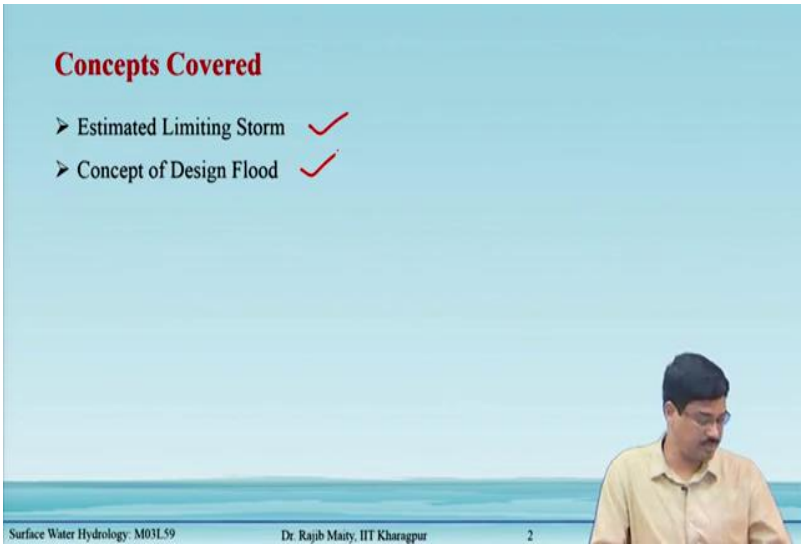
Surface Water Hydrology
Professor Rajib Maity
Department of Civil Engineering
Indian Institute of Technology, Kharagpur
Lecture 59
Estimated Limiting Storm and Design Flood

In week 12, we are discussing the estimated limiting storm and design flood. So, these are the main two things based on which there are different designs are started.

(Refer Slide Time: 0:56)



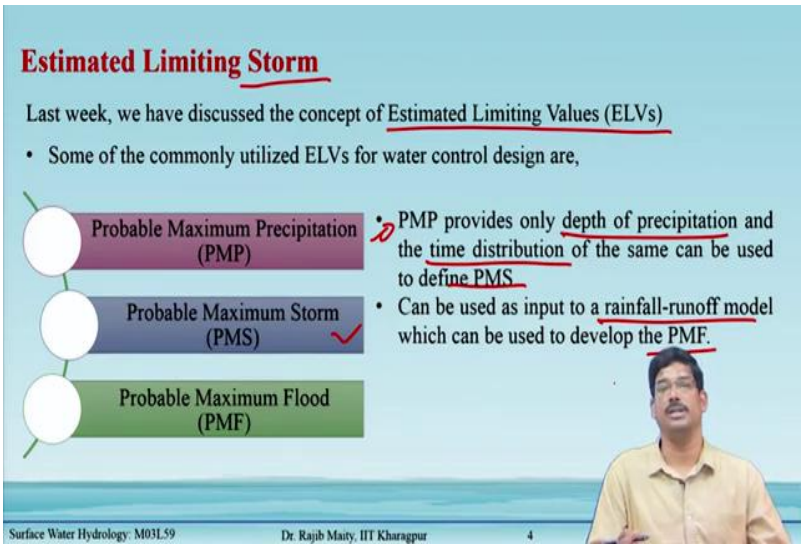
Under this concept cover, we will see that estimated limiting storm and concept of design flood, two are the main input to any water infrastructure design.

(Refer Slide Time: 1:10)

The outline of this lecture goes like this, the first will give some brief introduction, then under the estimated limiting storm., So, there are three things, one is the first one is the probable maximum precipitation, then the probable maximum storm, and then a probable maximum flood.

And then comes the concept of design flood, evaluation of design flood, there are some guidelines are there for selecting a design flood, these are mostly applicable for the or kind of guideline from the central water commission India. And then, Indian standard guidelines for design flood for dams, before we go to the summary.

(Refer Slide Time: 2:27)



Estimated Limiting Storm

In the last week, we have discussed the concept of estimated limiting values.

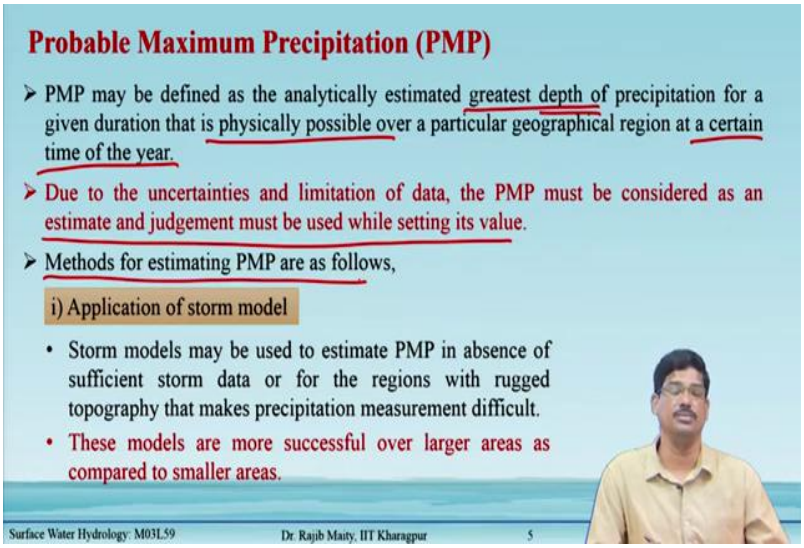
Some of the commonly utilized ELVs for water control design is,

- Probable Maximum Precipitation (PMP)
- Probable Maximum Storm (PMS)
- Probable Maximum Flood (PMF)

PMP provides only depth of precipitation and the time distribution of the same can be used to define PMS.

PMS can be used as input to a rainfall-runoff model which can be used to develop the PMF.

(Refer Slide Time: 4:23)



Probable Maximum Precipitation (PMP)

PMP may be defined as the analytically estimated greatest depth of precipitation for a given duration that is physically possible over a particular geographical region at a certain time of the year.

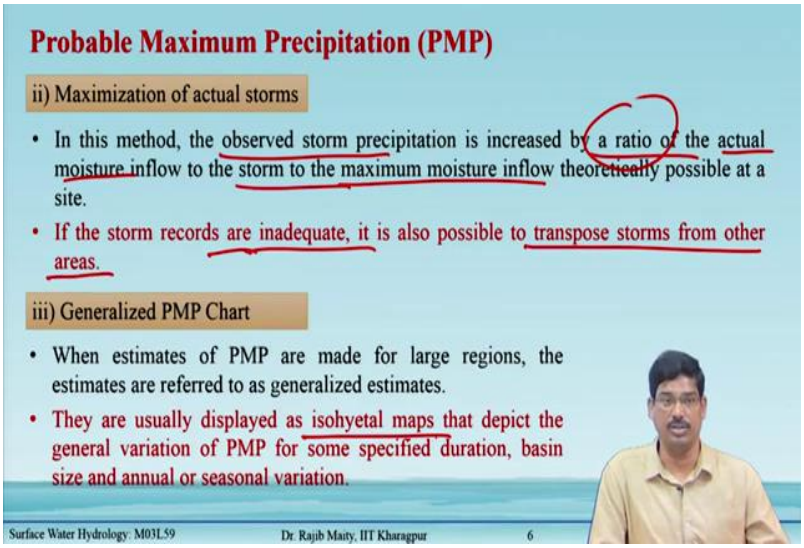
Due to the uncertainties and limitations of data, the PMP must be considered as an estimate and judgment must be used while setting its value.

Methods for estimating PMP are as follows,

i) Application of storm model

- Storm models may be used to estimate PMP in absence of sufficient storm data or for the regions with rugged topography that makes precipitation measurement difficult.
- These models are more successful for larger areas as compared to smaller areas.

(Refer Slide Time: 6:28)



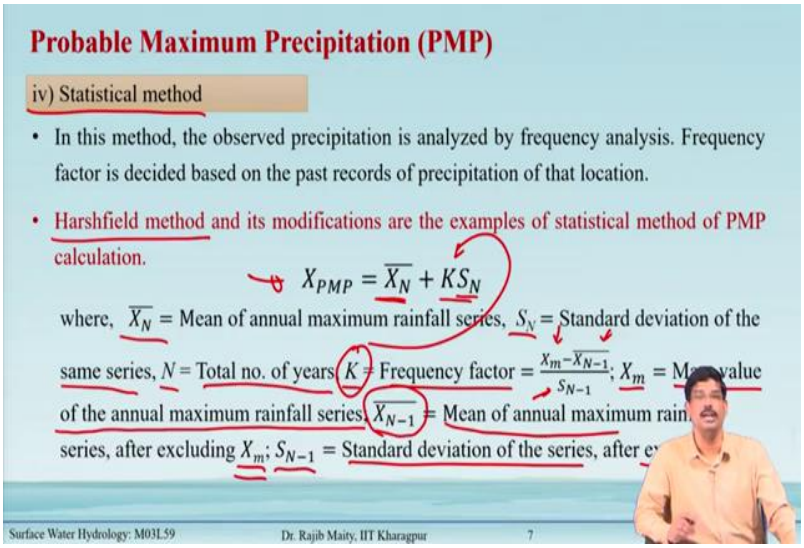
ii) Maximization of actual storms

- In this method, the observed storm precipitation is increased by a ratio of the actual moisture inflow to the storm to the maximum moisture inflow theoretically possible at a site.
- If the storm records are inadequate, it is also possible to transpose storms from other areas.

iii) Generalized PMP Chart

- When estimates of PMP are made for large regions, the estimates are referred to as generalized estimates.
- They are usually displayed as Isohyetal maps that depict the general variation of PMP for some specified duration, basin size, and annual or seasonal variation.

(Refer Slide Time: 8:27)



iv) Statistical method

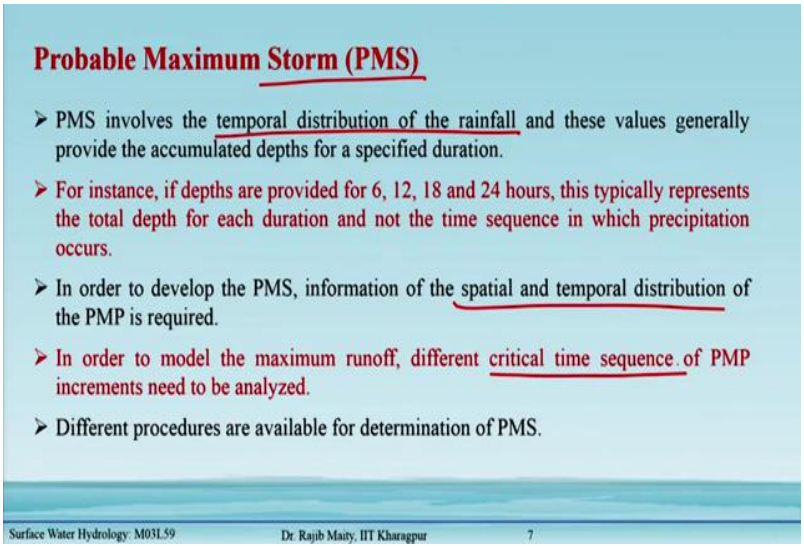
In this method, the observed precipitation is analysed by frequency analysis. The frequency factor is decided based on the records of precipitation of that location.

Harshfield method and its modifications are examples of a statistical method of PMP calculation.

$$X_{PMP} = \overline{X_N} + KS_N$$

Where, $\overline{X_N}$ = Mean of annual maximum rainfall series, SN = Standard deviation of the same series, N = Total no. of years, K = Frequency factor= $\frac{X_m - \overline{X_{N-1}}}{S_{N-1}}$; X_m = Max. Value of the annual maximum rainfall series; $\overline{X_{N-1}}$ = Mean of annual maximum rainfall series, after excludingXm; S_{N-1} = Standard deviation of the series, after excluding Xm.

(Refer Slide Time: 10:13)

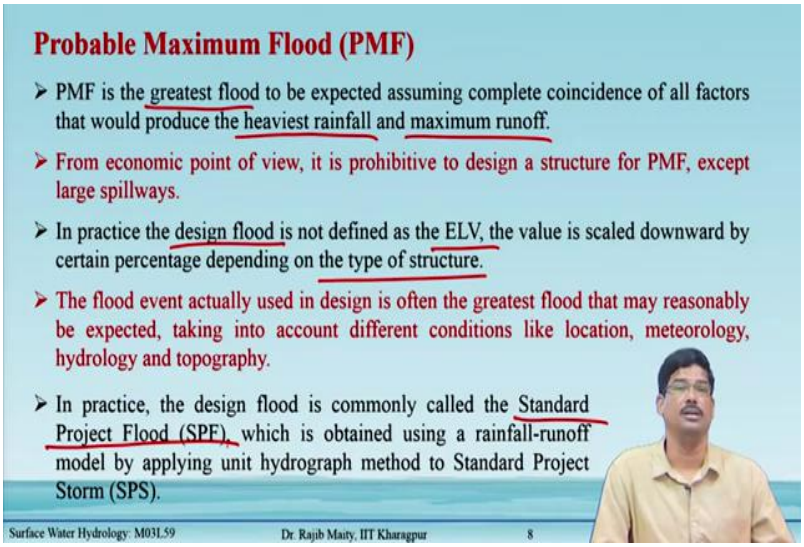


Probable Maximum Storm (PMS)

PMS involves the temporal distribution of the rainfall and these values generally provide the accumulated depths for a specified duration.

For instance, if depths are provided for 6, 12, 18, and 24 hours, this typically represents the total depth for each duration and not the time sequence in which precipitation occurs. To develop the PMS, information on the spatial and temporal distribution of the PMP is required. To model the maximum runoff, the different critical time sequences of PMP increments need to be analysed. Different procedures are available for the determination of PMS.

(Refer Slide Time: 11:32)



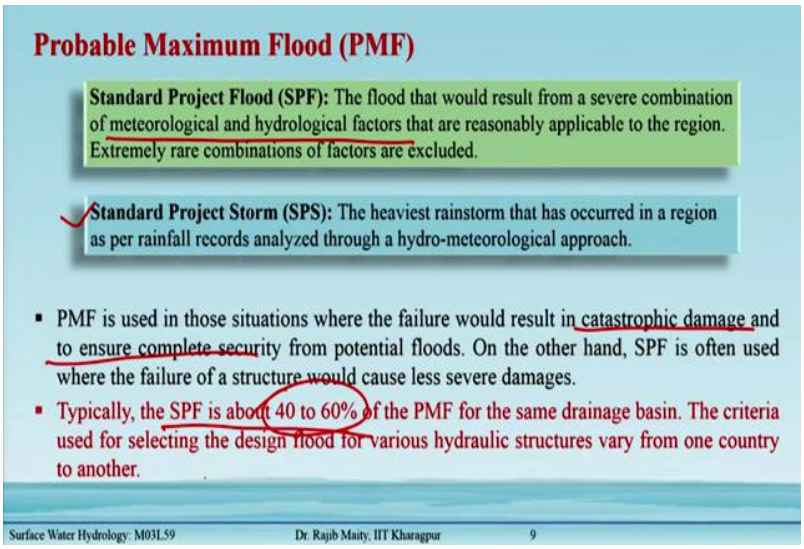
Probable Maximum Flood (PMF)

PMF is the greatest flood to be expected assuming complete coincidence of all factors that would produce the heaviest rainfall and maximum runoff. From an economic point of view, it is prohibitive to design a structure for PMF, except for large spillways. In practice the design flood is not defined as the ELV, the value is scaled down by a certain percentage depending on the type of structure.

The flood event used in the design is often the greatest flood that may reasonably be expected, taking into account different conditions like location, meteorology, hydrology, and topography.

In practice, the design flood is commonly called the Standard Project Flood (SPF), which is obtained using a rainfall-runoff model by applying the unit hydrograph method to the Standard Project Storm (SPS).

(Refer Slide Time: 12:58)



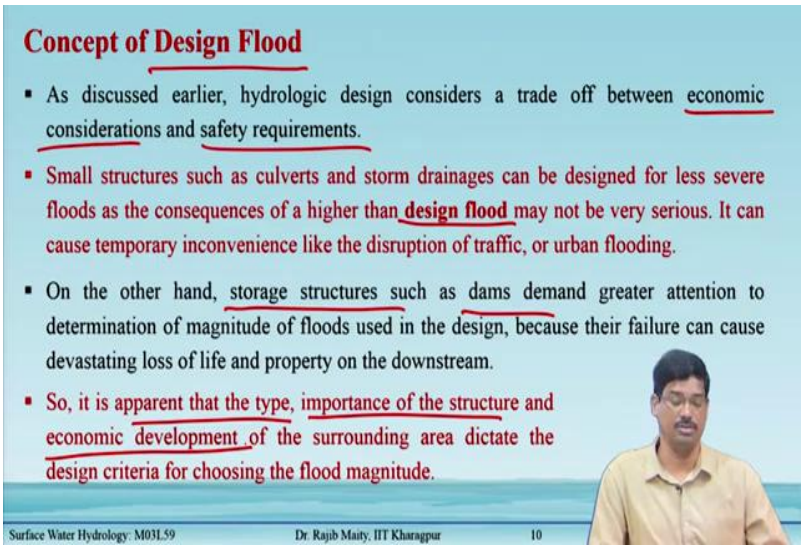
Standard Project Flood (SPF): The flood that would result from a severe combination of meteorological and hydrological factors that are reasonably applicable to the region. Extremely rare combinations of factors are excluded.

Standard Project Storm (SPS): The heaviest rainstorm that has occurred in a region as per rainfall records analyzed through a hydro-meteorological approach.

PMF is used in those situations where the failure would result in catastrophic damage and ensure complete security from potential floods. On the other hand, SPF is often used where the failure of a structure would cause less severe damage.

Typically, the SPF is about 40 to 60% of the PMF for the same drainage basin. The criteria used for selecting the design flood for various hydraulic structures vary from one country to another.

(Refer Slide Time: 14:23)



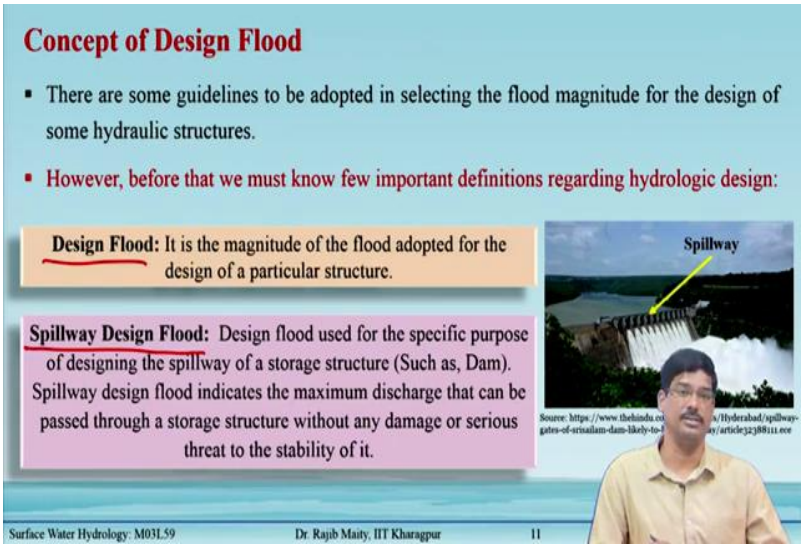
Concept of Design Flood

The design flood is the flood that is considered in some hydrologic design, there should be a trade-off between two things, one is called the economic consideration, and another one is the safety requirement. A small structure such as a culvert or the storm drainage can be designed for a less severe flood as a consequence of the higher than the design flood may not be very serious, it can cause the temporary inconvenience like the disruption of traffic, carbon flooding, those things, but at the same time the if we even want to avoid that kind of thing then the cost or the economic aspects becomes very high, which sometimes may not be feasible also.

And on the other, hand the storage structures such as the dams, if that demand the greater attention to determine the magnitude of the flood used in the design, because their failure can cause the devastating loss of life and property the downstream. So, it is apparent that the type importance of the structure and the economic development of the surrounding area dictate the

design criteria for choosing the flood magnitude, whenever we have we consider that design flood.

(Refer Slide Time: 15:37)



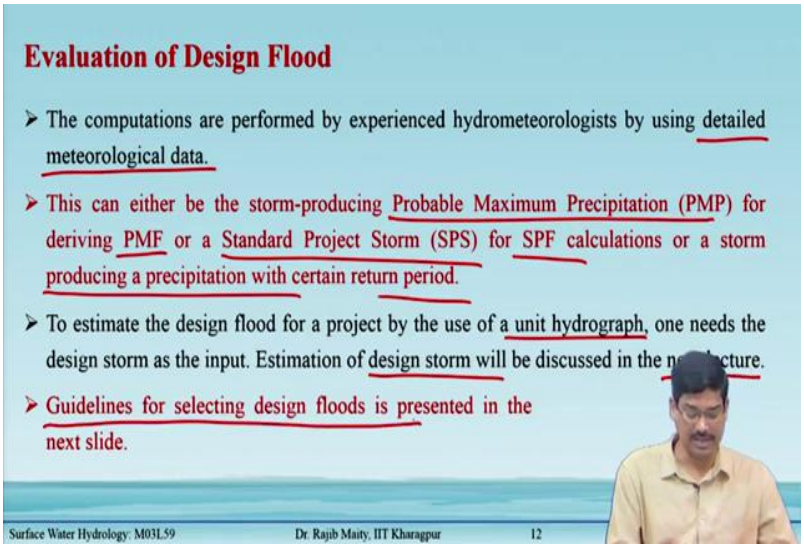
There are some guidelines to be adopted in selecting the flood magnitude for the design of some hydraulic structures.

However, before that, we must know a few important definitions regarding hydrologic design:

Design Flood: It is the magnitude of the flood adopted for the design of a particular structure.

Spillway Design Flood: Design flood used for the specific purpose of designing the spillway of a storage structure (Such as a Dam). Spillway design flood indicates the maximum discharge that can be passed through a storage structure without any damage or serious threat to its stability of it.

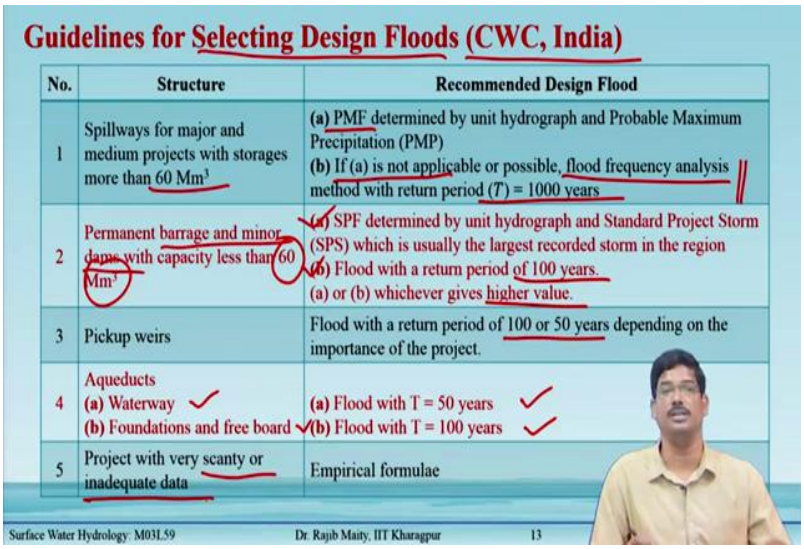
(Refer Slide Time: 16:37)



Evaluation of Design Flood

Evaluation of the design flood the computations are performed by the experienced hydro meteorologist by using the detailed meteorological data that is available for that particular region. And this can either be the storm producing probable maximum precipitation, so we can start from the PMP for deriving this PMF or we can just take a standard project storm for the standard project flood calculation or a storm producing precipitation with certain return periods. Now, to estimate the design flood for a project by the use of the unit hydrograph, one needs the design storm as input, and estimation of the design storm will be discussed in the next lecture, here are some of the guidelines for selecting the design flood is presented in the next slide.

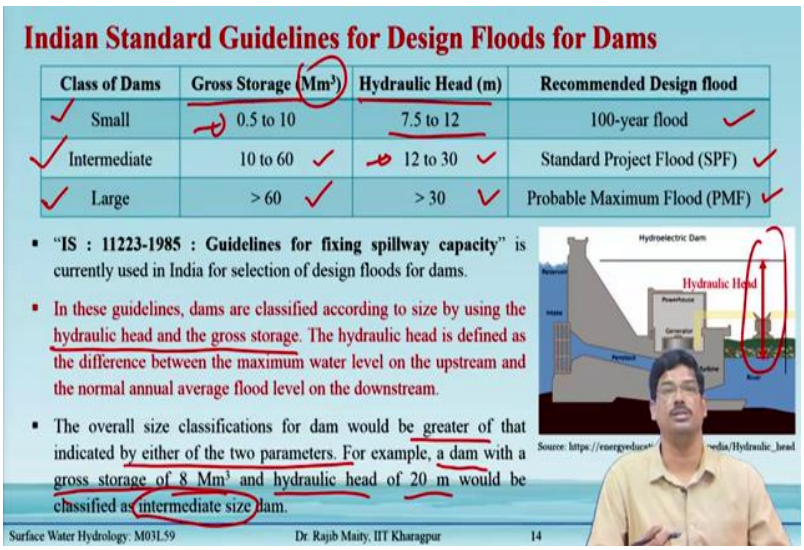
(Refer Slide Time: 17:28)



Guidelines for Selecting Design Floods (CWC, India)

No.	Structure	Recommended Design Flood
1	Spillways for major and medium projects with storages more than 60 Mm^3	**(a)** PMF determined by unit hydrograph and Probable Maximum Precipitation (PMP) **(b)** If (a) is not applicable or possible, flood frequency analysis method with return period (T) = 1000 years
2	Permanent barrage and minor dams with capacity less than 60 Mm^3	**(a)** SPF determined by unit hydrograph and Standard Project Storm (SPS) which is usually the largest recorded storm in the region **(b)** Flood with a return period of 100 years. (a) or (b) whichever gives higher value.
3	Pickup weirs	Flood with a return period of 100 or 50 years depending on the importance of the project.
4	Aqueducts **(a)** Waterway **(b)** Foundations and free board	 **(a)** Flood with T = 50 years **(b)** Flood with T = 100 years
5	Project with very scanty or inadequate data	Empirical formulae

(Refer Slide Time: 19:55)

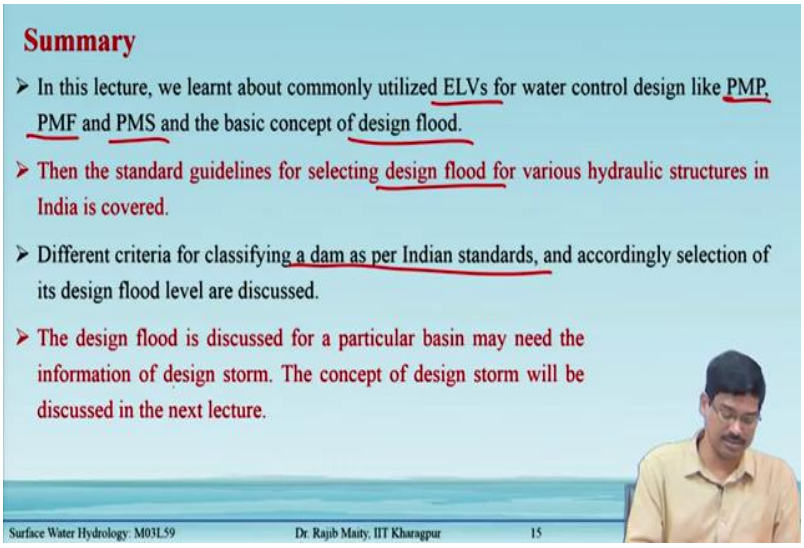


Indian Standard Guidelines for Design Floods for Dams

Class of Dams	Gross Storage (Mm^3)	Hydraulic Head (m)	Recommended Design flood
Small	0.5 to 10	7.5 to 12	100-year flood
Intermediate	10 to 60	12 to 30	Standard Project Flood (SPF)
Large	> 60	> 30	Probable Maximum Flood (PMF)

- "**IS: 11223-1985: Guidelines for fixing spillway capacity**" is currently used in India for the selection of design floods for dams.
- In these guidelines, dams are classified according to size by using the hydraulic head and the gross storage. The hydraulic head is defined as the difference between the maximum water level upstream and the normal annual average flood level downstream.
- The overall size classifications for the dam would be greater than that indicated by either of the two parameters. For example, a dam with a gross storage of 8 Mm^3 and a hydraulic head of 20 m would be classified as an intermediate size dam.

(Refer Slide Time: 22:11)



Summary

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

- In this lecture, we learned about commonly utilized ELVs for water control design like PMP, PMF, and PMS and the basic concept of the design flood.
- Then the standard guidelines for selecting design flood for various hydraulic structures in India are covered.
- Different criteria for classifying a dam as per Indian standards and accordingly selection of its design flood level is discussed.

- Next, the steps for determining the design flood are discussed for a particular basin that needs the information on the design storm (discussed in the next lecture).
- A brief discussion on the frequency analysis for partial duration series is also presented.