Lecture 3.29

Site Selection of Hydroelectric Power Plant

Agenda

- 1. Introduction to Site Selection Importance
- 2. Hydrological Factors (Water Availability)
- 3. Topography and Gross Head
- 4. Geological Foundation Requirements
- 5. Water Storage and Reservoir Area
- 6. Transportation and Accessibility
- 7. Proximity to Load Centers
- 8. Environmental and Social Considerations
- 9. Sedimentation and Catchment Analysis
- 10. Economic Viability
- 11. Key Takeaways and Summary

Introduction to Site Selection

- Site selection is a complex, multi-disciplinary optimization problem.
- It involves hydrology, geology, topography, environmental science, and civil engineering.
- A poor site choice can lead to catastrophic dam failure, sub-optimal power generation, or severe environmental degradation.
- The primary goal is to maximize the available hydraulic energy (head $\times$ flow rate) while minimizing construction costs and social impact.

Hydrological Factors: Water Availability

- Water is the primary 'fuel' for a hydro plant; continuous and reliable flow is mandatory.
- Requires analysis of historical rainfall data, run-off characteristics, and river gauging records (usually spanning 25-50 years).
- Flow duration curves and mass curves are utilized to determine the dependable flow and predict variations during dry and monsoon seasons.
- Estimation of maximum flood discharge is critical for designing the spillway capacity to prevent dam overtopping.

Topography and Gross Head

- Power generation is directly proportional to the gross head (vertical fall of water) and discharge (P = \ensuremath{\eta} * \ensuremath{\rho} * g * Q * H).
- Ideal topography features a narrow, steep-sided gorge or a V-shaped valley.
- A narrow gorge minimizes the required length and volume of the dam structure, drastically reducing capital costs.
- The upstream area should ideally widen out into a broad, flat valley to provide maximum reservoir storage with minimum dam height.

Geological Foundation Requirements

- The foundation rock must be capable of withstanding the immense static and dynamic loads of the dam structure and the stored water.
- Thorough geological surveys (core drilling, seismic tests) are required to detect faults, fissures, or weak strata.
- The rock bed should be impermeable to prevent massive seepage and water loss beneath the dam.
- Seismic activity history of the region must be evaluated; highly active fault zones are generally avoided or require highly expensive earthquake-resistant designs.

Water Storage and Reservoir Area

- Since river flow fluctuates seasonally, a large reservoir is required to store water during high flows for use during low flows.
- The reservoir basin should have high water retention capabilities (impermeable sides and bottom) to avoid excessive seepage losses.
- Evaporation rates in the region must be considered; large, shallow reservoirs in arid climates suffer severe evaporation losses.
- Topographical surveys establish the Elevation-Area-Capacity curves for the proposed reservoir.

Access to Site and Transportation

- Hydroelectric sites are frequently located in remote, rugged, and mountainous terrains.
- Transporting heavy machinery (turbines, generators, transformers) and massive quantities of construction materials (cement, steel) requires robust infrastructure.
- The feasibility and cost of laying new access roads or rail links must be factored into the overall project cost.
- Inaccessible sites can render a otherwise technically sound project economically unviable.

Distance from Load Centers

- Ideally, the power plant should be located close to the load center to minimize transmission line costs and line losses (I\ensuremath{^2}R losses).
- However, good hydro sites are rarely near industrial or urban load centers.
- High Voltage AC (HVAC) or High Voltage DC (HVDC) transmission lines are required to transmit bulk power over long distances.
- The cost of these transmission lines and the right-of-way acquisition must be justified by the cheap generation cost of the hydro plant.

Environmental and Social Considerations

- Submergence of land: Large reservoirs drown forests, agricultural lands, and wildlife habitats.
- Rehabilitation and Resettlement (R&R): Displacing local communities is a major socio-political challenge and requires massive compensation budgets.
- Impact on aquatic life: Dams obstruct fish migration routes; fish ladders or hatcheries may be required.
- Environmental Impact Assessment (EIA) clearance is a mandatory and often lengthy legal hurdle.

Sedimentation and Catchment Area

- Rivers carry silt and sediment which gradually deposit in the quiet waters of the reservoir, reducing its useful storage capacity over time (silting).
- A catchment area heavily prone to soil erosion will dramatically shorten the lifespan of the hydroelectric project.
- Catchment Area Treatment (CAT) plans, like afforestation and check dams, are evaluated during site selection to mitigate sediment inflow.
- Sites with clear, fast-flowing water from rocky catchments are preferred over muddy rivers.

Site Selection Criteria Matrix

- A structured matrix approach is used to compare alternative sites.
- Weightages are assigned to different factors (Hydrology, Topography, Geology, Social Impact, Cost).
- Sites are scored based on extensive field surveys and feasibility reports.

Summary

- Site selection balances technical feasibility, economic viability, and environmental sustainability.
- Hydrology (water availability) and Topography (head) dictate the power capacity.
- Geological stability ensures the safety of the massive civil structures.
- Accessibility, transmission distance, and socio-environmental impacts heavily influence the final cost and project approval.

Next Lecture Preview

- Topic: Classification of Hydroelectric Power Plants
- We will categorize plants based on head (low, medium, high), capacity, and plant type (run-of-river, storage, pumped storage).
- Understanding how site characteristics dictate the type of plant constructed.