GEOLOGY SEMESTER IV

GT 403 – ENGINEERING GEOLOGY AND ENVIRONMENTAL GEOLOGY

Topic – Basic aspects of canal construction

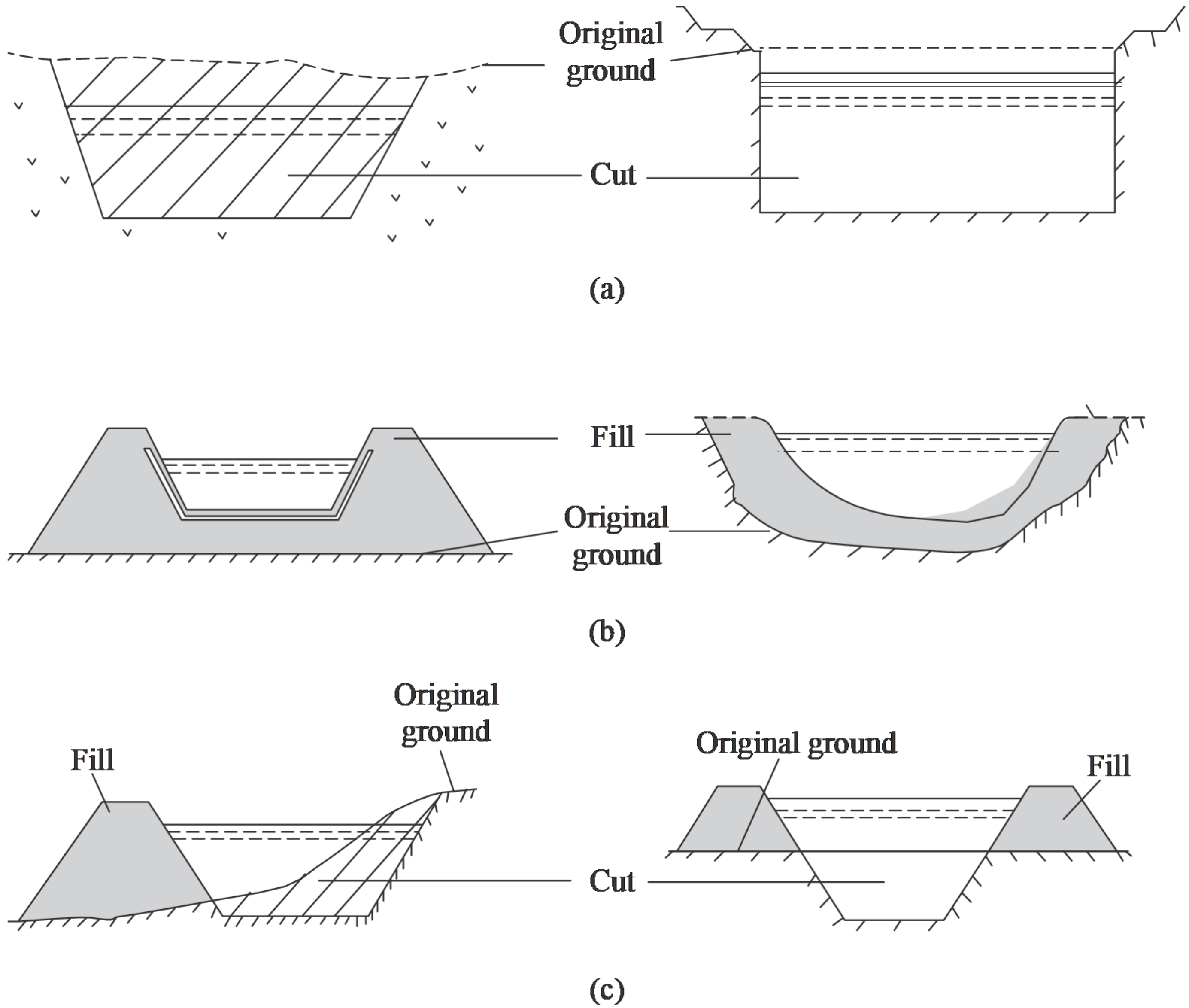
Excavation and Filling Involved in Canals

Depending upon the terrain morphology and geology, a canal construction may involve entirely excavating or entirely filling, or both cut and fill .

The canals are commonly rectangular or semicircular in cross section when construction involves cutting and/or filling of steep soil or blasting of rock. Canals that are trapezoidal or polygonal in cross section are made in clayey soil ground, attributing better stability and operational facility.

The major problems in a canal excavation pertain to providing stable side slope of the canal and that of the hill side traversed by the canal; settlement, scouring, heaving, and cracking of ground of canal bed; and seepage from the soil or fractured rocks traversed by the canal.

It is a favorable feature if the canal passes through a terrain having ground elevation coinciding with the top level of the canal. This is because the cutting involved in such case will be only for the canal dimension.



Canal construction: (a) entirely in cut; (b) entirely in fill; and (c) both cut and fill

Design Aspects of Soil Slope and Water Depth of a Canal

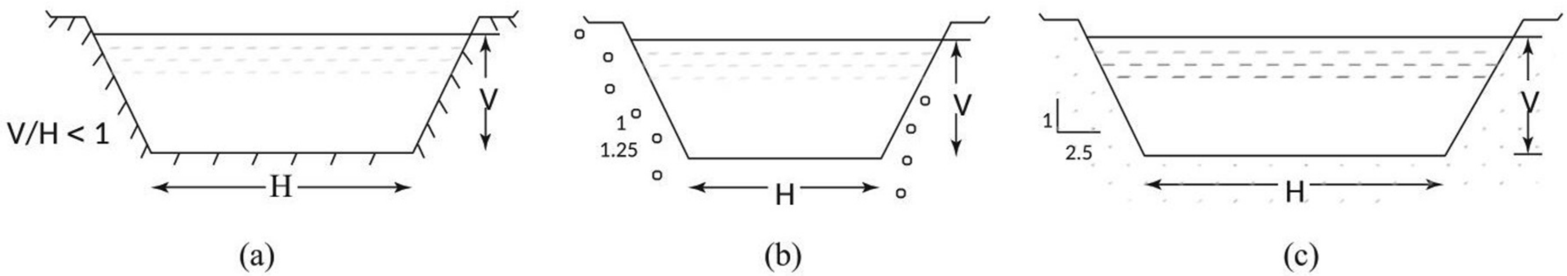
In the design of a canal, the side slopes provided for the underwater portion of the canal are slightly steeper than the portions over water (in berms). The side slope in unconsolidated material is kept such that the ratio of vertical-to-horizontal distance is always less than 1:1. The approximate design slopes of vertical (V) to horizontal (H) for a 5 m-deep canal for different types of deposits are as follows:

(i) Fine sand 1:2

(ii) Pebbly and sandy soil and also in clayey loam 1:1.25

(iii) Decomposed peat 1:2.5

(iv) Medium-to-coarse sands and also in sandy loam 1:1.5



Designs of soil slope for canal: (a) unconsolidated material; (b) pebbly and sandy soil; and (c) decomposed peat

The channel gradient of a lined canal is not steeper than 1V:1.5H. The slopes provided in canal walls are steep to vertical while passing through hard rock. Rectangular canals as such are very common in rocky hill slopes.

The rock types and their degree of alteration are to be considered in estimating the rock slope. In hard and massive rocks such as granite, the slope may be vertical, whereas in hard shale or sandstone 1V:0.5H to 1V:1H slope will be safer. However, in soft shale or sandstone, slopes steeper than 1V:1H will be unsafe.

A survey of the natural slopes in rocky hilly faces and rock cut quarries provides proper guidance regarding the stable excavation slopes for canals in similar geological set-up. While deciding on the safe slope angle, due consideration needs to be given to the heights of the slope faces.

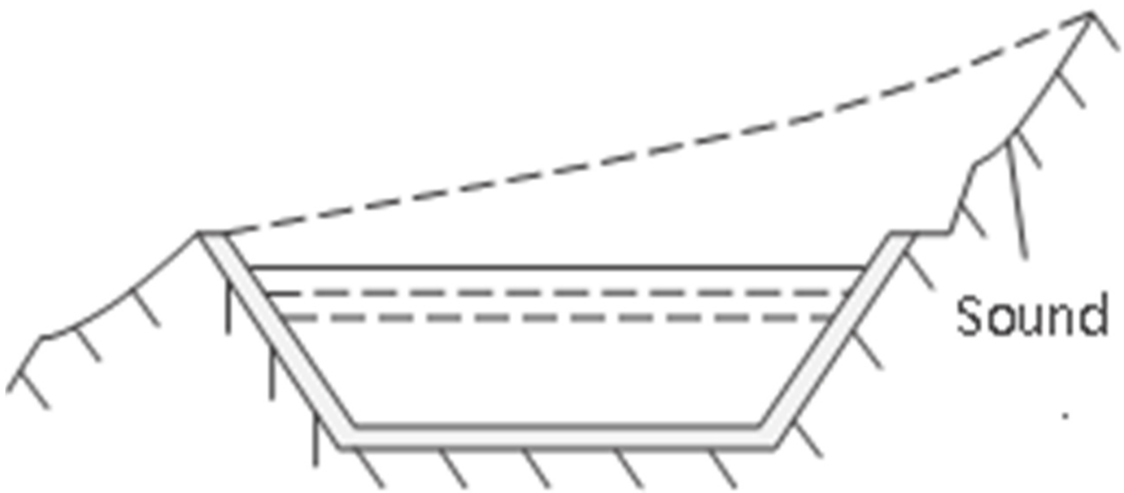
Cutting and stability

Deep cutting is involved when the canal alignment traverses hilly terrain or high ground above the proposed level of the canal level as shown in following Fig. The stability of the hill slope or the high ground slope is significant for the safety of the tunnel and needs consideration.

It is advisable to always take the canal through flatter hill slope involving shallow cut. From the stability point too, a canal laid on a flat terrain is always safer than that passing through a hilly terrain. Canals made by deep cutting of hill slopes are subject to landslides.

Canals dug in unconsolidated materials of hill slopes may cause debris slide and subsidence leading to complete destruction of the canals, especially during rainy season. If the hill slope is made of jointed rock, the undercutting of the hill face for canal construction disturbs the rock mass and initiates rock slides, resulting in damage of the canals.

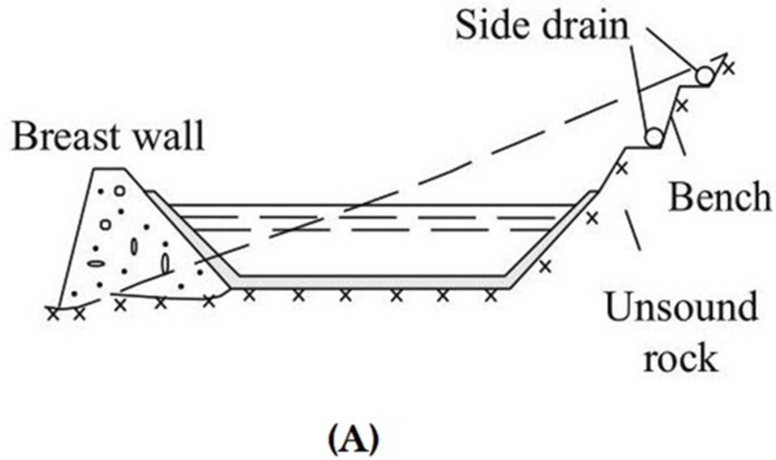
Structural study of the rock types traversed by canal alignment with respect to faults, joints, bedding dip, and so on helps to ascertain the failure mechanism of rock slopes. The laboratory test results on shear, cohesion, internal friction, and so on of soil mass are used to decide the safe angle in soil slope.

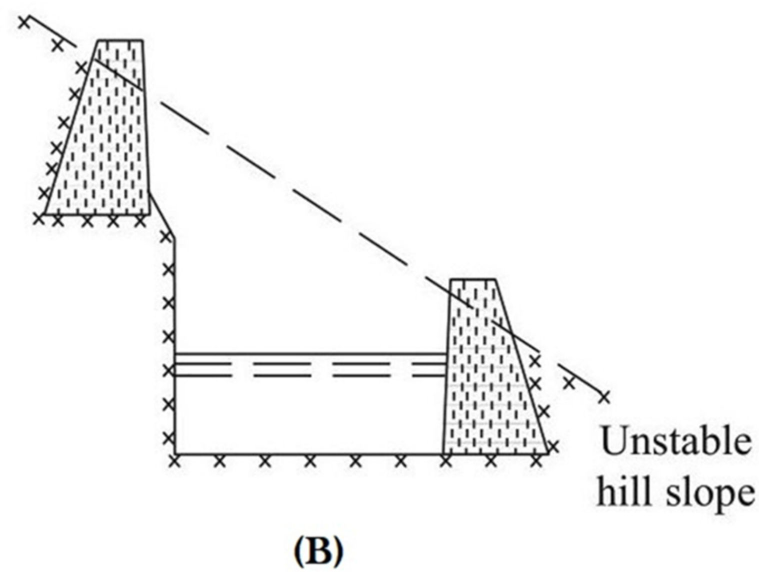


Canals traversing steep hill side: deep cutting of hill slope in sound rock

Remedial measures for protection against slides

Remedial measures for protection against slides of hill slopes should be taken up for the safety of the canal structure. If the hill slopes are devoid of sound rock, benches of 1 m or 2 m width are provided with side drains in the upper reaches. This is needed to ease the overlying load, prevent rainwater flow to the canal, and arrest rock fall or debris slide. If the pathways of the canal involve cutting of unstable hill slopes, retaining structures are provided, which include breast wall or other structures with side drainage as shown in following Fig. A and B





Canals traversing steep hill side: (A) protective measures in unsound rock such as benching with side drain and breast wall in the downhill; (B) protection of uphill and downhill slopes by breast walls

In soft and pervious strata, the measures adopted include compaction of soil followed by lining. If the soil is of swelling type, which creates problems of heaving and cracking of the canal bed and walls, the expansive clay materials are removed and backfilled by normal earth followed by lining to the affected part as shown in following figure.

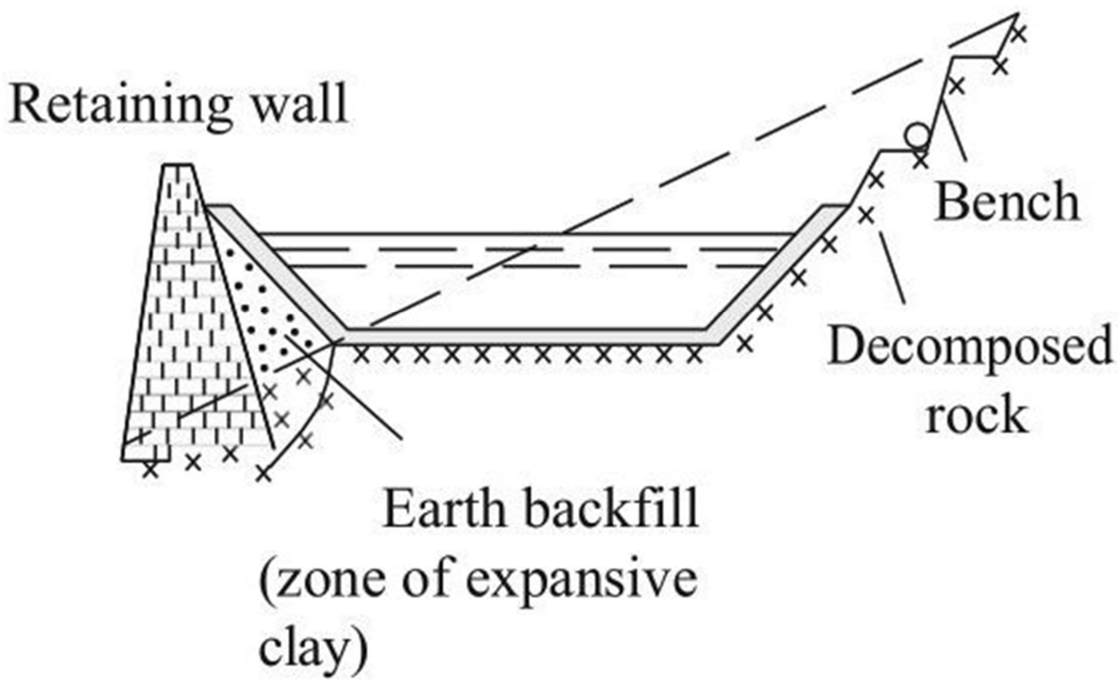


Fig. Canals traversing steep hill side: removal of expansive clay, backfilling with normal earth, and benching of uphill slope and downhill retaining wall

Groundwater condition of canal

Groundwater condition of canal areas is known by measuring the seasonal variations in water levels through the piezometers inserted into the completed boreholes.

If the water table lies near the surface, special drainage measures will be necessary.

The design should provide proper drainage arrangement for draining surface water for the quantity of water that enters into the canal during rains. Similarly, the drainage measures should ensure stability of the canal slope and prevent groundwater hazards.

Soil conditions

Canals passing through loess type of soil may cause subsidence and deformation with the consequent creation of fissures through which water flows out.

Peaty soil is also not good for canal construction.

Vegetation cover is provided by the sides of the canals to protect them from slide and slumping. The canal water carries certain percentage of particles in suspension, which are carried away and cannot settle down in the canal if the water moves under certain velocities.

Settlement of suspended materials may cause an increase in water level and consequent siding in canal wall.

Protection from water loss

Some amount of water in the canal is lost by evaporation and seepage through the canal bed or walls.

Lining is provided to the canals to prevent water percolation or seepage and to avoid scouring of canal when it passes through loose sandy or clayey soil. It also reduces silting and arrests slides in unstable areas.

The velocity of water flowing in canals is designed such that there will be no scouring and siltation. This non-scouring velocity is dependent on the depth of canal water and the average diameter of the bed material. The non-scouring velocity of a 5 m-deep canal is 11 m/s in sedimentary rock and 17 m/s in a concrete-lined canal.

Depending upon the materials used, linings are of two types—*anti-seepage* and *protective* linings. Anti-seepage lining uses compact clay, asphalt, and bituminous coating in addition to concrete or reinforced concrete. Protective linings are given to prevent erosion and scouring of canal bed by paving stone slabs and pitching with reinforced concrete slab. If the soil of the canal contains swelling clay, reinforced lining is provided to prevent heaving and avoid creation of fractures in the soil.

All types of lining in canals are subjected to pressure when the water table is high. It is, therefore, necessary to make drainage arrangements underneath the lining to avoid adverse effect during drawdown and dewatering of canals. In hard rock lining is not needed, but it is provided in uneven rock surface for smooth flow and complete prevention of water outflow through the pores and fractures.

Source :

- Peter T. Bobrowsky_ Brian Marker - Encyclopedia of Engineering Geology-Springer International Publishing (2018)
- Subinoy- Gangopadhyay- Engineering Geology, first edition,(2013)