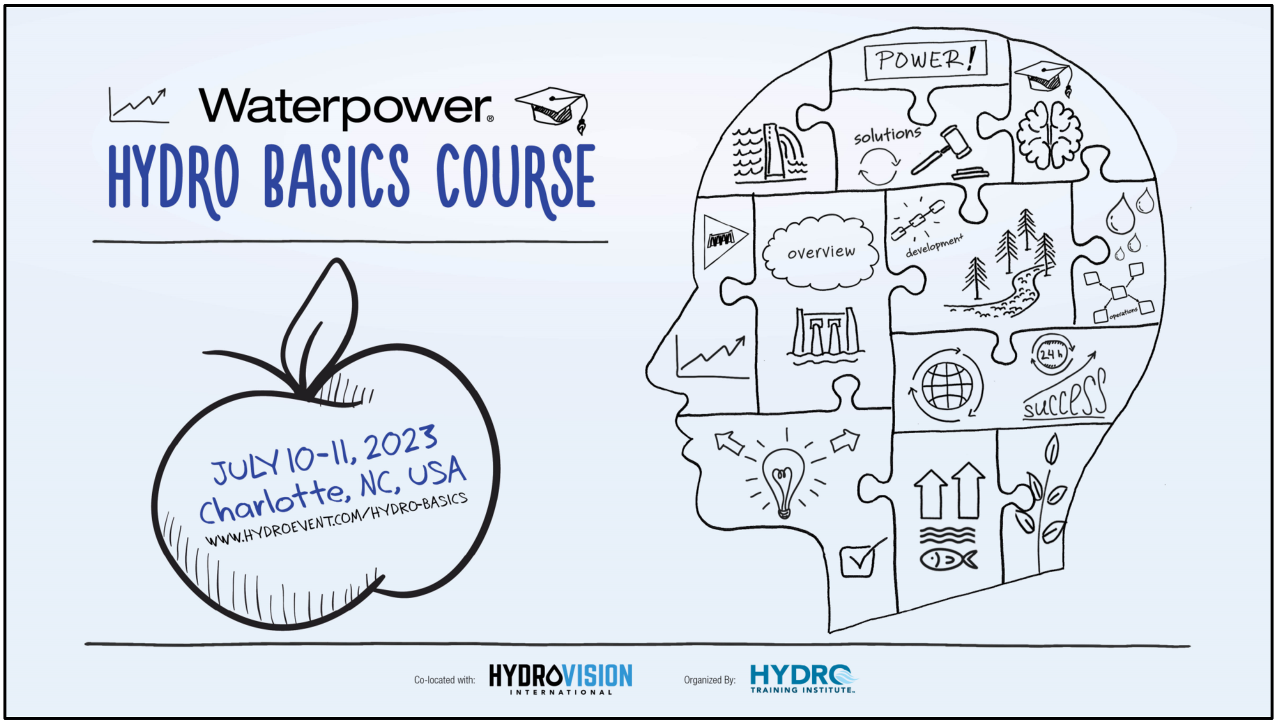
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Structure Definition

- **Water Retaining Structures**
  - Dams, Spillways, Intakes, Powerhouses, Locks
- **Water Conveyance Structures**
  - Penstocks, tunnels, flumes, canals & ditches
  - Forebays, balancing reservoirs
- **Water Regulating Structures**
  - Upstream gates, valves, bulkheads, stoplogs, operators
  - Downstream turbine isolation valves, bypass valves

3

The overriding **goal** of a hydro project **is to provide power**, and the fuel for that power is **"falling" water**, so every structure must be arranged and **designed with this in mind**.

We are going to talk **about three major structures** today – those that **retain** the water, those that **convey** the water, and those that **regulate** the water.

The selection of each type of structure is a key element of the design for any hydropower project and can take years of **planning**, **investigations**, and **studies**.

The selection process is <u>iterative</u> as the type of retaining structure selected often dictates the type of conveyance structure that then narrows the regulating structures available for use and vice versa.

Though engineering behind the structures is similar from site to site, no two hydro projects are identical.

Gravity rules.

Water Retaining Structures

Dams

- Gravity
- Fill
- Structural

Spillways

- Uncontrolled
- Controlled

Design Considerations

4

Water Retaining Structures - Dams

- Gravity Structures
  - Rely on mass
  - Concrete, RCC, masonry
- Fill Dams
  - Rely on frictional resistance of materials and mass
  - Earthfill, rockfill, hydraulic fill, levees
- Structural
  - Rely on their structural configuration
  - Arch dams, buttress, flood walls

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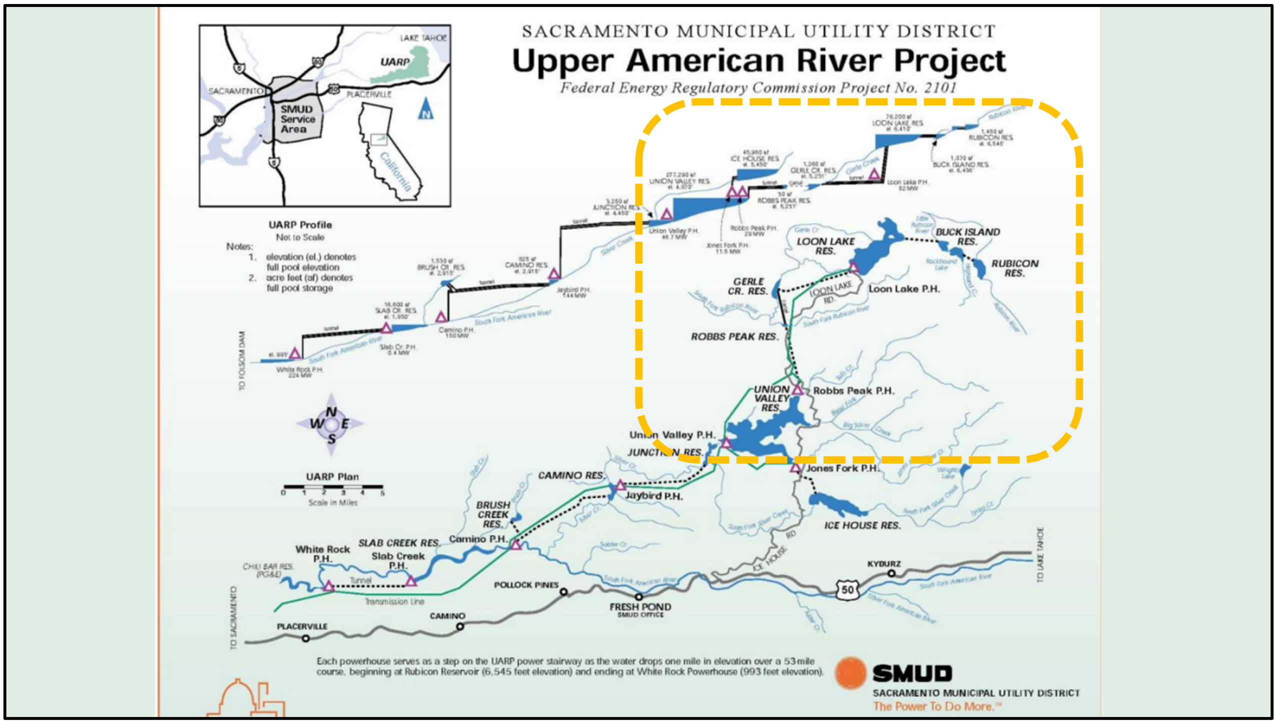
<u>Dam vs. Levee</u>

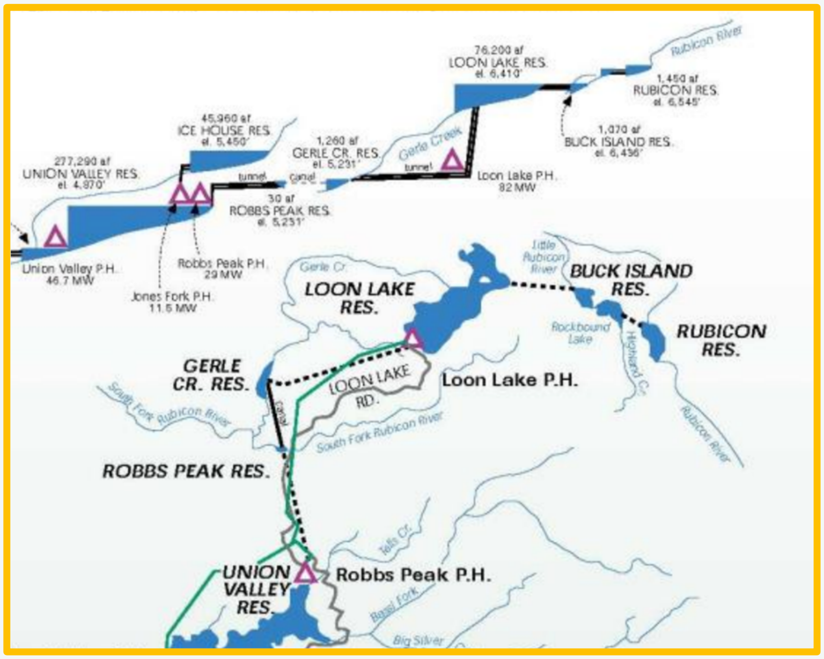
<u>Dams</u> means any **artificial barrier** that has the ability to **impound** water, wastewater, or any liquid-borne material, for the purpose of **storage or control** of water.

<u>Levees</u> an **embankment** whose primary purpose is to furnish **flood protection** from seasonal high water and which is therefore subject to water loading for periods of **only a few days or weeks** a year (USACE, 2000)

Dam engineering is an evolving science.

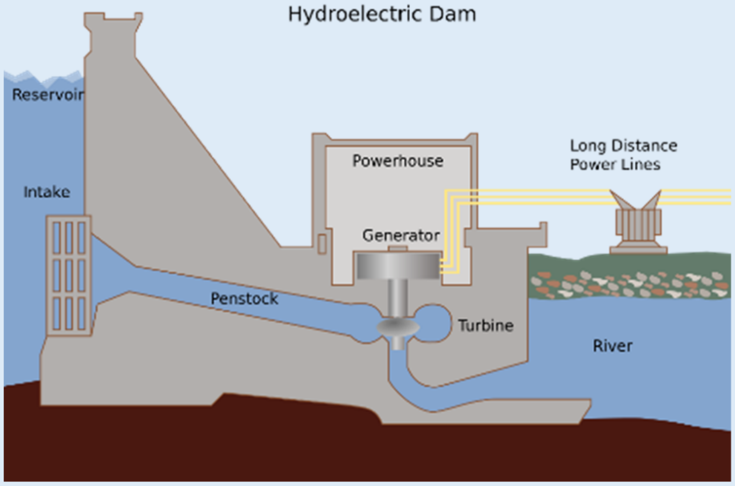
Dam type selection is a complex process that must incorporate **site** conditions, project **needs**, material **availability**, and **foundation** characteristics to name a few.


SACRAMENTO MUNICIPAL UTILITY DISTRICT
Upper American River Project
Federal Energy Regulatory Commission Project No. 2101
SMUD Service Area
UARP Profile
Not to Scale
Notes:
1. elevation (el.) denotes full pool elevation
2. acre feet (af) denotes full pool storage
UARP Plan
Scale in Miles
LOON LAKE RES.
BUCK ISLAND RES.
RUBICON RES.
GERLE CR. RES.
Loon Lake P.H.
ROBBS PEAK RES.
UNION VALLEY RES.
Robbs Peak P.H.
Union Valley P.H.
JUNCTION RES.
Jones Fork P.H.
CAMINO RES.
Jaybird P.H.
ICE HOUSE RES.
BRUSH CREEK RES.
SLAB CREEK RES.
Camino P.H.
White Rock P.H.
Slab Creek P.H.
POLLOCK PINES
FRESH POND
KYBURZ
PLACERVILLE
CAMINO
TO SACRAMENTO
TO LAKE TAHOE
Each powerhouse serves as a step on the UARP power stairway as the water drops one mile in elevation over a 53 mile course, beginning at Rubicon Reservoir (6,545 feet elevation) and ending at White Rock Powerhouse (993 feet elevation).
SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
The Power To Do More.™



76,200 af
LOON LAKE RES.
el. 6,410'
Rubicon River
1,450 af
RUBICON RES.
el. 6,545'
45,960 af
ICE HOUSE RES.
el. 5,450'
1,260 af
GERLE CR. RES.
el. 5,231'
Gerle Creek
1,070 af
BUCK ISLAND RES.
el. 6,436'
277,290 af
UNION VALLEY RES.
el. 4,870'
tunnel
canal
tunnel
Loon Lake P.H.
82 MW
30 af
ROBBS PEAK RES.
el. 5,231'
Union Valley P.H.
46.7 MW
Robbs Peak P.H.
29 MW
Jones Fork P.H.
11.5 MW
Gerle Cr.
Little Rubicon River
BUCK ISLAND RES.
LOON LAKE RES.
Rockbound Lake
RUBICON RES.
GERLE CR. RES.
LOON LAKE RD.
Loon Lake P.H.
South Fork Rubicon River
Highland Cr.
canal
South Fork Rubicon River
Rubicon River
ROBBS PEAK RES.
Tells Cr.
UNION VALLEY RES.
Robbs Peak P.H.
Bassi Fork
Big Silver

Gravity Structures



- Cast-in-place, roller compacted, precast, pre-placed aggregate and underwater placed concrete
- Masonry and cyclopean
- Powerhouses, intakes, spillway headworks, etc.
- Greater cross section but needs lower foundation strengths

8

Gravity structures: the name says it all.

Typically built in blocks called **monoliths** anywhere from 50-ft to 90-ft wide. Monoliths are **independently stable**. Heights are limited by foundation characteristics.

Temperature effects must be addressed for large concrete gravity structures.

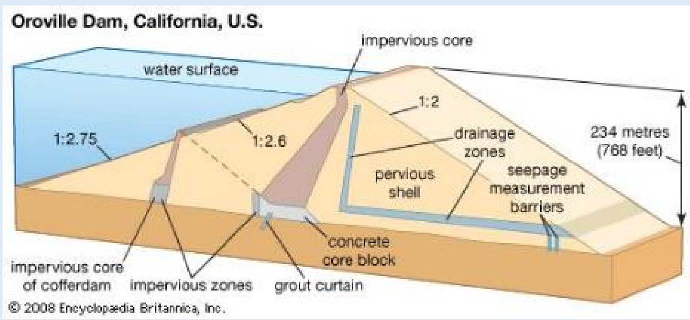
Structure **shape** is important – abrupt changes in section shape should be avoided.

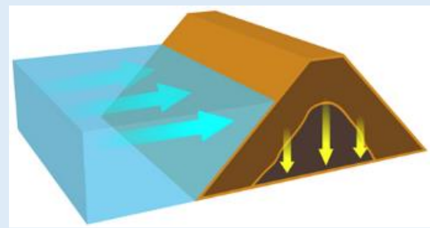
Cyclopean masonry entails large irregular stone blocks embedded in concrete
RCC = Roller-Compacted Concrete

Many times, structures are incorporated into gravity dams including **powerhouses, intakes, and spillways**.

Earthfill Embankments

- Variety of material choices
  - Gravels, sands, silts, clay, manufactured products
- Homogeneous
  - 1 impervious material
- Zoned
  - Impervious core protected by filter, drain and shell materials
- Low foundation strength required





Two sub-categories of fill dams:

- **Earthfill**
- **Rockfill**

Seepage through the embankment, foundation, and abutments must be **controlled** and **collected**.

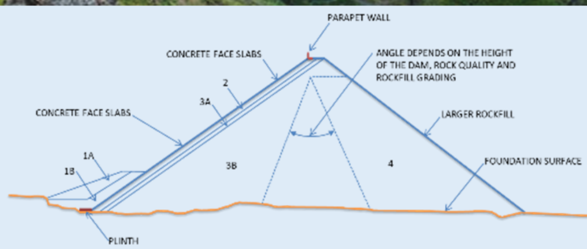
Freeboard and **erosion** protection is a **major** consideration for earthfill dams.

Zoning of a dam and the construction method dependent upon local **availability** of materials.

Material parameters and compaction are critical to earthfill dam **performance**.

Typical **slopes** range from 4H:1V to 2.5H:1V (H=horizontal, V=vertical). For reference, 4H:1V is 14 deg and 2.5H:1V is nearly 22 deg.

Rockfill Embankments



- Earth-core: impervious core and filter materials within dam body
- Upstream lined: concrete, asphalt, or membranes
- Steeper slopes → higher foundation strength required

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Similar to earthfill, but materials generally **more stable** typically resulting in steeper slopes, commonly 1.6 to 1.75H:1V, but up to 1.3H:1V (**38** deg).

Final slopes dependent upon foundation characteristics as well as rockfill characteristics.

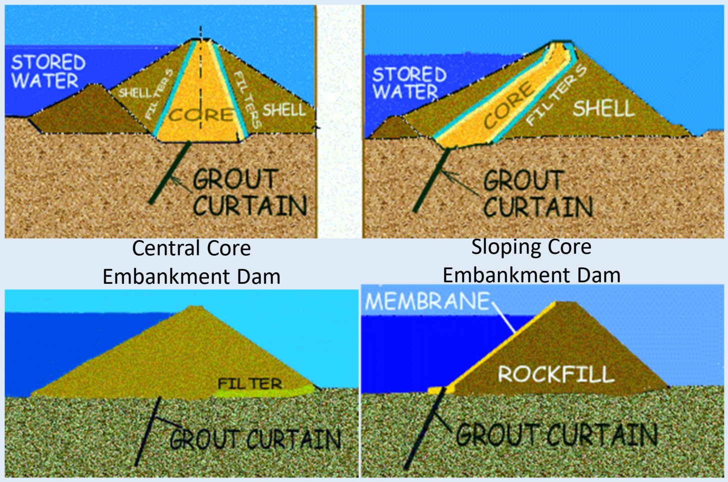
Typically placed in **lifts** and **compacted**, just like earthfill.

ECRD = Earth-Core Rockfill Dam
CFRD = Concrete Face Rockfill Dam

CFRD terminology:

- Face Slab = reinforced concrete panels on the slope.
- Plinth = reinforced concrete toe slab upon which the face slabs are founded and anchored to rock.

Dam Cross Sections



Central Core Embankment Dam

Sloping Core Embankment Dam

Homogeneous Embankment Dam

Upstream Lined Embankment Dam

11

Illustrations from http://www.users.tpg.com.au/houlsby1/Dams%20Usage.htm

As many varieties as there are materials available.

Some fundamentals for fill dams:

- **Water barrier**: impervious core, upstream lining, etc.
- **Seepage barrier**: grout curtain, cutoff wall, slurry trench, etc.
- **Filters**: measures to control seepage gradients and prevent internal erosion of materials (types include chimney drains, blanket drains, toe drains, finger drains, etc).
- Shell materials to support and protect the core and to maintain stability

Piping – occurs when the seepage forces overcome the resistive force of the soil resulting in the 'washing away' of fines and the formation of conduits or pipes within the material. As fines wash away, flow increases and more fines wash away, increasing flow further, thereby washing more fines away, etc.

Note: many fill dams **incorporate the cofferdam into the final design section.** Cofferdams are temporary dams constructed in advance to allow dewatering of the site and proper construction of the permanent facilities including dams, powerhouses, locks, etc.

Structural Dams

- Arch Dams
  - Small cross sections
  - Require high foundation and abutment strengths
- Buttress Dams
- Coffer Dams
- Timber Crib
- Flood Walls

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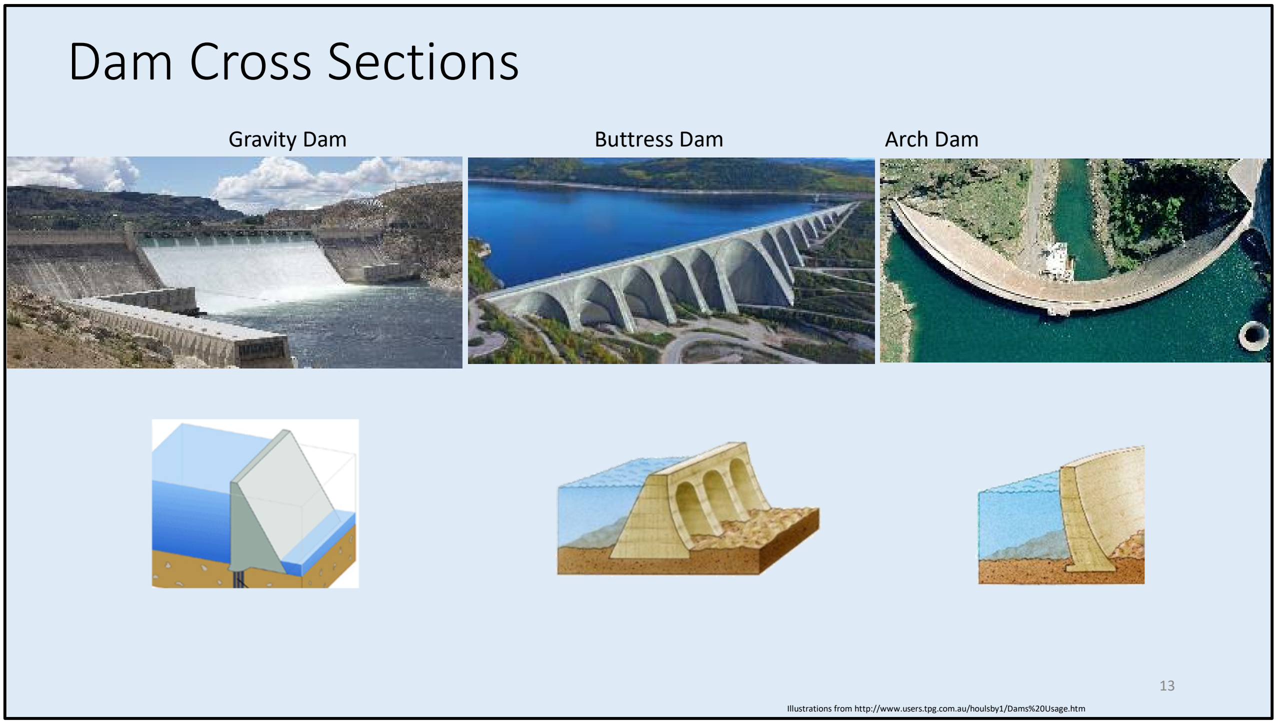
Rely on their structural configuration to pass the water loads into the foundation.

Arch dams carry a major portion of their **loads horizontally into the foundations** on either side of the dam, called abutments.

Arch dams are typically designed with **curves** in two directions – horizontally and vertically.

Other structural dams rely on the structural strength of the components in combination with the dam’s weight to resist the water loads.

Structural dams require **strong foundations** and abutments as well as careful consideration and treatment of **seepage**.



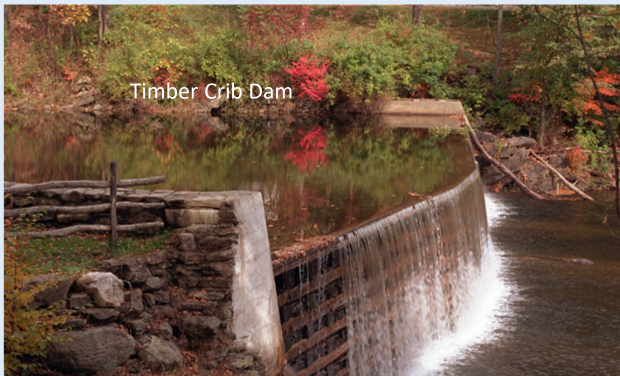
Seepage control is very important for gravity and structural dams as well.

Typically, **drainage curtains** are employed to reduce **uplift pressure**.

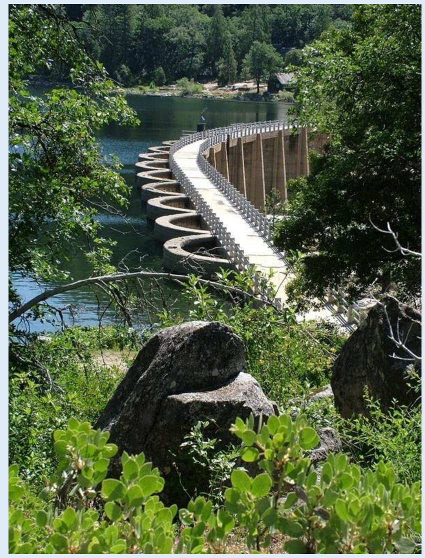
Uplift pressure results from the **hydrostatic** forces **caused by seepage** at the foundation line (or lift line or within the dam body itself).

Uplift is very hard to predict **but can be measured**.

Drains can only be effective if **appropriately maintained**.



Timber Crib Dam



Multi-Arch Dam

Spillways & Outlet Works

permit passage of excess reservoir water

Energy dissipation is extremely important!

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Spillways:
Structures **designed to release surplus** water or floodwater that cannot be contained in the reservoir. Hydrologic data needed includes:

- Water surface profiles and stream flow data (USGS typically)
- Reservoir elevation-area-capacity curves
- Tailwater rating curves

The importance of properly designed spillways cannot be understated – many dam **failures** have been **attributed** to **improperly designed or undersized spillways**.

Spillway setting and **capacity** requirements **set by hazard** classification of the dam.

In addition to providing sufficient capacity, the spillway must be **hydraulically and structurally adequate** and must be located so that spillway discharges do **not erode** or undermine the downstream toe of the dam.

As with seismic issues, flood magnitudes are being redefined and are generally increasing in size **often times yielding an insufficient spillway** capacity at older facilities.

Classified according to mode of control as free (uncontrolled) or gated (controlled) spillways;
Also **classified**: according to function as main **service**, **emergency** and **auxiliary** spillways;
Also **hydraulic criteria**, i.e. type, as overfall, side channel, chute, shaft, siphon and tunnel spillways

Spillway Types

“Uncontrolled” Spillways

- Maintain water levels automatically without reliance on personnel or machines
- Ungated overflow weirs, side channel, labyrinth, drop inlet, fuse plugs

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Spillway Components:

• **Control** Structure: regulates the outflows from the reservoir, limiting or preventing outflows below fixed reservoir levels and regulating releases when the reservoir rises above that level.

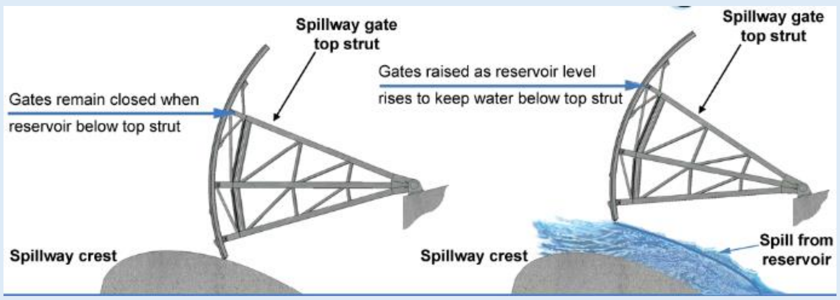
• Discharge **Channel**: flow released through the control structure is conveyed to the streambed below through the discharge channel.

• **Terminal** Structure: provided at the base of the discharge channel to dissipate the energy of the spilled water.

Spillway Types

“Controlled” Spillways

- Provide reservoir drawdown capability during or following a flood event
- Gated spillway, discharge outlet, stoplogs, flashboards, etc.



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Spillway design is governed by hydraulics. Common terms include:

- **Ogee**: the term given to an overflow spillway shaped to **maximize the discharge efficiency** – also referred to as S-shaped.
- **Cavitation**: the formation of a **water vapor cavity** that **results in a high-pressure jet** when the cavity collapses – particularly significant where water velocities exceed 80 ft/s.
- **Aeration**: the introduction of air near the flow surface to **reduce the potential for cavitation**.
- **Plunge** Pool: water bodies provided to **absorb the energy** of falling water from overfall spillways, etc.
- **Deflector/Flip** Buckets: structures designed to **redirect** the spillway discharge flow **upwards** (normally not more than 30 degrees) to minimize the need for additional downstream streambed protection works.
- **Stilling** Basins: structures of specific width and length **to force the hydraulic jump to occur within the basin**, again to minimize the need for additional downstream streambed protection works.

Design Considerations

Material

- Availability
- Thermal behavior

Foundation

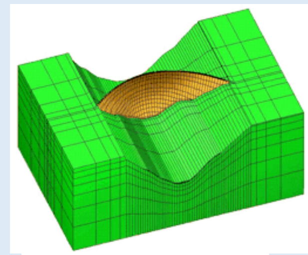
- Bearing, sliding, seepage, liquefaction, and settlement

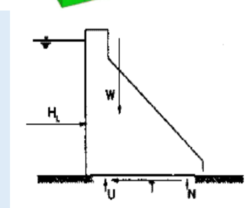
Stability

- Sliding
- Overturning
- Slope stability
- Water barriers and drains

Strength

Performance





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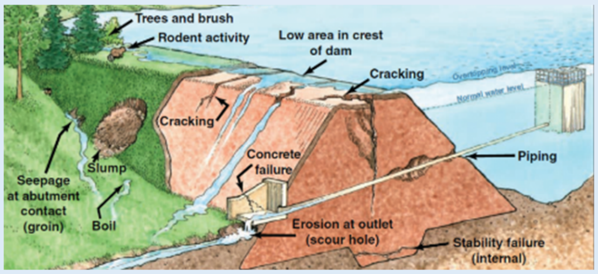
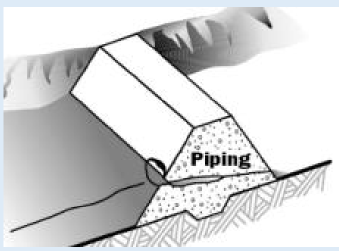
Material **availability**: local materials for aggregates, rockfills and their strengths. Also affect the way of placing and construction schedule.
Thermal effects: Seasonal temperatures and heat of hydration, like a cake in the oven, causing large strains before material reaches strength causing cracks. Can last for years.
Bearing: Pressures transferred to foundation should be well within its capacity. Shape can affect structural design, needs close collaboration between disciplines, local foundation failure mechanisms must be checked, sometimes leads to foundation treatments and reinforcements.
Liquefaction is the sudden large **decrease** of the shearing **resistance** of a cohesionless soil (such as sands). It is caused by a collapse of the soil by shock or other type of strain and is associated with a **sudden but temporary increase of the pore-filled pressure**. It involves a temporary **transformation** of the material into a **fluid** mass. Hydraulic fill dams may vulnerable to this type of failure as well as some foundations.
Stability analysis is dam type dependent. Common analyses include **overturning, sliding, and floatation**.
FoS calculated as the ratio of resisting/capacity. Depends on load probability of occurrence.

Sliding → displacement, for very high return periods MCE, dams/structures are allowed to displace → performance based design.
Overturning avoid tipping over, can be local.
Stability is looked at global level (whole dam), local level (blocks, lifts), likelihood of unstable portion to compromise structure.

Design Considerations



- Seepage, leakage, and piping
- Settlement
- Material Deterioration
- Overtopping / Surface Erosion
- Seismic Resistance



Settlement causes large relative displacements that compromise the structural integrity. Granular materials can accommodate more easily to settlement than rigid structures like concrete.

Materials can deteriorate over time leading to a weak link in the load path.

Seismic resistance is a **big issue** for both new and old dams.

Historically, seismic design was not sophisticated, and many times **was not even considered in older** designs.

Seismicity studies have become **more advanced** and many dams thought not to be in seismic zones in the past must now be evaluated and **retrofitted to meet the new seismic standards**, which can be very costly.

<u>Seismic Analysis Terms:</u>

- Maximum Design Earthquake (MDE): maximum earthquake event for which the structure is designed to withstand. Now called **SEE = Safety Evaluation Earthquake → prevent sudden release of the reservoir, and damage is**

acceptable

• Maximum Credible Earthquake (MCE): the maximum earthquake event that may occur at a given site.

• Operating Basis Earthquake (OBE): an event for which the facilities are designed to resist and remain in operation.

Design Considerations

- Hazard Potential Classification
  - Categorizes dams based on adverse incremental consequences of a failure or mis-operation
  - Not an indication of the current or expected condition of the dam
  - Classification determines design criteria for the dam such as Inflow Design Flood (IDF), freeboard, spillway and outlet requirements, seismic resistance and analysis requirements, etc.

<u>Inflow **Design** Flood (IDF)</u>
The **maximum** flood against which a structure is **protected**.

<u>Probable **Maximum Precipitation** (PMP)</u>
The **greatest depth of precipitation** for a given duration, given area, given location, and given time of year, with no allowance for long-term climatic trends.

<u>Probable **Maximum Flood** (PMF)</u>
The maximum runoff condition resulting from the **most severe combination** of hydrologic and meteorologic conditions (i.e., snowmelt, PMP, etc.) that are considered reasonably possible for the drainage basin under study.

Need to look at antecedent or subsequent flood events as well.

Dam Downstream Hazard Potential Classifications

CATEGORY[1]	LOW	SIGNIFICANT	HIGH
Direct Loss of Life[2]	None expected (due to rural location with no permanent structures for human habitation)	Uncertain (rural location with few residences and only transient or industrial development)	Certain (one or more extensive residential, commercial or industrial development)
Lifeline Losses[3]	No disruption of services - repairs are cosmetic or rapidly repairable damage	Disruption of essential facilities and access	Disruption of critical facilities and access
Property Losses[4]	Private agricultural lands, equipment and isolated buildings	Major public and private facilities	Extensive public and private facilities
Environmental Losses[5]	Minimal incremental damage	Major mitigation required	Extensive mitigation cost or impossible to mitigate

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I. **Categories** are based upon project **performance** and do not apply to individual structures within a project.

2. **Loss of life** potential based upon **inundation mapping** of area downstream of the project. Analyses of loss of life potential shall consider the extent of development and associated population risk, time of flood wave travel and warning time.

3. **Indirect threats to life** caused by the **interruption of lifeline services** due to project failure, or operation, i.e., direct loss of (or access to) critical medical facilities or loss of water or **power supply, communications**, etc.

4. Direct economic impact of value of **property** damages to project facilities and downstream property and indirect **economic impact due to loss of project services**, i.e., impact on navigation industry of the loss of a dam and navigation pool, or impact upon a community of the loss of water or power supply.

5. **Environmental** impact downstream caused by the incremental flood wave produced by the project failure, beyond which would normally be expected for the magnitude flood event under a **without project conditions**

Notes:

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Water Conveyance Structures

- Conveyance Components
- Design Considerations
  - Channels & Canals
  - Penstocks
  - Tunnels & Shafts
  - Outlet Works

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Include also diversion structures needed during project construction.

Water Conveyance Structures

Conveyance Structures

Goals

- Deliver the required flow to the turbines
- Minimize head loss
- Maximize power and/or energy output

All for the Least Cost !

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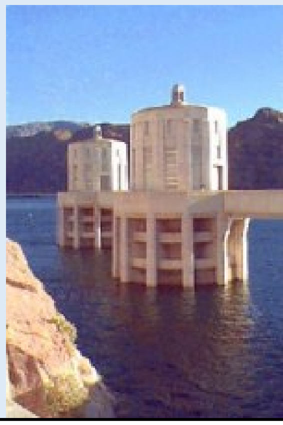
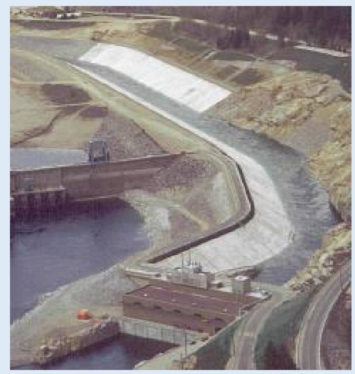
Conveyance Components

- **Channels & Canals:** manmade streams or rivers
- **Forebays:** water storage for operation regulation
- **Intakes:** control inflow and block debris, fish, ice, etc. from entry





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Channels & Canals:
• Typical **lining** options: clay, concrete, membranes, asphalt, etc.
• **Uplift relief** and **drainage** beneath the lining is an important consideration.
• Typically convey high flows to low head plants, want to minimize losses; i.e., low velocities, large sections, smooth surfaces.
• Need to balance hydraulic design with field application.

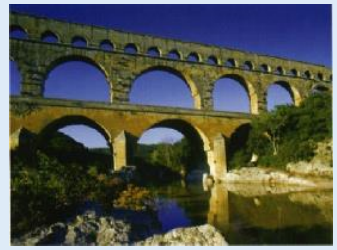
Forebay: storage for load **acceptance** (surplus water) and load **rejection** (surplus storage). like an **approach** channel or small lake, allows for **regulation**.

Intake elevation is key – can be dictated by **capacity** needs, submergence requirements for mitigating air entrainment, temperature levels, silt levels, water quality, etc. Oftentimes intakes are **multilevel** for this reason.

Intake **geometry** is also key – need uniformity of **flow velocity and direction**. Model studies, both physical and CFD, are often done to confirm the geometry in advance.

Conveyance Components

- **Flumes:** open conduit, normally elevated, for conveying water
- **Penstocks:** pipe to convey water under pressure
- **Tunnels & Shafts**
- **Surge Chambers:** for pressure fluctuations in water conductors



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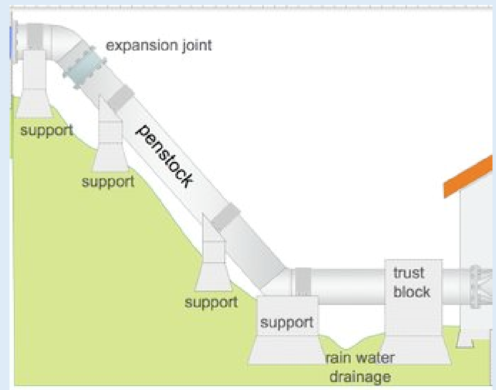
Conveyance Structure Design Considerations

- Alignment issues
- Hydraulic requirements
  - Flow, Velocity, Head
- Leakage and seepage control
- Dewatering and inspection provisions



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If the project is regulated by the Federal Energy Regulatory Commission (**FERC**), the project features are to be **inspected** every five years.

Intake setting (**submergence**) and shape is important. Also, protection against **debris** and sometimes wildlife entering the conveyance structures is normally required.

Conveyance structure design must account for **pressure variations** caused by unit operation. These can sometimes be **severe**.

Loads generated by the flowing water must be taken into account where changes in direction take place. Directional changes also result in additional losses. This causes also loads for trust support deign.

Channels & Canals
Design Considerations

- Unlined or lined (clay, concrete, membranes, asphalt, etc.)
- Generally larger volumes of water and slower velocities (losses, erosion, etc.)
  - Unlined: 2 to 6 fps
  - Lined with rock or riprap: up to 10 fps
  - Lined with concrete: up to 20 fps
- Uniformity of cross section and alignment to minimize losses
- Uplift relief and drainage beneath the lining is an important consideration.

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Lining requirements for tunnels and shafts must be carefully reviewed for items such as **head loss**, **leakage**, and hydraulic **jacking** as well as for **support** needs both **during construction and long-term operation**.

The need and type of **tunnel lining** is governed by the **rock mass characteristics**, jointing, available rock cover, leakage control, reduction of losses, etc.

Interaction between the **tunnel lining** and the **surrounding rock** must be considered in the design of the lining.

Steel liners are typically adopted to control leakage, where insufficient rock cover exists, or where the tunnel pressures are high and may result in stability issues in the surrounding geology.

Conveyance Structures
Design Considerations

Penstocks & Tunnels

Internal pressure design: *normal operations, transient conditions (surge), negative pressures*

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When **dewatering** existing structures or designing new ones, careful consideration must be given to the ‘**reverse conditions**’ that will occur following the dewatering of a tunnel, shaft or buried penstock.

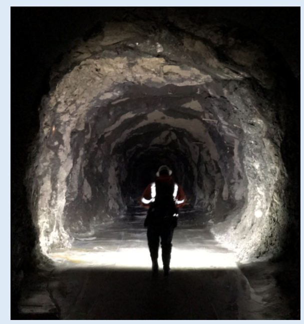
Conveyance Structures Design Considerations

Penstocks & Tunnels

External pressure design: *ground loads, grouting, groundwater*

System design:

supports, thrust blocks, expansion/contraction, coatings, access



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When **dewatering** existing structures or designing new ones, careful consideration must be given to the ‘**reverse conditions**’ that will occur following the dewatering of a tunnel, shaft or buried penstock.

Penstocks

- Supported, buried or encased.
- Materials:
  - Steel, wood stave, concrete, and fiberglass.
  - Steel to be pressure vessel quality steel (refer to ASME guidelines and ASCE 79).
- Design must be done in conjunction with the turbines to ensure water supply is consistent with the machine
  - Water starting time and mechanical starting time
  - Design pressures due to water hammer

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Common penstock **materials** include **steel**, **wood** stave, **concrete**, and **fiberglass**. Typically, steel **penstocks** are made with **pressure vessel quality** steel (refer to ASME guidelines and ASCE 79).

Typically, only **fine-grained carbon steel plate** intended for use in pressure vessels should be used for penstocks.

Penstock **design** must be done in **conjunction** with the **turbines** to ensure water supply is consistent with the machine (water starting time and mechanical starting time) and the design pressures are appropriate (**water hammer**).

Tunnels and Shafts

Is a lining needed?

- Reduce losses
  - Unlined, velocity ~ 5 to 8 fps
  - Concrete lined, velocity ~ 10 to 20 fps
  - Steel lined, velocity ~ 20 to 30 fps (though upwards of 70 fps near the entrance to the units)
- Leakage / hydraulic jacking
- Support needs, both during construction and long-term operation.

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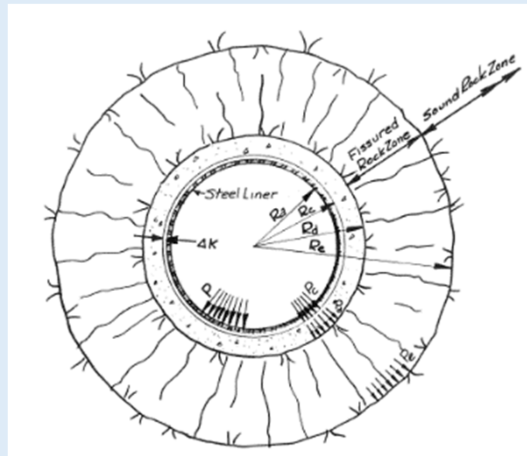
Hydraulic jacking – pressurization of the rock to a point where the **pressure in the joints and fractures exceeds the weight of the rock** and essentially 'floats' the rock.

Rock bolts used to stabilize surrounding material, installed with patterns depending on site characteristics (boreholes used for inspecting conditions).
Like reinforcing the rock mass.

Lining Design

- Optimum design incorporates the steel liner, concrete lining, and rock zones
- Air gap between steel and concrete
- Minimum thicknesses
  - Handling for the steel liner
  - Constructability for concrete (min. 12”, 18” to 24” for drill and blast)



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Important to design each component as the load is shared. For example, when the water pressurizes the steel liner, steels takes some load, then concrete behind takes some portion, and supporting rock also takes part of the load. All working together. Weak zones can be challenging, design must adjust along the tunnel alignment. Inter-disciplinary coordination key.

Outlet Works

- To allow the release of water to satisfy river flow requirements when the power plant is not in operation
- Temporary diversion during initial filling
- To allow for lowering of reservoir for inspection and repairs
- To provide additional spill capacity

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Mainly control structures.

Outlet Works

- Basic components include control structures, discharge channels, and terminal structures.
- Discharge channel or conveyance system is often times closed such as a pipe or conduit.
- Releases; i.e., size of outlet dictated by:
  - Flood control regulation / storage regulation
  - Water supply or irrigation demands
  - Navigation
  - Environmental
  - Drawdown

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Some sample drawdown requirements:

- Capability to release the upper 10-ft of the reservoir at full pool in ten days;
- Within four months, be able to release the stored water from full pool to a depth equivalent to 20-ft above the pre-project “full channel” elevation; and
- Capability to release 90% of the storage volume in four months.

Outlet Works

- Reservoirs are subject to sedimentation
  - Leads to loss of storage volume for water supply, hydropower generation, flood storage, etc.
  - Impacts pool depths that can affect navigation and recreation
  - Restricts flow of sediment downstream sometimes leading to scour downstream and prevents replenishment of downstream bottomlands
- Submergence important
- Trashracks may be needed

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Outlet Works

- Water quality related issues may include:
  - Temperature
  - Oxygen concentration
  - Turbidity
  - Minimum flow requirements
- Water below the outlet works is considered “dead storage”

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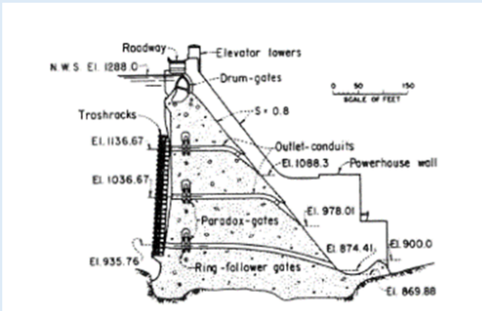
Outlet Works



- Energy dissipation is extremely important
- Common velocities:
  - Concrete lined conduits = 65 fps
  - Steel lined conduits = 160 fps
- Air must be supplied downstream of the gate to prevent cavitation and damage to conduit due to high velocity flow

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Water Regulating Structures

Gate vs Valve

Gates

- Low Head
- High Head

Valves

Design Factors & Considerations

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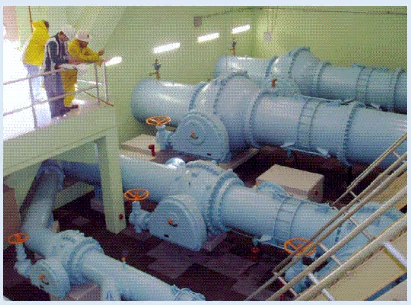
Water Regulating Structures

Goals

Regulate the flow

Provide needed flow range and accuracy

Installation, removal, and maintenance ease



All for the Least Cost !

Water Regulating Structures

Gate

Closure device in which a leaf (closure member) is moved across the fluidway from an external position

Valve

Closure device in which the closure member remains fixed axially with respect to the fluidway and is either rotated or moved longitudinally

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Principal differences:

Gates:
- Located in a free standing structure;
- Guides and sealing surfaces are attached to an independent structure;
- Hydrostatic pressures are external; and
- Lower fit tolerances.

Valves:
- Located in, or at the end of a pressurized conduit;
- Have bodies that incorporate sealing surfaces to transfer load;
- Interior of the valve is pressurized;
- Sealing, seating, and mating surfaces require fine machined tolerances.

Control of flow in closed pipes such as penstocks conveying water for hydropower is also done by valves, which are different from gates in the sense that they come together with the driving equipment, whereas gates require a separate drive or hoisting equipment.

Questions ??

Thank you all very much !!!

Enjoy the rest of the course

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