23CE506: HYDROLOGY AND WATER RESOURCES ENGINEERING

Topic: Hydrograph – Introduction

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Importance of Hydrograph

- Study of catchment response
- Flood prediction and management
- Design of bridges, culverts, dams and reservoirs
- Estimation of runoff characteristics

Components of Hydrograph

1. Rising limb: Portion where discharge increases due to rainfall contribution.
2. Peak discharge: Maximum flow rate during the storm.
3. Recession limb: Falling part after rainfall stops.
4. Base flow: Groundwater contribution to stream flow.

Factors Affecting Hydrograph Shape

- Basin area and shape
- Catchment slope
- Soil permeability
- Vegetation cover
- Rainfall intensity and duration
- Drainage density

Unit Hydrograph – Definition

- A unit hydrograph is the direct runoff hydrograph produced by one unit depth of effective rainfall uniformly distributed over a basin for a specified duration.

Principles of Unit Hydrograph Theory

1. Linear response: runoff is proportional to effective rainfall.
2. Time invariance: same rainfall duration produces similar hydrograph shape.
3. Uniform distribution of rainfall over catchment.

Assumptions of Unit Hydrograph

- Effective rainfall is uniformly distributed over the basin.
- Rainfall excess has constant intensity.
- Basin characteristics remain unchanged.
- Superposition principle is applicable.

Derivation of Unit Hydrograph

Steps:

1. Obtain storm hydrograph.
2. Separate base flow.
3. Calculate direct runoff volume.
4. Convert runoff depth into unit depth.
5. Plot direct runoff hydrograph.

Applications of Unit Hydrograph

- Flood forecasting
- Runoff estimation
- Reservoir design
- Design of drainage structures
- Prediction of floods from future storms

S-Curve Hydrograph

S-curve is obtained by adding successive unit hydrographs of equal duration.

Applications:

- Developing unit hydrographs of different durations.
- Continuous rainfall analysis.

Flood Hydrograph

- Flood hydrograph represents variation of flood discharge with time during a flood event.

- Used for flood analysis and hydraulic structure design.

Flood Estimation

Flood estimation determines expected maximum flood discharge.

Methods:

- Empirical methods
- Statistical methods
- Regional flood frequency methods

Rational Method

Used for small catchments.

Peak discharge depends on:

- Rainfall intensity
- Runoff coefficient
- Catchment area

- It is widely used in urban drainage design.

Flood Frequency Analysis

- Statistical technique used to estimate probability of occurrence of floods.
- Uses historical flood records and predicts design floods.

Return Period

- Return period is the average interval between occurrence of floods of equal or greater magnitude.

- Higher return period indicates larger design flood.

Gumbel Distribution Method

- A statistical method for extreme value analysis.
- Used for estimating maximum floods based on past records.

Design Flood

Design flood is the selected flood magnitude used for designing hydraulic structures.

Selection depends on:

- Structure importance
- Economic considerations
- Safety requirements

Reservoir Routing

- Reservoir routing is the process of determining changes in reservoir storage, water level and outflow during floods.

Purpose of Reservoir Routing

- Predict maximum reservoir level
- Design spillways
- Control flood peaks
- Improve reservoir operation

Flood Routing Methods

1. Hydrologic routing – based on storage relationship.
2. Hydraulic routing – based on flow equations.
3. Modified Puls method – used for reservoir routing.

Channel Routing

- Channel routing studies movement of flood waves through rivers and channels.

- It helps determine downstream flood conditions.

Stream Gauging

Stream gauging is measurement of river discharge.

It involves:

- Measuring water level (stage)
- Measuring velocity
- Calculating discharge

Rating Curve

- Rating curve represents relationship between river stage and discharge.
- It is used to estimate discharge from observed water levels.

Rainfall–Runoff Relationship

It explains conversion of rainfall into runoff.

Affected by:

- Rainfall characteristics
- Soil condition
- Land use
- Basin characteristics

Catchment Characteristics

Important characteristics:

- Area
- Shape
- Slope
- Drainage density
- Soil type
- Land use