Surface Water Hydrology
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Lecture: 37
Introduction to Floods and Rational Method

This week we will cover a topic which is Floods and Flood Control. In this week's lecture 37, we will discuss an introduction to floods, and one of the very popular methods to estimate the peak discharge which is known as a Rational Method.

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The three concepts will be covered in this lecture, the first one is the Flood and its different types, the attributes of the Flood, and the Rational Method to estimate peak discharge.

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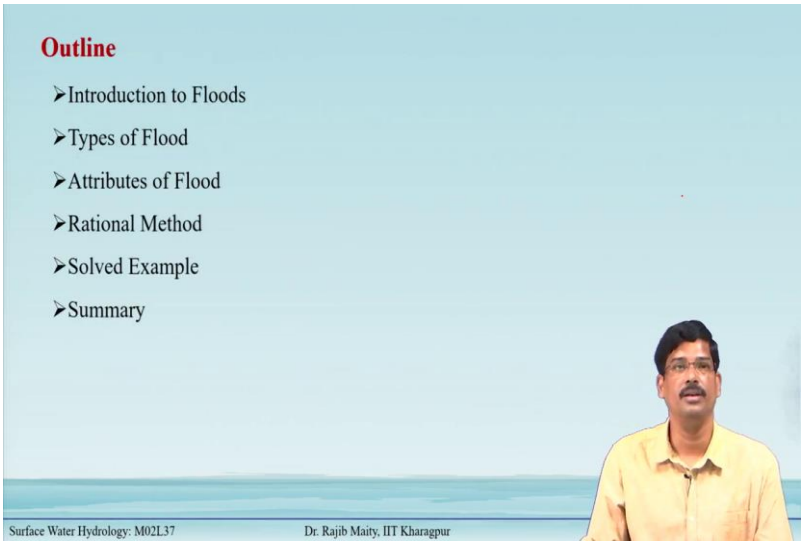

The outline of this lecture was like this, the Introduction to Floods after that different types of floods will discuss, and different attributes characterize a particular flood event that we will discuss, then we come to discuss different methods and the rational method comes in the first of it and different methods will be there and in this lecture based on the Rational Method, how to apply it within solved example we will saw before we go to the summary.

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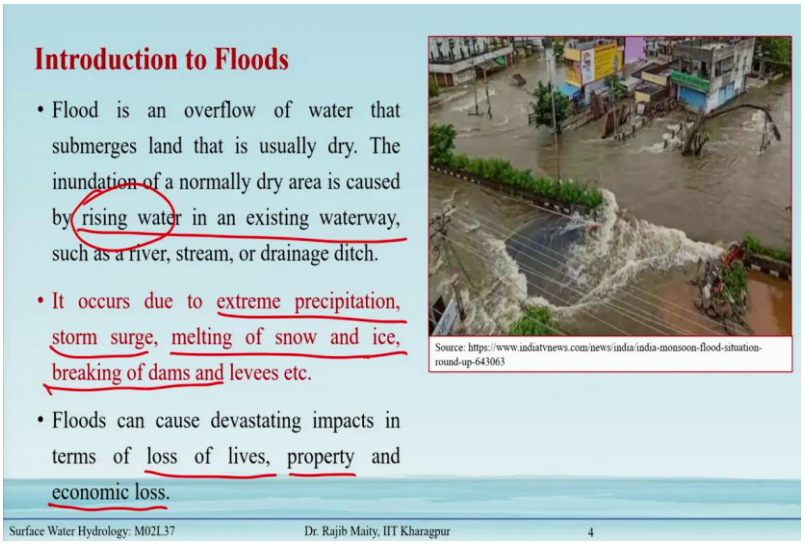

Introduction to Floods

A flood is an overflow of water that submerges usually dry land. The inundation of a normally dry area is caused by rising water in an existing waterway, such as a river, stream, or drainage ditch. The rising of this water can be caused by different reasons, but in general when it rises in such a way that it disrupts the normal activity of the ecosystem or by human beings then we called a particular flood event, it occurs due to the extreme precipitation and one of the obvious causes.

Then there are some storm surges, particularly in the coastal region, then melting up the snow and ice melting of snow and ice sometimes is associated with this heavy rainfall also. So, these two are together and that cause several devastations in different places and inconvenience to the society including, the large mishaps like breaking of dams and levees, etc.

So, floods can cause a devastating impact in terms of the loss of lives, which is very high in the impact that can be significant property loss as well and there can be economic loss, these are some of the high levels of disrupting the society as an example, but sometimes some sort of low-intensity flood also can disrupt the normal human activity and our ecosystem as well.

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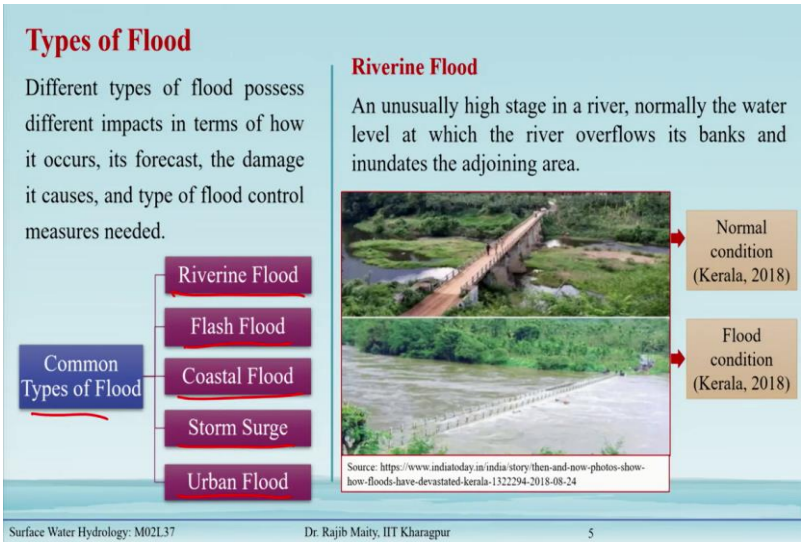

Types of Floods

Different types of floods possess different impacts in terms of how it occurs, their forecast, the damage it causes, and the type of flood control measures needed.

The common type of floods is as follows:

I. Riverine Flood
II. Flash Flood
III. Coastal Flood
IV. Storm Surge
V. Urban Flood

I. Riverine Flood

Riverine Flood is one of the most common floods it is generally the unusually high stage in a river. Normally the water level at which the river overflows its banks or inundates sometimes may cause some devastation to the water infrastructure that is there in the course of the river.

There are different causes for these river floods. Most of the causes that come from this river in flood are generally there are heavy downpours in the upstream area. And that causes the washout of these downstream surrounding areas that inundates the different areas.

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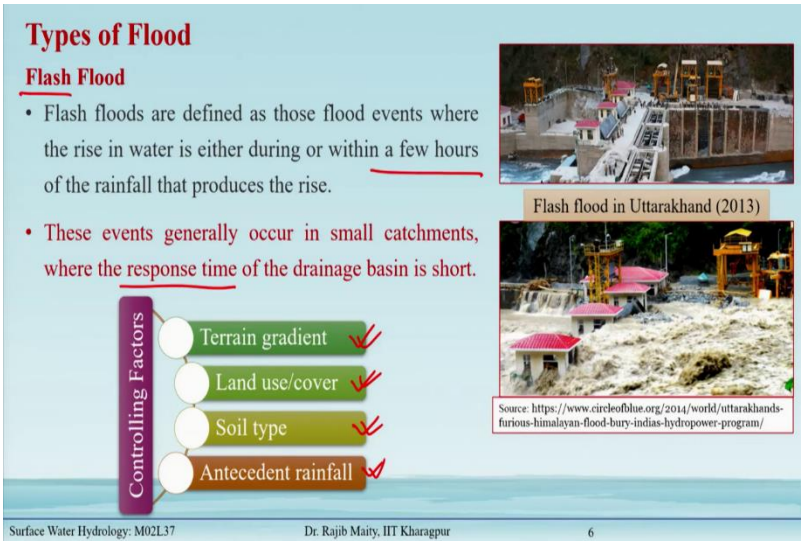

II. Flash Flood

Flash floods are defined as those flood events where the rise in water is either during or within the few hours of the rainfall that produce the rise. So, here the most important feature is that within a very short time it comes and it devastates the entire area. So, that is why the name is there as a Flash Flood.

So, these events generally occur in small catchments where the response time of the drainage basin is short. So, response time what we mean is that there some rainfall occurs and, it results in a runoff. So, the lag between these two times is the response time of the basin and which we can understand that it is when it is short and if there is heavy rainfall in that catchment then within a very short time, he was flooded can come which is termed as a flash flood.

Apart from the size of this catchment there are other controlling factors are also there so, far as the flash flood is concerned, for example, the Terrain gradient generally occurs where the terrain gradient is higher, land use land cover sometimes you know that it assists this higher runoff depending on the condition in the basin.

Soil type if it is more impermeable or more clay then it is the flash flood is more and the antecedent rainfall condition is also one of the factors where if there is already some rainfall is occurring for the past couple of days then additional rainfall, of course, means in causing a favorable condition for the Flash Flood.

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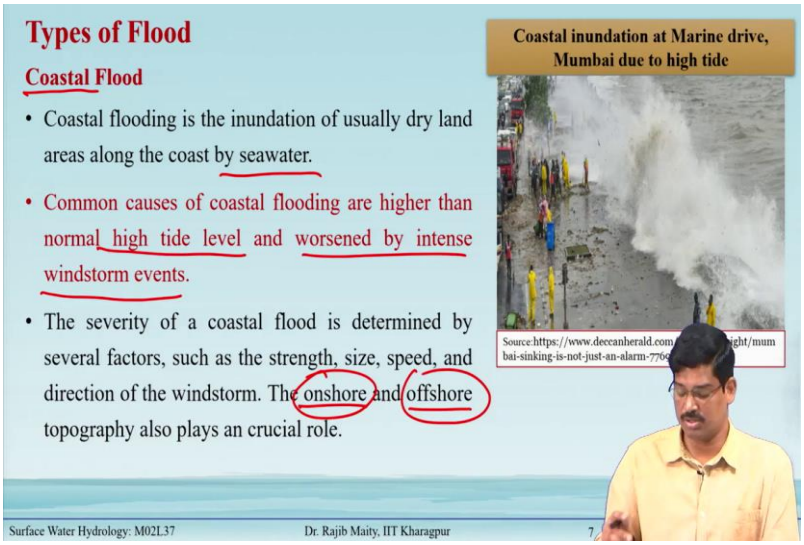

III. Coastal Flood

This type of flood occurs near the coast. It is generally the dry lands are inundated across the coast and it is due to the seawater in seawater that comes inside the land area which is generally drier regions. The common causes for this coastal flooding are higher than normal high tide levels and worsened by intense windstorm events.

The two things generally occur. During the high tide level and the instant windstorm, two are combined that time some seawaters come inside the land area and inundate a large area which is one of the major causes of this Coastal Flood. The severity of the coastal flood is determined by several factors its strength, size, speed, and the direction of the windstorm.

The onshore and offshore topography also plays a crucial role here. From the shoreline is the borderline between the water area and the land area from there if we go inside the land, then that is called the onshore and if it goes towards the ocean that is the offshore.

There is some topography which is known as the bathymetry below the ocean that also causes how much area will be inundated even if the strength and other parameters of the wind storms remain the same. So, this topography is also important so far as the coastal floods are concerned.

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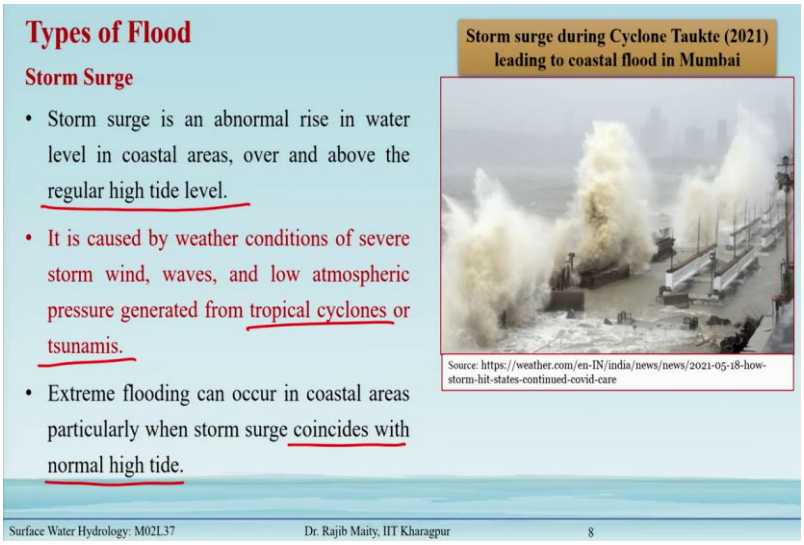

IV. Storm Surge

Storm Surge is also near the coastal areas only and this is this occurs due to the abnormal rise in the water level. In the coastal areas over and above the regular high tide level as you know that there is a diurnal rise and diurnal fall due to the tidal effects near the coastal areas.

However, during the storm surge, it is generally caused by the weather condition when the severe storm wind waves and the low atmospheric pressures generate tropical cyclones or tsunamis. So, that time due to this kind of extreme event, extreme flooding can occur in the coastal areas particularly when the storm surge coincides with a normal high tide.

These two things when they coincide, then the seawater comes inside through the different channels that generally drain to the in the normal condition is drain towards the ocean, but that time that takes the path through these channels and come inside and inundated a very large area, where this flood occurs and that is what is known as the Storm Surge.

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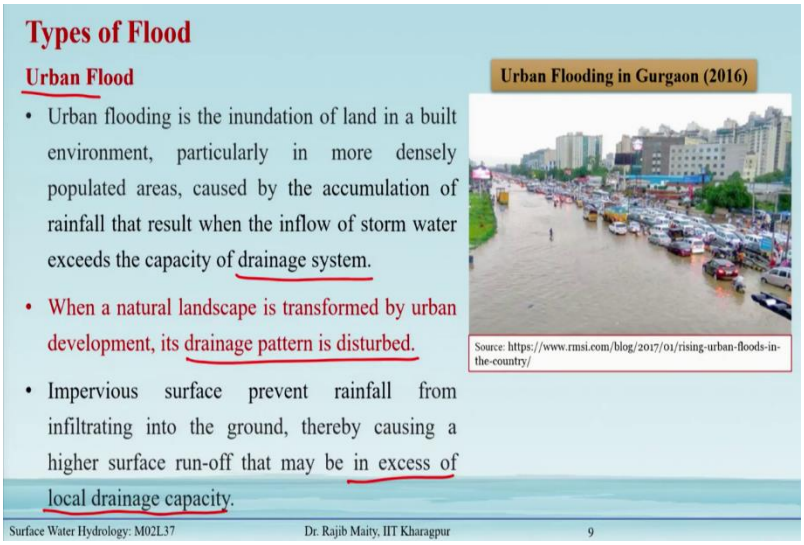

V. Urban Flood

Urban Flood is generally slightly different from other types of floods. It is generally the inundation of the land in a built environment, particularly in more densely populated areas caused by the accumulation of rainfall that results when the inflow of the storm water exceeds the capacity of the drainage system. Most of the surface area is impervious, it is paved. So, there is the infiltration facilities are very and most of the rainwater is generally drained through the drainage system.

When the rainfall occurs in an amount that exceeds the capacity of the drainage system, that time there are some water loggings and that causes the urban flood. So, when a natural landscape is transformed by the Urban Development, the drainage pattern is disturbed by this impermeable paved surface.

The percentage of the amount that joins the surface runoff is very high in an urban setup. So, that causes the urban flood or causes a favorable condition for the urban flood. So, the impervious surface prevents the rainfall from infiltrating into the ground thereby causing the higher surface runoff that may be in excess of this local drainage capacity.

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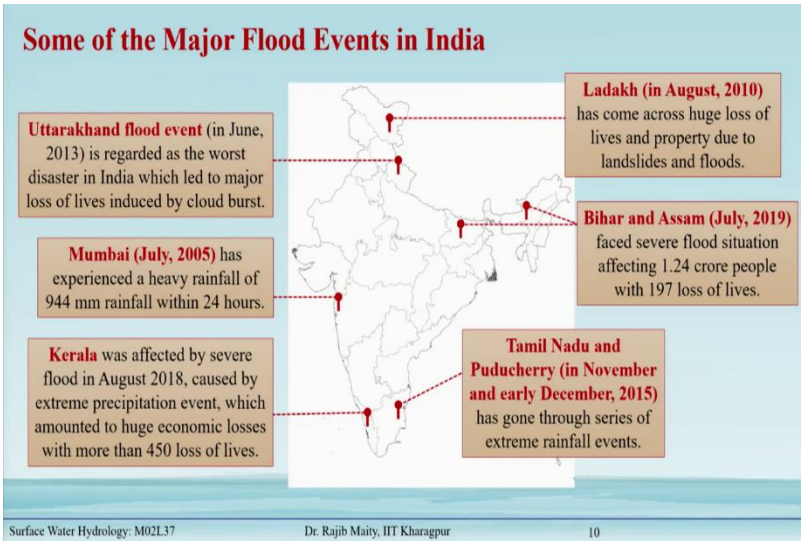

Some of the Major Flood Events in India

- **Uttarakhand flood event** (in June 2013) is regarded as the worst disaster in India which led to a major loss of lives induced by a cloud burst.
- **Mumbai (July 2005)** has experienced heavy rainfall of 944 mm rainfall within 24 hours.
- **Kerala** was affected by a severe flood in August 2018, caused by an extreme precipitation event, which amounted to huge economic losses with more than 450 losses of lives.
- **Ladakh (in August 2010)** has come across a huge loss of lives and property due to landslides and floods.
- **Bihar and Assam (July 2019)** faced a severe flood situation affecting 1.24 crore people with 197 losses of lives.
- **Tamil Nadu and Puducherry (in November and early December 2015)** have gone through a series of extreme rainfall events.

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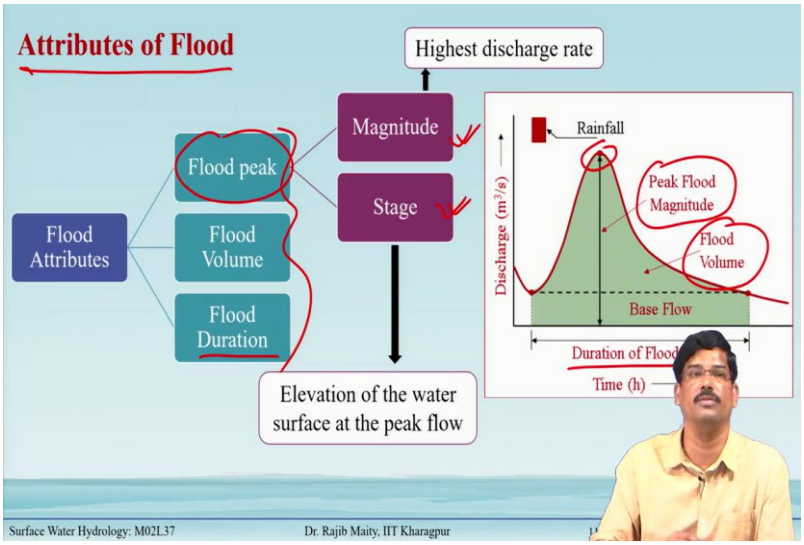

Attributes of Flood

The three major things that we use to characterize a flood are the three things one is Flood Peak that is peak discharge, the total Flood Volume, how much water is there below the entire flood hydrograph, and the Flood Duration. Duration means how long the thing has occurred. For the flash flood the duration will vary less and for the riverine flood may be longer than the flash flood. Taking the Flood Peak, again two different attributes one is the magnitude of course, in that what is the total amount that is shown by this peak and also another thing that is also important in many applications that are called the stage so, how much what is the water level at that time. So, the magnitude means the highest discharge rate that you mean and the stage means, what is the elevation of the water surface at the peak flow level.

Now, fig.1 shows the general flood hydrograph so, the starting and the ending of this one determine the duration of this flood here. Similarly, this is a magnitude higher it is the peak that occurred and this is the peak flood magnitude, this is the flood volume of this one. So, the total amount of total shaded area we can call the flood volume just as in a very simplistic diagram we saw the different attributes of this flood.

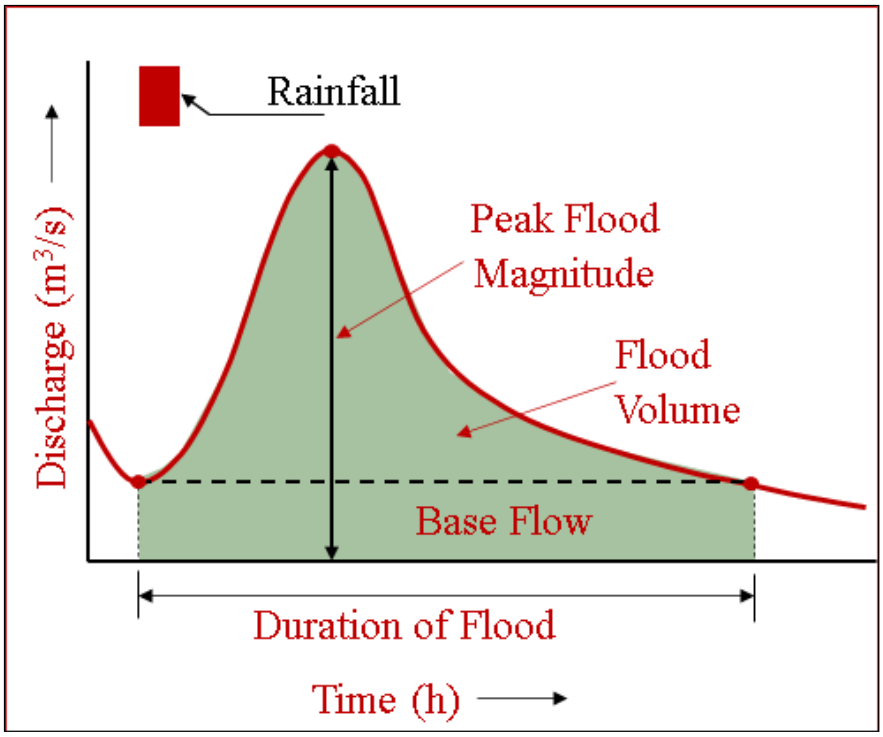

Fig. 1 shows a typical figure of the flood hydrograph

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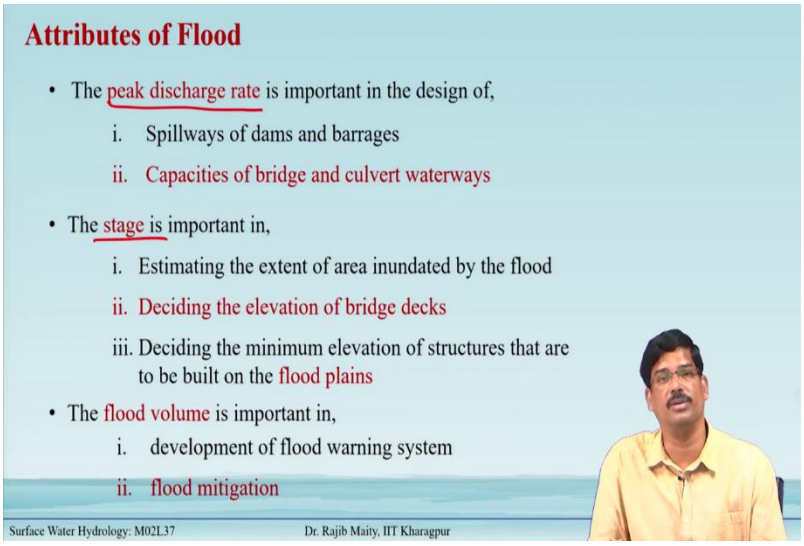

- The peak discharge rate is important in the design of,

I. Spillways of dams and barrages

II. Capacities of bridge and culvert waterways

- The stage is important in,

I. Estimating the extent of the area inundated by the flood

II. Deciding the elevation of bridge decks

III. Deciding the minimum elevation of structures that are to be built on the flood plains

- The flood volume is important in,

I. development of flood warning system

II. flood mitigation

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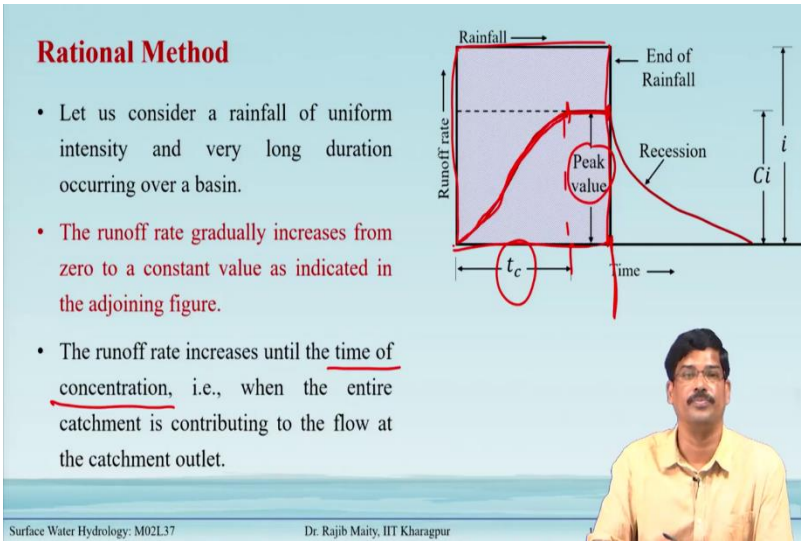

Rational Method

One of the most common and popular methods is the rational method to calculate the peak value of the flood as you can see in fig.2, let us consider a rainfall of uniform intensity and very long duration. So, in fig.2 the shades area is this total block this shaded area is showing the rainfall magnitude we have just considered for a demonstration we consider as a uniform intensity and this is the time when the rainfall ends.

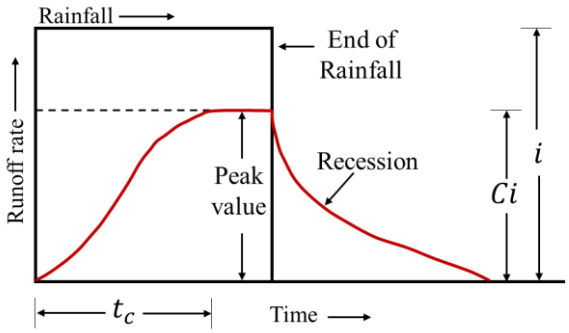

Fig.2 shows the runoff hydrograph due to uniform rainfall

In fig.2 the run-off rate will gradually increase and it will gradually increase from 0 to it will reach a constant value at some point time which it reaches a maximum alone after that it remained constant. So, the run-off rate increases until a particular time which is very important to know and we have discussed this one earlier also this is called the time of concentration.

So, that means up to this point in time this runoff rate increases and then it reaches a constant value till the end of this rainfall after rainfall is over. Then the recession of this curve starts and it is gradually coming down.

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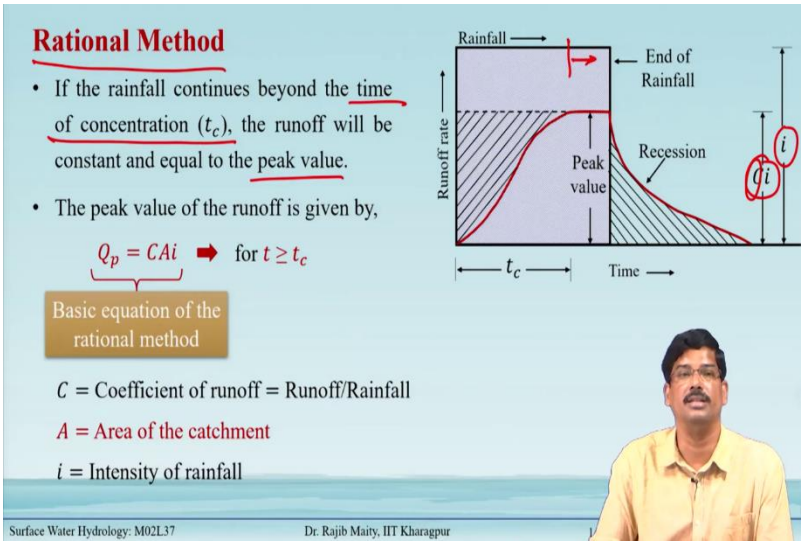

If the rainfall continues beyond the time of concentration (t_c), the runoff will be constant and equal to the peak value.

The peak value of the runoff is given by,

$$Q_p = CAi \quad \Rightarrow \text{ for } t \geq t_c$$

C= Coefficient of runoff = Runoff/Rainfall

A= Area of the catchment

i= Intensity of rainfall

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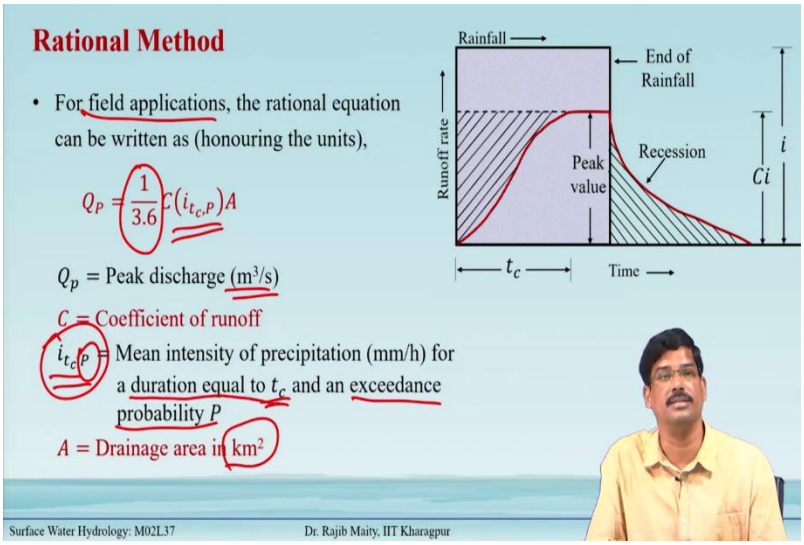

For field applications, the rational equation can be written as (honoring the units),

$$Q_P = \frac{1}{3.6} C(i_{t_c,P})A$$

Where Q_p= Peak discharge (m^3/s)

C= Coefficient of runoff

i_{tc}, P = Mean intensity of precipitation (mm/h) for a duration equal to t_c and an exceedance probability P

A= Drainage area in km^2

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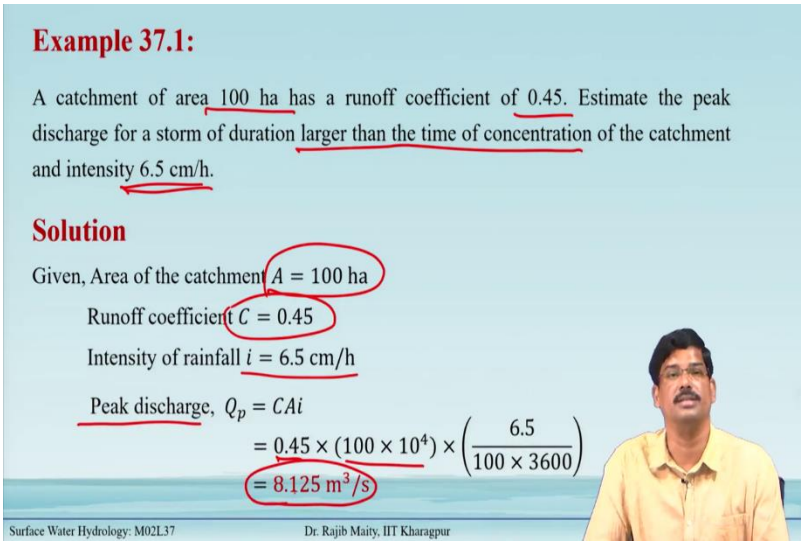

Example 37.1:

A catchment of area 100 ha has a runoff coefficient of 0.45. Estimate the peak discharge for a storm of duration larger than the time of concentration of the catchment and intensity of 6.5 cm/h.

Solution

Given, Area of the catchment A=100 ha

Runoff coefficient C=0.45

The intensity of rainfall i=6.5 cm/h

Peak discharge, $Q_p = CAi$

$$= 0.45 \times (100 \times 10^4) \times \left(\frac{6.5}{100 \times 3600}\right)$$

$$= 8.125\ m^3/s$$

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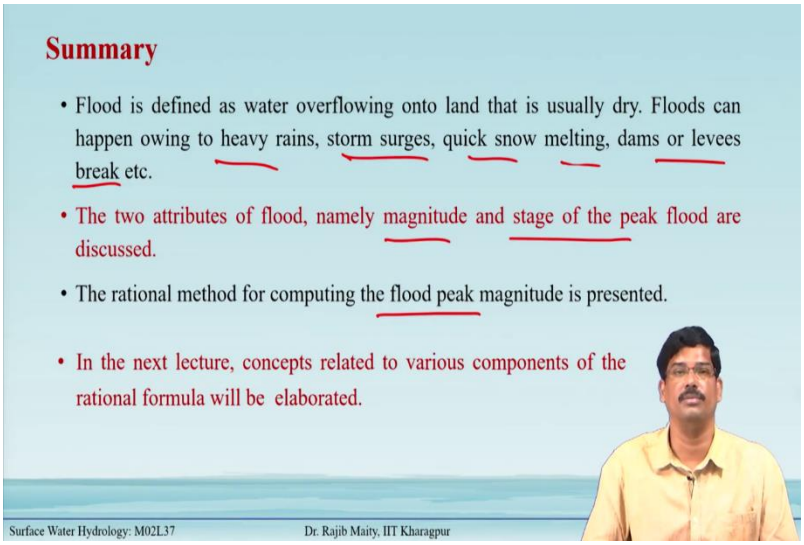

Summary

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

- A flood is defined as water overflowing onto land that is usually dry. Floods can happen owing to heavy rains, storm surges, quick snow melting, dams or levees breaking, etc.
- The two attributes of the flood, namely magnitude, and stage of the peak flood are discussed.
- The rational method for computing the flood peak magnitude is presented.
- In the next lecture, concepts related to various components of the rational formula will be elaborated.