Unit-IV

Bunds

* Bunds are small embankment type structures, constructed across the slope of the land, either with soil or stone.
* Popular soil and water conservation measures.

Functions of Bunds

* To prevent soil erosion.
* To collect the surface runoff.
* To increase the water infiltration.
* To prevent the gully formation.

Suitable Conditions for Bunding

* Low rainfall areas.
* Lands with 2-6% slope.
* Red clay soils and mixed soils are suitable for constructing bunds.

Advantages of bunds

* Effective in storing surface runoff and preventing soil erosion.
* Relatively simple and cheap implementation.
* Easy in maintenance.
* Applicable to fields that are already under cultivation.
* Result in effective utilisation of nutrients and fertilizers as these are not washed away.

Disadvantages of Bunds

* Loss of cultivable area.
* Interference with the farm operations.
* Contour bunds need an even ground, otherwise, water will collect in lower spots which may cause mosquito breeding.

* For stone bunds, Construction cost may be higher.
* Temporary waterlogging problem may be faced in heavy clay soils.

Types of bunds

Based on the functional requirements, bunds are of Two types:

1. Contour bunds (for storage of water)
2. Graded bunds (for safe disposal of excess water)

Adaptability

Type	Land Slope (%)	Soil depth	Annual Rainfall (mm)
Contour bunding	<8%	shallow & light	< 700
Graded bunding	<8%	shallow & light	>700
	<8%	Heavy (clay)	<700

Other types of bunds

Side bunds

Constructed along the slope at the two sides of - contour bunds.

Lateral bunds

Constructed along the slope in between two side bunds for preventing the concentration of water on a side.

Design Criteria for bunds

1. Allowable Submergence of land.

Since the area of land Submerged due to Ponding affects crops, the level of waste weir and the amount of land to be Submerged should be Carefully chosen

* For Paddy which requires ponding water on the field, the bunds dimensions should be such that no runoff is Permitted.

* For other crops, heights of waste weirs should be such that the bunds store just sufficient water to meet the requirement of the crops.

2. Economy in Construction

The Cost of bunding should be kept at the minimum.

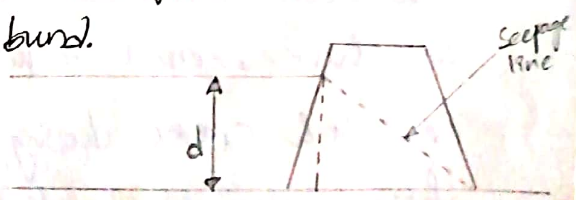
* Cost Should include expenses on earthwork and the value of the land lost Permanently due to bunds.

3. Seepage Consideration

While designing the bund cross-section, the seepage through bunds, due to accumulation of water behind it, should be taken into account.

* The Seepage rate is affected mainly by the head of water impounded, the side Slopes of the bund and the Permeability of the soil.

As a thumb rule, the seepage line must pass through the base of the bund.



4. Non-erosive velocity

* The flow velocity in the channel is determined by - formula, with typical value of 0.04 for Manning's roughness coefficient.

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

Here, $n = 0.04$.

* The resultant velocity should be non-erosive.
* Typical upper limit for the non-erosive velocity is as follows:

Sandy soil — 0.5 m/s

Erosion resistant soils – 0.65 m/s.

1. Contour bunds

Contour bunding is the construction of small bunds across the slope of the land on a contour so that the long slope is cut into a series of small ones and each contour bund acts as a barriers to the flow of water.

Contour bunds are generally used in relatively low rainfall areas for the purpose to control the soil erosion and to store the rain water. Contour bunds and level - terraces are the synonymous term. Therefore, sometimes contour bunding is also denoted as level terrace. Experience has shown that contour bunds constructed in shallow, medium and medium deep soils have stood well and have been beneficial to farmers. "Bunds in deep black soils have been a failure because of the nature of the soil which cracks during the hot weather. Broad bed & furrow system is a method suitable for managing rainwater in black soils."

Limitations

1. This practice is suitable for those areas, which receive the annual rainfall up to 600 mm and existing soil involves greater permeability.
2. It is not used in clayey soils.
3. Contour bunding is not technically feasible on the land slopes, greater than 6%.

Design of contour bunds

The design of contour bund includes determination of spacing, both horizontal and vertical and bund cross-section. Bund cross-section includes base width, side slope, and bund height. Bund height should be sufficient to store the expected runoff from a rainfall of 10 years recurrence interval. The base width, side slope and top width are decided by the nature of soil.

Spacing of contour bunds:

As the water flows through a sloping land, it attains erosive velocity. The bund should be spaced in a such a way so as to intercept the erosive velocity. Again the spacing should not be too close to interfere with the farming operations. Different relationships have been developed for the spacing of bunds.

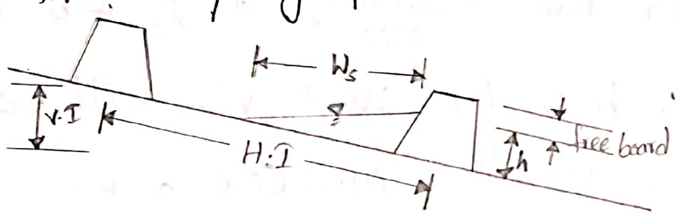


Fig. Definition sketch for a contour bund.

Ramser's formula: C.E. Ramser conducted expe... Two + where.

Semi-humid areas

$$V.I = 0.3\left(\frac{S}{3}+2\right)$$

where, V.I = vertical Interval, m.

S = land slope, %

Limitation

1. The above formula does not take into account soil and rainfall characteristics and applicability can't be generalized.

When the above formula is used for soils with high infiltration rate and good conservation practices such as contour farming, growing of cover crops etc., then 25% extra-spacing can be used. On the other hand, in soils of low infiltration capacity and unfavourable conservation measures the spacing should be reduced by 15%.

A general relationship of the following form may be used & constants should be evaluated for the specific site.

$$V.I = \frac{S}{a}+b$$

where, a & b are constants.

For heavy rainfall, $a = 1/10$ & $b = 60$

for low rainfall area, $a = 1/15$ & $b = 60$.

In both the cases, V.I will be in cm.

Cox's formula: M.P. Cox a water management specialist of USAID gave following formula for spacing of contour bunds.

$$V.I = 0.3\,(XS+Y)$$

where, X = Rainfall factor

Y = Infiltration & Crop-cover factor

S = land slope, %

V.I = vertical Interval, m.

Values of rainfall factor i.e. 'X'

Rainfall distribution	Annual Rainfall, mm	value of 'X'
Scanty	640	0.80
Moderate	640 - 900	0.60
Heavy	>900	0.40

Values of the infiltration and crop cover factor

Intake rate	Crop cover during critical period	value of 'Y'
Below average	Low coverage	1.0
Average or above	Good coverage	2.0
One of the above two factors is favourable and other is unfavourable		1.5

USDA formula: The USDA (United States Department of Agriculture) has also formulated an equation for V.I. of bund given as under

$$V.I = 0.3 \left(\frac{S}{4} + 2\right)$$

where, V.I = vertical interval

S = slope of land, %.

Cross-section:

The cross-section of the bund includes height, top width and bottom width. The shape of the bund is trapezoidal and therefore, Cross-sectional area of the bund = (base width + Top width / 2) × height of the bund

Cross-sectional area of the storage space required can be computed by the following formula,

$$\text{Storage area required, } m^2 = \frac{\text{Maximum Potential runoff, cm} \times H.I, m}{100}$$

Height of Contour bund:

The runoff volume from 1m width of the land between two bunds is given by

$$R_v = R/100 \times H.I \quad \rightarrow (1)$$

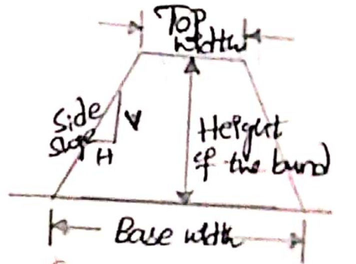


Fig. Cross-section of Contour bund.

where, R_v = Volume of runoff, m^3

R = 24-hr excess rainfall to be stored, cm.

$H.I$ = Horizontal interval between the bunds, m.

The value of excess rainfall R can be calculated from the hydrologic soil cover complex method. The Horizontal Interval (H.I) is related with the vertical Interval (V.I) by the following formula

$$H.I = \frac{V.I}{S} \times 100$$

where, S = slope of land, %.

Neglecting the minor effects due to side slopes of the bund, the storage volume behind the bund is given by

$$S_v = \frac{W_s \times h}{2} \quad \rightarrow (2)$$

where, S_v = Storage volume of contour bund of one meter wide, m^3

W_s = water spread length behind the bund, m. &
h = depth of impounding near the bund, m.

Equating eqⁿ ① & ②, we get

$$\frac{W_s \times h}{2} = \frac{R \times H.I}{100}$$

$$h = \frac{R}{50} \times \frac{H.I}{W_s} \rightarrow ③$$

From the figure, concept of similar triangles

$$\frac{W_s}{H.I} = \frac{h}{V.I}$$

$$W_s = \frac{H.I \times h}{V.I} \rightarrow ④$$

Substituting the eqⁿ ④ in eqⁿ ③, we get

$$h = \frac{R}{50} \times \frac{H.I}{\left(\frac{H.I \times h}{V.I}\right)}$$

$$h = \frac{R}{50} \times \frac{V.I}{h}$$

$$h^2 = \frac{R \times V.I}{50}$$

$$h = \sqrt{\frac{R \times V.I}{50}} \rightarrow ⑤$$

Equation ⑤ gives the depth of water that will be impounded immediately behind the bund. To this depth of flow over the waste weir and free board of about 25% should be added. Generally a depth of flow of 30cm is considered above the weir.

Other details about Contour bunding

1. Length of contour bund: It is determined by calculating the Horizontal interval of the bund, formed.

The length of bund per hectare area of land is given as

$$L = \frac{10000}{H.I}$$

or $$L = \frac{10{,}000 \times S}{V.I \times 100}$$

$$L = \frac{100S}{V.I}$$

2. Area Lost due to Contour bunding:

It is calculated by multiplying the length of contour bund per hectare to its base width, i.e.

$$A_L = \frac{10{,}000}{H.I} \times b$$

where b = base width

$$A_L = \frac{10{,}000 \times S}{V.I \times 100} \times b$$

$$A_L = \frac{100Sb}{V.I}$$

This equation computes, only the area lost due to main contour bund, not the area lost due to side & lateral bunds.

Usually, the area lost due to side and lateral side and the lateral bund is taken as 30% of the area lost due to main contour bund.

$$\frac{100S}{V.I} \times b + \frac{100S}{V.I} \times b \times \frac{30}{100} = 1.3 \times \frac{100 \times S}{V.I} \times b.$$

$$A_L = 1.3 \times \frac{100S}{V.I} \times b$$

The above equation can also be written in the following form, to compute the values of area lost in percentage (%)

$$A_L, \% = \frac{1.3 \times S \times b}{V.I}$$

Numerical Problems on design of Contour bunds

Problem-1: Using Ramser's formula, calculate V.I. of the Contour bunds on a 4.5% land slope. The rainfall is moderate with average infiltration rate & good coverage of the land with vegetation.

Sol:- Given

$S = 4.5\%$

$$V = \left(\frac{S}{3} + 2\right) 0.3$$

$$= 0.3\left(\frac{4.5}{3} + 2\right)$$

$V.I = 1.05\,m$

for soils having high infiltration & Permeability and good Conservation Practice - V.I is increased by 25%.

Low infiltration rate & Permeability, unfavourable cropping Condition - V.I is decreased by 15%.

V.I is increased by 25%.

$$V.I = 1.05 + \frac{25}{100} \times 1.05$$

$$V.I = 1.05 + 1.25$$

$$\boxed{V.I = 1.31\,m}$$

Problem-2:- Calculate the height and cross-sectional area of Contour bund to be constructed on a land slope of 5%. The other details are as follows:

(i) Rainfall excess for 24-h duration = 100cm.

(ii) H.I = 10m

(iii) Depth of water flowing over the weir = 30cm.

Sol:- Given

$S = 5\%$

$R_e = 100cm = 1m$

$H.I = 10m$

depth of water flow over flo weir $= 30cm = 0.3m$

$$H.I = \frac{V.I}{S} \times 100$$

$$10 = \frac{V.I}{5} \times 100$$

$$V.I = \frac{10 \times 5}{100}$$

$$V.I = 0.5m$$

The theoretical height of bund = (depth of water impounding behind the bund)

$$h = \sqrt{2 R_e V.I}$$

$$h = \sqrt{2 \times 1 \times 0.5}$$

$$h = 1.0m$$

The Practical height of the bund will include the depth of water flow over weir & free board. (assumed as 25% of h)

Total bund height = h + depth of water flow over weir + free board.

$$= 1 + 0.3 + 0.25 \times 1$$

Total bund height = 1.55m

Cross-sectional area of bund, $A = \left(\frac{\text{base width} + \text{Top width}}{2}\right) \times$ height of the bund.

Assuming Top width = 0.5m

Base width = 2.0m

$$A = \left(\frac{0.5+2}{2}\right) \times 1.55$$

$A = 1.94m^2$

Problem-3: Calculate the storage area required and dimensions of contour bund in loam soil having an average slope of 2.5%. The maximum expected rainfall having 10 years recurrence interval is 18 cm. The infiltration capacity of the soil of the area is such that 40% of the rainfall is absorbed in the field. The rainfall in the area is moderate & both the soil cover conditions are favourable for erosion control.

Sol:- Given

$S = 2.5\%$

Loamy soil

Rainfall moderate

Soil cover conditions favourable for erosion control.

The maximum expected rainfall having 10 year recurrence interval $= 18$ cm $= 0.18$ m.

Runoff Potential $= 60\%$ of the rainfall
(as 40% of the rainfall is absorbed as infiltration)

The bund system needs to be designed to handle the maximum runoff potential.

Maximum runoff to be stored $= 60\%$ of rainfall

$= \frac{60}{100} \times 0.18$

$= 0.108$ m.

Storage area required, A = max. runoff to be stored × H.I

$A = 0.108 \times H.I$

$H.I = \frac{V.I}{S} \times 100.$

Cox formula, $V.I = 0.3(XS + Y)$

$= 0.3(0.6 \times 2.5 + 2) \Rightarrow V.I = 1.05$ m.

$$H.I = \frac{1.05}{2.5} \times 100 = 42m.$$

Hence, Storage area required, A = Max. runoff Potential × H.I

$= 0.108 \times 42$

$= 4.54 m^2.$

Now, the bund cross-section should be decided so as to store $4.54 m^2$ of water behind it.

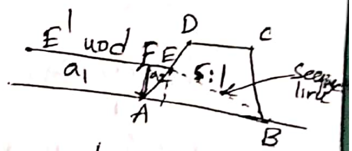
Since the soil type is given as 'loam', the side slope of bund will be 1.5:1.

Let 'd' is the depth of water stored.

Total water storage area $= 4.54 m^2$

$A = 4.54 m^2$

$a_1 + a_2 = 4.54 m^2$



$d = \frac{wS}{100}$

$w = \frac{100d}{25}$

$w = 40d$

Hence, $a_1 = \frac{1}{2} \times d \times 40d$

$a_2 = \frac{1}{2} \times d \times 1.5d$

$(\frac{1}{2} \times d \times 40d) + (\frac{1}{2} \times d \times 1.5d) = 4.54$

$20.75 d^2 = 4.54$

$d^2 = 0.2187$

$d = 0.47m$

Hence, the depth of water stored $= 0.47m$.

Free board = 25% of d.

$= \frac{25}{100} \times 0.47 + 0.47$

$= 0.12m + 0.47$

Total height of bund $= 0.59m$.

Hence, from the figure,

Base width $= 1.5d + 5d = 6.5d$

$= 6.5 \times 0.47$

Base width $= 3.06m$.

Top width $= 3.06 - 2 \times 1.5 \times 0.59 = 1.29m$.

Problem-4: Calculate the volume of earthwork for a 100 ha Catchment which has a land slope of 3%. For the Contour bund, the following dimensions were calculated:

$V.I = 1.3m$

Base width = 2.25m.

Top width = 0.45m.

Height of the bund = 0.90m.

Also determine the total area lost due to bunding.

Sol:- Given

** The total earthwork Per ha = Total length of bund/ha × cross-sectional area of bund

length of the bund/ha, $L = \frac{100S}{VI} = \frac{100 \times 3}{1.3}$

$L = 230.8m.$

For total length of the bund/ha, the calculated value is increased by 30% to account for side & lateral bunds.

Hence, total length of the bund/ha $= 230.8 + 230.8 \times \frac{30}{100}$

$= 230.8 * 1.3$

$= 300m.$

Given, base width = 2.25m

Top width = 0.45m

Height of bund = 0.90m

Cross-sectional area of bund, $A = \left(\frac{2.25+0.45}{2}\right) \times 0.90$

$A = 1.215 m^2$

Hence, the total earthwork/ha $= 300 \times 1.215$

$= 364.5 m^3.$

The total earthwork for the 100ha watershed = 100 x 364.5
= 36450 m³.

The area lost under the bund/ha, $A_L = \frac{100S}{V.I} \times b$

$= \frac{100 \times 3 \times 2.25}{1.3}$

$A_L = 519.2 m^2$

The total area lost due to bunding will also include area lost under side & lateral bunds.

Hence, total area lost /ha $= 519.2 \times \frac{30}{100} + 519.2$

$= 519.2 \times 1.3$

$= 675 m^2$

The total area lost/100ha $= 675 \times 100$

$= 67500 m^2$

For the 100ha watershed,

Total earthwork = 36450 m³

Total area lost = 67500 m².

Surplus water outlets or waste weirs

In contour bunds, water is impounded by closing the ends of the strip by side bunds, but after reaching a head of about 30 cm of impounded water. The safety of the contour bunds made of soil is at risk. To maintain a head of water of about 30 cm behind the bund, the following types of arrangements are recommended for overflow of the surplus water above the head of 30cm. These structures are known as waste weirs. It is advisable to dispose of the excess water as quickly as possible. The catchment area should be preferably less than 40ha.

1. Weirs

a) Clear over fall Stone weirs

b) Stone Channel weir

c) Ramp-cum-waste weir

2. Pipe outlets.

3. Grassed outlets

These outlets are provided either on the main Contour bunds or on the side bunds. Generally, the crest level of the weir is kept at 30cm above the ground level.

2. Graded Bunds

Graded Bunds are laid out in areas where the land is susceptible to water erosion, the soil is less Permeable and the area has water logging Problems. A graded bund System is designed to dispose of excess runoff safely from agricultural fields.

A graded bund is laid out with a longitudinal slope gradient leading to the outlet. The gradient can be either uniform or variable. Uniform graded bunds are suitable where the length of bund is less and the discharge behind the bund or in the channel is not large. Uniform graded is given throughout the length of the bund. Variable graded bunds are suitable where length of bunds and discharge are more. Variable bunds are provided in different sections of the bund so that the velocity of flow is within non-erosive limits. This Practice is suitable for these areas, which receive the annual rainfall greater than 800mm.

The design of graded bunds involves the selection of the vertical interval and the Provision of suitable grades and cross-sections for the bund and channel. The required capacity of the channel at a given section of bund can be determined by using the Rational method. The dimensions of the channel can be obtained by applying the Manning's formula and other Practical Considerations. A free board of 15 cm or 20% of design depth whichever is more, is necessary.

Recommended Side slopes for graded bunds

Type of Soil		Side slope H : V
Clayey soil	—	1:1
Sandy soil	—	2:1
Loamy soil	—	1.5:1

Recommended slopes of Seepage line for bunds

Type of Soil		Side line slope
Clay soil	—	3:1
Sandy soil	—	6:1
Sandy loam soil	—	5:1

Conservation ditching

Conventional type of bunding and terracing are not suitable for black soils having low infiltration -rates, excessive swelling when wet and shrinkage on drying which results in cracks causing breaching of bunds. Hence as an alternative, the concept of conservation ditching which are practically inverted bunds dugouts in the soil, are suitable in these regions. It works on the principal that if properly designed, it stores most of the runoff and reduces erosion in the downstream reaches of the ditch. The water stored in the ditch is utilized for providing supplemental irrigation during the drought spells in the rainy season. Hence, it is a dual purpose structure suitable for arable lands under specific soil and climatic conditions.

Construction

In construction, the conservation ditch is essentially an inverted form of a contour bund (sunken into the ground) with flatter upstream side slopes provided for safety against scouring by the incoming runoff. Contour ditches, spaced at 75m interval with dimensions of 30 m length, cross-section area of 1583 sq.m. (base width 0.61 m; side slope upstream 5:1, downstream 1.5:1; & depth 0.61m) have been evaluated for storing 20% of a 10-year frequency and 24 hours rainfall along with the runoff. ~~Most of the eroded soil could~~ also be soil loss ~~from 7.3 tonne/ha to 2.6 t/ha in vertisols~~

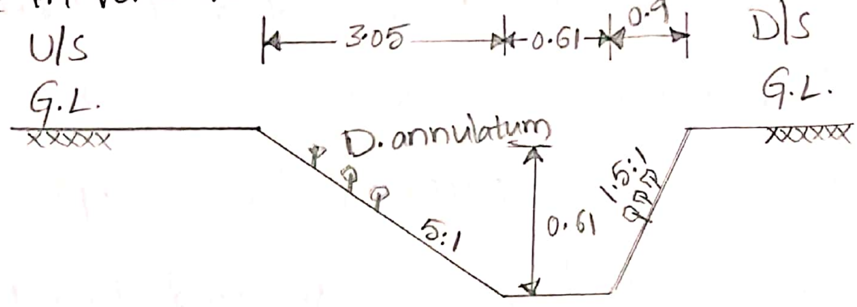


Fig. Cross-Section of a Conservation ditch.

Conservation ditches were found effective in reducing runoff by about 70-90% and soil loss from 7.3 t/ha to 2.6 tonne/ha in vertisols. The stored water when used for irrigation of rabi, jowar increased the yield of 36%. Dichanthium annulatum grass planted on the upstream (5:1) and downstream (1.5:1) side slopes yielded on an average 3.4 t/ha forage in low rainfall year & as high as 15.5 t/ha in good rainfall years when ditches were full of water.

Terraces

A terrace is an earth-embankment, Constructed across the bund to Control runoff and minimize the soil erosion. A terrace acts as an intercept to land slope and divides the sloping land surface into strips. In limited widths of strips, the length of runoff is reduced. It has been found that soil loss is proportional to the square root of the length of slope is increased as twice the soil erosion increases in proportion of 1.4 times.

By shortening the length of the slope, terraces contribute greatly to reducing soil loss. About 70% of the soil distributed by splash erosion moves downhill. Terraces produce a barriers to partially stop this downhill movement of soil. A great part of the splashed soil is deposited in the terrace Channel.

The terracing Practice is adopted for soil & water Conservation in that area, where land slope is greater than 10%, soil is more erodible and prevails high rainfall intensity. Terracing Practice is not Possible, Particularly on those hill sloped areas, where soil depth is not Sufficient

Classification of Terraces / Types of Terraces

In India, the terraces are Classified into two major types. 1. Broad base terraces

2. Bench terraces.

Terraces types

- Broad base terraces
  - Graded terraces (Drainage channel type)
    - with proper channel
    - without proper channel.
  - Level terraces (Absorption or ridge type)
- Bench terraces
  - Levelled table top
  - Sloping outward
  - Sloping inward
  - Puertorican

Bench Terraces

* Bench terraces are the platform like construction which are constructed along the contour of the sloping land.
* This type of terraces are generally constructed on the land of 15 to 33% slope.
* Bench terraces play a significant role to make the hilly land suitable for cultivation.
* In this system, the hilly land is modified in the form of several steps, which intercept the following water through the soil surface.
* These steps are also used for cultivation purposes.
* Generally, tea, coffee, sugarcane, etc are successfully grown on these terraces depending upon the climatic factors such as rainfall etc.

Level Bench Terraces

* This type of bench terraces consists of level top surface.
* The level bench terraces are also known as irrigated bench terraces as well or table top or paddy terraces.

* Level bench terraces are generally used in the areas which receive medium rainfall and have highly Permeable soils.
* The level bench terraces used for paddy cultivation.

Bench terraces sloping inward

* Bench terraces sloping inward are Preferred to construct in the areas of heavy-rainfall and less Permeable soils, from where large portion of rainwater is drained as surface runoff.
* Such type of bench terraces have a provision to drain the runoff from their inner side by constructing a drainage channel.
* This type of bench terrace is also known as hill type bench terrace.
* The inwardly sloping bench terraces are usually Preferred for growing those crops, which are extremely susceptible to water-logging, such as potato.

Bench terraces sloping outward

* Such bench terraces are adopted in low rainfall areas with Permeable soil.
* For these terraces a shoulder bund is essential even though this bund is also provided in other two types.
* The main function of shoulder bund is to provide the stability to the outer edge of the terrace.
* In addition, this bund also helps in retaining the surface runoff on the benches that is either absorbed by the soil or drained.

* Bench terraces sloping outward are also known as orchard type bench terraces.

* For outwardly sloping bench terraces constructed on soils having poor permeability, the provision of graded channel at lower end is most essential for dispersing surplus surface water to the grassed water way.

Design of Bench Terraces.

1. **Spacing of Bench Terrace** - It is the vertical distance between two successive bench terraces.

$$V.I = 0.3\left(\frac{S}{2} + 2\right)$$

Spacing for graded terrace

$$V.I = aS + b$$

where, $V.I$ = vertical Interval, m

S = land slope, %

a & b are constants depending upon geographical locations, erodibility and cover condition

i) Vertical interval for batter slope 1:1

$$V.I = \frac{WS}{100 - S}$$

ii) Vertical interval for batter slope ½:1

$$V.I = \frac{2WS}{200 - S}$$

2. **Width of Bench Terrace**

$$W = \frac{200D}{S}$$

where, W = width of terrace, m

D = Depth of cut, m

S = slope, %

3. Peak Runoff rate from the Upstream Bench Terrace

$$Q_{peak} = \frac{CIA}{360}$$

$$A = \frac{LW}{10,000}, ha$$

where, L = length of terrace, m

W = width of terrace, m

A = drainage area of terrace, ha.

4. Volume of Earthwork Per Hectare

a) for level bench terraces

* $$E_W = 1250\ V.I$$

$$= 1250 \times \frac{WS}{100}$$

$$E_W = 12.5\ WS$$

b) For inward sloping bench terrace

$$E_W = 1250\ V.I$$

$$E_W = 12.5\ W(S+s)$$

c) For outward sloping bench terrace

$$E_W = 1250\ V.I$$

$$E_W = 12.50\ W(S-s)$$

Where, E_W = volume of Earthwork Per hectare, m^3.

W = width of terrace, m

S = land slope, %

Small 's' = inward or outward slope of the bench, %

V.I = vertical Interval, m.

5. Total Length of Terrace Per Hectare.

$$L = \frac{10,000}{H.I}$$

6. Area Lost in Bench Terrace

a) when batter slope is 1:1

$$A_L = \frac{S+200}{\frac{200}{S} + \frac{S}{100}}$$

b) when batter slope is ½:1

$$A_L = \frac{S+100}{\frac{200}{S} + \frac{S}{100}}$$

where, A_L = Area lost due to terracing

S = land slope, %

Problem-1: Bench terraces are constructed on a 10% hill slope. If the vertical interval is 1.5m, calculate the volume of earthwork per hectare (m^3)

Solution, Given

$S = 10\%$

$V.I = 1.5m$

Volume of earthwork/ha, $E_W = 12.5\,WS$

$$\frac{WS}{100} = V.I$$

$$V.I = \frac{WS}{100}$$

$$1.5 = \frac{W \times 10}{100}$$

$W = 15m.$

$$E_W = 12.5\,WS$$

$= 12.5 \times 15 \times 10$

$$E_W = 1875\ m^3.$$

Problem-2: Bench terraces are to be constructed on a hill having 15% slope. If the vertical interval of the terrace is 1.5 m. Calculate area lost (%) when the batter slope of terrace is 1:1.

Solution: Given

$S = 15\%$

$V.I = 1.5\,m$

Batter slope is 1:1

$$\text{Percentage (\%) of area lost} = \frac{S + 200}{\frac{200}{S} + \frac{S}{100}}$$

$$\boxed{A_L = \frac{S+200}{\frac{200}{S} + \frac{S}{100}}}$$

$$A_L = \frac{15+200}{\frac{200}{15} + \frac{15}{100}}$$

$$\boxed{A_L = 15.94\%}$$

Problem-3: It is proposed to construct bench terraces on 10% hill slope. If the batter slope is ½:1, the percent area that will be lost for cultivation due to bench terracing is

Sol:- Given

$S = 10\%$

batter slope = ½:1

$$\boxed{A_L = \frac{S+100}{\frac{200}{S} + \frac{S}{100}}}$$

$$A_L = \frac{10+100}{\frac{200}{10} + \frac{10}{100}}$$

$$\boxed{A_L = 5.47\%}$$

Contour Trenching:

Contour trenching is commonly Practiced to Conserve runoff water. The trenches may be in long line across the slope on contour or may be of the staggered type. Contour trenches are Constructed across the slope on sloping land. The excavated materials are placed on the downstream side of the trench so as to form an embankment or bund. planting is usually done on the toe of the embankment with the trench at the upstream.

Contour trenches intercept and break the velocity of the runoff water and Provide for Pounding of the intercepted flow. When the runoff water exceeds the Storage capacity of the trenches, the excess flow is drained at non erosive velocity. The rain-water thus collected Provides for soil moisture storage. The water thus collected Provides for soil moisture storage. The deep Percolation and Seepage Contribute to the soil moisture in downstream reaches. The trenches when laid in long runs across the slope with a non-erosive gradient are identical to graded terrace.

Contour trenches are classified into two types

1. Graded trenches &
2. Staggered trenches.

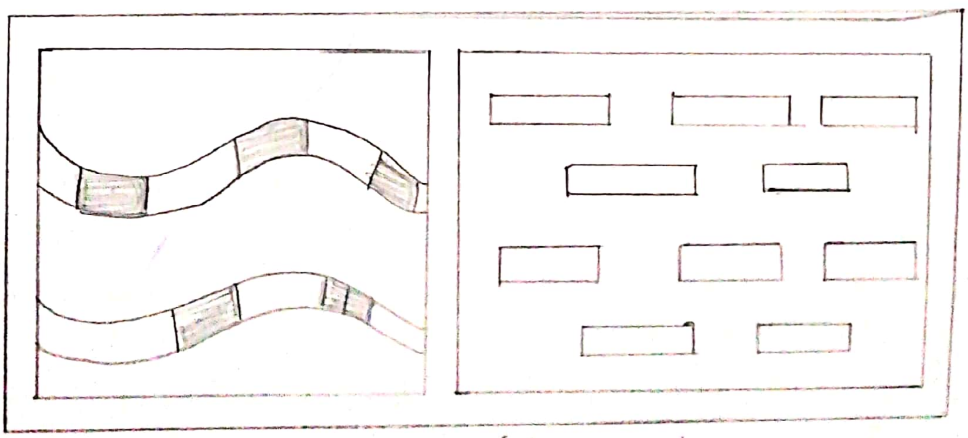
1. Graded Trenches:-

Graded trenches are suitable in high rainfall areas while level trenches laid on contour are suitable for low rainfall regions.

The cross-section of the trench is about 30 cm x 30 cm. The catchment area of each trench is the inter space between adjacent trenches. The side slopes of the trench range between 1:1 to ½:1, depending upon on the type of soil.

2. Staggered Trenches:

Staggered trenches are of short length, compared to the graded trench or contour trench. They are laid in row along the contour with inter space between them. The inter spaces are usually of the same length as the trench. The length of staggered trenches ranges from 3 to 4m. The inter space between the trenches range from 2.5 to 3m. The cross-section is trapezoidal with a bottom width of 30 to 45cm. The side slopes range from ½:1 to 1:1. The vertical interval between two successive trenches is decided on the basis of the anticipated runoff from the area above, without over flow. In a staggered sequence, alternate rows of trenches are located directly below one another.



(a) Contour Trenching (b) Staggered Trenching.

Contour trenching has been found suitable even in situations where the land slope exceeds 33% or more in regions with high rainfall. The trench could be as long as 100 to 500m starting from the farthest end to the outlet. Usually, the trenches are run level or very gently sloping in the initial reach up to about 100m. A gradient of about 500 to 1 in 300 is provided as the trench approaches the outlet.

Contour trenching has been found to be very effective especially in afforestation programmes. A common practice in case of staggered trenches is to have 4m long trenches at intervals of 4m long a contour line.