2.65	11856
50	1.0204	3.9019	3.3534	13668
100	1.0101	4.6001	4.0516	15466
200	1.005	5.2958	4.7473	17258
1000	1.001	6.9073	6.3588	21409

Annual Flood Discharge=Q (Cumecs)

Fig.7 - Gumbel Distribution

D-INDEX TEST-

D-index is the lowest deviation of recorded data, it's calculated using recorded peak discharge and return period. The lowest value of D-index is considered as the most appropriate method of flood analysis.

Where,

$$D = \frac{1}{Q} \sum_{1}^{n} |M - X|$$

D = D-index test, Q = mean of yearly peak discharge, M = estimated discharge, X = highest value of recorded discharge.

Table No.-4: Calculation of D-Index

Q	X	Gumbel	Log Normal	Log Pearson	∣G-X∣	∣LN-X∣	∣LP3-X∣
5031.1	17227	4562.397	4540.7229	4473.951657	12665	12686	12753
		9414.417	8073.5586	8142.715497	7812.6	9153.4	9084.3
		11856.5	9965.56006	10269.84994	5370.5	7261.4	6957.2
		13668.17	11417.6018	11968.66742	3558.8	5809.4	5258.3
		15466.47	12900.433	13774.27001	1760.5	4326.6	3452.7
		17258.21	14432.5987	15696.47899	31.208	2794.4	1530.5
		21408.61	18178.3512	20705.85555	4181.6	951.35	3478.9
					35380	42983	42515
D - Index		7.032203	8.5434011	8.450389186			

Fig. 8- Comparison Curve

RISK ASSESSMENT-

For calculating the risk assessment total return period is 1000 years and the expected life of hydraulic structure is 25 years.

Flood return period (T) = 1000 yearsRisk = 1 - (1 - 1/T) ^n

Risk Assessment = 0.024

Type of distribution	D - Index Value
Gumbel Distribution	7.032203439
Log Normal	8.543401103
Log Pearson Type - III	8.450389186

IV. RESULTS AND DISCUSSION

For designing the hydraulic structure risk assessment is taken as 2.4702%.

V. CONCLUSION

After showing all distribution value, Gumbel extreme value distribution is the best probability distribution as D-Index value is least for Gumbel's distribution. In the Gumbel extreme value distribution, the value of estimated discharge is 21408.61 m^3/sec for a recurrence interval of 1000 years. For designing the hydraulic structure risk assessment is taken as 2.4702%. These methods are undertaken keeping in view of frequency of floods occurring. Comparison of all three method gives the best fitted method to find the frequency of it. After showing all distribution value, Gumbel Extreme Value Distribution is the best probability distribution as D- index value is least for Gumbel Distribution. In the general extreme value distribution, the value of estimated discharge is 21408.61 cubic meter per second for a recurrence interval of 1000 years

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