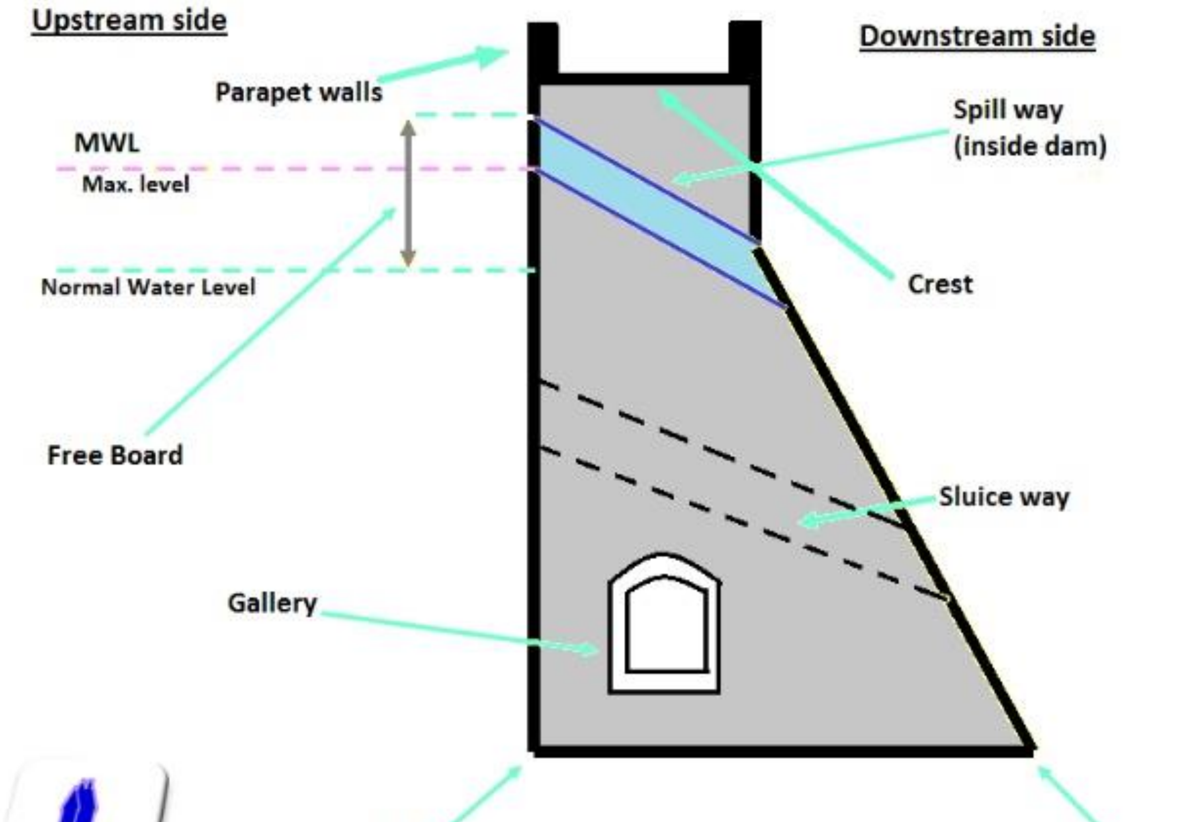
DAM

A dam is a water-retention structure suitably built across a river valley to block the flow of river water and form an artificial lake in its upstream part called reservoir. Construction of a dam covers the river valley or channel section and parts of the two sides of the valley called abutments.



A typical dam has following parts –

- Crest – The top of dam. In some cases, this provides a roadway or walk way.
- Parapet walls – Low protective walls on the either side of the road way on the crest.
- Abutments – The valley slopes on the either side of dam wall to which it is keyed.
- Free board – The space between the highest level of water in the reservoir and crest of the dam.

- Heel – The upstream portion of the dam in contact with the river bed or foundations.
- Toe – The downstream portion of the dam wall for the discharge of surplus water from the reservoir.
- Spillway – The passage in the dam wall for the discharge of surplus of water from the reservoir.
- Gallery – Level or gently sloping tunnel like passage transverse or longitudinal within the dam wall with drains in the floor for seepage water

Construction of a dam ensures availability of water in the reservoir throughout the year, which serves the following purposes:

(i) The stored water is supplied to the farmers for irrigation of lands even in dry period. An unfertile land or arid region is irrigated to produce crops by diverting the reservoir water by a system of canals.

(ii) City and town people are supplied water from the reservoir for drinking and domestic use. The supply remains uninterrupted even during the summer months when there is scarcity of water.

(iii) The artificial lake created by damming of the river is used as a center of recreation such as for boating and fishing activities. It facilitates growth of tourism and helps navigation.

(iv) Water is needed in industrial units associated with various production works. The demand for water in industries is mostly met by water from the reservoir.

(vi) Many of the dams with large reservoir capacity release water for generation of hydroelectric power. People in both rural and urban areas and many industries benefits t from the power generated.

(v) Heavy rains in the upstream parts of many rivers cause flooding of downstream areas. Building of dam stores the excess water in the reservoir and thus controls floods.

When a dam is constructed, the impounded water exerts Pressure on the upstream wall of the dam tending to push it Downstream whereas the gravity tends to resist it. The larger The dam with respect to its height, the greater will be the Pressure from reservoir water. The gravitational force of a Dam depends on the density of the dam body.

Dams are broadly classified into the following four groups on the basis of the types of material

Used in their construction:

Concrete dam   Masonry dam   Rock-fill dam   Earth dam

Concrete Dams

Depending on their bearing strength and stability, concrete dams are subdivided into three Categories, namely gravity, arch, and buttress dams.

Gravity dams have straight or slightly curved axes and are generally triangular or trapezoidal In cross section with bed widths about two-thirds their heights. The downstream face of these Dams can be straight or curved. The thick concrete body of a gravity dam provides the necessary Weight to withstand the forces due to water thrust and uplift pressure. A narrow valley with Sound rock is the ideal place for constructing a concrete gravity dam , but It can be successfully built in soft sedimentary strata also after strengthening the foundation.

Arch dams are arched or curved in their Configuration and hence the name. The 169m-high Idukki dam in Kerala constructed on massive granite gneiss of a canyon site is an example of large arch gravity dam In fact, arch dams are curvilinear in plans with the convex side facing headwaters. In cross section (vertical section), these dams are relatively thin and curved in shape Fig. 14.6 (b). In an arch dam, a part of the thrust due to reservoir water is distributed to the abutment rock by the arch action. The thickness and curvature of the body of an arch dam are so designed that more than half of the acting load is transferred to the abutment. As such, the abutment and foundation rocks should have suffi cient strength to bear the load. In case more than half the dam load is kept on the foundation, it is to be called an arched gravity dam. Arch dams are generally constructed in narrow valleys or canyons such that the heights are generally more than the axial lengths.

Buttress dams are massive, thin, or arched slabs supported by vertical walls or buttresses. The slabs having upstream slopes bear the water thrust while the buttresses acting normal to the planes of the slabs take the load of the headwater and transfer it to the foundation. Steep beams or girders spaced between the buttresses prevent their bending. The structural parts of the buttress dams are made of concrete or reinforced concrete. . Buttress dams require firm rock in the river bed where they buttress. The interior part being hollow, these dams consume less concrete than other types of dams; hence, their construction cost is comparatively less.

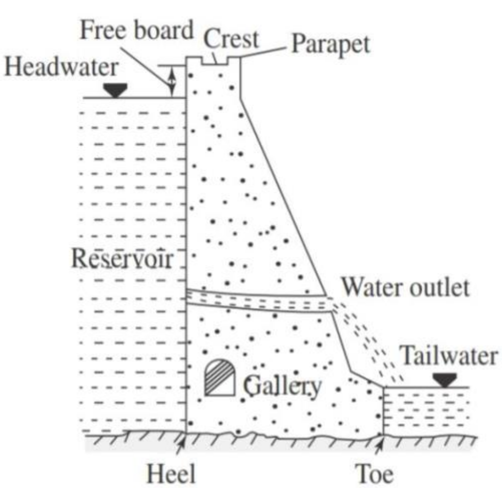


Fig. 14.2 Cross section of a concrete gravity dam illustrating different parts

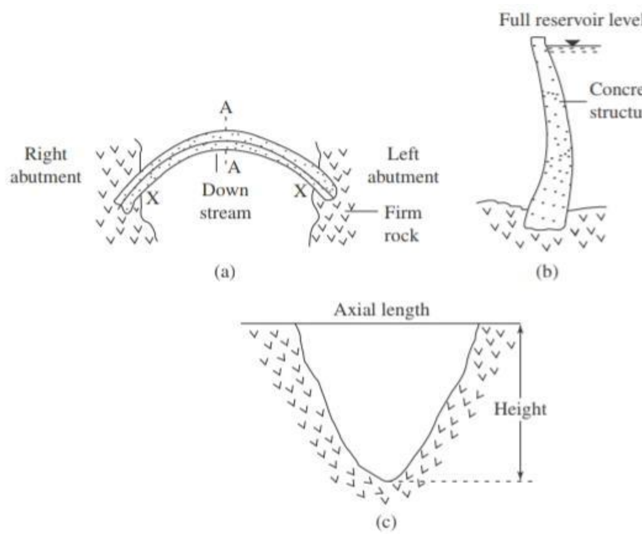


Fig. 14.6 Arch gravity dam: (a) plan view; (b) cross section across the arch dam (A–A); and (c) cross section along the axis (X–X) of the arch dam

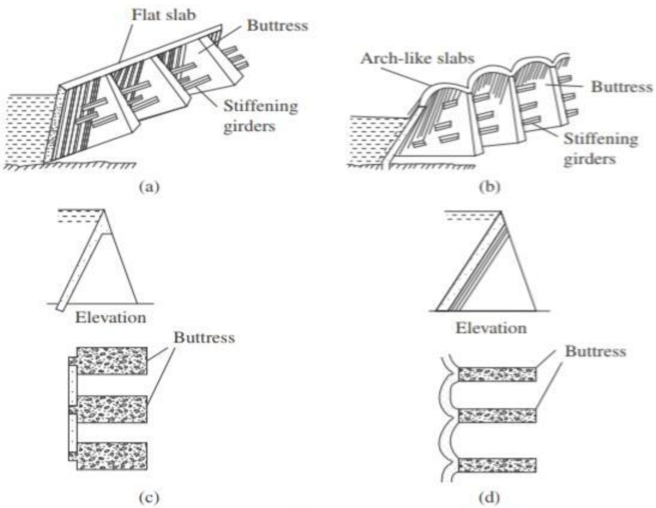


Fig. 14.7 Buttress dam: (a) three-dimensional view of flat slab type dam; (b) three-dimensional view of arch type dam; (c) elevation and section of flat slab type dam; and (d) elevation and section of arch type dam

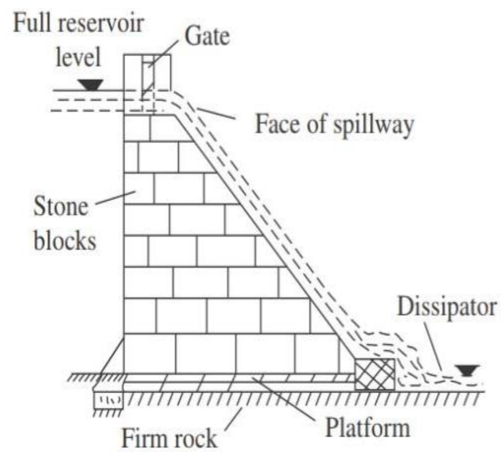


Fig. 14.8 Masonry dam made of cut blocks of sound rock having gated spillway

Masonry Dams

Masonry dams (Fig. 14.8) are made of big undressed blocks of rocks including river boulders bound together by concrete. The rocks selected for construction of masonry dams are non-porous and the binding among the rock fragments or boulders creates a watertight body. As such, the entire body of the masonry dam acts as an impermeable barrier against leakage of reservoir water. Only the cemented joint portions among the blocks must be watertight to avoid seepage. Many old dams in India are stone masonry structures. The 139 m-high Srisailam dam in Andhra Pradesh is an example of masonry

construction.

Rock-fill Dams

Rock-fill dams are made up of an admixture of ground spoils, river deposits (e.g., gravels, pebbles, and boulders), and crushed rocks. They are trapezoidal in cross section with side slope commonly in excess of 1:1. Depending upon the nature of impermeable membrane provided in the rock-fi ll dams, they are grouped into the following two types:

(i) Dams with concrete wall in the upstream face, which creates the impermeable barrier against leakage
(ii) Dams with impervious earth or clay (core) in the central part, which acts as the impermeable membrane

Earth Dams

Earth dams are trapezoidal in cross section with Gentle side slopes (Fig. 14.11). An earth dam is Generally constructed in a broad valley where it Is very expensive to build a concrete or masonry Structure. The earth dam also does not require Rocky foundation and it can be founded on firm Soil. However, availability of adequate quantity Of homogeneous earth of both pervious and semi-Pervious types is to be assured for constructing An earth dam.

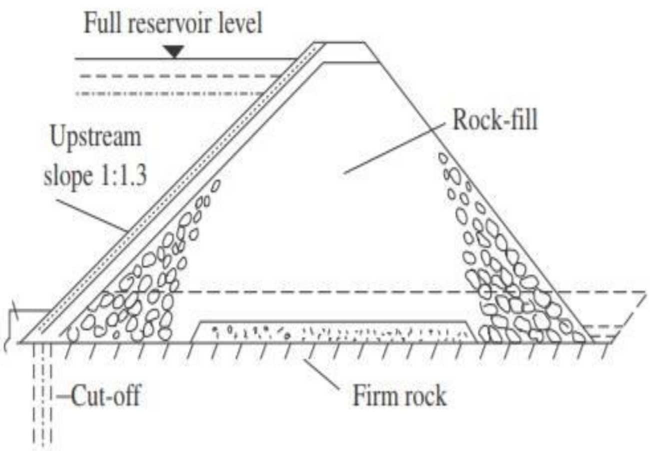


Fig. 14.9 Rock-fill dam with concreted upstream slope

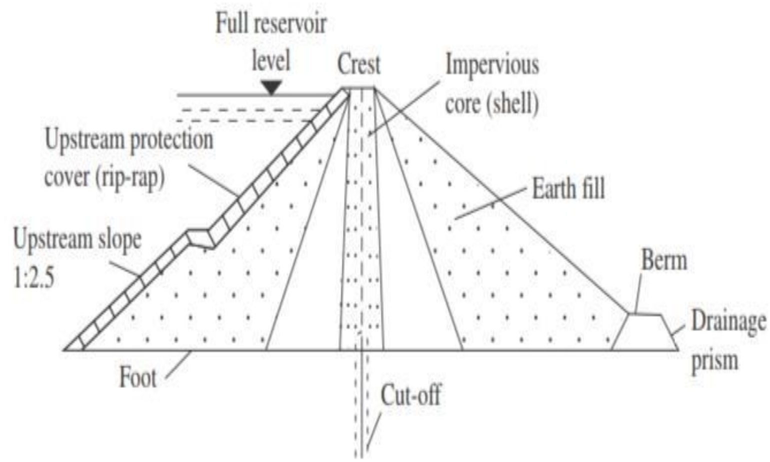


Fig. 14.11 An earth dam with impermeable core and gentle slopes

Geological Considerations in the Selection of Dam Site

- Narrow River Valley
- Occurrence of Bedrock at a shallow Depths
- Competent rocks to offer Stable Foundations
  - ➢Suitability of different types of rocks
  - ➢Influence of weathering
  - ➢Effect of occurrence of intrusions
  - ➢Effect of fracturing
- Effect of Associated Geological Structures
- Leakage below Dams

Narrow River Valley

- At proposed dam site, if the river valley is narrow, a small dam is required which reduces the cost of construction.
- A Few defects at narrow river valley are as follows
  - ➢ Narrowing of valley due to landslides, rock creep, rock fracturing, thick superficial deposits such as residual soil, talus, boulders, silt and clay etc.,
  - ➢ The occurrence of buried river channels crossing the site, either below or adjacent to river bed.
  - ➢ Unsuitability of rocks due to presence of soluble minerals like gypsum or due to faulting which may be concealed beneath sediments.

Occurrence of Bedrock at a shallow Depths

- Shallower bed rock aims lesser foundation cost
- Bed rock occurs at shallow depths in young rivers since the sediments deposited in less. The problems with younger formation is as follows:
  - ➢ This hilly terrains may not provide a suitable topography for larger reservoir basin
  - ➢ The flow of water may not be high, therefore only small dams can be constructed
- To know depth of bed rock geophysical investigations has to be carried out.

❖ Sedimentary Rocks

- Shales have slippery base hence undesirable at dam site
- Well Cemented siliceous and ferruginous sandstones are competent and suitable for dam foundation
- Laterites, limestone & conglomerates are undesirable.
- Thick massive sedimentary formations with less porosity are desirable.
- Alternating soft and hard rocks of small thickness are undesirable.

❖ Igneous Rocks

- The massive plutonic & hypabyssal igneous rocks are most desirable at dam site
- Volcanic rocks which have vesicular & amygdaloidal are not desirable.
- Massive basalts which are fine grained are desirable at dam site when they don't have vesicular structure.

❖ Metamorphic Rocks

- Gneiss unless they posses high degree of foliation and mica minerals is suitable at a dam site.
- Schist are undesirable
- Quartzite are very hard and highly resistant to weathering. They are neither porous, nor permeable.
- Marbles even tough compact by virtue of their chemical composition they are unsuitable at dam site.
- Slates are undesirable as it is soft, weak and have a slaty cleavage.

Influence of Weathering

- Weathering reduces strength, durability of rock hence the extent of weathering should be carefully assessed to ascertain whether a rock is suitable or unsuitable.
- Dull appearance, faded color and emitting a dull sound to a hammer blow are some simple indications of weathering.

Effect of Occurrence of Intrusions

- Black Dolerites and white quartz occurs frequently as intrusions.
- The intrusive contribute to heterogeneity at dam site and hence undesirable.
- The contact planes of intrusive serve as weak plane.
- Grouting can be done at weak planes to improve the competence of the site.

Effect of fracturing

- Fracturing is common in all rocks, they reduces the cohesion or compactness of rock.
- Fractures contribute to porosity, permeability of rocks.
- If the fractures are numerous and if occur in large areas they should be treated by grouting.
- Beds which are thick, compact, uniform and without any structural defect are very desirable at dam site.
- Alternating soft and hard beds, when inclined are not desirable at dam site because slippage of hard bed over softer one occurs.

Effect of Associated Geological Structures

- The properties of rock gets modified either advantageously or disadvantageously when geological structure occurs in rock.
- The various geological structures which are common in nature are as follows
  - ➢ Horizontal Strata
  - ➢ Beds lie perpendicular to the length of valley
    - Tilted Beds
    - Vertical Beds
    - Beds which are folded
    - Faulted Beds
    - Beds with joints
  - ➢ Beds parallel to length of Valley

Beds With Horizontal Strata

- This geological situation is good at the dam site because the load of the dam acts perpendicular to the bedding planes.
- The seepage of water is also prevented by weight of dam. Thus, uplift pressure can be reduced.
- If the strata are composed of alternating hard and soft rocks it shall be undesirable.

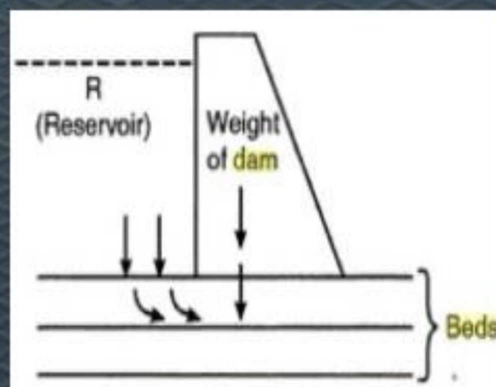
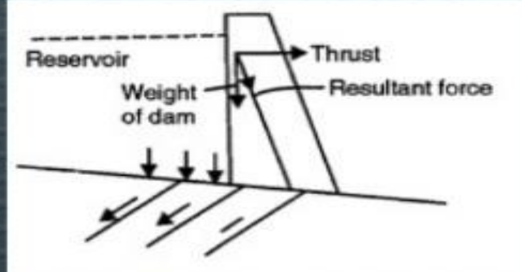


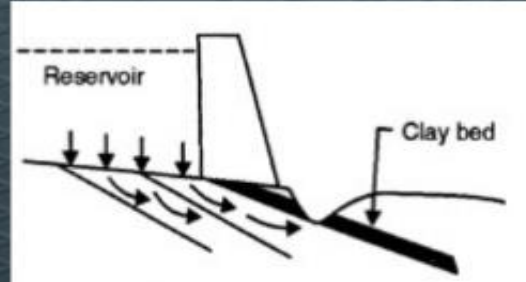
Fig. 18.8 A gravity dam over horizontal beds

- Tilted Beds with Gentle Upstream Dip (10^0-30^0 Inclination)
  - ➢ It is ideal situation for dam construction.
  - ➢ The resultant force acts more or less perpendicular to bedding planes. Hence takes load effectively.
  - ➢ Any percolated water is directed by bedding plane to upstream side i.e., there is no scope for leakage of water and uplift pressures.



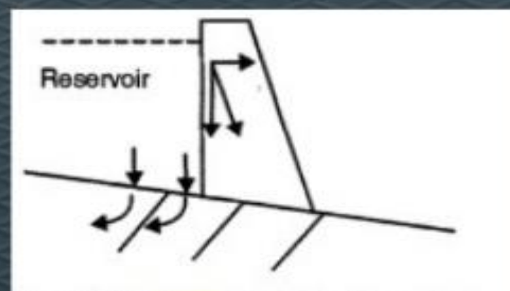
g. 18.9 Dam over gently inclined beds in upstream direction

- Tilted Beds with Gentle Down stream Dip
  - ➢ It is very undesirable for dam location.
  - ➢ The resultant load and bedding planes are in same direction which makes it less competent to with stand forces.
  - ➢ The water in reservoir percolates with pressure thereby causing uplift pressure and loss of water.



ig. 18.11 Dam over downstream side inclined beds

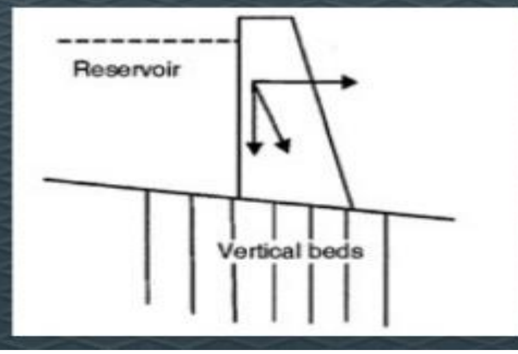
- Tilted Beds with Steep Upstream Dip
  - ➢ It is not bad but not as advantageous as that of previous case.
  - ➢ There will not any uplift pressure on dam and no leakage of water from reservoir.
  - ➢ The resultant load is not perpendicular to bedding plane which makes it less competent than previous case.



ig. 18.10 Dam over steeply upstream side inclined beds

Beds Perpendicular to valley

- Vertical Beds
  - It will not pose problem of uplift pressure on dam or leakage of reservoir.
  - It will not have advantage interms of competence of rocks.
  - The Escales Dam in the Spain, lies on such site composed of limestone and cretaceous marl.



- Folded Beds
  - It is generally less dangerous than faulting.
  - The folded rocks will be under strains and are also physically fractured along the crests
  - Grouting & other precautions have to be considered, to improve the stability and competence of rocks at site.

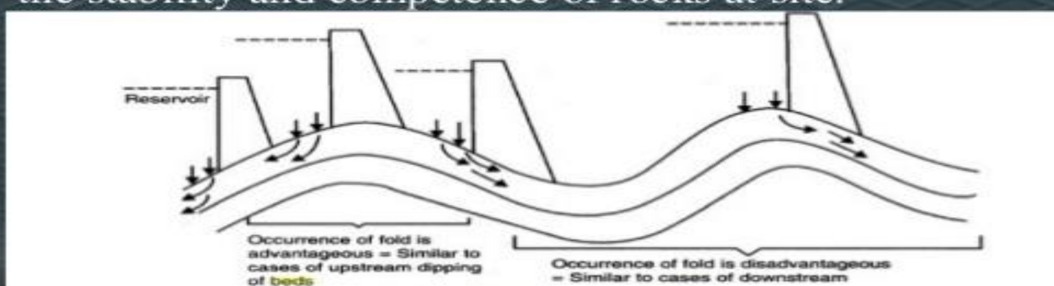


Fig. 18.14 Dam over folded beds

- Faulted Beds
  - It is generally undesirable.
  - The active faults causes displacements of the site and also increases the chances for occurrence of earthquake.
  - Faults increases porosity which aids for water percolation which intern reduces competence and causes leakage of reservoir.
  - If faults occurs in the upstream with downstream dipping faults are dangerous.

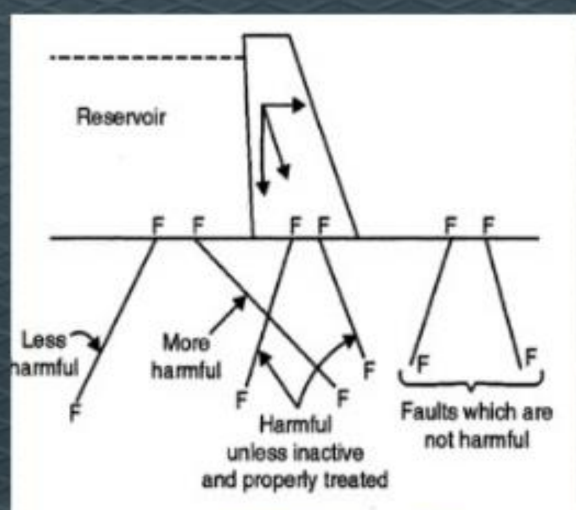
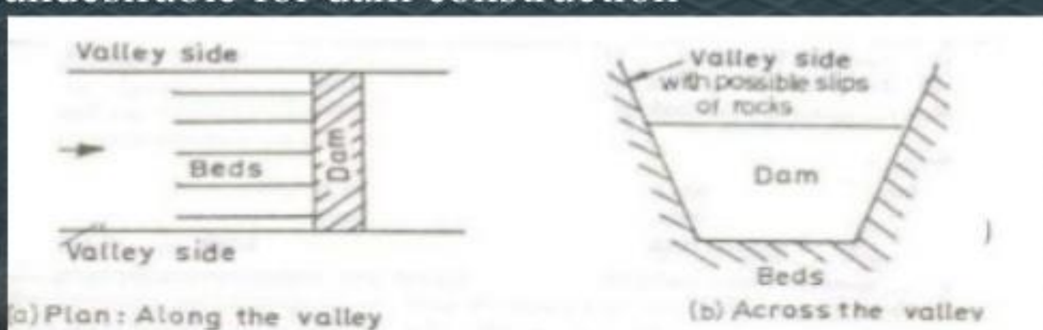


Fig. 18.15 Dam over faulted beds

- Jointed Beds
  - They contribute to physical weakness of rock and also to porosity and permeability.
  - Grouting is used to overcome this defects.

Beds Parallel to length of valley

- There is a danger of slippage of rocks along bedding plane.
- The water from reservoir have a adequate chance to percolate below the dam which is undesirable.
- The foundation and abutments of dam rests on different rock which is undesirable.
- It is undesirable for dam construction



SELECTION OF DAM SITE:

Selection of site – The selection of dam site across a river is to impound water behind the dam. Following points are required that –

Topographically, a place which is most suitable for the purpose is selected. Ideally it should be narrow or a small valley with enough catchment areas available behind so that when a dam is placed there it would be easily store a calculated volume of water in reservoir created upstream.

Technically, the site should be as sound as possible, strong, impermeable and stable. Strong rocks for design, impermeable for inventory of stored water and stability with references to seismic failures.

- Constructionally, the site should not be far from deposits of materials which would be required for construction.
- Economically, the benefits arising out of a dam is proposed to be placed at a particular site should be realistic and justified in terms of land irrigated , power generated and water stored i/c floods averted.