6

CANAL SECTION

6.1 TERMS RELATING TO CANAL SECTION

The canal section may be in fully cutting or fully banking or partial cutting and partial banking according to the natural ground surface and the permissible bed slope of the canal. But there are several terms in the canal section with which a civil engineer should be acquainted to design the section and to execute the work. The following are the different terms related to the canal section (Fig. 6.1).

1. Canal bank
2. Berm
3. Hydraulic gradient
4. Counter berm
5. Free board
6. Side slope
7. Service road or inspection road
8. Dowel or Dowla
9. Borrowpit
10. Spoil bank
11. Land width

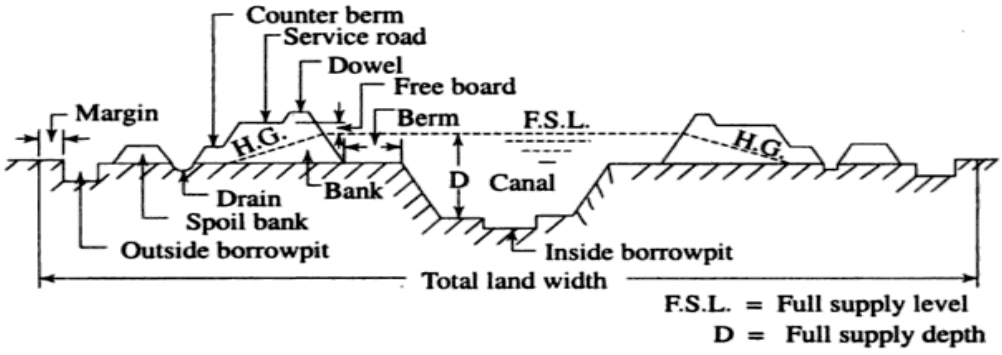

Fig. 6.1 Canal section

6.2 CANAL BANK

The canal bank is necessary to retain water in the canal to the full supply level. But the section of the canal bank is different for different site conditions. The following are the different forms for different site conditions.

(a) When the Canal Fully in Cutting In this case, the banks are constructed on both sides of the canal to provide only a inspection road. Here, the hydraulic gradient has no function. So, the height of the bank will be low and the top width will be minimum just to provide the road way. The side slope will be $1\frac{1}{2}$: 1 or 2 : 1 according to the nature of the soil (Fig. 6.2).

(b) When the Canal in Partial Cutting and Banking In this case, the banks are constructed on sides of the canal to retain water. The height of the banks depend on the fully supply level of the canal. Again, the section of the canal depends on the hydraulic gradient. The top width and the side slope of the bank should be such that the hydraulic gradient should have a minimum cover of 0.5 m (Fig. 6.3).

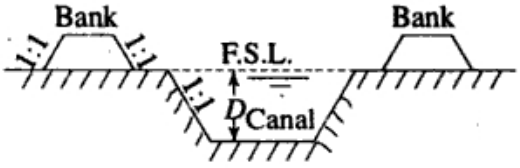

Fig. 6.2 Canal in full cutting

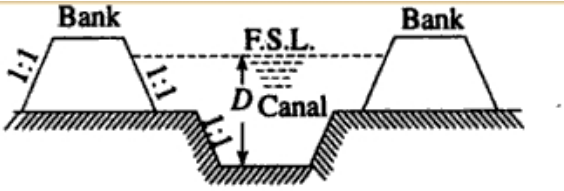

Fig. 6.3 Canal in partial cutting and partial banking

(c) When the Canal in Full Banking In this case, the canal and both the canal banks are constructed above the ground level. The height of the bank will be high and its section will be large due to the hydraulic gradient. But to minimise the cross section of the bank a core wall of puddle clay is provided which deflects the hydraulic gradient downwards (Fig. 6.4).

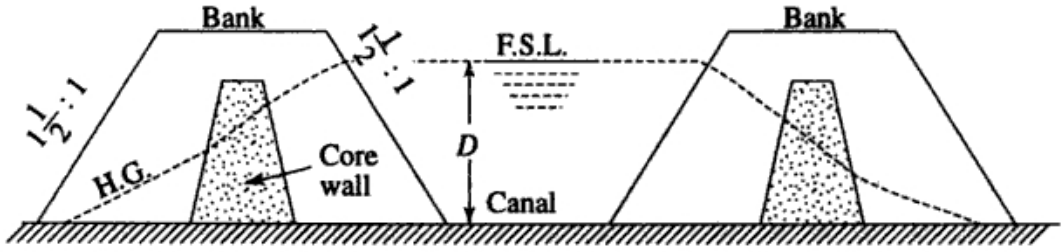

Fig. 6.4 Canal in full banking

6.3 BERM

The distance between the toe of the bank and the top edge of cutting is termed as berm (Fig. 6.5). The berm is provided for the following reasons,

(a) To protect the bank from erosion.
(b) To provide a space for widening the canal section in future if necessary.
(c) To protect the bank from sliding down towards the canal section.

(d) The silt deposition on the berm makes an impervious lining.
(e) If necessary borrowpit can be excavated on the berm.

The width of the berm depends on various factors such as capacity of the canal, the nature of the soil, the site condition, etc. However, the width of the berm varies from D to 2 D, where, D is the full supply depth of the canal.

6.4 HYDRAULIC GRADIENT

When the water is retained by the canal bank, the seepage occurs through the body of the bank. Due to the resistance of the soil, the saturation line forms a sloping line which may pass through countryside of the bank. This sloping line is known as the hydraulic gradient or saturation gradient. The soil below this line is saturated, but the soil above this line is dry. The hydraulic gradient depends on the permeability of the soil. So, while constructing the bank, the soil should be tested in soil testing laboratory and the nature of the hydraulic gradient should be ascertained.

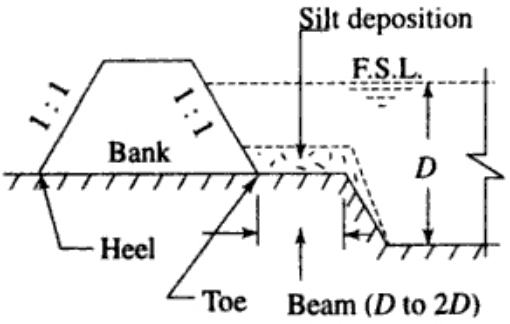

Fig. 6.5 Berm

This will help in fixing the height, top width and side slope of the bank. The following are the approximate values of hydraulic gradient for different soil (Fig. 6.6).

Soil	–	H.G.
Clayey soil	–	1 : 4
Alluvial soil	–	1 : 5
Sandy soil	–	1 : 6

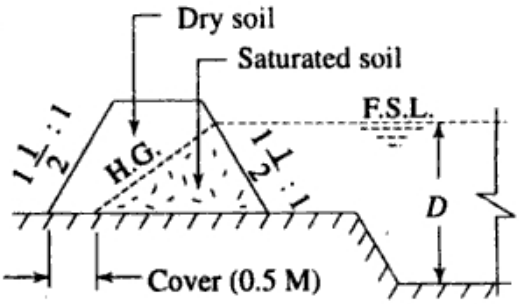

Fig. 6.6 Hydrualic Gradient

6.5 COUNTER BERM

When the water is retained by a canal bank the hydraulic gradient line passes through the body of the bank. For stability of the bank, this gradient should not intersect the outer side of the bank. It should pass through the base and a minimum cover of 0.5 m should always be maintained. Sometimes, it may occur that the hydraulic gradient line intersects the outer side of the bank. In that case, a projection is provided on the bank to obtain minimum cover. This projection is known as counterberm. The width of this berm depends on the site condition (Fig. 6.7).

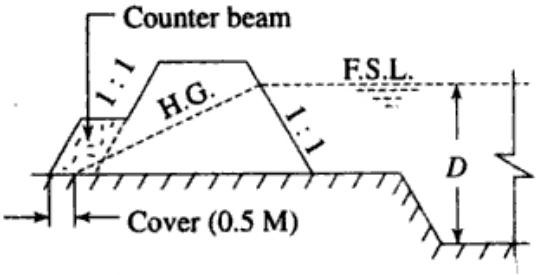

Fig. 6.7 Counter berm

6.6 FREE BOARD

It is the distance between the full supply level and top of the bank. The amount of free board varies from 0.6 m to 0.75 m.

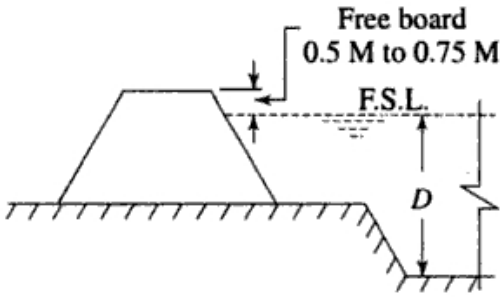

Fig. 6.8 Free board

It is provided for the following reasons (Fig. 6.8).

(a) To keep a sufficient margin so that the canal water does not overtop the bank in case of heavy rainfall or fluctuation in water supply.

(b) To keep the saturation gradient much below the top of the bank.

6.7 SIDE SLOPE

The side slopes of the canal bank and canal section depend on the angle of repose of the soil existing on the site. So, to determine the side slopes of different sections, the soil samples should be collected from the site and should be tested in the soil testing laboratory. The necessity of such test is that if the permissible slope (to maintain angle of repose) is not provided in an embankment or cutting, then the soil in that place will go on sliding gradually until the angle of repose for that particular soil is attained.

For instance, suppose an embankment was constructed with side slope 1:1 but according to the nature of the soil, the side slope should be $1\frac{1}{2}$: 1. Then the initial shape *A B C D* will automatically take the final shape A_1, B_1, C_1, D_1 after slide in the due course (Fig. 6.9).

Again, an opposite incident may occur, suppose, an embankment was constructed with side slope 2:1, but latter it was found that the side slope of 1:1 was sufficient to maintain the angle of repose for that soil. In this case, an unnecessary earthwork was done (Fig. 6.10).

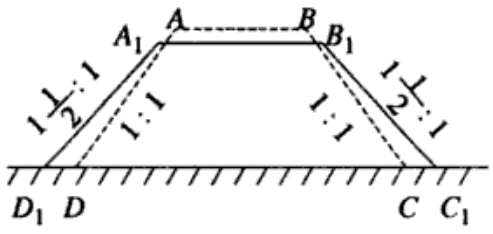

Fig. 6.9 Sliding of bank

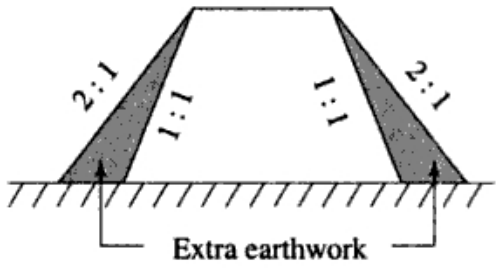

Fig. 6.10 Extra earth filling

The permissible side slopes for some soil are given in the following table:

Type of soil	*Side slope in cutting*	*Side slope in banking*
Clayey soil	1:1	$1\frac{1}{2}$:1
Alluvial soil	1:1	2:1
Sandy loam	$1\frac{1}{2}$:1	2:1
Sandy soil	2:1	3:1

6.8 SERVICE ROAD

The roadway which is provided on the top of the canal bank for inspection and maintenance works is known as service road or inspection road. For main canal, the service roads are provided on both the banks. But for branch canals, the road is provided on one bank only. The width of the service roads for main canal varies from 4 to 6 m. The width of the road for the branch canal varies from 3 to 4 m.

The initial purpose of the service road is to conduct inspection and maintenance works. But finally these roads serve the purpose of communication between the different villages and for transporting agricultural goods. Therefore it becomes necessary to construct metalled road to serve these purposes (Fig. 6.11).

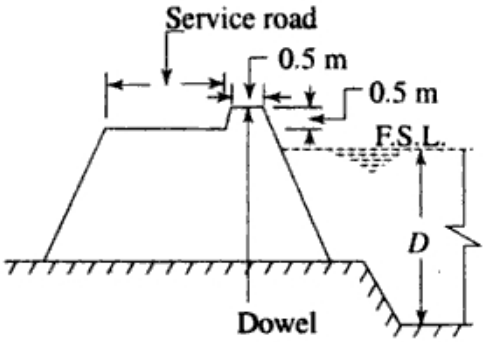

Fig. 6.11 Service road and dowel

6.9 DOWEL OR DOWLA

The protective small embankment which is provided on the canal side of the service road for the safety of the vehicles plying on it is known as dowel or dowla. Practically it acts as a curb on the canal side of the road. It is provided above the F.S.L. with a provision of freeboard. The top width is generally 0.5 m and the height above the road level is about 0.5 m. The side slope is similar to the side slope of the bank (Fig. 6.11).

6.10 SPOIL BANK

When the canal is constructed in full cutting, the excavated earth may not be completely required for forming the bank. In such a case, the extra earth is deposited in the form of small banks which are known as spoil banks. The spoil banks are provided on one side or both sides of the canal bank depending on the quantity of excess earth and the available space. The spoil banks run parallel to the main bank. But are not continuous, sufficient spaces are left between the adjacent spoil banks for proper drainage (Fig. 6.12).

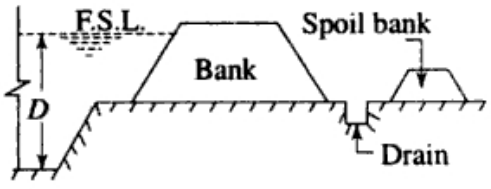

Fig. 6.12 Spoil bank

6.11 BORROWPIT

When the canal is constructed in partial cutting and partial banking, the excavated earth may not be sufficient for forming the required bank. In such a case, the extra earth required for the construction of banks is taken from some pits

which are known as borrowpits. The borrowpits may be inside or outside, the canal.

The inside borrowpit may be located at the centre of the canal. The width of the borrowpit should be half of the base width of canal. The maximum depth should be 1 m. The excavation is done in a number of borrowpits leaving a gap between them. The gap is generally half of the length of each borrowpit. The idea behind this is that the borrowpits will act as water pockets where the silt will be deposited and ultimately the canal bed will get levelled up.

The outer borrowpit may be adjacent to the heal of the bank with a clearance of 1 m between the heel and edge of borrowpit. But the outer borrowpit may create some inconvenience. So, it is better to borrow earth from the barren lands far away from the canal (Fig. 6.13).

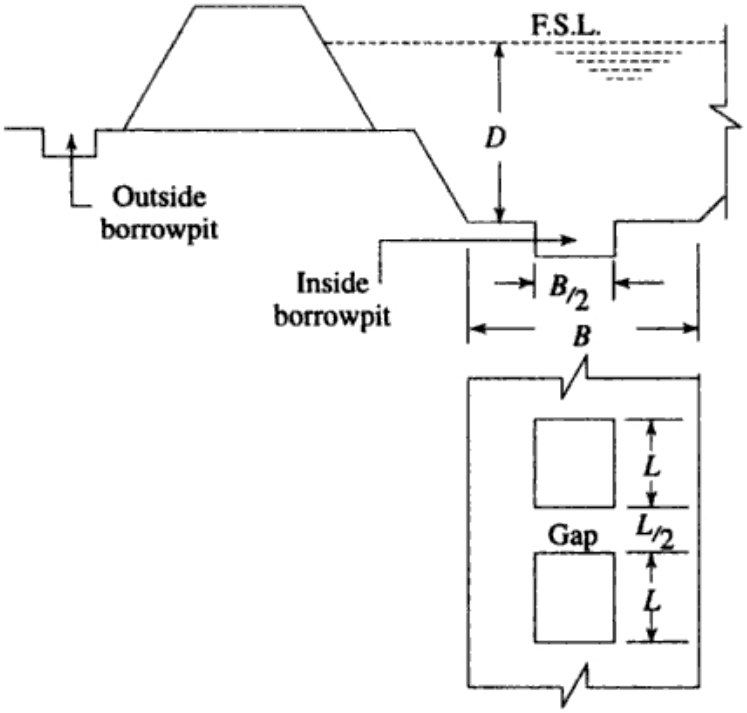

Fig. 6.13 Borrowpits

6.12 LAND WIDTH

The total land width required for the construction of a canal depends on the nature of the site condition, such as fully in cutting or fully in banking or partly in cutting and partly in banking. These conditions arise according to the designed bed level of the canal and the natural ground surface. So, total land width differs with the site condition. However, to determine the total land width the following dimensions should be added

1. Top width of the canal.
2. Twice the berm width.
3. Twice the bottom width of banks.
4. A margin of one metre from the heel of the bank on both sides.

5. Width of external borrowpit if any.
6. A margin of 0.5 m from the outer edge of borrowpit on both sides, if external borrowpit becomes necessary.

6.13 BALANCING DEPTH

In constructing a canal section, if the quantity of excavated earth can be fully utilised for making the banks on both sides, then that canal section is known as economical section. The depth of cutting for that ideal condition is known as balancing depth. In this case, no borrowpit on spoil bank needs to be constructed. This condition may not occur in all the cases. It happens only when the canal section is partly in cutting and partly in banking. The cost of earth work will also be balanced.

The method of finding the balancing depth is described here.

Example Find the balancing depth for a canal section having the following data.

1. Base width of canal = 10 m.
2. Side slope in cutting = 1 : 1.
3. Side slope in banking = 2 : 1.
4. Top width of bank = 3 m.
5. Height of bank above G.L. = 3 m.

Solution Refer Fig. 6.14.

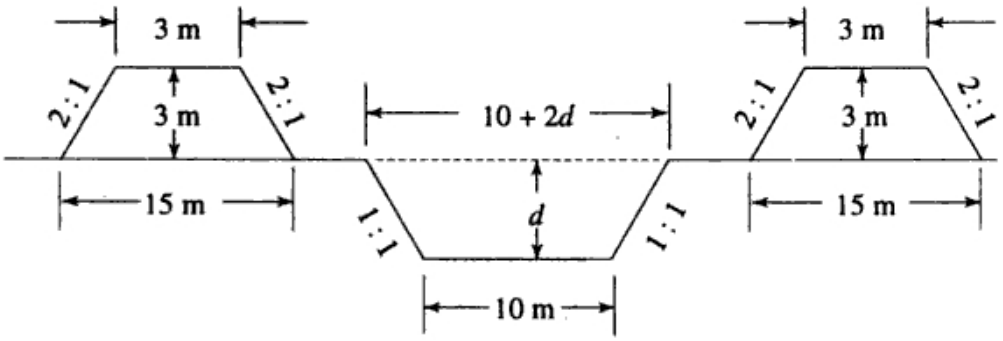

Fig. 6.14

$$\text{Area of banking} = 2 \times \frac{15+3}{2} \times 3 = 54 \text{ sq. m.} \quad (1)$$

Let d be the balancing depth of cutting.

$$\text{Area of cutting} = \frac{10+10+2d}{2} \times d = (10+d)\,d \quad (2)$$

Equating the area of banking and cutting,

$$(10+d)\,d = 54$$

$$d^2 + 10d - 54 = 0$$

$$d = \frac{-10 \pm \sqrt{100 + 216}}{2} = \frac{-10 \pm 17.8}{2}$$

$$d = \frac{-10 + 17.8}{2} = 3.89 \text{ m} \qquad \text{(Neglecting the negative sign)}$$

So, the balancing depth is 3.89 m.

6.14 CANAL IN FULL CUTTING

Draw the section of a canal in full cutting with the following data

(a) R.L. of G.L. = 152.50 m.
(b) R.L. of canal bed = 150.00 m.
(c) Bed width of canal = 15.00 m.
(d) Top width of bank = 3 m.
(e) height of bank = 1.5 m.
(f) Berm = 1.0 m.
(g) Side slope in cutting = 1:1
(h) Side slope in banking = 2:1
(i) Full supply depth = 2.5 m.

Find also the total land width required.

Solution Refer Fig. 6.15.

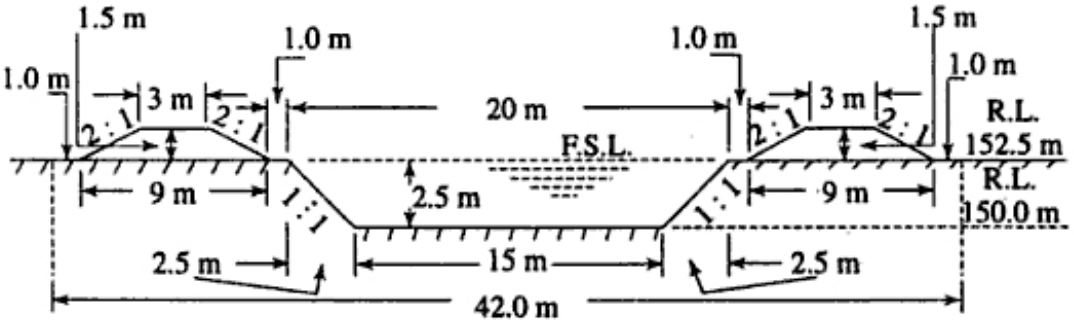

Fig. 6.15

6.15 CANAL IN FULL BANKING

Draw the section of a canal in full banking with the following data

(a) R.L. of G.L. = 148.00.
(b) The canal bed is just at G.L.
(c) Bed width of canal = 12.0 m.
(d) Fully supply depth = 2.0 m.
(c) Free board = 0.5 m.
(f) Hydraulic gradient = 1 in 4.
(g) Top width of bank = 3 m.
(h) Side slope of bank – {1:1 (canal side), 2:1 (country side)}

Final also the land width.

Solution Refer Fig. 6.16.

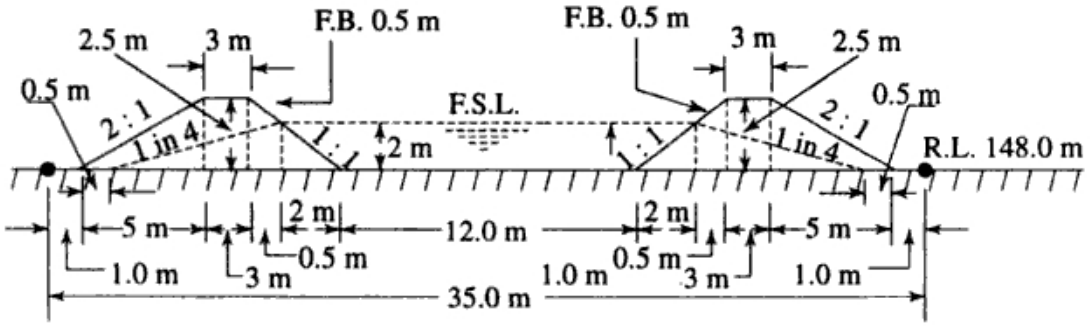

Fig. 6.16

6.16 CANAL IN PARTIAL CUTTING AND PARTIAL BANKING

Draw the section of a canal in partial cutting and partial banking with the following data

(a) R.L. of G.L. = 150.00 m.
(b) R.L. of canal bed = 149.00 m.
(c) Full supply depth = 2.0 m.
(d) Free board = 0.5 m.
(e) Berm = 1.0 m.
(f) Canal bed width = 10.0 m.
(g) Top width of bank = 3.0 m.
(h) H.G. line = 1 in 6.
(i) Side slope in banking = 2 : 1.
(j) Side slope in cutting = 1 : 1.

Mark the total land width.

Solution Refer Fig. 6.17.

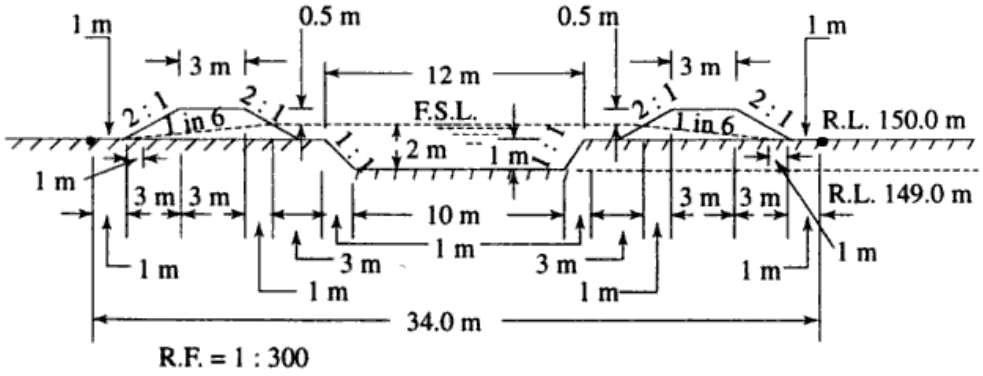

Fig. 6.17

REVIEW QUESTIONS

1. Fill up the blanks with appropriate word/words.
   (i) The distance between the top of the bank and top edge of cutting is known as _____

(ii) In case of canal bank a _____ may be required to provide a minimum cover over the hydraulic gradient.

(iii) The distance between the F.S.L. and the top of embankment is known as _____ .

(iv) For the safety of the vehicle running, over the service road _____ is provided.

(v) In case of canal in full cutting a _____ bank may be required to be constructed.

(vi) In case of canal bank sometimes extra earth is taken from _____ .

2. Distinguish between the following terms.
   (a) Berm and counter berm.
   (b) Spoil bank and canal bank.
   (c) Hydraulic gradient and longitudinal gradient.
3. What are the different types of canal section? Explain with sketch.
4. (a) What is meant by balancing depth of cutting and banking?
   (b) Why it is required?
   (c) How it is determined?
5. Distinguish, with neat sketch, between the canal in full cutting and the canal in full banking.

ANSWERS

1. (i) berm
   (ii) counter berm
   (iii) free board
   (iv) dowel
   (v) spoil
   (vi) borrowpit