EXERCISE:

A 0.04ha pond has to be built in clayey soil with dikes 1.50m high and 1m wide at the top. If SD = 1.5: 1 and SW = 2:1. Calculate the base width of the dike (Hint : settlement allowance of expanded clay volume is 20%).

Solution:

Design height = (100% – 20%) = 80% of constructing height

Construction height = 1.50m/0.80 = 1.88m

Dike base width = 1m + (1.88m x 1.5) + (1.88m x2) = 7.55m

CH = DH ÷ [(100 - SA) ÷ 100]

Calculating the cross-section of a dike on horizontal ground

For the above 0.04-ha pond to be built in clayey soil, calculate the size of the cross-section of the dike as:

- area 1 = 1 m x 1.88 m = 1.88 m^2;
- area 2 = (1.5 x 1.88 m) x (1.88 m ÷ 2) = 2.6508 m^2;
- area 3 = (2 x 1.88 m) x (1.88 m ÷ 2) = 3.5344 rn^2
- cross-section = 1.88 m^2 + 2.6508 m^2 + 3.5344 m^2 =8.0652 m^2.

Calculating the cross-section of a dike on sloping ground

The cross-section of a dike *on sloping ground* can be calculated most easily using a scale drawing.

(a) Draw a horizontal line from D, meeting AE at E'.

(b) Draw a horizontal line from C, meeting BF at F'.

(c) Draw a vertical line PO down the centre line of the dike.

(d) Cross-section = ADE + AEFB + BFC = 0.5(AE x DE') + (AB x PO) + 0.5(BF x F'C).

Note: Design height, DH, is the height dike should have after settling down to safely provide the necessary water depth in the pond = Water depth + Free board.

Construction height, CH, is the height the dike should have when newly built and before any settlement takes place. =design height + settlement height

Calculating the cross-section of a dike on sloping ground using a scale drawing

Calculating the cross-section of a dike on irregular ground using a scale drawing

Calculating the cross-section of a dike on irregular ground using squared paper

1 cm = 0.5 m

1 square of 0.5 m x 0.5 m = 0.25 m^2

15.2 squares x 0.25 m^2 = 3.8 m^2

Calculating the volume of dikes on horizontal and regular ground

To estimate how much soil will be needed for the construction of a dike, you need to know its volume. The calculation method depends on the site topography and on the type of pond to be built. If *the topography* of the construction *site is reasonably flat* (less than 0.30 m difference in average site levels) and regular, you can calculate the volume of the dike (in m^3) by multiplying the *crosssection* *of the dike*(in m^2 and halfway along the dike for an average area) *by its length* measured along the centre line (in m).

EXAMPLE

Using the figures from the example above, the cross-section of the dike equals 8.0652 m^2. If the length of the dike to be built is 20 m x 4 = 80 m, its volume is 8.0652 m^2 x 80 m = 653.216 m^3.

Calculating the volume of dikes on sloping or irregular ground

If the topography of the site is more steeply sloping or more irregular, you cannot calculate the volume of the pond dikes just by using one cross-section. There are several possible methods, depending on the type of ground and the accuracy you require.

With a first group of methods you can calculate the dike volumes by using *averages of the dike crosssections*

or you could use the average of the *cross-sections at the corners* of the dike.

EXAMLPE

A 400-m^2 (20 x 20 m) pond is to be constructed with wall heights of 0.5 m at corner A, 0.3 m at corner B, 1.1 m at corner C and 1.5 m at corner D. Crest width is 1 m and side slope 2:1 on both sides. The cross-section areas at each corner are:

A: (1 m x 0.5 m) + 2 x (0.5 m x 0.5 m x 1 m) = 1.5 m^2,

B: (1 m x 0.3 m) + 2 x (0.5 m x 0.3 m x 0.6 m) = 0.48 m^2,

C: (I m x 1. 1 m) + 2 x (0. 5 m x 1. 1 m x 2.2 m) = 3.52 m^2,

D: (1 m x 1.5 m) + 2 x (0.5 m x 1.5 m x 3 m) = 6.0 m^2.

Average area for wall AB = (1.5 m^2 + 0.48 m^2) ÷ 2 = 0.99 m^2 and volume for wall AB = 0.99 m^2 x 20 m = *19.8* m^3.

Similarly:

- for BC, average area = 2 m^2 and volume = *40* m^3;
- for CD, average area = 4.76 m^2 and volume = *95.2* m^3;
- for DA, average area = 3.75 m^2 and volume = *75* m^3.

Consequently, total volume of dikes = 19.8 m^3 + 40 m^3 + 95.2 m^3 + 75 m^3 = 230 m^3.

Average of areas at corners of dike

For a more accurate measurement of dike volume on rough ground, you should apply the following formula, known as Simpson's rule, where: $V = (d \div 3) \times [A_1 + A_n + 4(A_2 + A_4 + ... A_{n-1}) + 2(A_3 + A_5 + ... A_{n-2})]$. Proceed as follows:

(a) Divide the length of the dike into an *odd number n* of cross-sections at equal intervals of *d* metres.

(b) Calculate the area *A* of each cross-section as explained earlier.

(c) Introduce these values into the above formula.

The dike is 60 m long.

(a) At intervals *d* = 10 m, identify seven crosssections A_1 ... A_7 and calculate their respective areas to obtain A_1 = 10 m^2 ; A_2 = 16 m^2; A_3 = 18 m^2 ; A_4 = 11 m^2 ; A_5 = 8 m^2; A_6 = 10 m^2 ; A_7 = 12 m^2.

(b) Introduce these values into the Simpson's rule formula:

$V = (d \div 3)$ [A1 + A7 + 4(A2 + A4 + A6) +2 (A3 + A5)].

(c) Calculate $V = (10 m \div 3) [10 m^2 + 12 m^2 +$
$4(16 m^2 + 11 m^2 + 10 m^2 + 2(18 m^2 \div 8 m^2)] =$
$740 m^3$.

Calculating volumes of excavated material

You will need to know excavation volumes for:

- topsoil;
- borrow pits, dug near an earth structure to provide the material for its construction;
- excavated ponds, to provide the pond volume required;
- other structures such as harvest pits, supply channels, etc.

You will normally have to remove the topsoil before you reach soil good for construction material. Levels should therefore be taken *from the base of the topsoil* layer. In most cases, the sides of the excavation should be sloped to prevent them from collapsing. In many cases (ponds, channels, etc.) these will be of specified gradients.

For reasonably flat, level surfaces, where *excavated width is at least 30 times the depth*, volume of excavation can be estimated as:

V = top area x depth of excavation.

Where the *width is less than 30 times the depth*, you should correct for side slopes as follows:

V = [(top area + bottom area) ÷ 2] x depth.