Module 8: Dams and Spillways

1. Embankment Dams

Classification

- **Earthfill Dams:** Made primarily with compacted earth.
- **Rockfill Dams:** Constructed with compacted rock fragments, often with an impermeable core.

Design Considerations

- **Stable Side Slopes** (upstream/downstream) to prevent slip or failure[1].
- **Adequate Dimensions:** Height and width to safely convey and withstand water pressure.
- **Control of Seepage:** Includes internal drainage (filters, drains, toe drains), cutoff walls, upstream clay blankets[2] [3] [4] [5].
- **Slope Protection:** Riprap (rock) or turfing on the upstream slope to prevent erosion from waves and weather; proper grading, vegetation, or stone on the downstream side[4] [6].

Estimation and Control of Seepage

- **Seepage Analysis:** Computational models to predict seepage rates, gradients, and pore pressure[2].
- **Control Measures:**
  - Internal filters and drains to collect seepage.
  - Cutoffs (trenches/impermeable barriers) beneath or within the dam[2] [3] [4].
  - Upstream impervious blankets.
  - Relief wells, toe drains, and weep holes for collecting seepage after construction[5] [7].

Slope Protection

- **Upstream:** Riprap, precast concrete blocks, or vegetative covers.
- **Downstream:** Turfing or stone pitching; provision of drainage layers to manage any seepage that emerges[3] [4] [6].

2. Gravity Dams

Forces Acting on Gravity Dams

- **Water Pressure:** Hydrostatic force from reservoir.
- **Uplift Pressure:** Water percolating underneath dam tries to "lift" it.
- **Self-Weight:** The dead weight of the dam structure.
- **Silt Pressure:** Pressure from sediment against the dam.
- **Wave, Earthquake, Ice, and Wind Pressures:** As applicable, especially for large dams[8] [9] [10].

Causes of Failure

- **Overturning:** When moments due to horizontal forces exceed resisting moment from dam weight.
- **Sliding:** Horizontal forces exceed frictional/shear resistance at base.
- **Crushing (Compression):** Exceeded compressive strength at toe or heel.
- **Tension (Cracks):** Development of tensile stresses that exceed material capacity leads to cracks[8] [9].

Stress Analysis & Profiles

- **Stress Calculation:** Analyze base for maximum compressive and tensile stresses under major load scenarios[10].
- **Elementary Profile:** Theoretical profile assuming idealized conditions (wider at base, straight back).
- **Practical Profile:** Incorporates safety margins, foundation conditions, and material economic use—may have curved faces and additional width for stability.

3. Arch and Buttress Dams

Arch Dams

- **Form:** Curved in plan, transmits major water load to abutments by arch action.
- **Material Efficiency:** Requires less material than gravity dams; suitable for narrow, rocky gorges[11] [12].

Buttress Dams

- **Description:** Consist of a thin sloping deck supported by buttresses (walls) at intervals.
- **Types:** Deck slab, multiple-arch, and bulkhead buttress dams.
- **Advantages:** Save concrete compared to gravity dams; more flexible in foundation requirements[11] [13] [12].

4. Spillways

Components

- **Spillway Crest:** The overflow section.
- **Approach Channel:** Directs water to the crest.
- **Downstream Chute or Channel:** Carries released water away from the structure.
- **Energy Dissipators:** Prevent scour downstream.

Types of Spillway Gates

- **Radial (Tainter) Gates:** Curved, rotate about a trunnion; commonly used for large flows.
- **Sluice Gates:** Slide up/down; control entry/exit flow.
- **Drum Gates:** Cylindrical, pivot to release water.
- **Crest (Overflow) Gates:** Movable panels regulating flow over spillway crest.
- **Flash Boards, Stop Logs, Needle Gates:** Temporary or adjustable wooden or metal barriers[14] [15] [16].

5. Reservoirs

Types

- **Storage (Conservation) Reservoirs:** Store water for supply, irrigation, or power.
- **Flood Control Reservoirs:** Store excess flood water temporarily.
- **Multipurpose Reservoirs:** Serve two or more objectives (e.g., supply, flood control, recreation)[17].

Capacity and Yield

- **Capacity:** Determined based on demand, inflow, evaporation/sediment losses, and required yield.
- **Yield:** Maximum rate or quantity of water that can be supplied reliably; calculated via mass curve or sequent peak analysis[17].

Reservoir Regulation

- **Objective:** Match variable inflows (seasonal/annual) with fluctuating demand, maintain supply during drought or peak usage.
- **Methods:** Operating rules, zonal storage allocations, and scheduled releases.

Sedimentation

- **Process:** Sediments settle as velocity drops, reducing storage over time.
- **Assessment:** Periodic sediment surveys and inflow water quality tests.
- **Management:** Sediment flushing, bypassing, or upstream check dams[17] [18].

Economic Height of Dam

- **Definition:** Height which gives maximum economic benefit (storage ROI vs. cost/inundation).
- **Analysis:** Cost-benefit studies weigh increased storage (higher dam) against cost of land, structure, and social/environmental impacts.

Selection of Suitable Site

- **Hydrological:** Adequate catchment yield.
- **Topographical:** Preferably a narrow gorge with a broad, flat upstream valley for storage.
- **Geological:** Firm, impervious, stable foundations; minimal leakage risk.
- **Environmental/Social:** Low impact on population, minimal submergence of valuable land, ease of access, and compliance with legal/regulatory requirements[19].

Tables

Embankment vs. Gravity vs. Arch vs. Buttress Dams

Type	Key Features	Dam Site	Materials	Remarks
Embankment	Earth or rock, wide base, impervious core	Almost anywhere	Earth, rock	Needs seepage control
Gravity	Massive, resists forces by weight	Firm rock	Concrete	Most common for large dams
Arch	Curved, transmits load to abutments	Narrow gorges	Concrete	Material efficient
Buttress	Thin slab, supported by buttresses	Any, moderate foundations	Concrete	Less costly than gravity

Common Spillway Gate Types

Gate Type	Action/Use	Suitability
Radial/Tainter	Rotates upward	Large, main spillways
Sluice	Slides vert./horiz	Low/moderate flows, outlets
Drum	Rolls/pivots	Moderate flows, easy to operate
Crest/Overflow	Moves up/down	Regulates reservoir top water

Gate Type	Action/Use	Suitability
Stoplog/Needle	Removable bars	Temporary, maintenance

In summary: The core of dam and reservoir engineering is the safe, economic, and sustainable design of structures and systems to store, control, and utilize water while ensuring minimum adverse impact on society and the environment. Each dam type and spillway system is selected, sited, and designed to address local geology, hydrology, functional goals, and long-term resilience [2] [3] [4] [5] [8] [11] [14] [19] [7] [9] [13] [15] [17] [10] [12] [16] [18].

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1. https://eopcw.com/find/downloadLectureNote/1044
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