

CHAPTER – 6

System of Irrigation Canal

Dr. M. R. Kabir

Professor and Head, Department of Civil Engineering

University of Asia Pacific (UAP), Dhaka

LECTURE 15



Alluvial and non-alluvial Canal

The soil which is formed by transportation and deposition of silt through the agency of water, over a course of time, is called the **alluvial soil**.

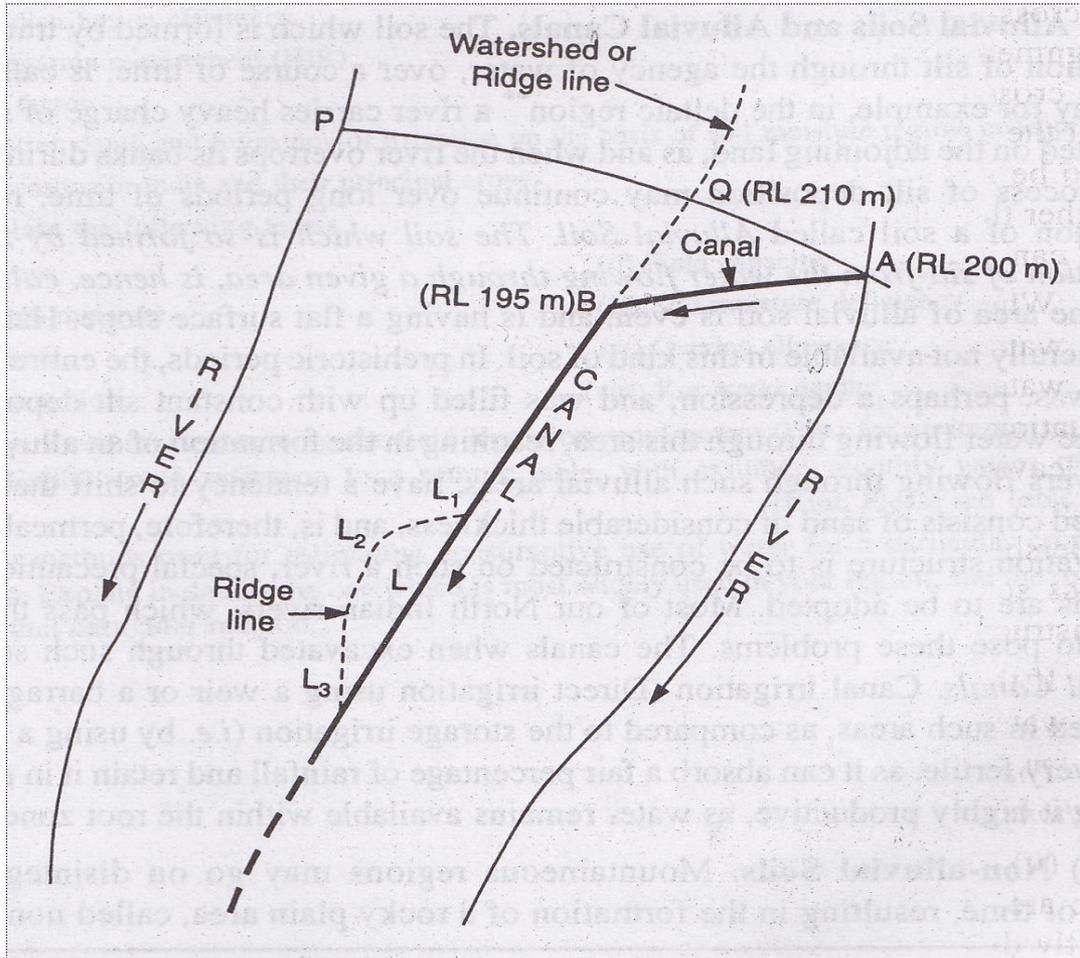
The canals when excavated through such soils are called **alluvial canals**. Canal irrigation (direct irrigation using a weir or a barrage) is generally preferred in such areas, as compared to the storage irrigation (i.e. by using a dam).

It has an uneven topography, and hard foundations are generally available. The rivers, passing through such areas, have no tendency to shift their courses, and they do not pose much problems for designing irrigation structures on them. Canals, passing through such areas are called **non-alluvial Canals**.

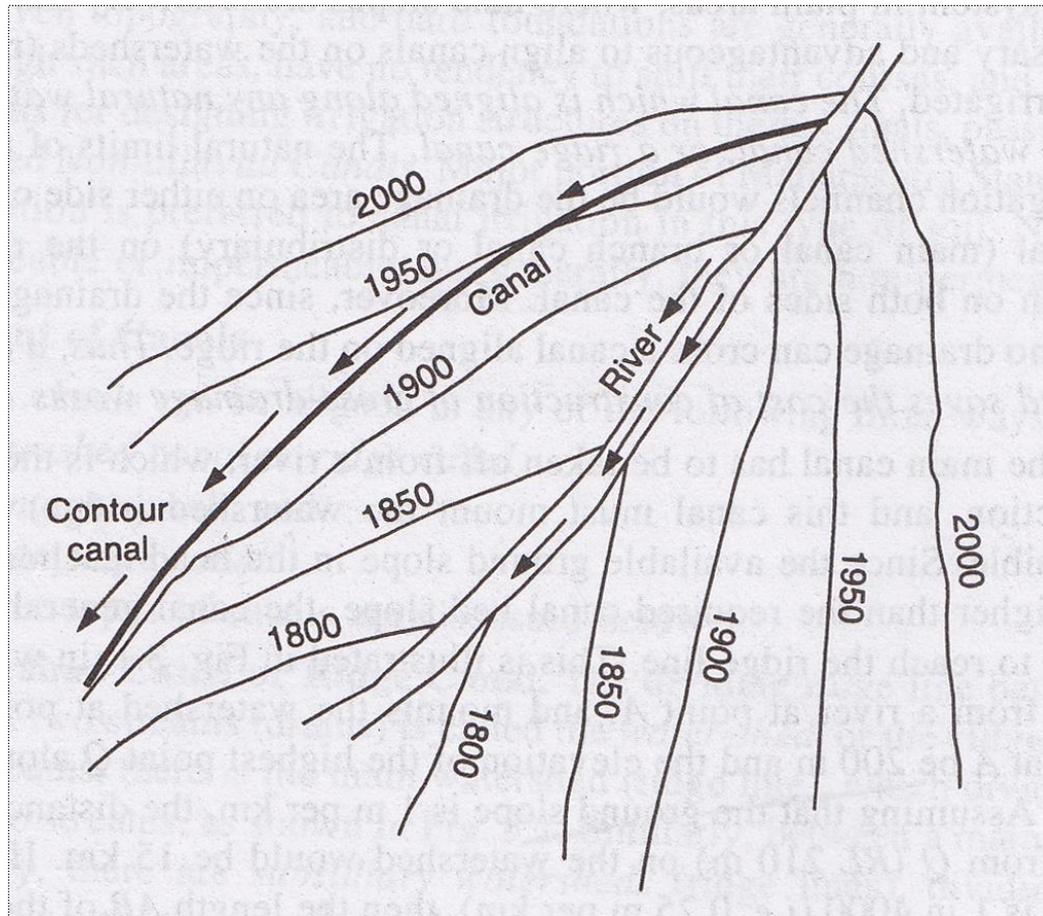
Alignment of Canals

- Water-shed Canal
- Contour Canal
- Side-slope Canal

Water-shed canal



Contour canal



Side-slope canal

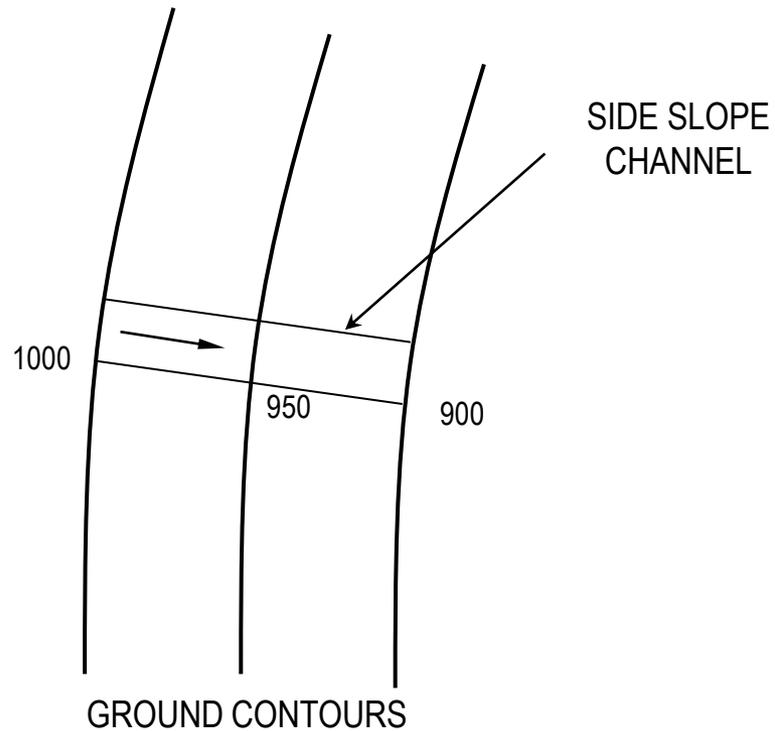
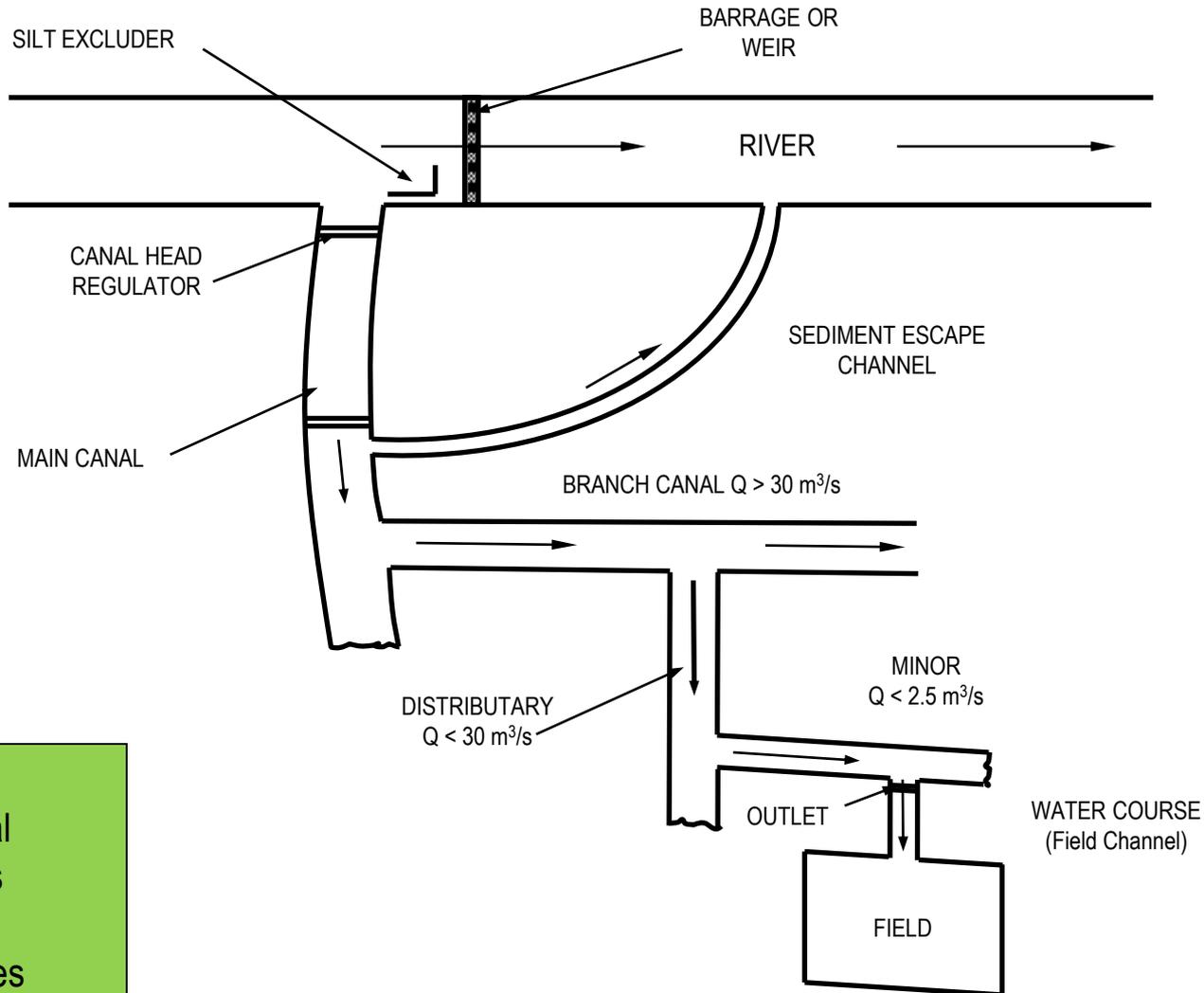


Fig: Alignment of a side slope canal

Distribution system for Canal Irrigation



Main Canal
Branch Canal
Distributaries
Minors
Water-courses

Definition of Important Terms

Gross Command Area (GCA)

The whole area enclosed between an imaginary boundary line which can be included in an irrigation project for supplying water to agricultural land by the net work of canals is known as GCA. It includes both the culturable and unculturable areas.

Uncultivable Area

The area where the agriculture can not be done and crops cannot be grown – marshy lands, barren lands, ponds, forest, villages etc. are considered as uncultivable area.

Cultivable Area

The area where agriculture can be done satisfactorily

❑ **Cultivable Command Area (CCA)**

The total area within an irrigation project where the cultivation can be done and crops can be grown

❑ **Intensity of Irrigation**

Ratio of cultivated land for a particular crop to the total culturable command area

$$\therefore \text{Intensity of irrigation, } I_i = \frac{\text{Cultivated Land}}{\text{CCA}}$$

Time factor and capacity factor

Time Factor

The ratio of the number of days the canal has actually been kept open to the number of days the canal was designed to remain open during the base period is known as **time factor**.

For example, a canal was designed to be kept open for 12 days, but it was practically kept open for 10 days for supplying water to the culturable area. Then the time factor is 10/12.

$$\begin{aligned}\therefore \text{Time factor} &= \frac{\text{No. of days the canal practically kept open}}{\text{No. of days the canal was designed to keep open}} \\ &= \frac{\text{Actual discharge}}{\text{Designed discharge}}\end{aligned}$$

Capacity Factor

Capacity Factor

Generally, a canal is designed for a maximum discharge capacity. But, actually it is not required that the canal runs to that maximum capacity all the time of the base period. So, the ratio of the average discharge to the maximum discharge (designed discharge) is known as **capacity factor**.

For example, a canal was designed for the maximum discharge of 50 cumec, but the average discharge is 40 cumec.

$$\therefore \text{Capacity factor} = 40/50 = 0.8$$

Problem

The culturable commanded area of a watercourse is 1200 hectares. Intensities of sugarcane and wheat crops are 20% and 40% respectively. The duties for the crops at the head of the watercourse are 730 hectares/cumec and 1800 hectares/cumec respectively.

- Find (a) The discharge required at the head of the watercourse
(b) Determine the design discharge at the outlet, assuming a time factor equal to 0.8.

Solution:

C.C.A = 1200 hectares

Intensity of irrigation for sugarcane = 20 %

∴ Area to be irrigated under sugarcane = $1200 \times (20/100) = 240$ ha

Intensity of irrigation for wheat = 40 %

∴ Area to be irrigated under wheat = $1200 \times (40/100) = 480$ ha

Again,

Duty for sugarcane and wheat = 730 ha/cumec and 1800 ha/cumec

∴ Discharge required for sugarcane = Area/Duty

$$\begin{aligned} \therefore &= (240/730) \text{ cumec} \\ &= 0.329 \text{ cumec} \end{aligned}$$

∴ Discharge required for wheat = $(480/1800)$ cumec

$$\therefore = 0.271 \text{ cumec}$$

Now, sugarcane requires water for all the 12 months and wheat requires water for only Rabi season. Hence, the water requirement at the head of the watercourse at any time of the year will be the summation of the two, i.e. equal to $0.329 + 0.271 = 0.6$ cumec

Hence, the discharge required at the head of the watercourse is 0.6 cumec
(ans)

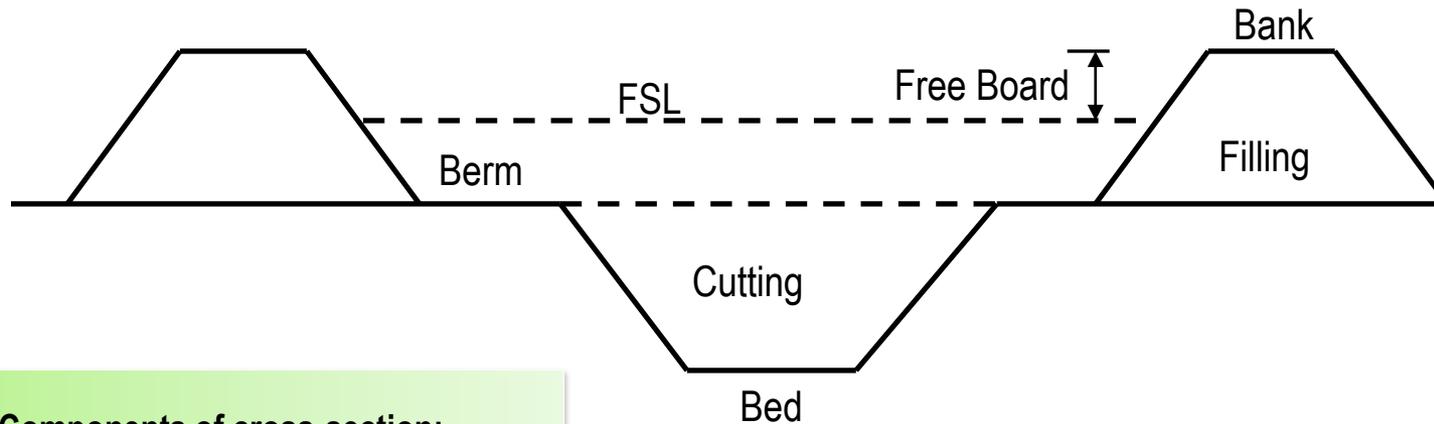
Note: The discharge during Rabi season will be 0.6 cumec and for the rest of the year, it will be 0.329 cumec

Time factor = 0.8; since the channel runs for fewer days than the crop days, therefore, the actual design discharge at the outlet = $(0.6/0.8) = 0.75$ cumec **(ans)**

LECTURE 16



Cross-section of an irrigation canal

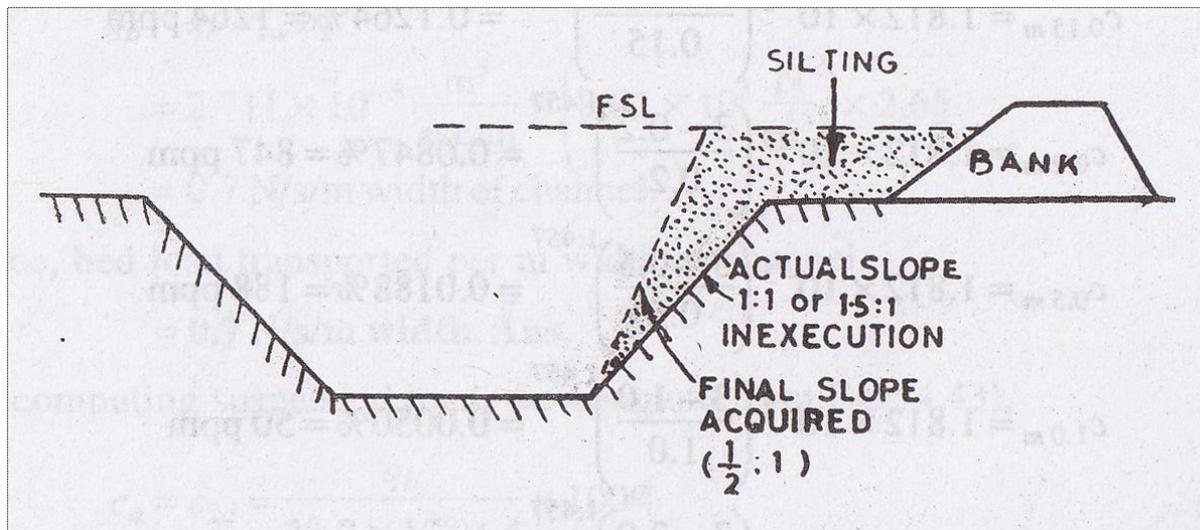


Components of cross-section:

- Side slopes
- Berms
- Freeboard
- Banks
- Service roads
- Back Berm or Counter Berms
- Spoil Banks
- Borrow Pits

Side Slopes

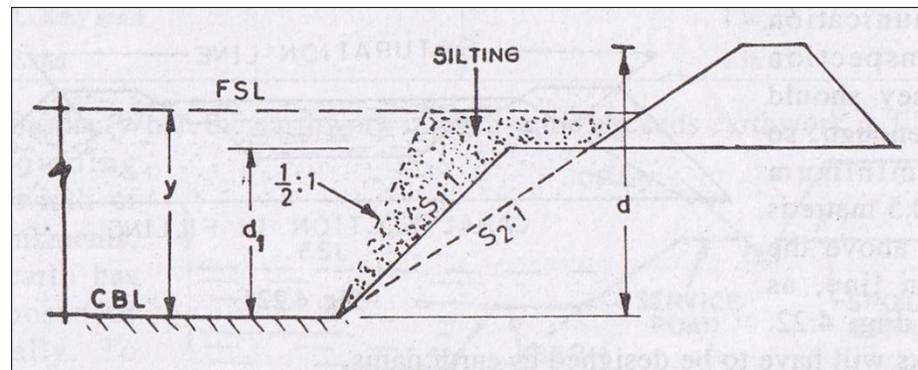
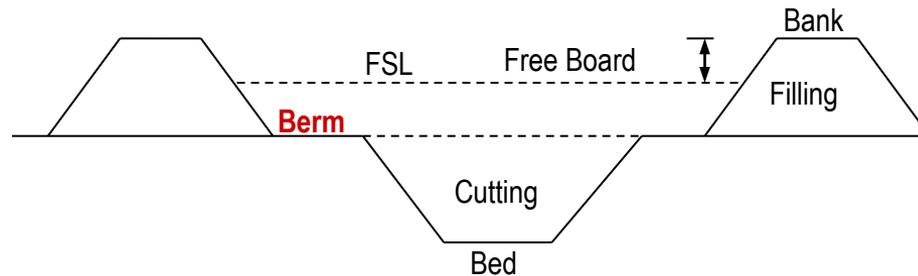
The side slopes should be such that they are stable, depending upon the type of the soil. A comparatively steeper slope can be provided in cutting rather than in filling, as the soil in the former case shall be more stable.



In cutting ----- 1H: 1V to 1.5 H: 1V
In filling ----- 1.5 H: 1V to 2H: 1V

BERMS

Berm is the horizontal distance left at ground level between the toe of the bank and the top edge of cutting.



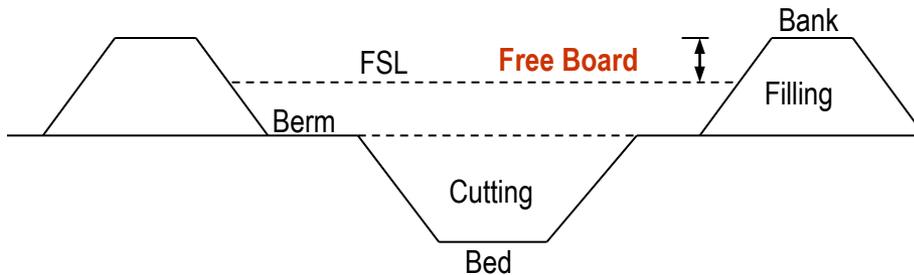
The berm is provided in such a way that the bed line and the bank line remain parallel. If $s_1:1$ is the slope in cutting and $s_2:1$ in filling, then the initial berm width = $(s_2 - s_1) d_1$.

Purposes of Berms

- They help the channel to attain regime conditions.
- They give additional strength to the banks and provide protection against erosion and breaches.
- They protect the banks from erosion due to wave action.
- They provide a scope for future widening of the canal.

Free Board

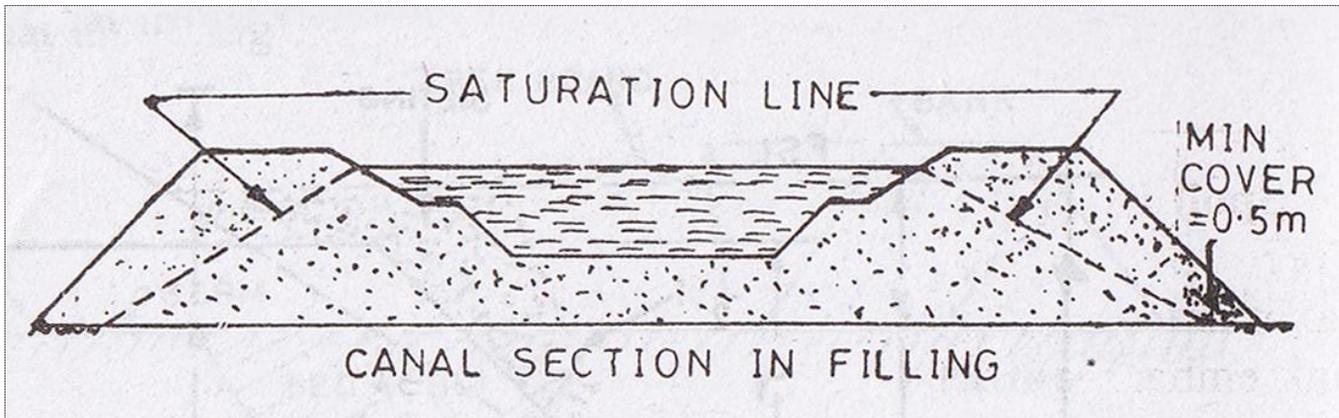
The margin between FSL and bank level is known as **freeboard**. The amount of freeboard depends upon the size of the channel. The generally provided values of freeboard are given in the table below:



Discharge (m ³ /s)	Extent of freeboard (m)
1 to 5	0.50
5 to 10	0.60
10 to 30	0.75
30 to 150	0.90

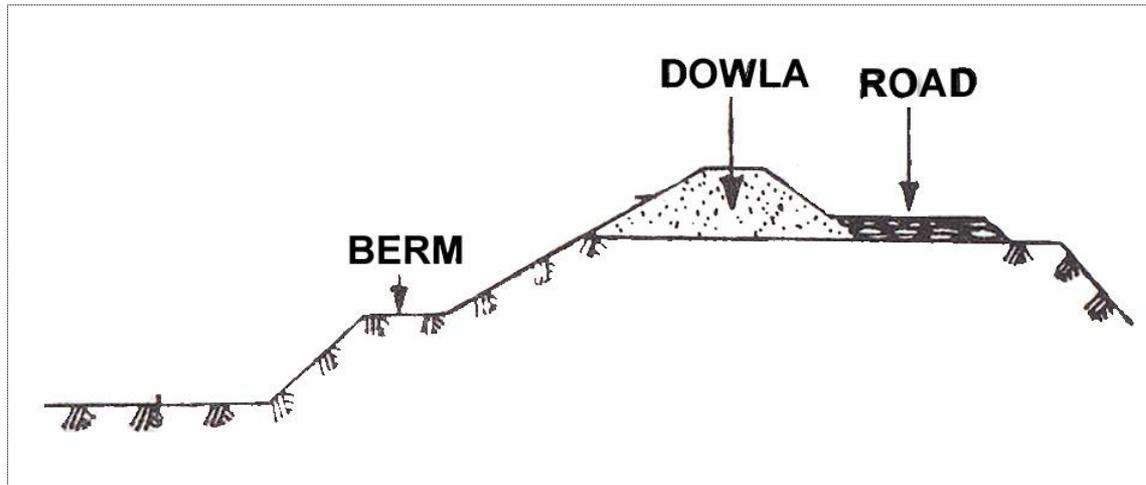
Banks

The primary purpose of banks is to retain water. This can be used as a means of communication and as inspection paths. They should be wide enough, so that a minimum cover of 0.50 m is available above the saturation line.



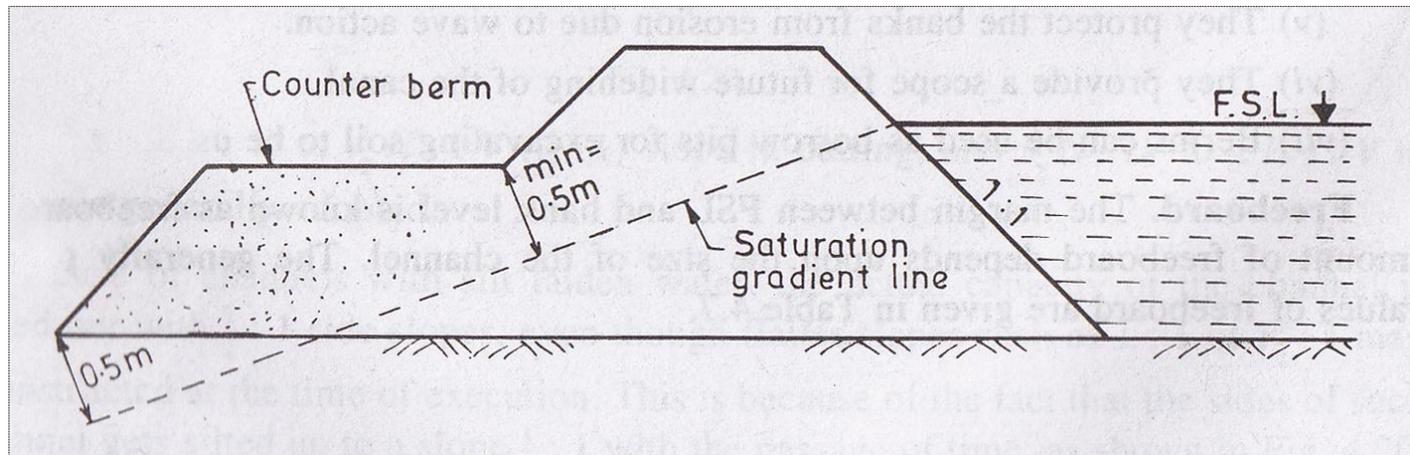
Service Roads

Service roads are provided on canals for inspection purposes, and may simultaneously serve as the means of communication in remote areas. They are provided 0.4 m to 1.0 m above FSL, depending upon the size of the channel.



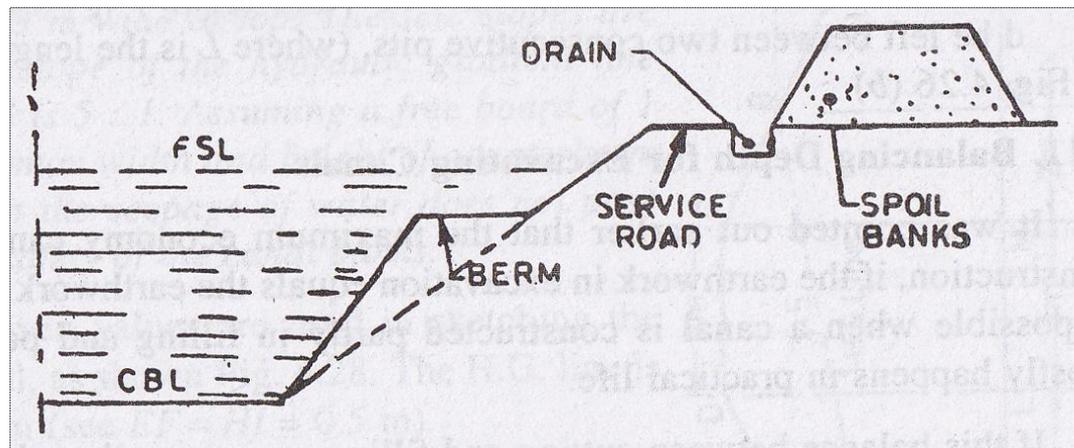
Back Berms or Counter Berms

Even after providing sufficient section for bank embankment, the saturation gradient line may cut the downstream end of the bank. In such a case, the saturation line can be kept covered at least by 0.5 m with the help of counter berms as shown in figure below.



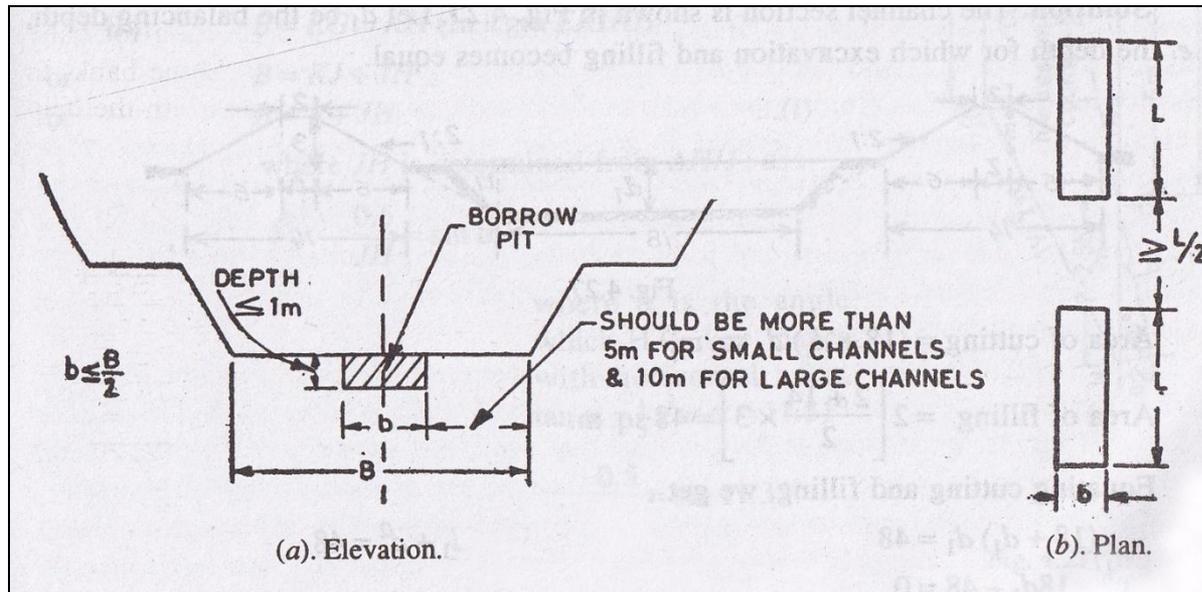
Spoil Banks

When the earthwork in excavation exceeds earthworks in filling, even after providing maximum width of bank embankments, the extra earth has to be disposed of economically. To dispose of this earth by mechanical transport, etc. may become very costly, and an economical mode of its disposal may be found in the form of collecting this soil on the edge of the bank embankment itself.



Borrow Pits

When earthwork in filling exceeds the earthwork in excavation, the earth has to be brought from somewhere. The pits, which are dug for bringing earth, are known as **Borrow Pits**.

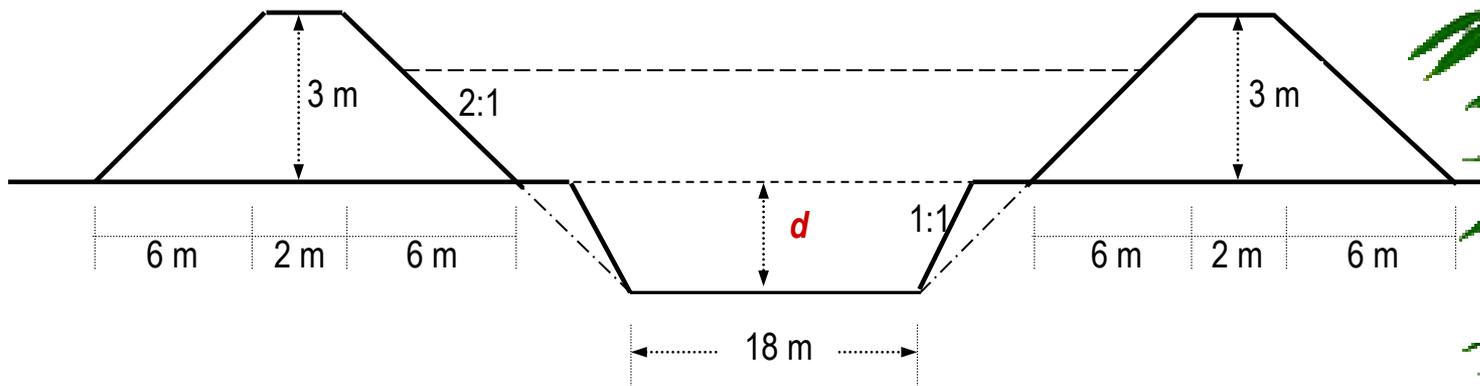


Design Requirements:

- ✓ The borrow pits should start from a point at a distance more than 5 m from the toe for small channels, and 10 m for large channels.
- ✓ The width of these pits b , should be less than half the width of the canal B , and should be dug in the entire.
- ✓ The depth of these pits should be equal to or less than 1 m.
- ✓ Longitudinally, these pits should not run continuous, but a minimum space of $L/2$ should be left between two consecutive pits, (where L is the length of one pits).

Problem

Calculate the **balancing depth** for a channel section having a bed width equal to 18 m and side slopes of 1:1 in cutting and 2:1 in filling. The bank embankments are kept 3.0 m higher than the ground level (berm level) and crest width of banks is kept as 2.0 m



Solution:

The channel section is shown below. Let d be the balancing depth, i.e. the depth for which excavation and filling becomes equal.

$$\text{Area of cutting} = (18 + d) d \text{ m}^2$$

$$\text{Area of filling} = 2(2+14)/2 \times 3 = 48 \text{ m}^2$$

Equating cutting and filling, we get

$$(18 + d) d = 48$$

$$\Rightarrow d^2 + 18d - 48 = 0$$

$$\Rightarrow d = 2.35 \text{ m (neglecting -ve sign)}$$

$$\therefore \text{Balancing depth} = 2.35 \text{ m}$$

End of Chapter – 6

