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Page (939 Garg)

UNIT-IV

Floods and Flood routing

causes of flood → controlling of floods

Floods

Flood may be defined as an over flow coming from some river (or) coming from some other water body. A river may get flooded due to excessive rain fall (or) excessive melting of snow (or) due to some other form of ice obstructions.

The water overflow the banks of the river is side to be flooded

Flood routing:-

→ The flood entering into reservoir having one shape of hydrograph and the flood water emerges (point out) out of the reservoir the shape of hydrograph will be changes because certain amount of water stored on reservoir the base water all are stoped and peak water gets reduced.

The extent by which Inflow hydrograph gets modified due to reservoir storage can be combuted by process known as flood routing and more particularly reservoir routing.

Spectrum

Stream Gauging

Stream gauging is defined as the process of measuring of stream discharge.

Factors are to be considered in selecting a stream gauging site

(i) An easy approachable site must be selected.

[In that side will be reaching easily why because maintaining purposes]

(ii) If the reservoir cross section is of "V" shape

[It is useful to the controlling of river water] and ~~sufficient depth of water for~~ It is considered as reliable site

(iii) The river water reaches to the site homogeneous and linear. for minimum length of the river should be taken 10 to 20 times the stream width

(iv) At the side, a permanent water controlling section must be situated at river down stream.

(v) The bed and banks of the river should be free from obstacles

[∵ నది మధ్యలో ఎలాంటి అడ్డంకులు ఉండకూడదు.]

(vi) The gauging station should be located at the down-stream so as to avoid back water effect

[ఈ gauging stations arrange చేయడం వల్ల దగ్గరలో water తిరిగి gauging stations లోకి రాకుండా ఉంటుంది]

ఒకవేళ వాటర్ gauging station కి దగ్గర్లో వేరే ఇంకో వాటర్ gauging stations ఉంటే కలుస్తాయి.

Spectrum

Direct and indirect methods used for the measurement of discharge in a river

(or)

What are the different methods used for the measurement of discharge in a river & explain any two

Direct methods:-

(a) Area-velocity method.

(b) Ultrasonic - method

(c) Electro magnetic method

(d) Salt concentration method.

Ultra sonic method:-

* It is a type of velocity method.
* It is used to determine the velocity measurements with the help of ultrasonic signals
* At a particular hight "h" two transducers R_1 and R_2 are fixed on the both the banks

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* Let T_1 be the time taken by the signal to travel from one transducer to other. (R_1 to R_2)

* Let T_2 be the time taken by the signal to return back from T_2 to T_1

* There fore, the velocity "v" of the water can be expressed as

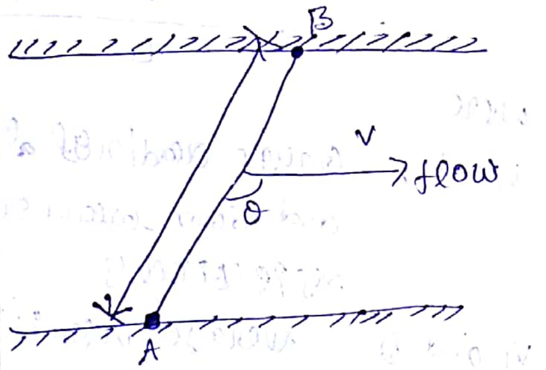
$$v = \frac{l(T_2 - T_1)}{2T_1 T_2 \cos\theta}$$

where

l = length from T_1 to T_2

θ = Angle which the velocity makes with the direction AB

* This method is quite costly due to use of advanced instruments.



Electro magnetic method:-

* This method is based on the electro-magnetic principle

* It comprises of huge coils are arranged on the ducts ([illegible]) and immersed at the bed of the river coils [illegible] openings [illegible] water [illegible].

~~* The vertical magnet~~

* The arranging of these coils to control the water flow and vertical magnetic field is generated. on coils result electrical current is generated in the coils

* The river water passes over the coils small amount of voltage is generated. This generated voltage is measured with the help of electrodes, which are provided at the banks ([illegible]) and is connected to the coils.

* The discharge is given by

$$Q = K_1 \left[\frac{Vd}{i} + K_2\right]^n$$

where,

V = voltage generated

d = Depth of the flow

i = current passing through coil

K_1, K_2 and n = system constants.

* This method is highly expensive due to the utilization of advanced instruments.

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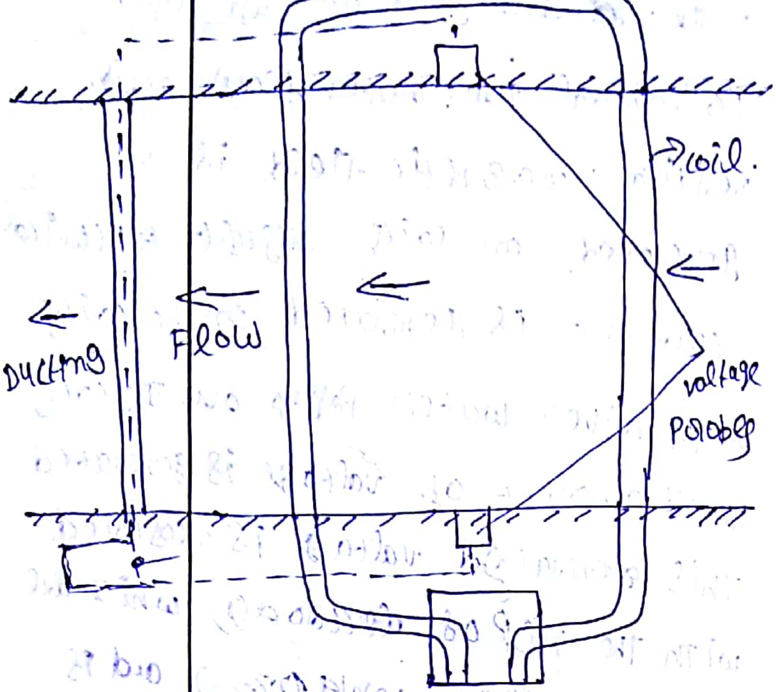

Indirect methods:-

(a) slope – Area method
(b) Hydraulic structures

(a) slope area method:-

The slope-area method used one of the two open channel formulae for computing the flow in the channel.

The open channel formula is manning's formula (or) chezy's formula which is given as.

$$\boxed{Q = AC\sqrt{R \cdot S}} \longrightarrow ①$$

$$\boxed{Q = \frac{1}{n} A R^{2/3} S^{1/2}} \longrightarrow ②$$

where A = cross sectional area.
S = energy slope.
R = Hydraulic radius
C = chezy's coefficient
n = manning's rugosity coefficient

This method is applied only if the passes straight and flow to the river in suitable slopes and also free from obstructions such as draw down curve, tributaries (to also agreed) joining down stream (or) up stream etc.

length of the stream reach must be five times of the width of the river (length must not be less than 300m in any case)

water surface drop in the reach should not be less than 150mm

The discharge is estimated by applying energy equation

$$S = \frac{(h_1-h_2) + \left[\frac{V_1^2}{2g} + \frac{V_2^2}{2g}\right]}{L} \longrightarrow ③$$

where

h_1 and h_2 = Gauge readings at upstream and down stream sections respectively

V_1 and V_2 = Average velocities of the reach at upstream and down stream sections respectively.

L = Length of the reach

3

From the past records such as a field surveys. The wetted perimeter and cross sectional area of the flow are calculated. at the beginning, Intermediate and end points or sections of the reach

From equations ① and ②

$$A = \frac{A_1 + 2A_3 + A_2}{4}$$

$$P = \frac{P_1 + 2P_3 + P_2}{4}$$

$$R = A/P$$

where P = wetted perimeter

The value of manning's co-efficient is obtained from field data.

* In the energy equation, the energy slope is taken as water surface slope ~~[illegible]~~ omitting (విస్మరించి) the velocity parameters and with the water surface slope.

* Discharge (Q) is calculated in the first step (or) trial of this method.

* In the next step (or) trial applying the values of cross sectional area and average velocities are calculated.

* After determining the values of cross-sectional area and average velocities, the energy slope is revised with the application of these average velocities on the eq'n ③

Hence, the discharge (Q) is computed using formula

$$\boxed{Q = AC\sqrt{RS}}$$

* Trials are done till two successive trials provide equal or similar result.

* This method is used where the use of Area-velocity method is not possible for various reasons. It is mainly used for flood discharge estimation.

An approximate result can be obtained in this method only when the following limitations are practiced.

(i) Care full selection of rugosity co-efficient "n"

(ii) Proper calculation of cross-sectional areas and

(iii) the slope used in estimation of discharge.

(b) Hydraulic structures :-

Hydraulic structures such as weirs, flumes, sluice gates, notches etc are used to measure the flow on streams.

At these structures, The discharge (Q) is a function of the geometry of The structure at a specified reference head (H)

The expression of discharge in this method is given as

$$\boxed{Q = f(H)}$$

where

f = Empirical coefficient

-> The discharge can also be determined at an existing dam across a river (or) at bridge opening (or) cause way.

-> The discharge at a dam is measured as a function of head of flow and length of The dam.

-> The discharge at a bridge opening is measured as a function of the flow area and drop in The water surface near The bridge.

Ni4

UNIT - IV

ADDITIONAL ANSWER SHEET
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PgNo 445 (SK garg)

Floods :-

A flood may be defined as an over flow coming from some river (or) coming from some other water body

Ex A river may get flooded due to excessive rainfall (or) excessive melting of snow (or) due to some other form of ice obstructions (ice అడ్డంకులు).

The water over flow the banks (ఒడ్డులు) of the river is side to be flooded.

A part from the over flow of rivers, the floods ~~may be~~ are coming ~~through~~ failure of some dam, sudden releses of huge amount of water, These cause of floods are coming may result considerable damage to life and property.

Ex:- A very Interesting example of formation of failure of a reservoir in India. in 1894.

In 1893 september. The River Ganga was completely blocked by a land slide near Gohna in Garhwal.

The river valley (నది లోయ) gets got filled up by rock & earth to a depth about 240 meters the river will be extended for a length of about $3\frac{1}{2}$ km thus, forming a kind of a dam.

So the water will be going back 230 ~~km~~ sq km. against this obstruction for nearly an year.

The lake is formed ~~on~~ upstream side. was surveyed by the wsried Indian crops of Engineers. After Investing the probable capacity of the lake was probable capacity of 46.6 million cubic meters will be filled up by Aug 15 1894. Infact

on 25th August 1894. (11.30 pm) huge amount of water will be released so much so that at 4 p.m of Aug. 26th the river level had fallen about 120 meters and by that time ~~at 4 P.M of Aug 26~~ about 28.3 million cubic metres of outflow has occurred. The maximum water rises level will be reached. extraordinary flood were observed.

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starting from a rise about 20 km in about 25 ~~...~~ minutes where the rise was about 5 meters and the distance of about 240 km the rise was about 3.4 m in about 12 hr

Specifically
Flood causes and effects

A flood may be defined as an over flow coming from some river (or) from some other water bodies.

Causes of floods :-

-> Flood results due to the heavy rainfall

-> Heavy snow melting due to the global warming effects of the snow melts faster, increasing the ocean level and causing floods

-> In sufficient channel capacity of the rivers also cause ~~of~~ floods
(సాధారణంగా dam నుండి నీరు బయటకు వదిలినప్పుడు over flow అవుతుంది)

-> De-forestation by constructing buildings and industries in the forest region due to which infiltration of water into the soil is prevented.
(water ని soil పీల్చుకోకుండా అడ్డుకుంటుంది)

-> High tides (waves), storms, hurricanes are the other causes of floods near the coastal regions.

Effects of floods :-

-> Financial (or) economic loss, agricultural loss and loss to the animals.

-> Population gets effected with diseases such as cholera, malaria, yellow fever etc.

-> Destruction of properties both fixed and movable properties

-> Soil erosion occurs and the land become infertile
(సాగుకు పనికిరాని, సారవంతమైన భూమి)

-> Silting of dams
water coming ~~from~~ to out-side of the dam (storage water) slowly one side to other side of the dam (ఊట)

Spectrum 4.9

5

Flood Frequency :-

(i) Flood is a natural Phenomenon. and Estimation of flood frequency depends upon the Past flood records

(ii) The Past ~~records~~ flood records, which are more than 25 years old. records is considered. This will give exact result about the feature flood frequencies.

(iii) If the ~~on~~ more Past records are taking. It will give more accurate result of frequency analysis can be obtained

~~(iv) It will gives~~

(iv) It is only approximately estimating the feature flood frequency

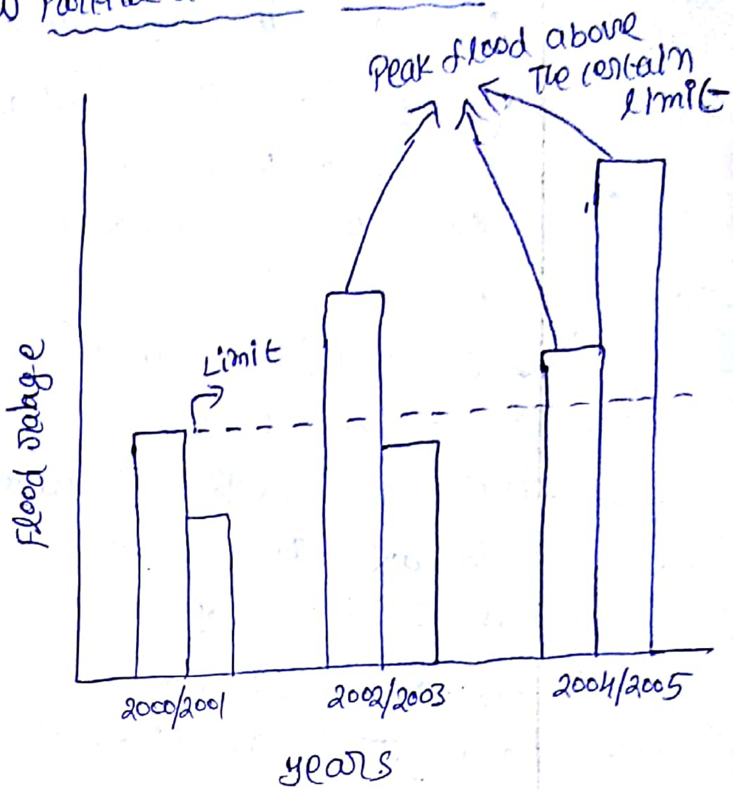
(v) The alterations (modifications) are not required in the Previous flood frequency records before taking (commencing = (approached)) the analysis

(vi) There are two method for collecting the record data they are follows (Past recorded data collection)

(a) Partial duration series

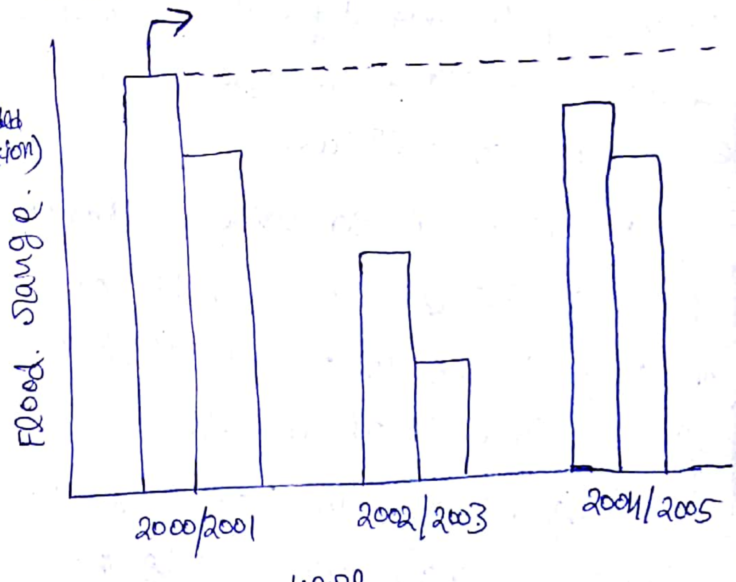
(b) Annual flood series

(a) Partial duration series



In Partial duration series ~~all the years~~ ~~all~~ Peak flood ~~values~~ ~~are selected~~. first fixing the certain limit in That limit above peak flood values are collected

(b) Annual series:-



In annual floor series only the largest flood of each year is considered.

But partial series may not provide accurate result for short period of floods (ఇంకా ~~[illegible]~~ certain limit ~~[illegible]~~ [illegible] water [illegible] consider [illegible] so ఖచ్చితమైన accurate values రావు)

Therefore preferably annual series method is adopted.

However, the analysis procedure is same for both the methods (annual and partial methods)

The analysis can be done using three methods given below

(i) Probability plotting method

(ii) Gumbell's method

(iii) Log-Pearson type III method.

Pg No 453 (5 Marks)

(i) Probability method :-

This method is used to determination of discharges for different frequency floods by using statistical (or) probability methods.

In this method used to find out feature floods on the basis of ~~[illegible]~~ (or) by using of available of the past flood records.

These methods are safely used to determine the maximum floods that is expected on a river with a given frequency.

If sufficient past records the exact values are coming

If the values are taking before the river flowing one frequency after. also no changing the ~~after the~~ frequency during after period of records

(values [illegible] river [illegible] values [illegible] river [illegible] width & depth [illegible])

These probability methods are unable to give precise (exact) [illegible] result. where lesser number of past records are available. In that case only will not give exact result

sufficient past records are must available for the success of any probability method.

Before advent (implementing, discovered, introducing) ~~[illegible]~~ [illegible] of unit hydrograph theory. This probability method almost exclusively used

Before discussing these probability methods ~~we have to~~ let us discuss the term ~~of~~ "chance flood" or "chance percentage"

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PQ No ~~454~~ (ప్రశ్న) PQ No 454

Chance flood

If a some amount of magnitude (పరిమాణం) of flood is occurs with an average frequency (time) of 100 years.

Then There exists $\frac{1}{100} \times 100 = 1$ Percent

max. flood వచ్చే సంభావ్యత / వంద years కి ఒక వర్షం. ×100

It means 1 Percent of chance for This flood occur in next 100 years

This flood is called as 1 Per cent chance flood.

Similarly

~~A flood will be~~

A flood will be coming (occur) having an average frequency of (time) 20 years

(20 సంవత్సరాలకు 1 సారి max flood వర్షం వస్తే)

It can be designated as $\frac{1}{20} \times 100 = 5\%$

∴ 5% of chanance max flood ~~occur~~ (This much of flood) occur in next 20 years

This method of designating (నిర్ణయించడం) (Identifying) floods by the reciprocal of its frequency (or) recurrence interval ×100 was suggested by Hazen, and may be Preferred to the traditional methods of representing flood frequencies (or) recurrance intervals

" In other words A flood having frequency of 100 years means A flood that will occur after 100 years But 1% chance for flood occuring. The flood will occur at any one time during 100 years "

Hence the probability of occurance of such a 100 year flood equalling or exceeding in a given year would be once in 100 years. (i.e) $\frac{1}{100} = 0.01$

This is probability of occurrence or exceedance is generally represented by P and would be equal to $1/T$

$$\therefore P = \frac{1}{T}$$

~~where~~ where

~~T~~ T = Recurrence interval

If the probability of occurence (such as precipitation or flood) is P Then the probability of it's non-occurence is q which would be equal to $1-P$

Hence $q = 1-p$

The binomial distribution can be used to find the probability of the event occurring (r) times in "n" successive years as

$$P_{r,n} = {}^nC_r \, p^r q^{n-r}$$

or

$$P_{r,n} = \frac{\lfloor n}{\lfloor (n-r) \lfloor (r)} p^r q^{n-r}$$

Example

(a) when $r=2$. Then the probability of occurrence/exceedence of an event twice in n successive years, would be.

$$P_{2,n} = \frac{\lfloor n}{\lfloor (n-2) \lfloor 2} p^2 q^{n-2}$$

(b) when $r=1$ Then the probability of occurrence/exceedence of an event once in n years.

$$P_{1,n} = \frac{\lfloor n}{\lfloor (n-1)} p^1 q^{n-1}$$

$$= n \, p^1 q^{n-1}$$

similarly.

(c) when $r=0$ Then the probability of occurrence/exceedence of an event zero in "n" days

$$P_{0,n} = \frac{\lfloor n}{\lfloor n-0 \lfloor 0} p^0 q^{n-0}$$

$$= \frac{\lfloor n}{\lfloor n} q^n$$

$$P_{0,n} = q^n$$

The probability of an event not occurring at all in "n" successive years (the maximum rain will not fall at all 'n' successive years) would be equal to q^n which is equal to $(1-p)^n$

The probability of event occurring at least once in 'n' successive years (R) (the maximum rain will occur at least once successive years (R)) would be equal to

$$1-q^n \text{ (or) } [1-(1-p)^n]$$

$[\because q = (1-p)]$

(or)

$$\boxed{R = 1-q^n = [1-(1-p)^n]}$$

This probability is called risk and hence represented by R

Problems (Probability method & papers)

Problems (Probability method)

(1) A flood ~~of~~ of a certain magnitude has a return period of 25 years

(a) what is its probability of exceedance ?

(b) what is the probability that this flood may occur in the next 12 years.

Sol:- Given data $T = 25$ years

(a) Probability of exceedance $(P) = \frac{1}{T}$

$= \frac{1}{25} = 0.04$

(b) The probability of non-occurrence of a flood in next "n" successive years is given by equation.

We know that $[\because q = (1-P)]$

$P_{o,n} = q^n$

$= (1-P)^n$ $[\because n=12$ given in problem$]$

$= (1-0.04)^{12}$

$= (0.96)^{12}$

$= 0.613$

$\therefore$ The probability of this flood may occurrence at least once in next 12 years

$R = 1 - 0.613$ $\quad [\because R = 1-(1-P)^n]$

$= 0.387$

(2) On the basis of isopluvial maps, the 50 year-24hr maximum rainfall at Bangalore is found to be 16 cm. Determine the probability of 24hr rainfall of magnitude equal to (or) greater than 16 cm occurring at Bangalore?

(a) At least once in 10 successive years;

(b) Two times in 10 successive years; and

(c) once in 10 successive years.

Sol :-

Given data

Frequency of rain fall $(T) = 50$ years

probability of exceedance $(P) = \frac{1}{T}$

$= \frac{1}{50}$

$= 0.02$

(a) The probability of this flood equaling (or) exceeding at least once in "n" successive years is given by the eq'n

$R = 1 - q^n$ $q = 1-P$

$R = 1 - (1-P)^n$

so

$R = 1 - (1-0.02)^n$ [$\because n = 10$ years given on problem]

$R = 1 - (1-0.02)^{10}$

$= 1 - (0.98)^{10}$

$= 1 - 0.817$

$= 0.183$

(b) probability of occurrence twice in "n" successive years is given by the eq/n   ②

$$P_{r,n} = {}^{n}C_r \, p^r \, q^{n-r}$$

$$P_{r,n} = \frac{\lfloor n}{\lfloor (n-r) \, \lfloor r} p^r . q^{n-r}$$

[$\because r = 2$]

$$P_{2,n} = \frac{n!}{(n-2)! \; 2!} p^2 . q^{n-2}$$

[n=10 given in problem]

$$P_{2,10} = \frac{10!}{(10-2)! \; 2!} p^2 . q^{10-2}$$

$q = 1-p$
$= 1-0.02$

$$= \frac{10!}{8! \; 2!} (0.02)^2 \times (0.98)^8$$

$$= \frac{10 \times 9 \times 8!}{8! \; 2!} (0.02)^2 \times (0.98)^8$$

$$= \frac{10 \times 9}{2 \times 1} \times (0.02)^2 \times (0.98)^8$$

$$= 0.0153$$

(c) probability of exceedance once in n years is given by eq/n.

once in 10 successive years

$$P_{r,n} = {}^{n}C_r \, p^r \, q^{n-r}$$

[$\because n = 10$, $r = 1$]

$$P_{1,10} = {}^{10}C_1 \, p^1 \, q^{10-1}$$

$$= 10 \times (0.02)^1 \times (0.98)^9$$

$$= 0.167$$

(3) What return period you would adopt in the design of a culvert on a drain if you are allowed to accept only 5% risk of flooding in the 25 years of expected life of the culvert?

Sol:-

5% risk means that there is a probability of 0.05 for a design of flood to occur at least once in successive 25 years. In other words, for 0.95 (i.e. 95%) probability the flood should not occur. using

$R = 1 - q^n$ $\quad [\because q = 1 - P]$

$R = 1 - (1-P)^n$

$\because$ we know that $R = 0.05$

$P = \frac{1}{T}$ where T is in return period

$P = 2$

$n = 25$ years

$\therefore R = 1 - (1-P)^n$

$0.05 = [1 - (1-P)^{25}]$

$(1-P)^{25} = 1 - 0.05$

$= 0.95$

$1-P = (0.95)^{1/25}$

$= (0.95)^{0.04}$

$= 0.99795$

$1 - 0.99795 = P$

$P = 0.00205$

$\because$ we know that $P = \frac{1}{T}$

$T = \frac{1}{P}$

$T = \frac{1}{0.00205}$

$= 487.8$

$T \simeq 488$ years

(pg No 464 Garg)

Gumbel's method:-

Gumbel's method is one of the method of flood frequency studies.

This method is also known as Gumbel's ~~method~~. distribution.

According to this theory If u have take one ~~rive~~ river on that river the water ~~flo~~ flows 365 days daily.

so it is possibul for higher flood comile is occuring on that area.

~~It is explain the~~

In this theory explain that how much flood is coming on that river which is equal to (or) greater than the value of x_0 (~~Pocitio~~ In coming water)

it means: extra water will be coming to the river this water will be equal to storage of dam (or) above of dam we have to find out. Storage it means discharge we can finding out

$$P(x \geq x_0) = 1 - e^{-e^{-y}} \longrightarrow (1)$$

where
y = is a constant with no dimensions and is given by

$$y = \alpha (X - \beta)$$

where
$$\beta = \bar{X} - 0.45005\,\sigma$$

σ = standard and deviation of variate X.

$\bar{X}$ = mean of x (variate)

so, $\alpha = \dfrac{1.2825}{\sigma}$

so,

$$y = \frac{1.2825}{\sigma}\left[x - (\bar{x} - 0.450050\sigma)\right]$$

$$y = \frac{1.2825}{\sigma}x - \frac{1.2825}{\sigma}(\bar{x} - 0.450050\sigma)$$

$$y = \frac{1.2825}{\sigma}x - \frac{1.2825}{\sigma}\bar{x} + \frac{1.2825 \times 0.45005\sigma}{\sigma}$$

$$y = \frac{1.2825}{\sigma}[x - \bar{x}] + 0.577 \longrightarrow (2)$$

(or)

In actual practice it is the value of $\bar{x}$ for a given probability (P) that is required so equation (1) can be written as

$$y_p = -\ln\left[-\ln(1-P)\right]$$

'y' value changes ~~from~~ for a given probability (P)

We know that

Probability $P = \frac{1}{T}$

$$T = \frac{1}{P}$$

The return period "T" can be given as

$$T = \frac{1}{P}$$

For a given value of T, the reduced variate (y_T) is given as

$$\boxed{y_{(T)} = -\left[\ln . \ln \frac{T}{T-1}\right]}$$

By the reference of equation (2)

$$y_{(T)} = \frac{1.2825}{\sigma}\left[x_{(T)} - \bar{x}\right] + 0.577$$

where (x_T) = value of x for a return period of "T"

$$\left(y_{(T)} - 0.577\right)\frac{\sigma}{1.2825} = \left[x_T - \bar{x}\right]$$

$$\left[\frac{y_{(T)} - 0.577}{1.2825}\right]\sigma + \bar{x} = x_T$$

$$x_T = \bar{x} + \left[\frac{y_{(T)} - 0.577}{1.2825}\right]\sigma$$

$$\boxed{x_T = \bar{x} + K\sigma}$$

where $K = \frac{y_T - 0.577}{1.2825}$ for $N \to \infty$ → (3)

where

$$y_T = -\left[\ln . \ln \frac{T}{T-1}\right]$$

K is known as frequency factor.

The equation (3) is the constitute the basic Gumbel's equation and are applicable to a sample of infinite size (i.e) $N \to \infty$

When N is smaller, and is of a finite value, then equation (3) is modified to vary K as

$$K = \frac{y_{(T)} - \bar{y}_n}{S_n}$$

where

$\bar{y}_n$ = reduced mean depending on N, values of which are given in Table

S_n = reduced standard deviation, depending on N, values of which are given in Table.

Problems (Gumbel's method)

PG No 468 (SK garg)

UNIT-IV

Problems (Gumbel's method) ①

(1) For a river, the estimated flood peaks for two return periods by the use of Gumbel's method, are given below

Return Period (T) (years)	Peak flood (m^3/s)
100	485
50	445

what flood discharge in this river will have a return period of 1000 years ?

Sol :-

Using Gumbel's equation

$$x_T = \bar{x} + K\sigma$$

where K is given by general equation as

$$K = \frac{y_T - \bar{y}_n}{S_n} \qquad \left[\because K = \frac{y_T}{S_n} - \frac{\bar{y}_n}{S_n}\right]$$

$$\therefore x_{100} = \bar{x} + \left[\frac{y_{100}}{S_n} - \frac{\bar{y}_n}{S_n}\right]\sigma = 485\ m^3/s \text{ (given on problem)} \rightarrow ①$$

and

$$x_{50} = \bar{x} + \left[\frac{y_{50}}{S_n} - \frac{\bar{y}_n}{S_n}\right]\sigma = 445\ m^3/s \text{ (given on problem)} \rightarrow ②$$

substracting ② from ① we get

$$\left[\frac{y_{100}}{S_n} - \frac{y_{50}}{S_n}\right]\sigma = 485 - 445\ m^3/s \text{ (~~given on problem~~)}$$
$$= 40\ m^3/s \longrightarrow ③$$

we know that

$$Y_{(T)} = -\left[\ln \ln \frac{T}{T-1}\right]$$

$$Y_{(100)} = -\left[\ln \ln \frac{100}{100-1}\right]$$

$$= -[-4.60015]$$

$$= 4.60015$$

and

$$Y_{(50)} = -\left[\ln \ln \frac{50}{(50-1)}\right]$$

$$= -[-3.90194]$$

$$= 3.90194.$$

substituting $Y_{(100)}$ and $Y_{(50)}$ values are in equation (3) we get

$$\left[\frac{Y_{100}}{S_n} - \frac{Y_{50}}{S_n}\right]\sigma = 40\ m^3/sec$$

$$(4.60015 - 3.90194)\frac{\sigma}{S_n} = 40$$

$$\frac{\sigma}{S_n} = \frac{40}{0.69821}$$

$$= 57.28.$$

or

Also, for given 1000 years T, we have

$\cancel{Y_{(1000)}}$

$$Y_{(T)} = -\left(\ln \ln \frac{T}{T-1}\right).$$

$$Y_{(1000)} = -\left[\ln \ln \frac{1000}{(1000-1)}\right]$$

②

$$Y_{1000} = -\left[\ln \ln \frac{1000}{999}\right]$$

$$= 6.90726$$

Also, from the basic equations for 1000 years and 100 years we have.

$$\left[Y_{1000} - Y_{100}\right] \frac{\sigma}{S_n} = X_{1000} - X_{100}$$

substituting values, we get -

$$\left[6.90726 - 4.600151\right] 57.28 = X_{1000} - 485$$

$$132.17 = X_{1000} - 485$$

$$X_{1000} = 132.17 + 485$$

$$\boxed{X_{1000} = 617.17 \ m^3/sec}$$ Ans

Pg NO 235
(B.C Punmia)

(2) Flood frequency computations for a flash river at a Point 50 km upstream of a bund site indicated the following

Return Period (T) (years)	50	100
Peak flood m^3/sec	20600	22150

Estimate the flood magnitude in the river with a return period of 500 years through use of Gumbel's method &

Sol :-

using Gumbel's equation.

$$x_T = \bar{x} + K\sigma$$

where K is given by general equation of

$$K = \frac{y_T - \bar{y}_n}{S_n} \Rightarrow K = \frac{y_T}{S_n} - \frac{\bar{y}_n}{S_n}.$$

K value substitute in above eq/n

$$x_T = \bar{x} + \left[\frac{y_T}{S_n} - \frac{\bar{y}_n}{S_n}\right]\sigma$$

∵ Return Period "T" = 100 years and 50 years (∵in Problem)

$$x_{100} = \bar{x} + \left[\frac{y_{100}}{S_n} - \frac{\bar{y}_n}{S_n}\right]\sigma = 22150 \rightarrow ①$$ (given in problem)

$$x_{50} = \bar{x} + \left[\frac{y_{50}}{S_n} - \frac{\bar{y}_n}{S_n}\right]\sigma = 20600 \rightarrow ②$$ (given in problem)

substituting ② in ① we get

$$\left[\frac{y_{100}}{S_n} - \frac{y_{50}}{S_n}\right]\sigma = 22150 - 20600$$

$$= 1550\ m^3/sec \rightarrow ③$$

we know that

$$Y_{(T)} = -\left[\ln \ln \frac{T}{T-1}\right]$$

$$Y_{(100)} = -\left[\ln \ln \frac{100}{100-1}\right]$$

$$= -[-4.60015]$$

$$= 4.60015$$

and

$$Y_{50} = -\left[\ln \ln \frac{50}{(50-1)}\right]$$

$$= -[-3.90194]$$

$$= 3.90194$$

substituting $Y_{(100)}$ and $Y_{(50)}$ values are in eq'n 3 we get

$$\left[\frac{Y_{100}}{S_n} - \frac{Y_{50}}{S_n}\right]\sigma = 1550\ m^3/sec$$

$$[4.60015 - 3.90194]\frac{\sigma}{S_n} = 1550\ m^3/sec$$

$$\frac{\sigma}{S_n} = \frac{1550}{0.69821}$$

$$= 2219.9$$

Return Period T = 500 years = 2.

$$Y_{(T)} = -\left[\ln \ln \frac{T}{T-1}\right]$$

$$Y_{(500)} = -\left[\ln \ln \frac{500}{(500-1)}\right]$$

$$Y_{(500)} = -\left[\ln \ln \frac{500}{499}\right]$$

$$= 6.21361$$

Also from the basic equations for 500 years and 100 years we have

$$\left[Y_{500} - Y_{100}\right] \frac{\sigma}{S_n} = X_{500} - X_{100}$$

$$\left[6.21361 - 4.60015\right] 2219.9 = X_{500} - 22150$$

$$3581.71 = X_{500} - 22150$$

$$X_{500} = 3581.71 + 22150$$

$$\boxed{X_{500} = 25732 \ m^3/sec}$$

(Pg No 236 B.C Punmia)

(3) A large sample of peak floods was available for a river. Flood frequency computations using Gumbel's method yield the following data

Return period (years)	peak flood m^3/sec
50	30800
100	36300

Estimate the magnitude of a flood for this river with a return period of 200 years

sol :- using Gumbel's equation.

$$X_T = \bar{X} + K\sigma$$

where K is given by general equation as

$$K = \frac{Y_T - \bar{Y}_n}{S_n} \qquad \left[\because K = \frac{Y_T}{Y_n} - \frac{\bar{Y}_n}{S_n}\right]$$

This "K" value substitute in above equation. we get

$$X_T = \bar{X} + \left(\frac{Y_T - \bar{Y}_n}{S_n}\right)\sigma$$

$$x_T = \bar{x} + \left[\frac{y_T}{S_n} - \frac{\bar{y}_n}{S_n} \right] \sigma$$

∵ Return period 'T' = 100 years and 50 years (in Problem)

$$x_{100} = \bar{x} + \left[\frac{y_{100}}{S_n} - \frac{\bar{y}_n}{S_n} \right] \sigma = 36300 \rightarrow ① \text{ (given in problem)}$$

$$x_{50} = \bar{x} + \left[\frac{y_{50}}{S_n} - \frac{\bar{y}_n}{S_n} \right] \sigma = 30800 \rightarrow ② \text{ (given in problem)}$$

substituting ② in ① we get

$$\left[\frac{y_{100}}{S_n} - \frac{y_{50}}{S_n} \right] \sigma = 36300 - 30800$$

$$= 5500 \ m^3/sec \rightarrow ③$$

we know that

$$y_{(T)} = -\left[\ln \ln \frac{T}{T-1} \right]$$

$$y_{100} = -\left[\ln \ln \frac{100}{100-1} \right]$$

$$= -[-4.60015]$$

$$= 4.60015$$

and

$$y_{50} = -\left[\ln \ln \frac{50}{50-1} \right]$$

$$= -[-3.90194]$$

$$= 3.90194$$

substituting y_{100} and y_{50} values are in eq'n ③ we get

$$\left[\frac{y_{100}}{S_n} - \frac{y_{50}}{S_n} \right] \sigma = 5500 \ m^3/sec$$

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$$[4.60015 - 3.90194]\frac{\sigma}{S_n} = 5500 \ m^3/sec$$

$$\frac{\sigma}{S_n} = 7877.3$$

Return period T = 200 years = ?

$$Y_T = -\left[\ln \ln \frac{T}{T-1}\right]$$

$$Y_{200} = -\left[\ln \ln \frac{200}{200-1}\right]$$

$$Y_{200} = -\left[\ln \ln \frac{200}{199}\right]$$

$$= 5.29581$$

Also from the basic equations for 200 years and 100 years we have.

$$[Y_{200} - Y_{100}]\frac{\sigma}{S_n} = X_{200} - X_{100}$$

$$[5.29581 - 4.60015]\,7877.3 = X_{200} - 36300$$

$$5479.92 = X_{200} - 36300$$

$$X_{200} = 5479.92 + 36300$$

$$X_{200} = 41779.92$$

$$\boxed{X_{200} \simeq 41780 \ m^3/sec}$$

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(Pg No 221 B.C.Punmia)

(4): For a given valley project, the following results were obtained from flood frequency analysis using Gumbel's method. (5)

Return period (T) years	peak flood m^3/sec
40	27000
80	31000

Estimate the flood magnitude with a return period of 240 years

sol :- using Gumbel's equation,

$$x_T = \bar{x} + K\sigma$$

where K is given by general equation as

$$K = \frac{y_T - \bar{y}_n}{S_n} \Rightarrow K = \frac{y_T}{S_n} - \frac{\bar{y}_n}{S_n}$$

This "K" value substitute on above equation we get.

$$x_T = \bar{x} + \left[\frac{y_T}{S_n} - \frac{\bar{y}_n}{S_n}\right]\sigma$$

∴ Return period "T" = 40 years and 80 years we get

$$x_{80} = \bar{x} + \left[\frac{y_{80}}{S_n} - \frac{\bar{y}_n}{S_n}\right]\sigma = 31000 \rightarrow (1)$$

$$x_{40} = \bar{x} + \left[\frac{y_{40}}{S_n} - \frac{\bar{y}_n}{S_n}\right]\sigma = 27000 \rightarrow (2)$$

substituting (2) in (1) we get.

$$\left[\frac{y_{80}}{S_n} - \frac{y_{40}}{S_n}\right]\sigma = 31000 - 27000$$

$$= 4000 \, m^3/sec \rightarrow (3)$$

we know that

$$Y(T) = -\left[\ln \ln \frac{T}{T-1}\right]$$

$$Y(80) = -\left[\ln \ln \frac{80}{80-1}\right]$$

$$= -[-4.37571]$$

$$= 4.37571$$

and

$$Y(40) = -\left[\ln \ln \frac{40}{40-1}\right]$$

$$= -[-3.67625]$$

$$= 3.67625$$

substituting Y_{80} and Y_{40} values are in eq (3) we get

$$\left[\frac{Y_{80}}{S_n} - \frac{Y_{40}}{S_n}\right]\sigma = 4000\ m^3/sec$$

$$[4.37571 - 3.67625]\frac{\sigma}{S_n} = 4000\ m^3/sec$$

$$\frac{\sigma}{S_n} = 5718.5$$

Return period $T = 240$ years $= ?$

$$Y_T = -\left[\ln \ln \frac{T}{T-1}\right]$$

$$Y_{240} = -\left[\ln \ln \frac{200}{200-1}\right]$$

$$= 5.47855$$

Also from the basic equations for 240 years and 80 years we have.

$$[Y_{240} - Y_{80}] \frac{\sigma}{S_n} = X_{240} - X_{80}$$

$$[5.47855 - 4.375774]\, 5718.5 = X_{240} - 31000$$

$$\boxed{X_{240} \cong 37300 \ m^3/sec}$$

(Pg.NO 214 BC Punmia)

(5) From the analysis of available data on annual flood peaks of a stream for a period of 40 years, the 50 years and 100 year floods have been estimated to be 878 m^3/sec and 970 m^3/sec using Gumbel's method estimate the 200 year flood for the stream.

Sol :-

N = 40 years we get the following values from the table 4.26(a) and table 4.26(b) Pg NO 204 BC Punmia.

$$\bar{Y}_n = 0.5436 \quad \text{and} \quad S_n = 1.1413$$

we know that -

$$\cancel{Y_{(T)} = -[\ln \ln \tfrac{T}{T-1}]}$$

$$\cancel{Y_{(50)} = -[\ln \ln \tfrac{50}{50-1}]}$$

$$\cancel{= 3.90194.}$$

using Gumbels

$$X_T = \bar{X} + K\sigma$$

where K is given by general equational

$$K = \frac{Y_T - \bar{Y}_n}{S_n} \Rightarrow K = \frac{Y_T}{S_n} - \frac{\bar{Y}_n}{S_n}$$

This "k" values substitutes on above equation we get

$$x_T = \bar{x} + \left[\frac{y_T}{S_n} - \frac{\bar{y}_n}{S_n}\right]\sigma$$

∴ Return period "T" = 50 year and 100 year we get.

$$x_{50} = \bar{x} + \left[\frac{y_{50}}{S_n} - \frac{\bar{y}_n}{S_n}\right]\sigma = 878 \ m^3/sec \rightarrow (1)$$

$$x_{100} = \bar{x} + \left[\frac{y_{100}}{S_n} - \frac{\bar{y}_n}{S_n}\right]\sigma = 970 \ m^3/sec. \rightarrow (2)$$

substituting (2) in (1) we get.

$$\left[\frac{y_{100}}{S_n} - \frac{y_{50}}{S_n}\right]\sigma = 970 - 878$$

$$= 92 \ m^3/sec \rightarrow (3)$$

we know that

$$y_{(T)} = -\left[\ln \ln \frac{T}{T-1}\right]$$

$$y_{(100)} = -\left[\ln \ln \frac{100}{100-1}\right]$$

$$= 4.60015$$

and

$$y_{(50)} = -\left[\ln \ln \frac{T}{T-1}\right]$$

$$= -\left[\ln \ln \frac{50}{50-1}\right]$$

$$= 3.90194$$

substituting $y_{(100)}$ and $y_{(50)}$ values are in eq (3) we get

$$\left[\frac{y_{100}}{S_n} - \frac{y_{50}}{S_n}\right]\sigma = 92 \ m^3/sec.$$

$$[4.60015 - 3.90194]\frac{\sigma}{S_n} = 92.$$

$$\frac{\sigma}{S_n} = 131.7655$$

Return period $T = 200$ years

$$Y_T = -\left[\ln \ln \frac{T}{T-1}\right]$$

$$Y_{(200)} = -\left[\ln \ln \frac{200}{200-1}\right]$$

$$= 5.29588$$

Also from the basic equations for 200 years and 100 years we have.

$$\left[Y_{200} - Y_{100}\right] \frac{\sigma}{S_n} = X_{200} - X_{100}$$

$$\left[5.29588 - 4.60015\right] 131.7655 = X_{200} - 970$$

$$\boxed{X_{200} = 1061.66 \ m^3/sec}$$

(Pg No 456 SK Garg)

Probability plotting on empirical relations :-

The main purpose of probability frequency analysis is to be obtain how much amount of flood will be coming how much amount of flood posibility to excedance (overflow)

This analysis may be done by empirical (or) analytical methods

The simplest empirical technique is

→ To arrange the given annual peak flood data in the decending order.

→ Assing the numbers in sequence order on each peak floods

It means Top flood value give ranking 1 and 2nd highest value of peak give ranking 2 ------

The least peak flood will be placed on last place (N^{th} place) and it's ranking will also "N"

8

The probability of an event equalling (or) exceeding is then computed by the empirical formulas

california formula.

$$P = \frac{m}{N}$$

and, the recurrence interval

$$(T) = \frac{1}{P}$$

$$= \frac{1}{m/N}$$

$$= \frac{N}{m}$$

Pg No 281 (SKGarg)

california probability method.

to determine recurrence interval

$$N = T \cdot m.$$

where.

N = Total number of years of recorded.

T = recurrence interval.

m = number of times the given rain is equalled or exceeded and is known as the ranking of the storm, (or) ranking number.

(SK garg Pg No 457)

After the values of recurrence interval (T) for different floods are calculated, by a graph can be plotted b/w frequencies and flood discharges other formulas are

(i) weibull formula.

$$P = \frac{m}{N+1}$$

(ii) Hazen formula.

$$P = \frac{m-0.5}{N}$$

(iii) chegodayev formula.

$$P = \frac{m-0.3}{N+0.4}$$

(iv) Blom formula

$$P = \frac{m-0.44}{N+0.12}$$

Problems (probability plotting on empirical equations)

2 papers

(1) Flood frequency records on a river has been collected for seventeen years starting from 1951 to 1967 and the peak values of the floods observed during each of these seventeen years are tabulated in table

Estimate the magnitude of flood having frequency equal to (a) 80 years (b) 400 years by using an ordinary graph paper and also by using a semi-log graph paper

Year	Flood Peak in cumecs
1951	3000
1952	4400
1953	6000
1954	3500
1955	2900
1956	4800
1957	3900
1958	3300
1959	6700
1960	5400
1961	4300
1962	3700
1963	4200
1964	9000
1965	4000
1966	3600
1967	5100

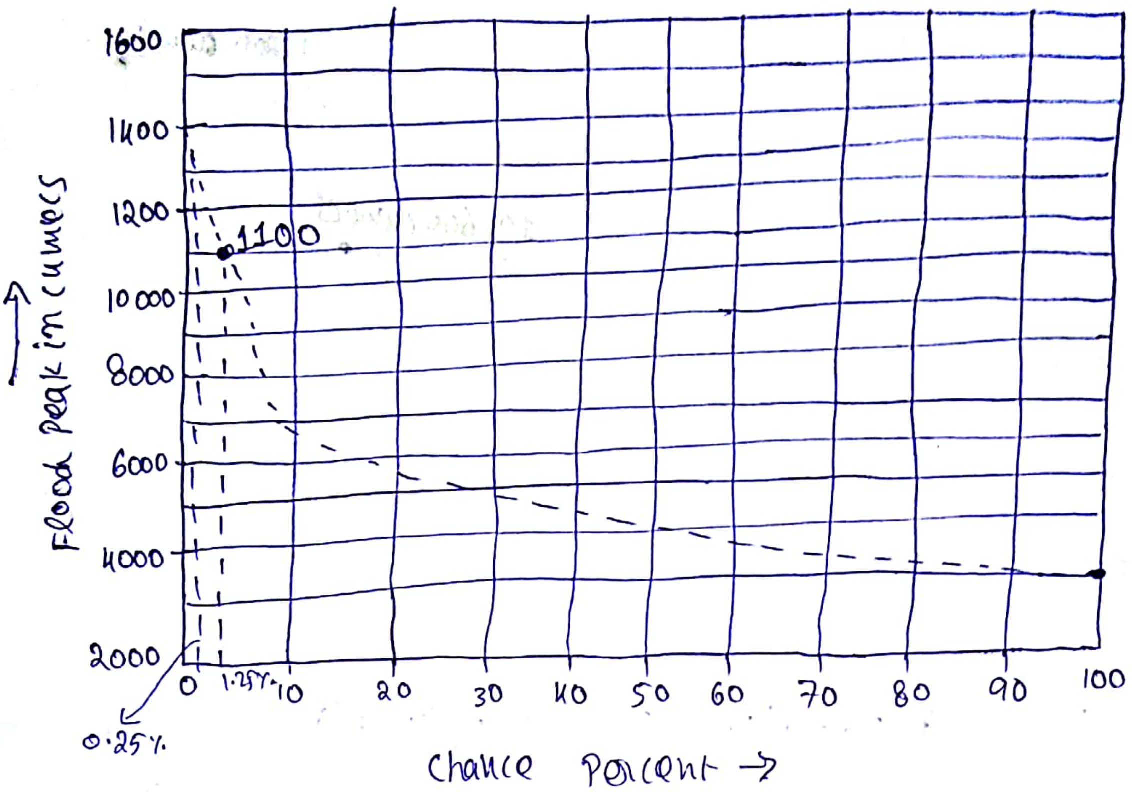
Sol:- The flood values are, first of all, arranged in their decreasing order in column ② column ③ represents the number of times flood exceeded in the year's (i,e) in column ④ represents the frequency $(T) = N/M$ and column ⑤ represents the chance of percent of flood in the year's

Year. (1)	Flood peaks in cumecs arranged in decreasing order. (2)	Number of times of an each year. flood exceeded. (i,e) ranking of flood (m) (3)	Frequency $T = \frac{N}{m} = \frac{17}{col ③}$ (4)	Chance of % $= 100/T = 100/\text{column ④}$ (or) $\frac{1}{col ④} \times 100$ (5)
1964	9000	1	17/1 = 17	$\frac{1}{17} \times 100 = 5.9$
1959	6700	2	17/2 = 8.5	$\frac{1}{8.5} \times 100 = 11.8$
1953	6000	3	17/3 = 5.67	=17.7
1960	5400	4	4.25	=23.5
1967	5100	5	3.4	=29.4
1956	4800	6	2.83	=35.3
1952	4400	7	2.43	=41.2
1961	4300	8	2.12	=47.1
1963	4200	9	1.89	=52.9
1965	4000	10	1.7	=58.9
1957	3900	11	1.55	=64.7
1962	3700	12	1.42	=70.5
1966	3600	13	1.31	=76.5
1954	3500	14	1.21	=82.4
1958	3300	15	1.13	=88.8
1951	3000	16	1.06	$\frac{1}{1.06} \times 100 = 94.1$
1955	2900	17	1.0	$\frac{1}{1.0} \times 100 = 100.0$

No. of floods
$N = 17$

Case (i) using an ordinary graph paper.

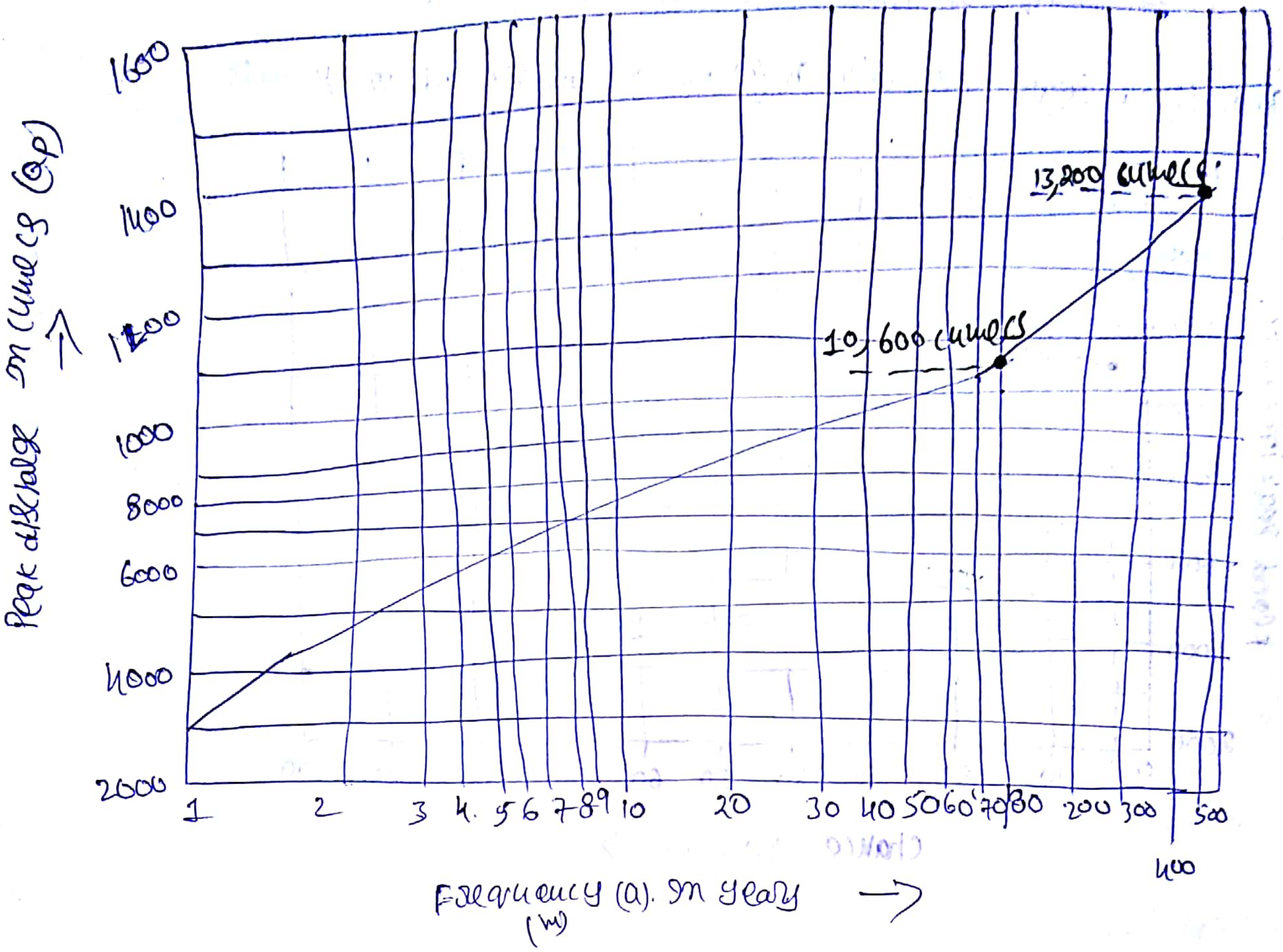
The values of chance percent of column 5 values are plotted on x-axis and flood peaks of column 2 values are plotted on y-axis



Case (a) The magnitude of flood frequency of 80 years (or) (chance percent $\frac{1}{80}\times 100 = 1.25\%$) can be directly read this above graph as 1100 cumecs. Ans

Case (b) similarly the magnitude of flood having a frequency of 400 years (or chance percent $= \frac{1}{400}\times 100 = 0.25\%$) can be read above graph as 13,200 cumecs Ans

Case (ii) using a semi-log paper



Note: [case (a) The flood having a frequency of 80 years

case (b) similarly, The magnitude of flood having frequency of 400 years]

~~The values of.~~ By finding out of a, and b, 80 years & 400 years frequencies on x-axis we have to take Frequency values and y-axis you have to take. Peak flood values in column number (2)

The magnitudes of floods having frequencies of 80 years and 400 years are than read out from it as 10600 cumecs and 13,200 cumecs

Pg NO 206 | B C Punmia

selection of design return period : Risk and Reliability

we know that

probability $P = 1/T$ indicates

The probability with which "T" years of duration max flood (or) minimum flood.

it means flood may be equalled (or) exceeded flood occur on any one year.

Hence it is useful to select a design of flood which is not useful to life period of structure.

so let us take the case of weir which is designed for "T" years flood and its useful life in "n" years

the probability ~~of~~ ~~flood~~ that the design flood is equalled (or) exceeded and hence the probability that the weir may fail in any year is $1/T$

The probability ~~of the~~ that the weir does not fail in the next "n" years is $\left[1-\frac{1}{T}\right]^n$

Hence the risk R_{SK} is the design. which is the probability that the weir may fail in any one of the next "n" years is given by

$$R_{SK} = 1-\left[1-\frac{1}{T}\right]^n$$

$$R_{SK} = 1-(1-P)^n$$

The reliability R_{el} is defined as

$$R_{el} = 1-R_{SK}$$

$$= \left[1-\frac{1}{T}\right]^n$$

$$R_{el} = (1-P)^n$$

This eq'n can be useful to determine the return period of the design flood for a given risk and given life period n.

Ex:- If the weir with life of 50 years is designed for a 50 year flood. then risk failure is..

$$R_{SK} = 1-\left[1-\frac{1}{50}\right]^{50}$$

$$= 0.636 \quad (or) \quad 63.6\,\%$$

If the weir is designed for a 100 year flood

$$R_{SK} = 1-\left[1-\frac{1}{100}\right]^{50} = 0.39 \text{ (or) } 39.4\%$$

If I want to reduce risk to 0.10 (or) 10%

$$0.10 = 1-\left[1-\frac{1}{T}\right]^{50}$$ which is given T = 475 years

$0.10 = 1 - \left[1 - \frac{1}{T}\right]^{50}$

which givens $T = 475$ years

$0.10 = 1 - \left[1 - \frac{1}{475}\right]^{50}$

$0.10 = 0.10$

both are equal

so $T = 475$ years

PONO234 (II) (Purnia)

Problems (Design of Return period Risk and Reliability)

UNIT-IV Problems (Design of Return Period Risk and Reliability)

(1) The regression analysis of a 30-year flood data at a point on a river yielded sample mean $\bar{x} = 1200\ m^3/sec$ and standard deviation $S_x = 650\ m^3/sec$ for what discharge would you design. The structure at this point to 95% assurance that the structure would not fail in the next 50 years & use Gumbel's method The value of mean and standard deviation of the reduced variate for $n=30$ are 0.53622 and 1.11238 respectively.

Sol:- Given data

Assurance $= 95\%$

Hence risk $R_{SK} = 100-95 = 5\% = 0.05$

$\sigma_{n} = S_x = 650\ m^3/sec$

we know that the eq/n

$R_{SK} = 1 - \left[1-\frac{1}{T}\right]^n$ where $n = 50$ years

$0.05 = 1 - \left[1-\frac{1}{T}\right]^{50}$

[∵ Assume T = 975.3 years]

$0.05 = 1 - \left[1-\frac{1}{973.5}\right]^{50}$

$0.05 = 0.05$

From which we got $T \cong 975.3$ years

For T = 975.3 years the reduced variate Y_T is given by.

$Y_T = -\left[\ln \ln \frac{975.3}{975.3-1}\right]$ $\left[\because Y_T = -\left[\ln \ln \frac{T}{T-1}\right]\right]$

$= 6.88184.$

$$K_T = \frac{Y_T - \bar{Y}_n}{S_n}$$

$$= \frac{6.88184 - 0.53622}{1.11238}$$

$$= 5.70454$$

Hence the design flood. $x_T = \bar{x} + K\sigma$

$$x_T = 1200 + 5.70454 \times 650$$

$$x_T = 4908 \ m^3/sec$$

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confidence limits of the estimate is desirable. The confidence interval indicates the limits about the calculated value between which the true value can be said to lie with a specific probability based on sampling errors only.

For a confidence probability c, the confidence interval of the variate x_T is bounded by values x_1 and x_2 given by[6]

$$x_{1/2} = x_T \pm f(c)\, S_e \tag{7.23}$$

where $f(c)$ = function of the confidence probability c determined by using the table of normal variates as

c in percent	50	68	80	90	95	99
$f(c)$	0.674	1.00	1.282	1.645	1.96	2.8

$$S_e = \text{probable error} = b\,\frac{\sigma_{n-1}}{\sqrt{N}} \tag{7.23a}$$

$$b = \sqrt{1 + 1.3K + 1.1K^2}$$

K = frequency factor given by Eq. (7.21)

σ_{n-1} = standard deviation of the sample

N = sample size.

It is seen that for a given sample and T, 80% confidence limits are twice as large as the 50% limits and 95% limits are thrice as large as 50% limits.

Example 7.8 Data covering a period of 92 years for the river Ganga at Raiwala yielded the mean and standard derivation of the annual flood series as 6437 and 2951 m^3/s respectively. Using Gumbel's method estimate the flood discharge with a return period of 500 years. What are the (a) 95% and (b) 80% confidence limits for this estimate.

Solution

From Tale 7.3 for $N = 92$ years, $\bar{y}_n = 0.5589$ and $S_n = 1.2020$ from Table 7.4.

$$Y_{500} = -[\ln \cdot \ln (500/499)] = 6.21361$$

$$K_{500} = \frac{6.21361 - 0.5589}{1.2020} = 4.7044$$

$$x_{500} = 6437 + (4.7044 \times 2951) = 20320 \text{ m}^3/\text{s}$$

From Eq. (7.33a)

$$b = \sqrt{1 + 1.3(4.7044) + 1.1(4.7044)^2} = 5.61$$

$$S_e \text{ probable error} = 5.61 \times \frac{2951}{\sqrt{92}} = 1726$$

(a) For 95% confidence probability $f(c) = 1.96$ and by Eq. (7.23)

$x_{1/2} = 20320 \pm (1.96 \times 1726)$ $x_1 = 23703$ m^3/s and $x_2 = 16937$ m^3/s

Thus estimated discharge of 20320 m^3/s has a 95% probability of lying between 23700 and 16940 m^3/s

(b) For 80% confidence probability, $f(c) = 1.282$ and by Eq. (7.23)

$x_{1/2} = 20320 \pm (1.282 \times 1726)$ giving $x_1 = 22533$ m^3/s and $x_2 = 18107$ m^3/s

The estimated discharge of 20320 m^3/s has a 80% probability of lying between 22530 and 18110 m^3/s.

For the data of Example 7.8, the values of x_T for different values of T are calculated and shown plotted on a Gumbel probability paper in Fig. 7.4. This variation is marked as "fitted line" in the figure. Also shown in this plot are the 95 and 80% confidence limits for various values of T. It is seen that as the confidence probability increases, the confidence interval also increases. Further, an increase in the return period T causes the confidence band to spread. Theoretical work by Alexeev (1961) has shown that for Gumbel's distribution the coefficient of skew $C_s \to 1.14$ for very low values of N. Thus the Gumbel's distribution will give erroneous results if the sample has a value of C_s very much different from 1.14.

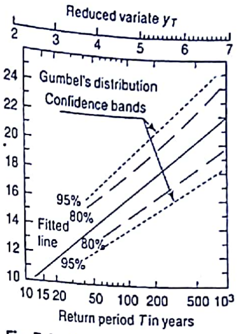


Fig. 7.4 *Confidence Bands for Gumbels Distribution—Example 7.8*

7.7 Log-Pearson Type III Distribution

This distribution is extensively used in *USA* for projects sponsored by the *US* Government. In this the variate is first transformed into logarithmic form (base 10) and the transformed data is then analysed. If X is the variate of a random hydrologic series, then the series of Z variates where

$$z = \log x \tag{7.24}$$

are first obtained. For this Z series, for any recurrence interval T, Eq. (7.13) gives

$$z_T = \bar{z} + K_z \sigma_z \tag{7.25}$$

where K_z = a frequency factor which is a function of recurrence interval T and the coefficient of skew C_s,

σ_z = standard deviation of the Z variate sample

$$= \sqrt{\Sigma(z - \bar{z})^2 / (N-1)} \tag{7.25a}$$

and C_s = coefficient of skew of variate Z

$$= \frac{N\Sigma(z - \bar{z})^3}{(N-1)(N-2)(\sigma_z)^3} \tag{7.25b}$$

$\bar{z}$ = mean of the z values

N = sample size = number of years of record

The variations of $K_z = f(C_s, T)$ is given in Table 7.6.

After finding z_T by Eq. (7.25), the corresponding value of x_T is obtained by Eq. (7.24) as

$$x_T = \text{antilog}\,(z_T) \tag{7.26}$$

Sometimes, the coefficient of skew C_s, is adjusted to account for the size of the sample by using the following relation proposed by Hazen 1930).

$$\hat{C}_s = C_s\left(\frac{1+8.5}{N}\right) \tag{7.27}$$

where $\hat{C}_s$ = adjusted coefficient of skew. However, the standard procedure for use of log-Pearson Type III distribution adopted by *U.S.* Water Resources Council does not include this adjustment for skew.

When the skew is zero, i.e. $C_s = 0$, the log-Pearson Type III distribution reduces to *log normal distribution*. The log-normal distribution plots as a straight line on logarithmic probability paper.

Table 7.6 *$K_z = F(C_s, T)$ for Use in Log-Pearson Type III Distribution*

Coefficient of skew, C_s	Recurrence interval T in years						
	2	10	25	50	100	200	1000
3.0	–0.396	1.180	2.278	3.152	4.051	4.970	7.250
2.5	–0.360	1.250	2.262	3.048	3.845	4.652	6.600
2.2	–0.330	1.284	2.240	2.970	3.705	4.444	6.200
2.0	–0.307	1.302	2.219	2.912	3.605	4.298	5.910
1.8	–0.282	1.318	2.193	2.848	3.499	4.147	5.660
1.6	–0.254	1.329	2.163	2.780	3.388	3.990	5.390
1.4	–0.225	1.337	2.128	2.706	3.271	3.828	5.110
1.2	–0.195	1.340	2.087	2.626	3.149	3.661	4.820
1.0	–0.164	1.340	2.043	2.542	3.022	3.489	4.540
0.9	–0.148	1.339	2.018	2.498	2.957	3.401	4.395
0.8	–0.132	1.336	1.998	2.453	2.891	3.312	4.250
0.7	–0.116	1.333	1.967	2.407	2.824	3.223	4.105
0.6	–0.099	1.328	1.939	2.359	2.755	3.132	3.960
0.5	–0.083	1.323	1.910	2.311	2.686	3.041	3.815
0.4	–0.066	1.317	1.880	2.261	2.615	2.949	3.670
0.3	–0.050	1.309	1.849	2.211	2.544	2.856	3.525
0.2	–0.033	1.301	1.818	2.159	2.472	2.763	3.380
0.1	–0.017	1.292	1.785	2.107	2.400	2.670	3.235
0.0	**0.000**	**1.282**	**1.751**	**2.054**	**2.326**	**2.576**	**3.090**
–0.1	0.017	1.270	1.716	2.000	2.252	2.482	2.950
–0.2	0.033	1.258	1.680	1.945	2.178	2.388	2.810
–0.3	0.050	1.245	1.643	1.890	2.104	2.294	2.675
–0.4	0.066	1.231	1.606	1.834	2.029	2.201	2.540

Contd

Table 7.6 *Contd*

–0.5	0.083	1.216	1.567	1.777	1.955	2.108	2.400
–0.6	0.099	1.200	1.528	1.720	1.880	2.016	2.275
–0.7	0.116	1.183	1.488	1.663	1.806	1.926	2.150
–0.8	0.132	1.166	1.448	1.606	1.733	1.837	2.035
–0.9	0.148	1.147	1.407	1.549	1.660	1.749	1.910
–1.0	0.164	1.128	1.366	1.492	1.588	1.664	1.880
–1.4	0.225	1.041	1.198	1.270	1.318	1.351	1.465
–1.8	0.282	0.945	1.035	1.069	1.087	1.097	1.130
–2.2	0.330	0.844	0.888	0.900	0.905	0.907	0.910
–3.0	0.396	0.660	0.666	0.666	0.667	0.667	0.668

[*Note:* C_s = 0 corresponds to log-normal distribution]

Example 7.9 For the annual flood series data of the river Bhima given in Example 7.4, estimate the flood discharge for a return period of (a) 100 years (b) 200 years, and (c) 1000 years by using log-Pearson Type III distribution.

Solution

The variate $z = \log x$ is first calculated for all the discharges (Table 7.7). Then the statistics $\bar{Z}$, σ_z and C_s are calculated from Table 7.7 to obtain

Table 7.7 *Variate Z—Example 7.9*

Year	Flood x (m³/s)	$z = \log x$	Year	Flood x (m³/s)	$z = \log x$
1951	2947	3.4694	1965	4366	3.6401
1952	3521	3.5467	1966	3380	3.5289
1953	2399	3.3800	1967	7826	3.8935
1954	4124	3.6153	1968	3320	3.5211
1955	3496	3.5436	1969	6599	3.8195
1956	2947	3.4694	1970	3700	3.5682
1957	5060	3.7042	1971	4175	3.6207
1958	4903	3.6905	1972	2988	3.4754
1959	3751	3.5748	1973	2709	3.4328
1960	4798	3.6811	1974	3873	3.5880
1961	4290	3.6325	1975	4593	3.6621
1962	4652	3.6676	1976	6761	3.8300
1963	5050	3.7033	1977	1971	3.2947
1964	6900	38388			

$$\sigma_z = 0.1427 \qquad C_s = \frac{27\times 0.0030}{(26)(25)(0.1427)^3}$$

$$\bar{Z} = 3.6071 \qquad C_s = 0.043$$

The flood discharge for a given T is calculated as below. Here, values of K_z for given T and $C_s = 0.04$ are read from Table 7.6.

T (years)	$\bar{z} = 3.6071$	$\sigma_z = 0.1427$	$C_s = 0.043$	x_T = antilog z_T (m³/s)
	K_z (from Table 7.6) (for $C_s = 0.043$)	$K_z\sigma_z$	$Z_T = \bar{Z} + K_z\sigma_z$	
100	2.358	0.3365	3.9436	8782
200	2.616	0.3733	3.9804	9559
1000	3.152	0.4498	4.0569	11400

Example 7.10 For the annual flood series data analysed in Example 7.9 estimate the flood discharge for a return period of (a) 100 years, (b) 200 years, and (c) 1000 years by using log-normal distribution. Compare the results with those of Example 7.9.

Solution

Log-normal distribution is a special case of log-Pearson type III distribution with $C_s = 0$. Thus in this case C_s is taken as zero. The other statistics are $\bar{z} = 3.6071$ and $\sigma_z = 0.1427$ as calculated in Example 7.9.

The value of K for a given return period T and $C_s = 0$ is read from Table 7.6. The estimation of the required flood discharge is done as shown below.

T (years)	$z = 3.6071$	$\sigma_z = 0.1427$	$C_s = 0$	x_T = antilog z_T (m³/s)
	K_z (from Table 7.6)	$K_z\sigma_z$	$Z_T = Z + K_z\sigma_z$	
100	2.326	0.3319	3.9390	8690
200	2.576	0.3676	3.9747	9434
1000	3.090	0.4409	4.0480	11170

On comparing the estimated x_T with the corresponding values in Example 7.9, it is seen that the inclusion of the positive coefficient of skew ($C_s = 0.047$) in log-Pearson type III method gives higher values than those obtained by the log-normal distribution method. However, as the value of C_s is small, the difference in the corresponding values of x_T by the two methods is not appreciable.

[**Note:** If the coefficient of skew is negative, the log-Pearson type III method gives consistently lower values than those obtained by the log-normal distribution method.]

Example 7.11 Annual flood flow series of a river were analysed and was found to follow log normal distribution. The frequency analysis of the data yielded the following results:

Return Period T in years	Peak Flood (m³/s)
100	12500
200	15000

The following table of the variation of frequency factor with the return period in log-normal distribution is available:

Return Period (T)	50	100	200	1000
Frequency factor (K_z)	2.054	2.326	2.576	3.090

Estimate the flood magnitude in the river with a return period of 1000 years.

Solution

Let x = Random variate (Flood discharge) in the problem

The transformed variate $z = \log x$ is distributed log-normally.

For the variate z at any return period T

$$z_T = \bar{z} + K_z\sigma_z$$

For the given data:

At $T = 100$ years: $x_{100} = 12500$, $z_{100} = \log 12500 = 4.0969$ and

$K_{100} = 2.326$

Hence, $\bar{z} + 2.326\ \sigma_z = 4.0969$ (i)

At $T = 200$ years: $x_{200} = 15000$, $z_{200} = \log 15000 = 4.1761$ and

$K_{200} = 2.576$

Hence, $\bar{z} + 2.576\ \sigma_z = 4.1761$ (ii)

From Eqs.(1) and (ii); $0.25\ \sigma_z = 0.0792$ and $\sigma_z = 0.3168$

Substituting for σ_z in Eq.(ii); $\bar{z} = 4.1761 - (2.576 \times 0.3168) = 3.3600$

When $T = 1000$ years, $K_{1000} = 3.090$

$$z_{1000} = \bar{z} + 3.090\ \sigma_z = 3.3600 + (3.090 \times 0.3168) = 4.3389$$

Flood with a return period of 1000 years = x_{1000} = antilog 4.3389 = 21,823 m³/s

7.8 *Partial Duration Series*

In the annual hydrologic data series of floods, only one maximum value of flood per year is selected as the data point. It is likely that in some catchments there are more than one independent floods in a year and many of these may be of appreciably high magnitude. To enable all the large flood peaks to be considered for analysis, a flood magnitude larger than an arbitrary selected base value are included in the analysis. Such a data series is called *partial-duration series*.

In using the partial-duration series, it is necessary to establish that all events considered are independent. Hence the partial-duration series is adopted mostly for rainfall analysis where the conditions of independency of events are easy to establish. Its use in flood studies is rather rare. The recurrence interval of an event obtained by annual series (T_A) and by the partial duration series (T_p) are related by

$$T_P = \frac{1}{\ln T_A - \ln(T_A - 1)} \tag{7.28}$$

Table 8.8 *Calculation of 3-Hour UH by Nash Method—Example 8.8*

$K = 3.3\ h$ $n = 4.5$ $\Gamma(n) = 11.632$ Area of the catchment = 300 km²

1 Time t in hours	2 (t/K)	3 $u(t)$ (cm/h)	4 $u(t)$ (m³/s)	5 $u(t)$ lagged by 1 hour	6 1-h UH (m³/s)	7 S_1– Curve addition	8 Ordinate of S_1– Curve	9 3-h lagged S_1– Curve	10 DRH of 3 cm in 3 hours (m³/s)	11 Ord. of 3-h UH (m³/s)
0	0.000	0.0000	0.000		0.000	0.000	0.000		0.000	0.00
1	0.303	0.0003	0.246	0.000	0.123	0.000	0.123		0.123	0.40
2	0.606	0.0025	2.054	0.246	1.150	0.123	1.273		1.273	0.42
3	0.909	0.0075	6.271	2.054	4.162	1.273	5.435	0.000	5.435	1.81
4	1.212	0.0152	12.676	6.271	9.473	5.435	14.909	0.123	14.786	4.93
5	1.515	0.0245	20.444	12.676	16.560	14.909	31.469	1.273	30.196	10.07
6	1.818	0.0343	28.583	20.444	24.513	31.469	55.982	5.435	50.547	16.85
7	2.121	0.0434	36.209	28.583	32.396	55.982	88.378	14.909	73.469	24.49
8	2.424	0.0512	42.676	36.209	39.442	88.378	127.820	31.469	96.351	32.12
9	2.727	0.0571	47.600	42.676	45.138	127.820	172.958	55.982	116.975	38.99
10	3.030	0.0610	50.834	47.600	49.217	172.958	222.175	88.378	133.797	44.60
11	3.333	0.0628	52.411	50.834	51.623	222.175	273.798	127.820	145.978	48.66
12	3.636	0.0629	52.490	52.411	52.451	273.798	326.248	172.958	153.291	51.10
13	3.939	0.0615	51.303	52.490	51.897	326.248	378.145	222.175	155.970	51.99
14	4.242	0.0589	49.112	51.303	50.207	378.145	428.353	273.798	154.555	51.52
15	4.545	0.0554	46.180	49.112	47.646	428.353	475.998	326.248	149.750	49.92
16	4.848	0.0513	42.751	46.180	44.466	475.998	520.464	378.145	142.319	47.44
17	5.152	0.0468	39.039	42.751	40.895	520.464	561.359	428.353	133.006	44.34
18	5.455	0.0422	35.219	39.039	37.129	561.359	598.488	475.998	122.489	40.83
19	5.758	0.0377	31.431	35.219	33.325	598.488	631.812	520.464	111.348	37.12
20	6.061	0.0333	27.779	31.431	29.605	631.812	661.417	561.359	100.058	33.35
21	6.364	0.0292	24.337	27.779	26.058	661.417	687.475	598.488	88.988	29.66
22	6.667	0.0254	21.153	24.337	22.745	687.475	710.221	631.812	78.408	26.14
23	6.970	0.0219	18.253	21.153	19.703	710.221	729.924	661.417	68.507	22.84
24	7.273	0.0188	15.647	18.253	16.950	729.924	746.875	687.475	59.399	19.80
25	7.576	0.0160	13.332	15.647	14.489	746.875	761.364	710.221	51.143	17.05
26	7.879	0.0135	11.295	13.332	12.313	761.364	773.677	729.924	43.753	14.58
27	8.182	0.0114	9.520	11.295	10.408	773.677	784.085	746.875	37.210	12.40
28	8.485	0.0096	7.986	9.520	8.753	784.085	792.838	761.364	31.474	10.49
29	8.788	0.0080	6.669	7.986	7.328	792.838	800.166	773.677	26.488	8.83
30	9.091	0.0067	5.546	6.669	6.108	800.166	806.273	784.085	22.188	7.40
31	9.394	0.0055	4.594	5.546	5.070	806.273	811.344	792.838	18.505	6.17
32	9.697	0.0045	3.792	4.594	4.193	811.344	815.537	800.166	15.371	5.12
33	10.000	0.0037	3.119	3.792	3.456	815.537	818.992	806.273	12.719	4.24
34	10.303	0.0031	2.558	3.119	2.838	818.992	821.831	811.344	10.487	3.50
35	10.606	0.0025	2.091	2.558	2.324	821.831	824.155	815.537	8.618	2.87
36	10.909	0.0020	1.704	2.091	1.897	824.155	826.052	818.992	7.060	2.35
37	11.212	0.0017	1.385	1.704	1.545	826.052	827.597	821.831	5.766	1.92
38	11.515	0.0013	1.123	1.385	1.254	827.597	828.851	824.155	4.696	1.57
39	11.818	0.0011	0.909	1.123	1.016	828.851	829.867	826.052	3.815	1.27
40	12.121	0.0009	0.733	0.909	0.821	829.867	830.688	827.597	3.091	1.03

8.10 Flood Control

The term *flood control* is commonly used to denote all the measures adopted to reduce damages to life and property by floods. Currently, many people prefer to use the term *flood management* instead of *flood control* as it reflects the activity more realistically. As there is always a possibility, however remote it may be, of an extremely large flood occurring in a river the complete control of the flood to a level of zero loss is neither physically possible nor economically feasible. The flood control measures that are in use can be classified as

1. Structural Measures
   - Storage and detention reservoirs
   - Flood ways (new channels)
   - Watershed management
   - Levees (flood embankments)
   - Channel improvement
2. Non-structural Methods
   - Flood plain zoning
   - Evacuation and relocation
   - Flood forecast/warning
   - Flood insurance

8.10.1 Structural Methods

1. Storage Reservoirs

Storage reservoirs offer one of the most reliable and effective methods of flood control. Ideally, in this method, a part of the storage in the reservoir is kept apart to absorb the incoming flood. Further, the stored water is released in a controlled way over an extended time so that downstream channels do not get flooded. Figure 8.15 shows an ideal operating plan of a flood control reservoir. As most of the present-day storage reservoirs have multipurpose commitments, the manipulation of reservoir levels to satisfy many conflicting demands is a very difficult and complicated task. It so happens that many storage reservoirs while reducing the floods and flood damages do not always aim at achieving optimum benefits in the flood-control aspect. To achieve complete flood control in the entire length of the river, a large number of reservoirs at strategic locations in the catchment will be necessary.

The Hirakud and Damodar Valley Corporation (*DVC*) reservoirs are examples of major reservoirs in the country which have specific volumes earmarked for flood absorption.

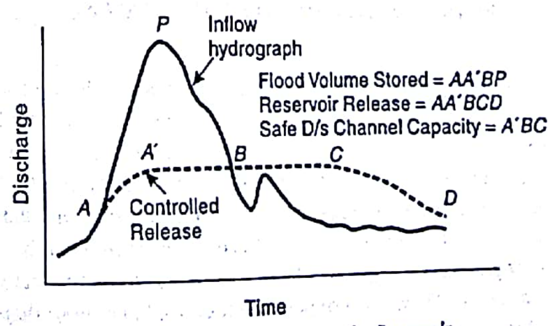


Fig. 8.15 *Flood Control Operation of a Reservoir*

Log-Person Type-III Distribution :-

This distribution is extensively used in USA for projects sponsored by US Government

→ In this method the variate is first transformed into logarithmic form. (base 10) and the transformed data is then analysed.

(ഈ methodൽ കിട്ടുന്ന variables ഒക്കെ ആദ്യം 1st logarithmic form ൽ $\log_{10}$ formൽ ആക്കി analyse ചെയ്യണം)

→ If "x" is the variate of random hydrologic series, then the series of "z" variates where

$$z = \log x$$

For this z series, for any recurrence interval "T"

from the eqn of $~~x_T = \bar{x} + K\sigma~~$

This eqn will give $z_T = \bar{z} + K_z \sigma_z$

where, K_z = a frequency factor which is a function of recurrence interval "T" and the coefficient of skew C_s

σ_z = standard deviation of the "z" variate sample

$$= \sqrt{\frac{\Sigma (z-\bar{z})^2}{(N-1)}}$$

C_s = coefficient of skew of variate "z"

$$= \frac{N \Sigma (z-\bar{z})^3}{(N-1)(N-2)(\sigma_z)^3}$$

where $\bar{z}$ = mean of the "z" values

N = sample size = number of years of record

The variations of $K_z = f(C_s, T)$ is given in the table 7.6

After finding z_T by the eqn of $z_T = \bar{z} + K_z \sigma_z$, the corresponding value of x_T is obtained by the eqn of $z = \log x$ as

$$x_T = \text{antilog of } (z_T)$$

Sometimes, the coefficient of skew C_s, is adjusted to account for the size of the ~~simple~~ sample by using the following relation proposed by Hazen (1930)

$$\hat{C_s} = C_s \left[\frac{1 + 8.5}{N}\right]$$

where $\hat{C_s}$ = adjusted coefficient of skew

However, the standard procedure for use of log-Person Type III distribution adopted by U.S. Water Resources council does not include this adjustment for skew

When the skew is zero (ie) $\hat{C_s} = 0$ the log-Person type III distribution reduces to log normal distribution.

The log-normal distribution plots as a straight line on logarithmic probability paper

[∵ skew = ചരിവ്]

Flood control methods

The flood control methods are used to reduce the damage of the structure increase the life of the structure.

The flood control methods are classified as

(1) Structural methods

(a) storage & detention reservoir

(b) Levees (flood embankments)

(c) channel improvement.

(d) flood ways (new channels) and

(e) soil conservation

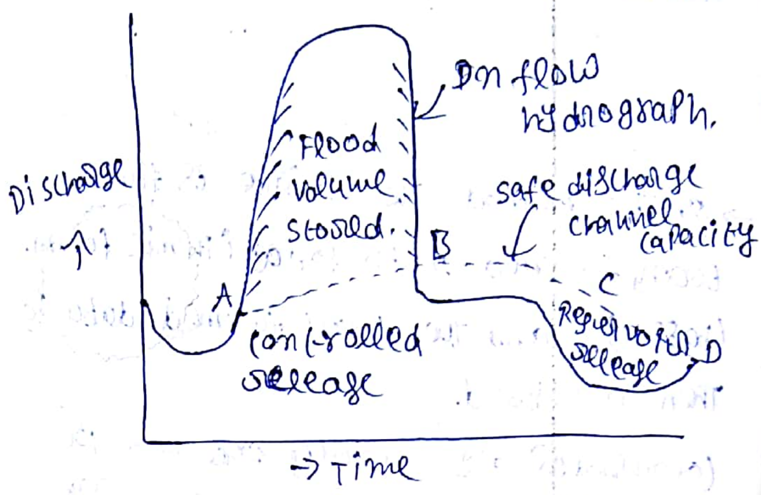
(2) Non-structural methods

(1) Structural methods

(a) storage & detention reservoir

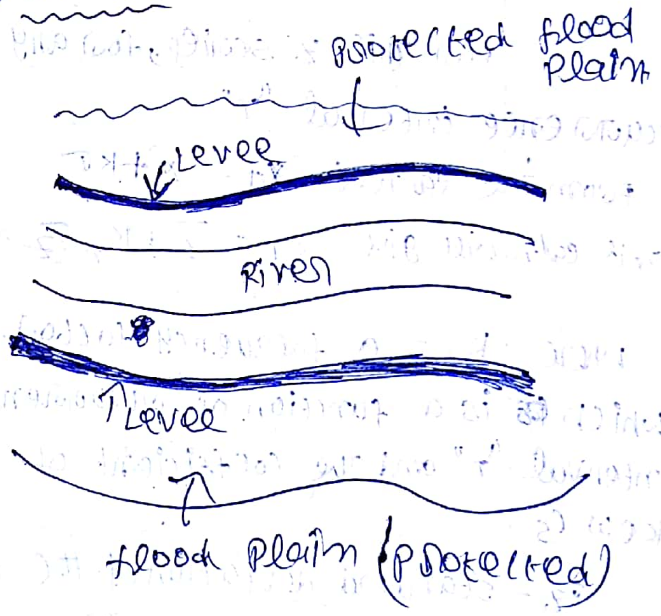
This method is most reliable (నమ్మదగిన) and effective (సమర్థవంతమైన) method of flood control.

In this method reservoir is constructed over the river. This reservoir absorb the incoming flood and storage of this flood released in a controlled way (particular way) on a particular time



→ So many storage reservoirs while reducing the floods and flood damages the complete flood control in the entire length of rivers.

(b) Levees:-



(a) play

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Table 7.6 $K_z = F(C_s, T)$ for use in log-Pearson type-III distribution

Coefficient of skew C_s	Recurrence interval T in years						
	2	10	25	50	100	200	1000
3.0	−0.396	1.180	2.278	3.152	4.051	4.970	7.250
2.5	−0.360	1.250	2.262	3.048	3.845	4.652	6.600
2.2	−0.330	1.284	2.240	2.970	3.705	4.444	6.200
2.0	−0.307	1.302	2.219	2.912	3.605	4.298	5.910
1.8	−0.282	1.318	2.193	2.848	3.499	4.147	5.660
1.6	−0.254	1.329	2.163	2.780	3.388	3.990	5.390
1.4	−0.225	1.337	2.128	2.706	3.271	3.828	5.110
1.2	−0.195	1.340	2.087	2.626	3.149	3.661	4.820
1.0	−0.164	1.340	2.043	2.542	3.022	3.489	4.540
0.9	−0.148	1.339	2.018	2.498	2.957	3.401	4.395
0.8	−0.132	1.336	1.998	2.453	2.891	3.312	4.250
0.7	−0.116	1.333	1.967	2.407	2.824	3.223	4.105
0.6	−0.099	1.328	1.939	2.359	2.755	3.132	3.960
0.5	−0.083	1.323	1.910	2.311	2.686	3.041	3.815
0.4	−0.066	1.317	1.880	2.261	2.615	2.949	3.670
0.3	−0.050	1.309	1.849	2.211	2.544	2.856	3.525
0.2	−0.033	1.301	1.818	2.159	2.472	2.763	3.380
0.1	−0.017	1.292	1.785	2.107	2.400	2.670	3.235
0.0	0.000	1.282	1.751	2.054	2.326	2.576	3.090
−0.1	0.017	1.270	1.716	2.000	2.252	2.482	2.950
−0.2	0.033	1.258	1.680	1.945	2.178	2.388	2.810

Coefficient of skew C_s	Recurrence interval "T" in years						
	2	10	25	50	100	200	1000
−0.3	0.050	1.245	1.643	1.890	2.104	2.294	2.675
−0.4	0.066	1.231	1.606	1.834	2.029	2.201	2.540
−0.5	0.083	1.216	1.567	1.777	1.955	2.108	2.400
−0.6	0.099	1.200	1.528	1.720	1.886	2.016	2.275
−0.7	0.116	1.183	1.488	1.663 ~~1.663~~	1.806	1.926	2.150
−0.8	0.132	1.166	1.448	1.606 ~~1.448~~	1.733	1.837	2.035
−0.9	0.148	1.147	1.407	1.549 ~~1.407~~	1.660	1.749	1.910
−1.0	0.164	1.128	1.366	1.492 ~~1.366~~	1.588	1.664	1.880
−1.4	0.225	1.041	1.198	~~1.198~~ 1.270	1.318	1.351	1.465
−1.8	0.282	0.945	1.035	1.069 ~~1.035~~	1.087	1.097	1.130
−2.2	0.330	0.844	0.888	0.900 ~~0.888~~	0.905	0.907	0.910
−3.0	0.396	0.660	0.666	0.666	0.667	0.667	0.668

Note $C_s = 0$ corresponds to log-normal distribution

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Problems on Log-Pearson Type III Distribution

(1) For the annual flood series data of the river Bhima given as

Year	1951	1952	1953	1954	1955	1956	1957	1958	1959
max. flood (m^3/s)	2947	3521	2399	4124	3496	2947	5060	4903	3757
Year	1960	1961	1962	1963	1964	1965	1966	1967	1968
max. flood (m^3/s)	4798	4290	4652	5050	6900	4366	3380	7826	3320
Year	1969	1970	1971	1972	1973	1974	1975	1976	1977
max. flood (m^3/s)	6599	3700	4175	2988	2709	3873	4593	6761	1971

Estimate the flood discharge for a return period of (a) 100 years (b) 200 years ; and (c) 1000 years by using log-Pearson Type III distribution?

Sol: The variate $z = \log x$ is first calculated for all discharges (see the below table) is given in ~~below~~. Then the statistics $\bar{z}$, σ_z and C_s are calculated as

Year	Flood x (m^3/s)	$z = \log x$
1951	2947	$\log 2947 = 3.4694$
1952	3521	$\log 3521 = 3.5467$
1953	2399	$\log 2399 = 3.3800$
1954	4124	3.6153
1955	3496	3.5436
1956	2947	3.4694
1957	5060	3.7042
1958	4903	3.6905

1959	3751	3.5748
1960	4798	3.6811
1961	4290	3.6325
1962	4652	3.6676
1963	5050	3.7033
1964	6900	3.8388
1965	4366	3.6401
1966	3380	3.5289
1967	7826	3.8935
1968	3320	3.5211
1969	6599	3.8195
1970	3700	3.5682
1971	4175	3.6207
1972	2988	3.4754
1973	2709	3.4328
1974	3873	3.5880
1975	4593	3.6621
1976	6761	3.8300
1977	1971	3.2947

$\bar{z}$ = mean of the z values

$$\bar{z} = \frac{\begin{array}{l} 3.4694 + 3.5467 + 3.3800 + 3.6153 + 3.5436 + 3.4694 \\ + 3.7042 + 3.6905 + 3.5748 + 3.6811 + 3.6325 + 3.6676 \\ + 3.7033 + 3.8338 + 3.6401 + 3.5289 + 3.8935 + 3.5211 \\ + 3.8195 + 3.5682 + 3.6207 + 3.4754 + 3.4328 + 3.5880 \\ + 3.6621 + 3.8300 + 3.2947 \end{array}}{27}$$

$$\bar{z} = \frac{97.3922}{27}$$

$$\bar{z} = 3.6071$$

σ_z = standard deviation of the "z" variate sample

$$= \sqrt{\frac{\Sigma (z-\bar{z})^2}{(N-1)}}$$

$$\therefore \Sigma (z-\bar{z})^2 = (3.4694-3.6071)^2 + (3.5467-3.6071)^2 + (3.3800-3.6071)^2$$
$$+ (3.6153-3.6071)^2 + (3.5436-3.6071)^2 + (3.4694-3.6071)^2$$
$$+ (3.7042-3.6071)^2 + (3.6905-3.6071)^2 + (3.5748-3.6071)^2$$
$$+ (3.6811-3.6071)^2 + (3.6325-3.6071)^2 + (3.6676-3.6071)^2$$
$$+ (3.7033-3.6071)^2 + (3.8388-3.6071)^2 + (3.6401-3.6071)^2$$
$$+ (3.5289-3.6071)^2 + (3.5289-3.6071)^2 + (3.8935-3.6071)^2$$

$+(3.5211-3.6071)^2+(3.8195-3.6071)^2+(3.5682-3.6071)^2$ ②

$+(3.6207-3.6071)^2+(3.4754-3.6071)^2+(3.4328-3.6071)^2$

$+(3.5880-3.6071)^2+(3.6621-3.6071)^2+(3.8300-3.6071)^2$

$+(3.2947-3.6071)^2$

$\Sigma(z-\bar{z})^2 = 0.529.$

$$\sigma z = \sqrt{\frac{\Sigma(z-\bar{z})^2}{(N-1)}}$$

$$= \sqrt{\frac{0.529}{(27-1)}} = \sqrt{\frac{0.529}{26}}$$

$$= 0.1427$$

$\therefore \sigma_z = 0.1427$

$\bar{z} = 3.6071$

$$C_s = \frac{N \sum (z-\bar{z})^3}{(N-1)(N-2)(\sigma_z)^3}$$

$$= \frac{27 \times 0.0030}{(27-1)\ (27-2)\ (0.1427)^3}$$

$$= 0.043$$

The flood discharge for a given "T" is calculated as below.

Here, values of K_z for given "T" and $C_s = 0.04$ are read from Table 7.6

T (years)	$\bar{z} = 3.6071$	$\sigma_z = 0.1427$	$C_s = 0.043$	$x_T = \text{antilog}\, z_T$ (m^3/sec)
	K_z (from Table 7.6) (for $C_s = 0.043$)	$K_z\, \sigma_z$	$z_T = \bar{z} + K_z\, \sigma_z$	
100	2.358	$2.358 \times 0.1427 = 0.3365$	$z_T = 3.6071 + \cancel{2.358 \times}\ 0.3365 = 3.9436$	8782
200	2.616	0.3733	3.9804	9559
1000	3.152	0.4498	4.0565	11400

Ex:- For the annual flood series data analysed in previous example estimate the flood discharge for a return period of (a) 1000 years, (b) 200 years, and (c) 1000 years by using log-normal distribution. Compare the result with those exo of example. (3)

sol:-

Log-normal distribution is a special case of log-person type-III distribution with $C_s = 0$. Thus in this case C_s is taken as zero. The other statistics are $\bar{z} = 3.6071$ and $\sigma_z = 0.1427$ as calculated in previous example.

The value of K for a given return period "T" and $C_s = 0$ is read from the Table 7.6. The estimation of the required flood discharge is done as shown below.

T (years)	$\bar{z} = 3.6071$	$\sigma_z = 0.1427$	$C_s = 0$	x_T = antilog z_T (m^3/sec)
	K_z (from Table 7.6)	$K_z \sigma_z$	$z_T = \bar{z} + K_z \sigma_z$	
100	2.326	$2.326 \times 0.1427 = 0.3319$	$z_T = 3.6071 + 0.3319 = 3.9390$	8690
200	2.576	0.3676	3.9747	9434
1000	3.090	0.4409	4.0480	11170

On comparing the estimated x_T with the corresponding values in previous example, it is seen that the inclusion of the positive coefficient of skew ($C_s = 0.047$) in log person type-III method gives higher values than those obtained by the log-normal distribution method. However, as the value of C_s is small, the difference in the corresponding values of x_T by the two methods is not appreciable.

Note:- If the coefficient of skew is negative, the log-person type III method gives consistently lower values than those obtained by the log-normal distribution method.

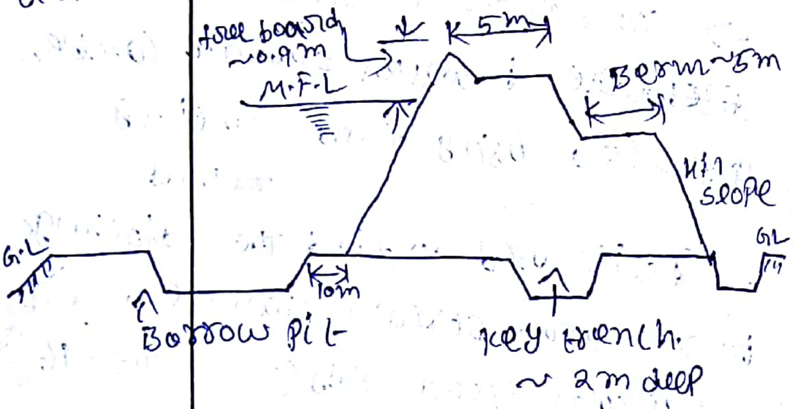
→ Levees are one of the oldest and most common method also cheapest of structural flood-control measures

→ In this method the ~~~~ river embankment of (కట్టలు) are protected by stone (or) concrete pavement (concrete surface)

→ maintenance will be required.

→ The ~~~~ river embankments only one side (i.e) water touching face are arranged stones (or) concrete ~~surface~~ pavements.

→ The C/S of the levee will have to be designed like an earth dam for complete safety against all kinds of saturation draw down possibilities



(b) C/S

(c) Channel improvement:- (11)

→ The channels increasing the widening (or) deepening it is useful to free flowing of water so water will not stored in one place. so flood will be reduce

→ Reduce the channel roughness by providing the smooth surface and remove the vegetation from the channel

it is reduce the flood in channels

(d) Flood ways:-

* The natural channel flood water will be diverted during high stage (high place)
(normal TP కంటే ఎక్కువ water ని వేరే కాలువలకు మళ్ళించడం)

* The flood way in natural channel (or) man-made channels ~~are~~ flood was controlled by essentially (ఆధారంగా) by the topography.

(e) Soil conservation:- (పరిరక్షణ)

→ Increase the infiltration and evaporation it will reduce the soil erosion.

→ Soil conservation measures in the catchment ~~when properly planned and~~ improvement in the catchment characteristics

→ small & medium floods are reduce by soil-conservation method

NON structural methods :-

The preventive measures that are under taken by government without construction any structures comes under this category.

→ First all the flood effected areas has to be located.

→ The low lying areas must be effected as flood in these areas special care must be taken

→ Before flood is coming warning to the people to leave the places

→ They must be constructed houses on other high locating areas

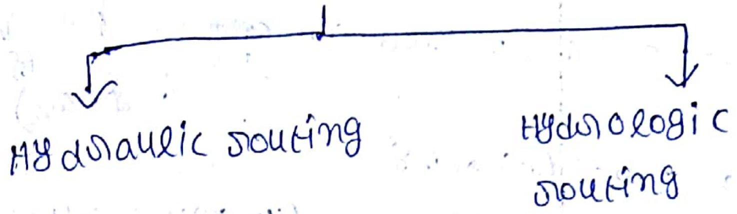
Flood ~~rou~~ routing :-

Flood routing is defined as the process of estimating the level of water in reservoir.

The hydrograph of a flood entering a reservoir will change in shape as it emerges (వరదస్థితి) out of the reservoir as certain volume of water is stored in the reservoir temporarily

The various methods of flood routing can be classified as follows

Flood routing.



* The Hydrologic routing method involves the equation of continuity

* The Hydraulic routing method involves both the equation of motion and equation of continuity

uses

→ The water level in a reservoir can be estimated using flood routing method

→ The maximum rise in the ~~discharge~~ & water surface can be estimated using flood routing method.

→ It is used to find the discharge in the down stream channel when a particular flood passes through it

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Hydrologic routing :-

Consider a flood wave "I" entering a reservoir

"t" is the time of flow of flood wave

"h" is the elevation of reservoir

"S" is the storage of the reservoir

"Q" is the discharge of the reservoir

$$Q = Q(h)$$

The storage and elevation is given by

$$S = S(h)$$

The water level in the reservoir changes with time

$$h = h(t)$$

The discharge and storage also changes with time

$S = S(t)$, $Q = Q(t)$ and $h = h(t)$ given $I = I(t)$ are required to be determined.

For an uncontrolled spill way in a reservoir

$$Q(h) = Q$$

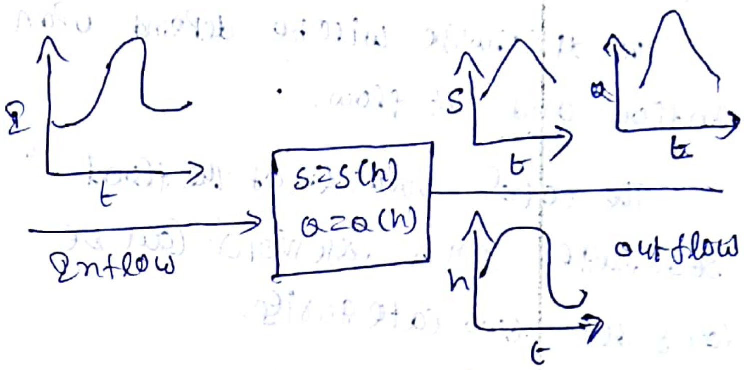
where $Q = 2/3\ C_d \sqrt{2g}\ L_e H^{3/2}$

H = Head over the spill way

Le = Effective length of the spill way

Cd = coefficient of discharge

The following data has to be known for reservoir routing



(storage routing)

(a) storage volume(V_s) elevation

(b) storage volume(V_s) outflow discharge

(c) Inflow hydrograph. $I = I(t)$

(d) The values of S, I, Q at t=0.

Reservoir routing of flood is estimated by different available methods by using the below equation in various rearranged manner

$$\bar{I}\,\Delta t - \bar{Q}\,\Delta t = \Delta S$$

where $\bar{I}$ = Average inflow.

$\bar{Q}$ = Average outflow.

Channel and reservoir routing

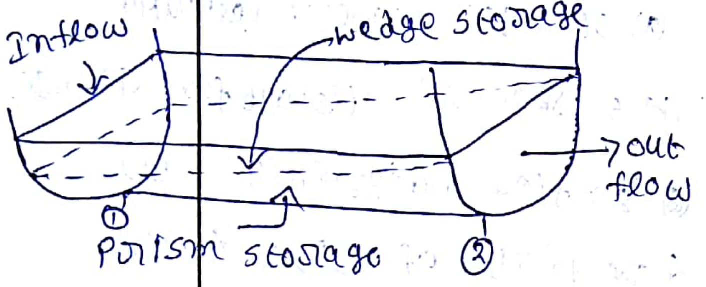
-Muskingum method

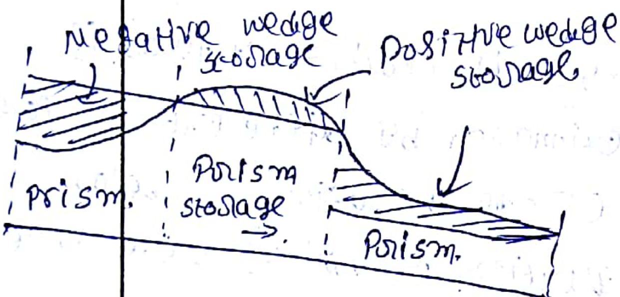
In this method used to find out the discharge.

The discharge will be depend upon inflow and out flow.

The total volume of the flood storage in a reservoir can be consider two categories.

1) Prism storage
2) wedge storage





Prism storage:-

The volume of water uniform flow occured at down stream depth (i/e) in Prism storage ~~(at 1 Point~~ see that 1st diagram. The dotted lines bottom water will be stable, that is Prism storage (2 sides of the channel the water will be equal level, no changes)

The dotted lines above water was wedge storage,

wedge storage:-

The wedge storage water was dotted line above water in 1st diagram the water can not be stable fluctuation will be there see that 2nd diagram.

This wedge water will be utilization purposes and Prism storage water will be stored in reservoir

At down stream section of a river reach prism storage is Constant while the wedge storage changes from a Positive value at an advancing flood to a nagative value during receding (reversed) flood.

* Prism storage Sp is similar to a reservoir and can be expressed as function of out flow discharge

$$Sp = f(Q)$$

* wedge storage can be accounted for by Prism ~~fig.~~ as

$$Sw = f(I)$$

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Total storage in the channel reach can be expressed as

$$S = K[x I^m + (1-x) Q^m]$$

where

K and x are constants

m a constant exponent

The value of "m" varies from 0.6 for rectangular channel to a value of about 1.0 for natural channels.

using m=1.0 The above eqn reduces to linear relationship for "S" in terms of I & Q as

$$S = K[x I^{(1)} + (1-x) Q^{(1)}]$$

$$S = K[xI + (1-x) Q]$$

This relationship is known as muskingum equation

In This the parameter "x" is known as weighting factor and takes a value b/w "0 to 0.5"

when x=0 obviously the storage is a function of discharge only and the above eqn changes to

$$S = K[(0) I + (1-0) Q]$$

$$S = KQ$$

when x=0.5 both the inflow and outflow are equally important in determining the storage 13

* The equation of continuity used in all hydrologic primary equation states that the difference b/w the inflow and outflow rate is equal to the rate of change

$$I - Q = \frac{dS}{dt}$$

where

I = inflow

Q = outflow

S = storage

Alternatively in a small time interval Δt the difference b/w the total inflow and outflow volume in a reach is equal to the change in storage

$$\bar{I}(\Delta t) - \bar{Q}(\Delta t) = \Delta S$$

where $\bar{I}$ = average inflow in time (Δt)

$\bar{Q}$ = average outflow in time Δt

ΔS = change in storage

By taking

$$\bar{I} = \frac{I_1 + I_2}{2}, \quad \bar{Q} = \frac{Q_1 + Q_2}{2}$$

$\Delta S = S_2 - S_1$ with suffixes 1 and 2 to denote beginning and end of time interval Δt

The above eqn written as

$$\left[\frac{I_1+I_2}{2}\right]\Delta t - \left[\frac{Q_1+Q_2}{2}\right]\Delta t = S_2 - S_1 \quad \rightarrow (1)$$

Δt should be sufficiently short so that the inflow and outflow hydrographs can be assumed to be straight line.

For a given channel reach by selecting a routing interval Δt and using the muskingum equation change in storage is

$$S_2 - S_1 = K[x(I_2 - I_1) + (1-x)(Q_2 - Q_1)] \quad \rightarrow (2)$$

From the eqn (1) & (2) Q_2 is evaluated as:

$$\frac{1}{2}[(I_1+I_2).\Delta t] - \frac{1}{2}[(Q_1+Q_2)\Delta t] = S_2 - S_1 \quad \rightarrow (1)$$

$$S_2 - S_1 = KxI_2 - KxI_1 + K(1-x)(Q_2 - Q_1)$$

$$S_2 - S_1 = KxI_2 - KxI_1 + KQ_2 - KxQ_2 - KQ_1 + KxQ_1 \quad \rightarrow (2)$$

$$0.5 I_1 \Delta t + 0.5 I_2 \Delta t - 0.5 Q_1 \Delta t - 0.5 Q_2 \Delta t - KxI_2 + KxI_1 - KQ_2 + KxQ_2 + KQ_1 - KxQ_1 = S_2 - S_1 - S_2 + S_1$$

$$\Rightarrow [0.5\Delta t - Kx]I_2 + [0.5\Delta t + Kx]I_1 + [-0.5\Delta t + K - Kx]Q_1 + [Kx - K - 0.5\Delta t]Q_2 = 0$$

$$\Rightarrow [-Kx + 0.5\Delta t]I_2 + [0.5\Delta t + Kx]I_1 + [K - Kx - 0.5\Delta t]Q_1$$

$$\cancel{[-K + Kx + 0.5\Delta t]Q_2} = -[Kx - K - 0.5\Delta t]Q_2 = 0$$

$$\Rightarrow [-Kx + 0.5\Delta t]I_2 + [0.5\Delta t + Kx]I_1 + [K - Kx - 0.5\Delta t]Q_1 = [K - Kx + 0.5\Delta t]Q_2$$

$$\left[\frac{-Kx + 0.5\Delta t}{K - Kx + 0.5\Delta t}\right]I_2 + \left[\frac{0.5\Delta t + Kx}{K - Kx + 0.5\Delta t}\right]I_1 + \left[\frac{K - Kx - 0.5\Delta t}{K - Kx + 0.5\Delta t}\right]Q_1 = Q_2$$

$$Q_2 = C_0 I_2 + C_1 I_1 + C_2 Q_1 \quad \rightarrow (3)$$

$$\therefore C_0 = \frac{-Kx + 0.5\Delta t}{K - Kx + 0.5\Delta t}$$

$$C_1 = \frac{Kx + 0.5\Delta t}{K - Kx + 0.5\Delta t}$$

$$C_2 = \frac{K - Kx - 0.5\Delta t}{K - Kx + 0.5\Delta t}$$

$C_0 + C_1 + C_2 = 1$ eqn (3) can be written in a general form for the n^{th} time step as

$$Q_n = C_0 I_n + C_1 I_{n-1} + C_2 I_{n-1}$$

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It has been found that for best result the routing interval "Δt" should be so choosen that

"$K > \Delta t > 2Kx$"

If $\Delta t < 2Kx$ the coefficient C_0 will be negative generally "-ve" of coefficient are avoided choosing approximate value of Δt the following procedure is needed

(a) knowing K & x select approximate value of Δt

(b) calculate C_0, C_1, C_2.

(c) starting from the initial condition I_1, Q_1 and known I_2 at the end of the first step Δt calculate Q_2

(d) The out flow calculate in step (c) becomes the known initial out flow for the next time step repeat the calculate for the entire inflow hydrograph.

UNIT-IV Problems (Muskingum method) 1

[Pg No 287 subramanyam]

(1) Route the following hydrograph through a river reach for which $K = 12$ hr and $x = 0.2$ at the start of the inflow flood. The outflow discharge is $10 m^3/s$

Time (h)	0	6	12	18	24	30	36	42	48	54
Inflow (m^3/s)	10	20	50	60	55	45	35	27	20	15

Sol :-

since

$K = 12$ hr and $2Kx = 2(12)0.2 = 4.8$ hr

$x = 0.2$

Δt should be such that $12 h > \Delta t > 4.8 h$.

In the present case $\Delta t = 6h$ is selected to suit the given inflow hydrograph ordinate interval.

[0-6 → Difference 6 hr

6-12 → Difference 6 hr

Calculate C_0, C_1, C_2

$$C_0 = \frac{-Kx + 0.5\Delta t}{K - Kx + 0.5\Delta t}$$

$$= \frac{-12(0.2) + 0.5(6)}{12 - 12(0.2) + 0.5(6)} = 0.048$$

$$C_1 = \frac{Kx + 0.5\Delta t}{K - Kx + 0.5\Delta t}$$

$$= \frac{12(0.2) + 0.5(6)}{12 - 12(0.2) + 0.5(6)} = 0.429$$

$$C_2 = \frac{K - Kx - 0.5\Delta t}{K - Kx + 0.5\Delta t}$$

$$= \frac{12 - 12(0.2) - 0.5(6)}{12 - 12(0.2) + 0.5(6)} = 0.523$$

For the first time interval, 0 to 6h

$I_1 = 10$ [∵ In table 0hr inflow $I_1 = 10$]

$I_2 = 20$ [∵ In " 6hr " $I_2 = 20$]

$Q_1 = 10$ [∵ Difference b/w 0hr - 6hr = 20 - 10 = 10]

we know that $C_0 I_2 + C_1 I_1 + C_2 Q_1$

$C_0 I_2 = 0.048 \times 20 = 0.96$

$C_1 I_1 = 0.429 \times 10 = 4.29$

$C_2 Q_1 = 0.523 \times 10 = 5.23$

$Q_2 = C_0 I_2 + C_1 I_1 + C_2 Q_1$

$= 0.96 + 4.29 + 5.23$

$= 10.48 \ m^3/s$

For the next ~~step~~ time step, 6 to 12hr, $Q_1 = 10.48 \ m^3/s$

The procedure is repeated for the entire duration of the inflow hydrograph. The computations are done in a tabular form as shown in below table.

By plotting the inflow and outflow hydrographs the attenuating and peak lag are found to be $10 \ m^3/s$ and 12 hr respectively.

$\Delta t = 6h$, $I_1 = 10$, $I_2 = 20$, $Q_1 = 10$

Time	I (m^3/s)	$0.048 I_2$ ($C_0 I_2$)	$0.429 I_1$ ($C_1 I_1$)	$0.523 Q_1$ ($C_2 Q_1$)	Q (m^3/s)
0	10				10
6	20	$0.048 \times 20 = 0.96$	$0.429 \times 10 = 4.29$	$0.523 \times 10 = 5.23$	$0.96 + 4.29 + 5.23 = 10.48$
12	50	$0.048 \times 50 = 2.4$	$0.429 \times 20 = 8.58$	$0.523 \times 10.48 = 5.48$	$2.4 + 8.58 + 5.48 = 16.46$
18	60	$0.048 \times 60 = 2.88$	$0.429 \times 50 = 21.45$	$0.523 \times 16.46 = 8.61$	$2.88 + 21.45 + 8.61 = 32.94$
24	55	$0.048 \times 55 = 2.64$	$0.429 \times 60 = 25.74$	$0.523 \times 32.94 = 17.23$	$2.64 + 23.60 + 17.23 = 45.61$
30	45	$0.048 \times 45 = 2.16$	0.429×55 23.60	$0.523 \times 45.61 = 23.85$	$2.16 + 19.30 + 23.85 = 49.61$
36	35	$0.048 \times 35 = 1.68$	$0.429 \times 45 = 19.30$	$0.523 \times 49.61 = 25.95$	$1.68 + 15.02 + 25.95 = 46.93$
42	27	$0.048 \times 27 = 1.30$	$0.429 \times 35 = 15.02$	$0.523 \times 46.93 = 24.55$	$1.30 + 11.58 + 24.55 = 40.87$
48	20	$0.048 \times 20 = 0.96$	$0.429 \times 27 = 11.58$	$0.523 \times 40.87 = 21.38$	$0.96 + 8.58 + 21.38 = 30.92$
54	15	$0.048 \times 15 = 0.72$	$0.429 \times 20 = 8.58$	$0.523 \times 30.92 = 17.74$	$0.72 + 8.58 + 17.74 = 27.04$

~~$I_1 = 10$~~ I