LECTURE 37

11-APRIL-2013

FREQUENCY ANALYSIS . . .

In the last lecture we discussed on using frequency analysis to describe the severity of an hydrological event.

→ That is, frequency analysis described the relation between

$$\boxed{\text{Magnitude of an Event}}$$

&

$$\boxed{\text{Probability of Exceedance}}$$

→ We have also seen an example on annual maximum (24 h) rainfall data.

↳ We found the average recurrence years for the event $X \geq x_T$ ($x_T = 12.0$ cm) by crude method and suggested it a return period.

→ We have also seen ~~what~~ is that

$$P(X \geq x_T) = p = \frac{1}{T}$$

→ Also the probability that the event should occur atleast once in N-years was given as:

$$P(X \geq x_T \text{ atleast once in N-years}) = 1 - \left(1 - \frac{1}{T}\right)^N$$

Now you understand that probability and return period are related. $p = \frac{1}{T}$ or $T = \frac{1}{p}$.

So if you have ample methods to evaluate the probability, then subsequently you can find the return period.

Plotting Position

This is ~~a~~ method to do frequency analysis

Usually the probability analysis can be done

→ Empirically

→ Analytically

* The plotting position method is an empirical technique.

↳ Here the annual maximum rainfall (24 h) data is arranged in a descending order.

↳ You assign order numbers $m = 1, 2, 3, \ldots$ in such a way that ~~the~~ in the descending order ~~assigned~~ arranged data the first value (which is the largest) is given order $m = 1$.

Subsequently for other values assigned $m = 2$, $m = 3$ ... upto $m = n$. (Note n = No. of observation years).

↳ The probability p of an event equalled or exceeded is then given by Weibull formula

$$p = \frac{m}{n+1}$$

∴ Now recurrence interval or Return Period $T = \frac{n+1}{m}$

* Please note that there are many other such probability relations (as given by Weibull here). You may use any convenient ~~one~~ and appropriate one.

↳ The exceedance probability of this event is called plotting position.

Q: For the given annual ~~rain~~ maximum rainfall (24 h) data, can you arrange in descending order and find the return periods.

Ans.:

m	Rainfall (cm)	$p = \frac{m}{n+1}$	$T = \frac{1}{p}$
1	16.0	0.0385	26
2	14.3	0.0769	13
3	13.5	0.1154	8.667
4	13.0	0.1538	6.5
5	12.8	0.1923	5.2
6	12.5	0.2308	4.333
7	12.0	0.2692	3.714
8	11.2		
9	11.0		
10	10.6		
11	10.5		
12	10.2		
13	9.6		
14	9.5		
15	9.0		
16	8.9		
17	8.9	0.5385	1.857
18	8.5		
19	8.4		
20	8.3		
21	8.0		
22	7.8		
23	7.6		
24	7.5		
25	6.0		

You can complete the work and interpret the results.

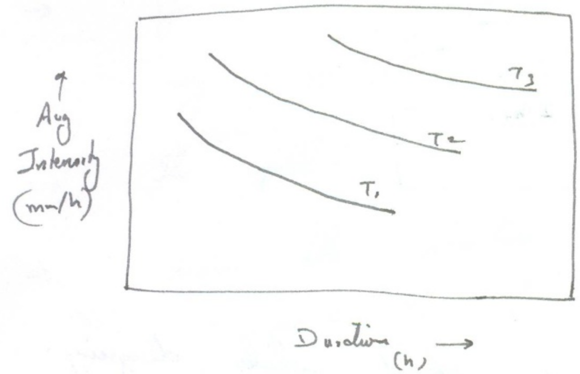
Higher the return period, higher is the magnitude of the rainfall event.

Intensity - Duration - Frequency

We have seen

* Intensity of storm decreases with storm duration
* Also now you can visualise that if the return period is larger, then for same duration the intensity of rainfall will be larger.

One can plot intensity - duration - frequency curves.



$T_3 > T_2 > T_1$

$$i = \frac{K T^{\alpha}}{(D + a)^{n}}$$

$i \rightarrow$ intensity

$D \rightarrow$ duration

$T \rightarrow$ return period

K, α, a, n are constants for a given catchment.

Depth - Area - Duration Relationships

For a given rainfall magnitude

→ Average depth decreases with the area

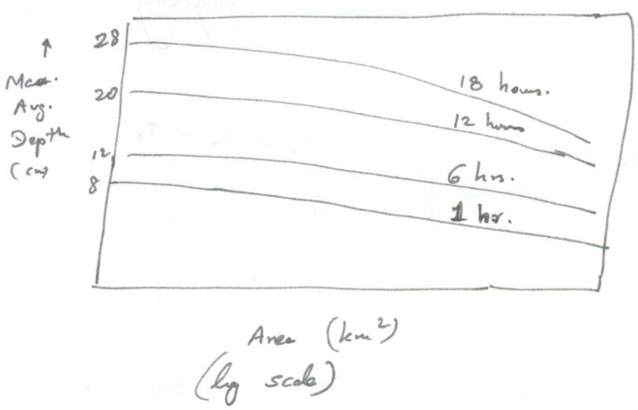
$$\bar{P} = P_0 \exp(-KA^n)$$

$\bar{P}$ → Average depth in cms over an area A (km²).

P_0 → highest amount of rainfall in (cm).

K →
n → } constants for a given catchment

A typical DAD curves look like



These curves can be referred while designing the hydraulic structure.

Probable Maximum ~~Flood~~ Precipitation (PMP)

→ We need to design hydraulic structures such that failure is as minimum as possible.

Because failures can cause huge damage.

→ So we usually use maximum possible precipitation that can be expected at a location.

→ The probable maximum precipitation (PMP) is greatest or extreme rainfall for a given duration that is physically possible

$$PMP = \bar{P} + K\sigma$$

$K \rightarrow$ a frequency factor

$\sigma \rightarrow$ standard deviation

FLOOD DESIGN

→ You require a design flood

say 100-yr, 200-yr, etc.

→ The spillway has to be designed appropriately.

→ Whether the structure has to withhold PMF or some % of PMF.

Risk

The probability of occurrence of an event $X \geq x_T$ at least once over a period of N successive years is called RISK.

$$\text{Risk} \quad \bar{R} = 1 - (1-p)^N$$

$$= 1 - \left(1 - \frac{1}{T}\right)^N$$

Reliability

$$R_e = 1 - \bar{R}$$
$$= \left(1 - \frac{1}{T}\right)^N$$

Acceptable risk

Then Reliability.