2. Classification of dams according to the method of construction

- **Embankment dams** : that could be filled with earth or rocks. Simple geometry with the same slopes on each side, a wide section and a high volume compared to its height.
- **Concrete dams** :
  - *gravity dams* : works because of it's own mass, the general geometry is triangular
  - *buttress dams* : continuous upstream face supported at regular intervals by downstream buttresses
  - *arch dams* : have a considerable upstream curvature more efficient than the other concrete dams
- **Steel dams** : consists of a steel framework, with a steel skin plate on its upstream face
- **Timber dams** : a dam made of wood.

3. Classification of dmas according to the transmission of loads to the dam

- Primary loads : most important loads such as water, seepage and wieght loads
- Secondary loads : less important like sediment loads or specific to a certain type of dam like thermal effects whithin a concrete dal
- Exceptional loads : having a low probability of occurence like seismi load

4. Design criteria for selecting the type of dam: topography, geology, seismism, climatology, hydrology, materials, ecology

- *Topography :* we have to consider the surface configuration of the damsite and of the reservoir area. The aessibility to the construction site is also important.
- *Geology :* the suitability of the various types of rock and soil as foundation for the dam
- *Materials available :* it's important to have various materials neer the construction site
- *Hydrology :* streamflow characteristics and precipitation may appreciably affect the cost of construction by influencing the treatment and diversion of water

- *Spillway :* depends of the size and type of the spillway and alos the natural restritions in its location
- *Earthquake :* if the dam lies in an area that is subject to earthquake shocks, the design must provide for the added loading and increased stresses

5. Basic types of embankment (earthfill/rockfill) dams, premeable and impermeable foundation

- Earthfill embakements : if compacted soils represnt more than 50% of the materials. This dam is built with soils compacted uniformly and intensively to controll moisture in it.
- Rockfill embankements : when more than 50% of materials are classified as rocks. Designed with elements of compacted earthfill or a slender concrete membrane.

6. Basic types of concrete gravity dams, design criteria

- designed that its own weight resists the external forces.
- there is an non-overflow and a spillway sections
- can only be constructed where there is a natural foundation that is strong enought
- design criteria depends on the loads applied on the dam
- need to check to cases : reservoir full and reservoir empty

7. Basic types of arch dam, design criteria

- obtain it's stability by transmitting the imposed loads by arch action
- it requires a site with abutments that sould resemble a smooth geometry curve composed of one or two parabolas or hyperbolas.
- design involve several tenataive for the shape, involving preliminary static stress analysis

8. Factors that must be taken into account when calculating the freeboard of the embankment (earthfill or rockfill) dam

Freeboard = distance between the top of the dam and the full supply level in the reservoir.
The facotrs are :

- rise in reservoir level due to flood
- seiche effects
- wind set-up of the water surface
- wace action on the dam

9. The basic types of slope protection of the earthfill or rockfill dams

- *Upstream slopes :* more treatment on them because they are exposed to wave action. Bellow the minimum water level the erosion is negligeable whereas a permanent protection is needed against waves.
- *Downstream slopes :* only erosion from rainfall and surface runoff and/or wind erosion must be considered.

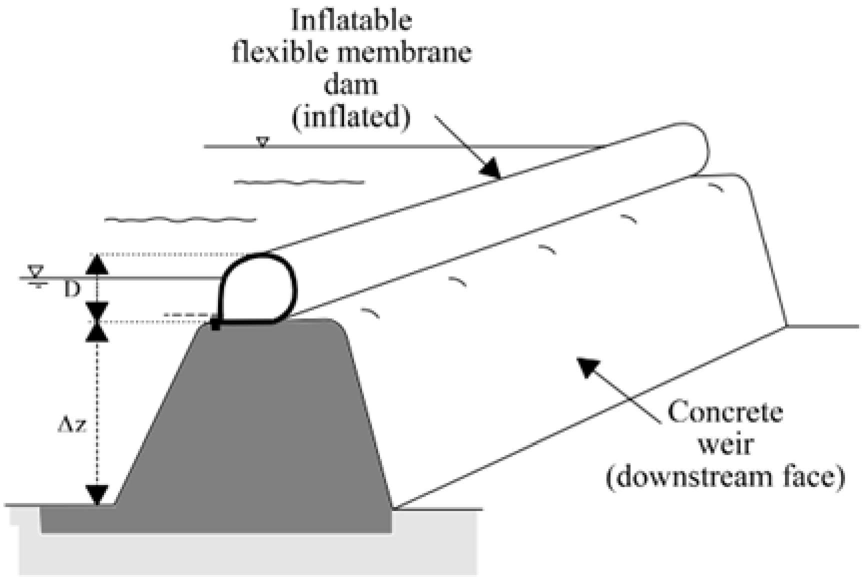
10. Basic elements of the barrage (gate-structure dam) with radial and vertical flat gates

- guide banks :direct the main river flow as centrally as possible to the diversion structure,
- wing walls : flanking the barrage and supporting the abutment
- gates : to control the flow rate over the crest
- regulators : controlling diversion into a supply canal
- dividing wall : separating the weir and the undersluices
- weir block and stilling basin
- navigation locks

11. Basic types of gate structures and range of usability

- *Crest gates* : works by its structure transferring the pressure acting on them.
- *Plain gates* : can have slide or wheeled support (can be vertical lifted or radial lifted)
- *Radial gates* : the advantages of radial over vertical lift gates are smaller hoist, higher stiffness, absence of gate slots, easier automation and better winter performance
- *Drum and sector gates* : drum = float on the lower face and sector are encloses on the upstream and dowstream surfaces. They are difficult to install and need careful maintenance but it's easy to automate, no need for lifting gear, fast and very accurate.
- *Flap gates :* the simplest and most frequently used types of regulating gates used mainly on weirs and barrages

12. Sketch and describe the principle of operation of the rubber dam



- used to raise waterlevel, increase water storage and prevent chemical dispersion
- easy to install but also easy to damage because of their instability that can destroy the rubber membrane

13. The differences between hydraulic gates and valves in free surface flow and submerged outlets, range of usability

<u>Free surface flow :</u>

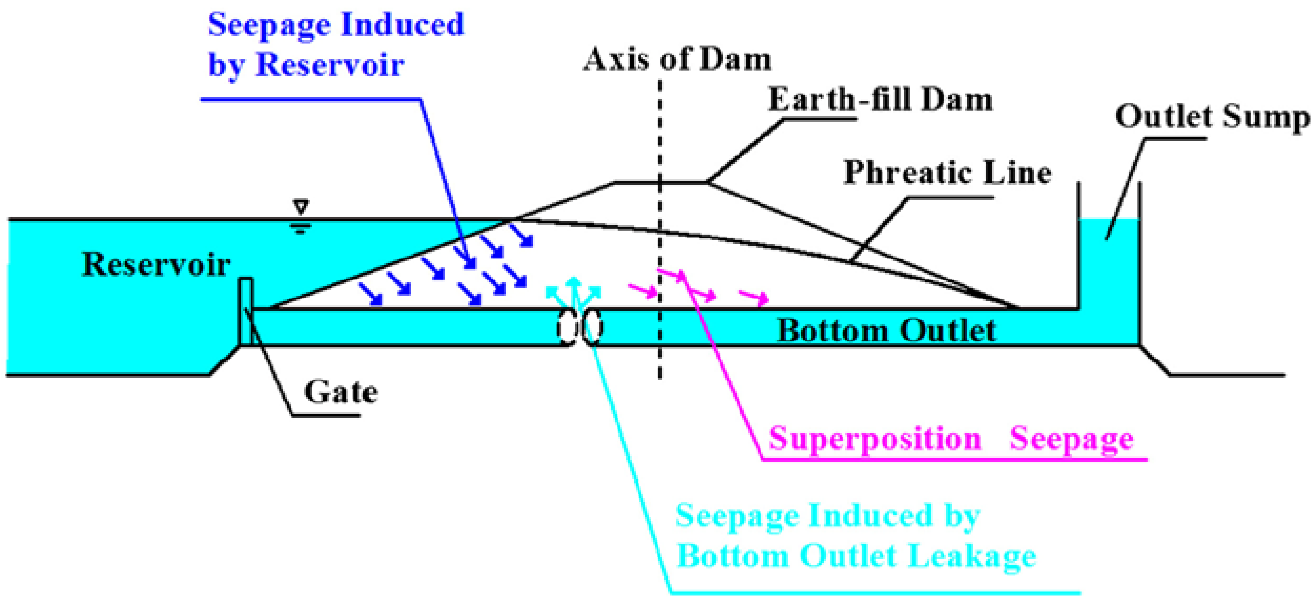
- *The sluice gate*, are classified according to the mode of movement in operation: translational or rotational. It can be operating without a power supply (gravity systems). It has a great resistance against floating objects or ice and a favourable dissipation of kinectic energy. But there are high frictional forces, it's difficult sealing of the contact between the gates and you need to build high columns due to the need for full lifting of the gates. Useful for dam up to 5 to 10m.
- *Segmental locks* need a lower lifting force, but need a more specific building geometry because of it's circular shape. Useful to dam of 10 to 40m. The advantage of segmental gates over sluice gates is the easy and reliable side and floor sealing. It is also possible to install a flap to regulate the level of the top water and to flush away ice and other floating objects.
<u>Submerged outlets :</u>
- Segmental locks (hydraulic gates), are only used for regulating, better than valve for reducing lifting forces, better outflow of water under de lock, lock bed is protected against flooding, increased structural rigidity, reduced exposure of the structure vibration.

- Sluice gates are use for control gates, safety gates and auxiliary locks, same design from free surface but build for higher loads.
- Flaps (valve) are reliable and simple to construct even for large diameter pipeline. Can operate deeper. But there is a lot of vibration when you close the valve and a high local loss coefficient when it's fully open.

14. The disposition of the main objects of the bottom outlet structure from the intake to the outlet

- Bottom outlets are openings in the dam used to draw down the reservoir level. It operate under pressure or free flowing.
- Designed to reduce the head loss, the flared outflow section and the air vent to protect the junction of the spillway from cavitation damage.
- To prevent the formation of vortices in the water level upstream of the inlet, its axis should be submerged sufficiently.

15. Describe and sketch an example of the implementation of a bottom outlet structure through the body of an earhfill dam



The spillway and outlet capacity must be sufficient to prevent over-topping of the embankment by the reservoir

17. The principle of the action of the siphon or shaft spillway

- *Shaft spillway* : it's a tunnel-shaped spillway, which the water enters a horizontal lip, drops through a vertical shaft and then flow to the downstream river channel through a horizontal tunnel
- *Siphon spillway* : closed conduits in the form of an inverted U with an inlet. It works because of the height between the intake and the outlet to create a pressure difference needed to remove excess water.

18. Gradual construction of mass concrete in case of gravity or arch dam, including the implementation of monolitization of the vertical construction joints and its importance

- *Constituent materials* : primary constituent : cement, mineral aggregate and water. secondary constituents : pozzolans and selected admixtures.
- *Concrete mix parameters* : responsible for controlling the properties of concretes manufactured
- *Concrete production and placing* : require a carefully planned central materials handling facility and concrete batching plant. The primary objective is to ensure the uniformity and the cconsistency of quality.

19. Loads scenario (principal, exeptional, extreme) on a dam in case of a concrete gravity dam, arch dam or embankment dam

<u>Embankment dam :</u>

- *primary loads* : water, self-weight, seepage
- *secondary loads* : sediments, hydrodynamic wave, ice, interactive effects
- *exceptional loads* : seismic, tectonic effects
  <u>Concrete dam :</u>
- *primary loads* : water, self-weight, uplift pressure
- *secondary loads* : silt, wave pressure, ice
- *exceptional loads* : earthquake
  <u>Embankment dam :</u>
- *primary loads* : water, self-weight, temperature
- *secondary loads* : silt, ice
- *exceptional loads* : earthquake

21. Describe and sketch how we measure the pore pressure of the dam body, the deformation on the dam surface and in the dam body, and describe the necessary instruments

- **Porewater pressure**:
  - *electrical dipmeter* to record the phreatic level, simple, reliable and low cost
  - *hydraulic piezometer*, more rapid response to porewater pressure change
  - *pneumatic piezometer*
  The electrical piezometer and the pneumatic piezometer offer rapid response to change in phreatic level, but may prove to be relatively expensive and less flexible in use than the hydraulic alternatives.

- **External deformation**:
  using optical or electronic distance measuring equipment or laser ar employed to determine the relative vertical and horizontal movement of the surface
- **Internal deformation**
  Vertical tuve extensometer can be installed during embankment fill construction. The internal deformation may be detemined by the borehole inclinomeyer or by adapting the principle of vertical extensometer gauge.