23CE506: HYDROLOGY AND WATER RESOURCES ENGINEERING

Topic: Groundwater Hydrology

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Introduction to Groundwater

Groundwater is water present below the earth surface in pores of soil and fractures of rocks.

Importance:

- Domestic water supply
- Irrigation
- Industrial requirements
- Drought management

Occurrence of Groundwater

Subsurface water zones:

1. Zone of aeration – pores contain air and water.
2. Zone of saturation – pores completely filled with water.
3. Water table – upper surface of saturated zone.

Groundwater Cycle

- Precipitation → Infiltration → Aquifer Recharge → Groundwater Flow → Springs/Rivers → Evaporation

- Recharge and discharge maintain groundwater balance.

Aquifers

An aquifer is a geological formation capable of storing and transmitting groundwater.

Characteristics:

- Storage capacity
- Transmitting ability
- Water yield potential

Types of Aquifers

Unconfined aquifer:

- Upper boundary is water table.

Confined aquifer:

- Water exists under pressure between impermeable layers.

Semi-confined aquifer:

- Partially separated by low permeability layers.

Aquifer Properties – Porosity

- Porosity is the ratio of void volume to total volume.
- Porosity = (Volume of voids / Total volume) × 100
- Higher porosity indicates greater storage capacity.

Permeability and Hydraulic Conductivity

- Permeability indicates ability to transmit water.
- Hydraulic conductivity depends on soil properties and fluid characteristics.

Specific Yield and Specific Retention

- Specific Yield: water released from saturated soil by gravity.
- Specific Retention: water retained by soil after drainage.
- Porosity = Specific Yield + Specific Retention

Groundwater Movement

Groundwater moves from higher hydraulic head to lower hydraulic head.

Movement depends on:

- Hydraulic gradient
- Hydraulic conductivity

Darcy's Law

- Darcy's law describes groundwater flow.

- Q = KIA

- Where:
- Q = discharge
- K = hydraulic conductivity
- I = hydraulic gradient
- A = cross-sectional area

Hydraulic Gradient

- Hydraulic gradient is the change in hydraulic head per unit distance.
- $I = \Delta h / L$
- It controls the direction and rate of groundwater movement.

Flow Nets

Flow nets consist of:

- Flow lines
- Equipotential lines

Applications:

- Seepage analysis
- Dam foundation studies
- Groundwater flow estimation

Well Hydraulics

Well hydraulics deals with groundwater movement towards wells during pumping.

Important terms:

- Drawdown
- Cone of depression
- Well yield

Types of Wells

- Open wells
- Tube wells
- Collector wells
- Recharge wells

Selection depends on aquifer conditions.

Cone of Depression and Drawdown

- During pumping, groundwater level decreases around the well forming a cone of depression.

- Drawdown = Original water level – Pumping water level

Steady Flow to Wells

- Steady flow occurs when water level around a pumping well becomes constant with time.

- Used for well discharge calculations.

Unsteady Flow to Wells

- In unsteady flow, drawdown changes with time after pumping starts.
- Theis method is commonly used for analysis.

Dupuit Assumptions

- Groundwater flow is horizontal.
- Hydraulic gradient equals water table slope.
- Velocity distribution is uniform.

Well Yield and Specific Capacity

- Well yield is quantity of water obtained per unit time.
- Specific capacity = Discharge / Drawdown
- Used to evaluate well performance.

Pumping Tests

Purpose:

- Determine aquifer properties
- Estimate transmissivity
- Calculate storage coefficient

Types:

- Constant discharge test
- Recovery test

Groundwater Recharge

Recharge is addition of water to groundwater storage.

Types:

- Natural recharge
- Artificial recharge

Artificial Recharge Methods

Methods:

- Recharge pits
- Recharge wells
- Percolation tanks
- Check dams
- Contour trenches

Groundwater Quality

Important parameters:

- pH
- Total Dissolved Solids (TDS)
- Hardness
- Chlorides
- Fluoride

Groundwater Pollution

Sources:

- Industrial waste
- Agricultural chemicals
- Sewage disposal

Control:

- Treatment
- Proper waste management

Groundwater Management

Objectives:

- Sustainable extraction
- Conservation
- Recharge improvement
- Pollution prevention