Surface Water Hydrology
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Lecture: 39
Estimation of Peak Flood Flow

In this lecture, we will discuss the Estimation of Peak Flood Flow.

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The concept covered the estimation of peak flood flow that we will discuss maybe you can say that two categories are Empirical Formulae and other formulae that we will see.

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The detailed outline for this lecture is like this, the Estimation of Peak Flood Flow, the first one that comes on this list should be the Rational Formula and some of the discussions apply to the other Empirical Formulae also.

Now, we are discussing here specifically some of the remaining empirical formulae that mostly depend on the flood peak and the area relationship. For example, the Dickens Formula, Ryves Formula, Inglis formula, Fuller's formula.

Among the other methods, it comes to the Envelop Curves between the Peak Flow and Drainage Area that will discuss the Unit Hydrograph Method of calculating the peak discharge we will discuss, Rating Curve Method also will discuss before going to the summary.

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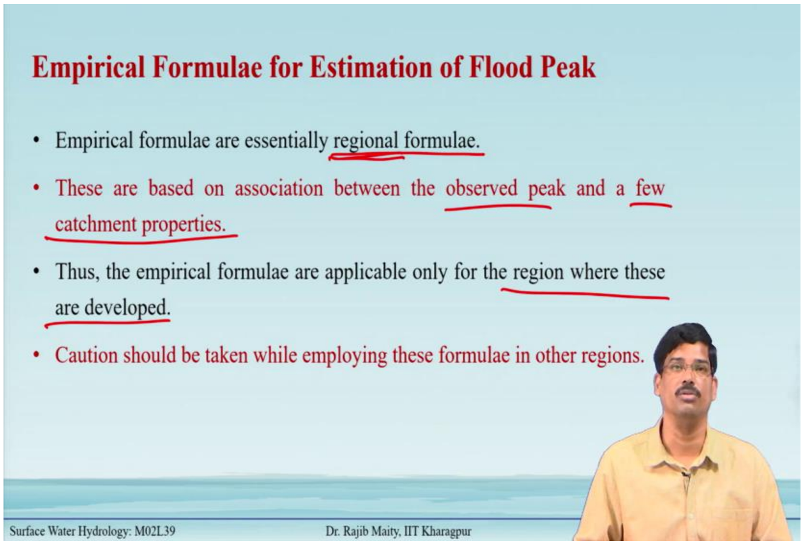

Empirical Formulae for Estimation of Flood Peak

The empirical formula is essentially the regional formulae. If we developed the empirical formulae for a particular region, we cannot apply that equation directly to some other region. They are maybe some changes in the constants and that is why we call that regional because that is applicable that constants are applicable for that particular region only.

That is why it is called the regional formula. Secondly, these are based on the association between the observed peak and a few catchment properties. So, these few catchment properties can vary from one equation to another equation, as we have already seen in the rational formula also, and we will see in Fuller's formula also in between, we will see that what are the different catchment properties that have been utilized, but the important part that has to be understood here is that these empirical formulae are applicable only for the region where these things are being developed.

So, that is why since it depends on this catchment property for this particular region, so, it is applicable there only, any translation of any special transferability of this kind of equation should be used with caution.

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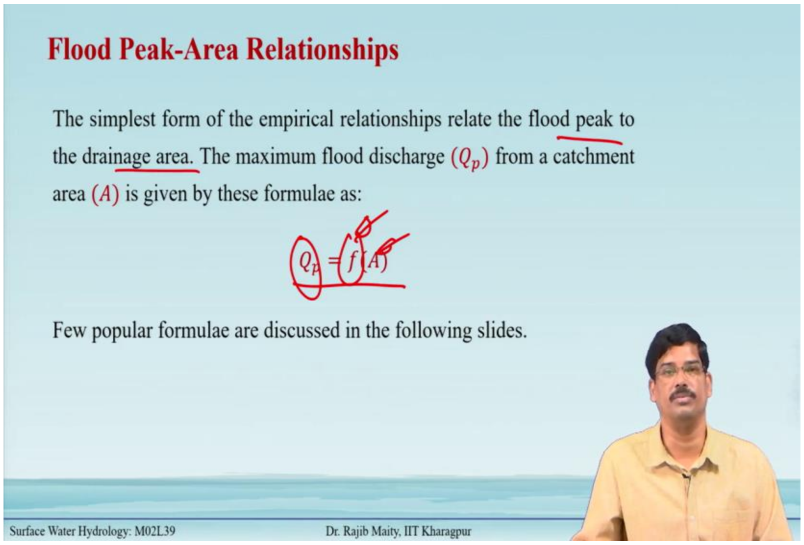

Flood Peak-Area Relationships

The simplest form of the empirical relationship relates the flood peak to the drainage area. The maximum flood discharge (Q_p) from a catchment area (A) is given by these formulae:

$$Q_p = f(A)$$

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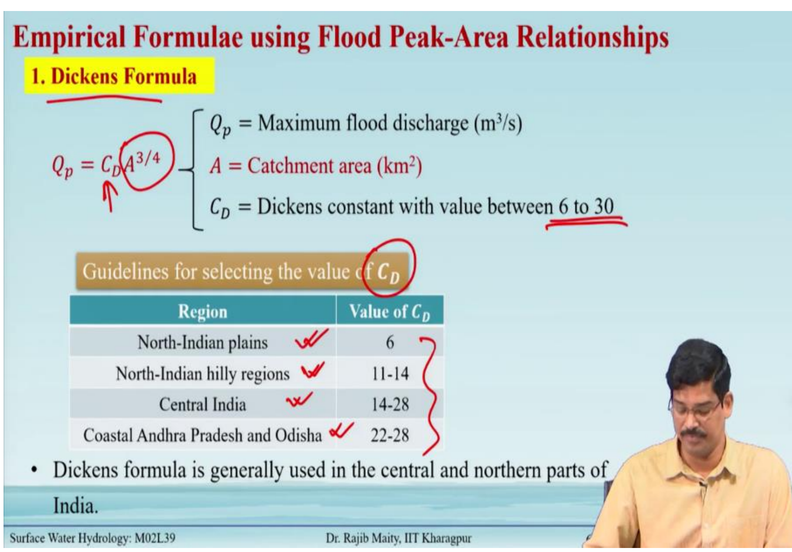

Empirical Formulae using Flood Peak-Area Relationships

1. Dickens Formula

$$Q_p = C_D A^{3/4}$$

Where

Q_p= Maximum flood discharge (m^3/s)

A= Catchment area (km^2)

C_D= Dickens constant with a value between 6 to 30

Guidelines for selecting the value of C_D

Region	Value of C_D
North-Indian plains	6
North-Indian hilly regions	11-14
Central India	14-28
Coastal Andhra Pradesh and Odisha	22-28

Dickens formula is generally used in the central and northern parts of India.

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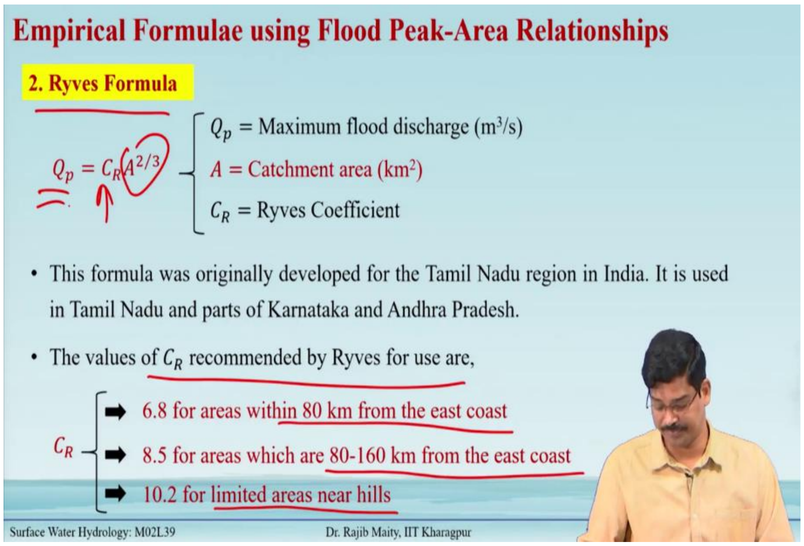

2. Ryves Formula

$$Q_p = C_R A^{2/3}$$

Where

Q_p= Maximum flood discharge (m^3/s)

A= Catchment area (km^2)

C_R= Ryves Coefficient

This formula was originally developed for the Tamil Nadu region in India. It is used in Tamil Nadu and parts of Karnataka and Andhra Pradesh.

The values of this C_R are recommended by different areas as follows 6.8 for the areas within 80 kilometers from the East Coast, 8.5 for which are 80 to 160 kilometers from the East Coast, and 10.2 for limited to the hilly near the hills the areas near the hills.

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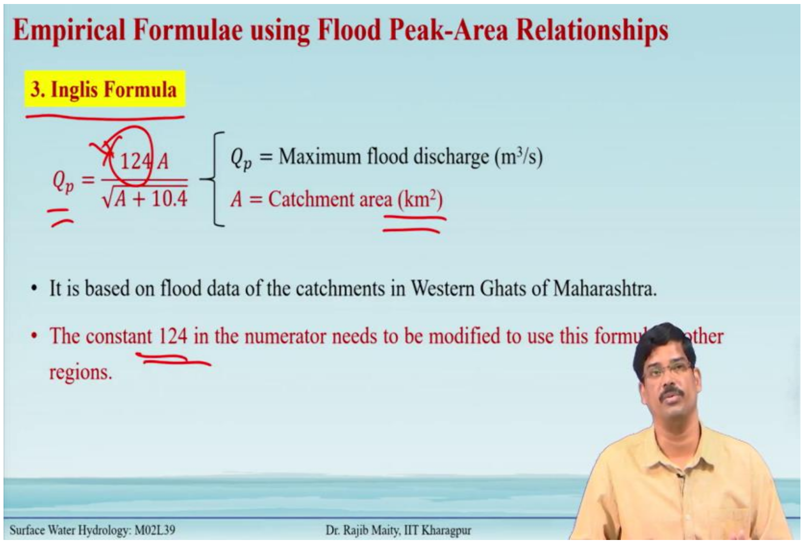

3. Inglis Formula

$$Q_p = \frac{124\, A}{\sqrt{A + 10.4}}$$

Where

Q_p= Maximum flood discharge (m^3/s)

A= Catchment area (km^2)

It was developed for the Western hertz regions in Maharashtra and the constant this 124, in the numerator, that is needed to be modified if we use this formula in some other regions.

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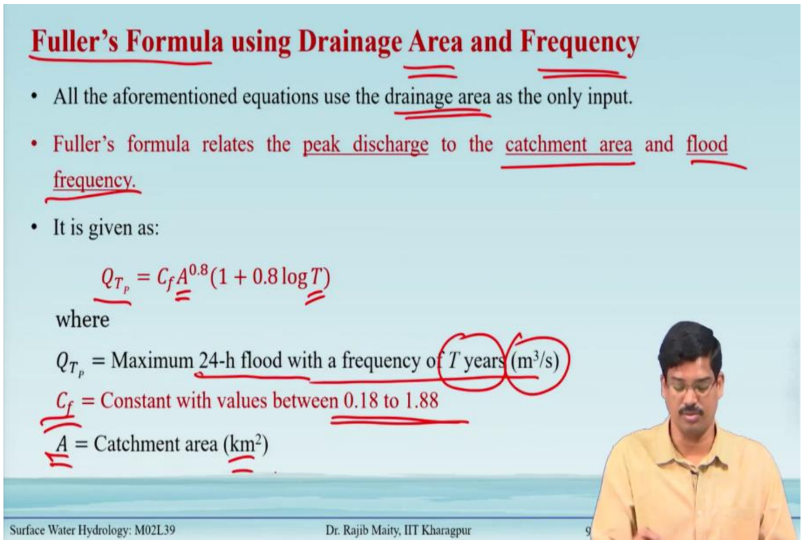

Fuller's Formula using Drainage Area and Frequency

All the aforementioned equations use the drainage area as the only input. Fuller's formula relates the peak discharge to the catchment area and flood frequency.

It is given as:

$$Q_{T_p} = C_f A^{0.8}(1 + 0.8 \log T)$$

Where Q_{T_P}= Maximum 24-h flood with a frequency of T years (m^3/s)

C_f= Constant with values between 0.18 to 1.88

A= Catchment area (km^2)

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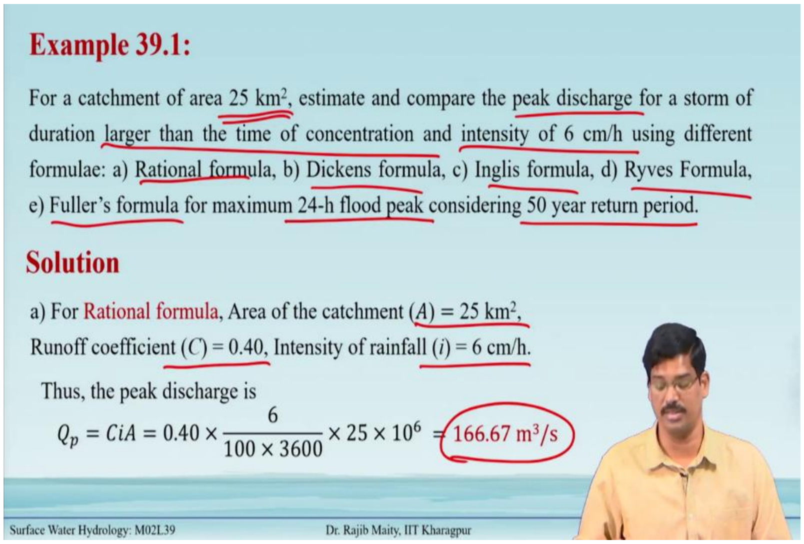

Example 39.1:

For a catchment of area 25 km^2, estimate and compare the peak discharge for a storm of duration larger than the time of concentration and intensity of 6 cm/h using different formulae: a) Rational formula, b) Dickens formula, c) Inglis formula, d) Ryves Formula, e) Fuller's formula for maximum 24-h flood peak considering 50-year return period.

Solution

a) For Rational formula, Area of the catchment (A) = 25 km^2, Runoff coefficient (C) = 0.40, Intensity of rainfall (i) = 6 cm/h.

Thus, the peak discharge is

$$Q_p = CiA = 0.40 \times \frac{6}{100 \times 3600} \times 25 \times 10^6$$

$$= 166.67 \text{ m}^3/\text{s}$$

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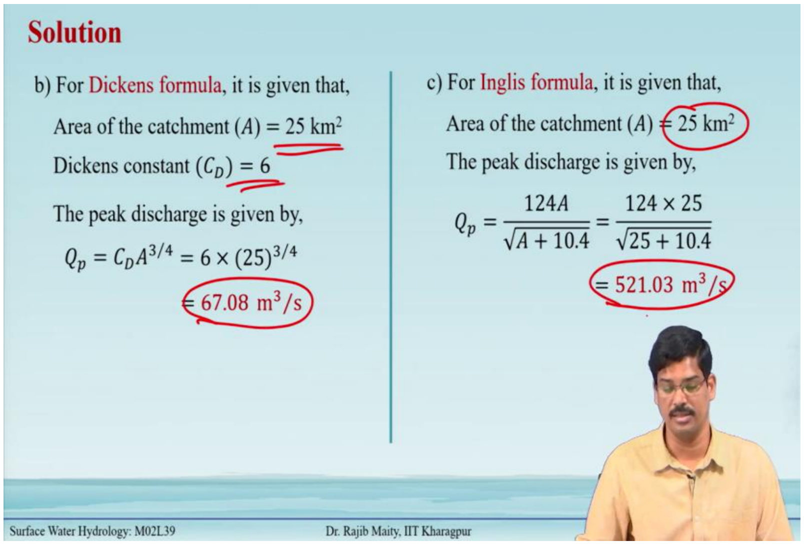

b) For Dickens formula, it is given that,

Area of the catchment (A) = 25 km^2

Dickens constant (C_D) =6

The peak discharge is given by,

$Q_p = C_D A^{3/4} = 6 \times (25)^{3/4}$

$= 67.08$ m^3/s

c) For the Inglis formula, it is given that,

Area of the catchment (A) = 25 km^2

The peak discharge is given by,

$$Q_p = \frac{124A}{\sqrt{A + 10.4}} = \frac{124 \times 25}{\sqrt{25 + 10.4}}$$
$$= 521.03 \text{ m}^3/\text{s}$$

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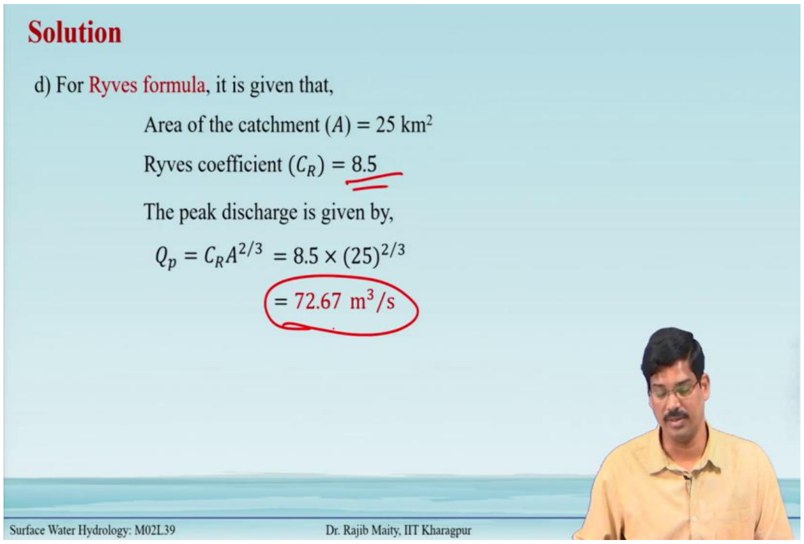

d) For Ryves formula, it is given that,

Area of the catchment (A) = 25 km^2.

Ryves coefficient (C_R) =8.5

The peak discharge is given by,

$$Q_p = C_R A^{2/3} = 8.5 \times (25)^{2/3}$$
$$= 72.67\ \text{m}^3/\text{s}$$

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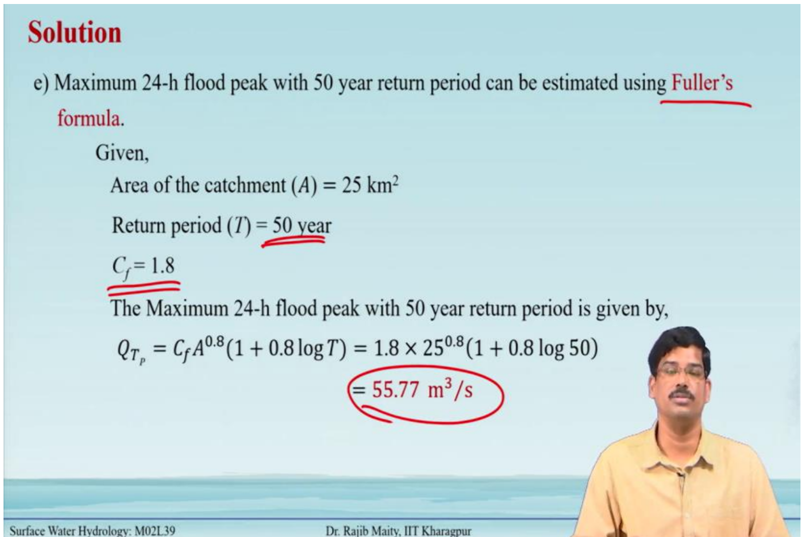

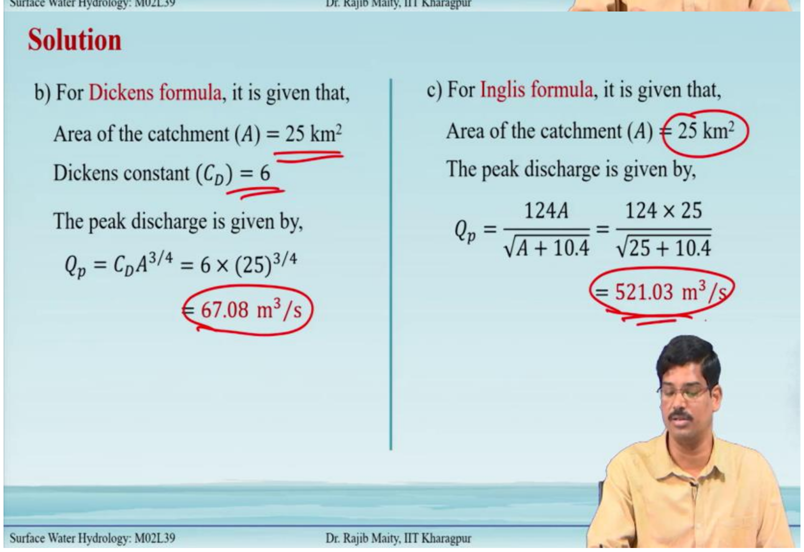

e) Maximum 24-h flood peak with a 50-year return period can be estimated using Fuller's formula.

Given,

Area of the catchment (A) = 25 km^2

Return period (T) = 50 year

C_f = 1.8

The Maximum 24-h flood peak with a 50-year return period is given by,

$$Q_{T_p} = C_f A^{0.8}(1 + 0.8 \log T) = 1.8 \times 25^{0.8}(1 + 0.8 \log 50)$$

$= 55.77\ m^3/s$

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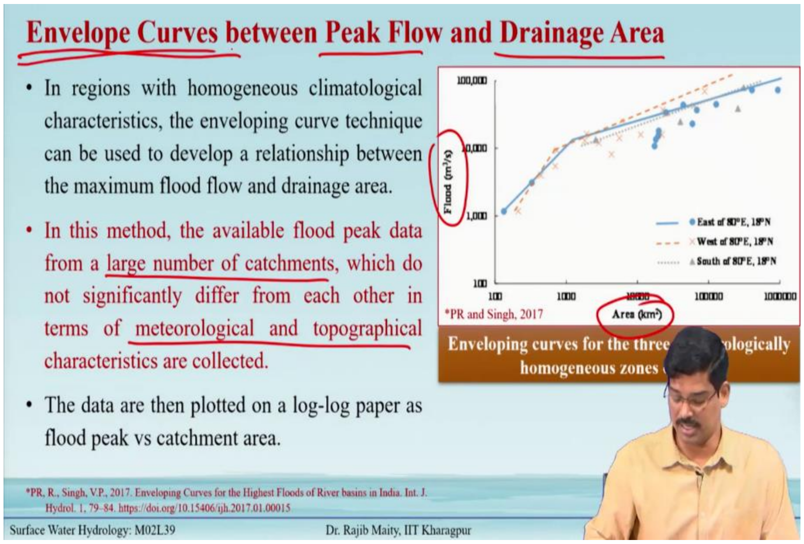

Envelope Curves between Peak Flow and Drainage Area

In regions with homogeneous climatological characteristics, the enveloping curve technique can be used to develop a relationship between the maximum flood flow and drainage area.

In this method, the available flood peak data from a large number of catchments, which do not significantly differ from each other in terms of meteorological and topographical characteristics are collected. The data are then plotted on a log-log paper as flood peak vs. catchment area.

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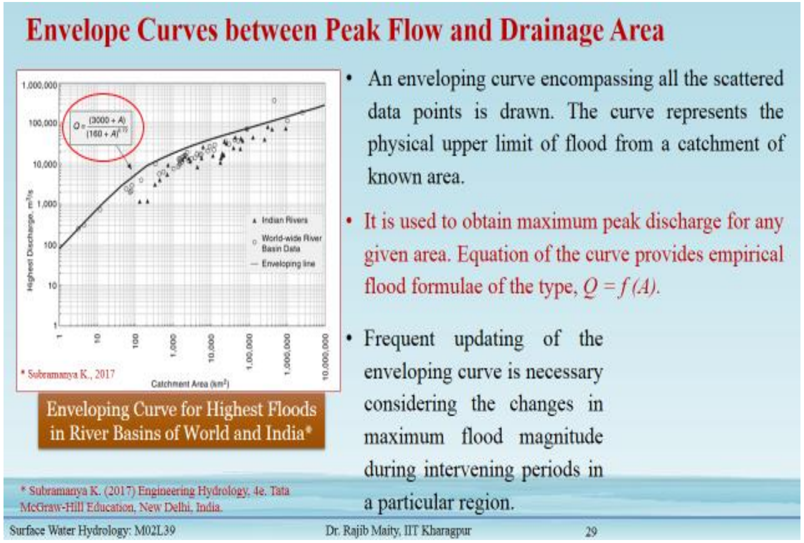

Envelope Curves between Peak Flow and Drainage Area

And another example with respect to the Indian context that an enveloping curve that encompasses all the scattered data points remember that is not the best fit line to cover all the scattered points in this way that curve is drawn and the curve represents the physical upper limit physical upper limit of the flood from the catchment of the known area.

In fig.1 x-axis is showing the catchment area and the y-axis is showing the highest discharge. So, if the solid line is covered for any specific area if we know then we can go and there may be some variation, but then what is the maximum possible thing that we can pick out from this kind of information if it is available.

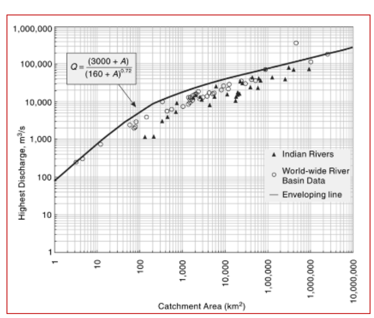

Fig.1 shows the enveloping Curve for the Highest Floods in River Basins of the World and India. (Subramanya K., 2017)

These things are heavily dependent on the data from the ground. So, this is used to obtain the maximum flood discharge of any given area equation of the curve provides the empirical flood formula of the type that we started with that $Q = f(A)$ and this f maybe can be seen in this enveloping curve.

Frequent updating of the enveloping curve is necessary considering the changes in maximum flood magnitude during intervening periods in a particular region.

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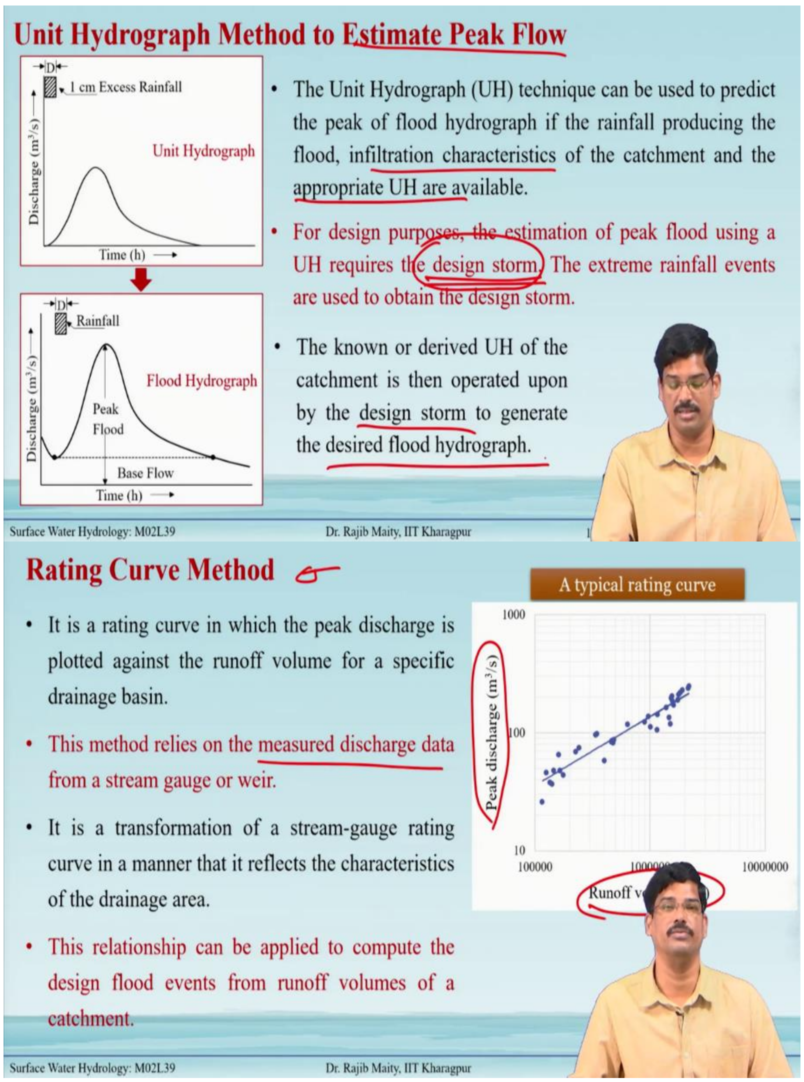

Unit Hydrograph Method to Estimate Peak Flow

Another method that comes under the unit hydrograph method to estimate this peak flow is the theory of unit hydrograph. It is used to estimate the peak flood hydrograph if the rainfall producing the flood infiltration characteristics of this catchment and the appropriate unit hydrograph were available. Three things are needed the infiltration characteristics of this catchment and the appropriate unit hydrograph of this duration that is available.

For the design purpose, the estimation of the peak flood using the unit hydrograph requires the design storm. So, this is important that design storm means which may not be occurring on this catchment. The derived unit hydrograph of this catchment is then operated upon the design storm to generate the desired flood hydrograph from which the peak can be decided.

Rating Curve Method

The rating curve is the peak discharge is plotted against the runoff volume for specific drainage. Then if we can see that it can be approximated through some best fit straight line or some best-fit equation, we can utilize that best fit equation to identify what could be the peak discharge for the runoff for a corresponding runoff volume. So, this method again relies on the measured discharge data from a stream gauge or the weir.

So, this depends on the field data. It is a transformation of a stream gauge rating curve in a manner that reflects the characteristics of this drainage area. So, this relationship can be applied to compute the design flood events from the runoff volume of a catchment.

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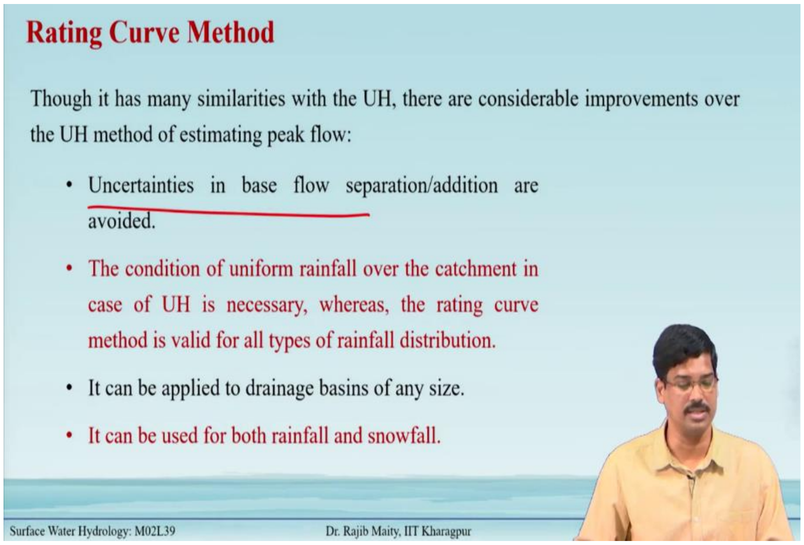

Though it has many similarities with the UH, there are considerable improvements over the UH method of estimating peak flow:

- Uncertainties in base flow separation/addition are avoided.
- The condition of uniform rainfall over the catchment in case of UH is unnecessary, whereas, the rating curve method is valid for all types of rainfall distribution.
- It can be applied to drainage basins of any size.
- It can be used for both rainfall and snowfall.

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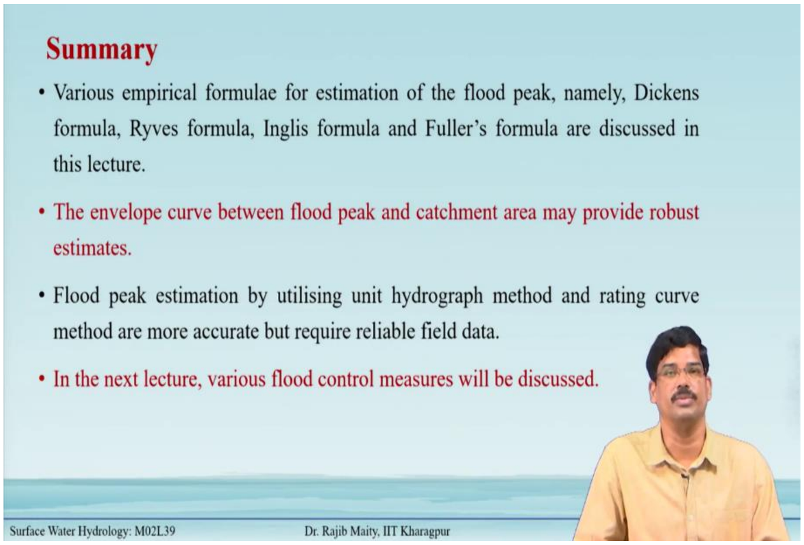

Summary

In summary, we learned the following points from this lecture:

- Various empirical formulae for estimation of the flood peak, namely, Dickens formula, Ryves formula, Inglis formula, and Fuller's formula are discussed in this lecture.
- The envelope curve between flood peak and catchment area may provide robust estimates.
- Flood peak estimation by utilizing the unit hydrograph method and rating curve method is more accurate but requires reliable field data.
- In the next lecture, various flood control measures will be discussed.

Reference

- Subramanya K. (2017) Engineering Hydrology, 4th edition. Tata McGraw-Hill Education, New Delhi, India.