SOIL EROSION CONTROL

MECHANICAL MEASURES

Mechanical measures play a vital role in controlling and preventing soil erosion on agricultural lands. They are adopted to supplement the agricultural practices (biological methods). The mechanical measures include **contour bund, graded bund, terraceing and contour stonewall** etc.

Contour Bunding

As discussed in exercise 8.

Design of contour bunds

Vertical Interval between bunds (V.I)

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

where,

S – land slope (%); a and b are constants

a = 3 and b =2 for medium and heavy rainfall zones

a = 2 and b =2 for low rainfall zones

Horizontal Spacing in between bunds (H.I)

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

Length of bund per hectare (L.B)

$$L.B. \text{ per ha} = \frac{100S}{V.I} \text{ or } \frac{10{,}000}{H.I}$$

Depth of water impounding before the bund (h)

$$h = \sqrt{\frac{D * R}{500}}$$

where,

D – vertical interval (m)

R – maximum rainwater on area basis (mm)

Actual height of the bund = h + 20% of h as freeboard

DIMENSIONS OF THE CONTOUR BUND

Type of soil	Bottom width (m)	Top width (m)	Height (m)	Side slope
Gravel soils	1.2	0.3	0.6	0.75: 1
Red soils	2.1	0.3	0.6	1.5: 1
Shallow to medium black soil	2.4	0.45	0.75	1.3: 1
Deep soils	3.3	0.60	0.675	2: 1

By knowing the cross section area of the bund, the volume of earthwork per hectare and the cost of earthwork per hectare can be determined.

Graded Bunds

Graded bunds are constructed in medium to high rainfall area having an annual rainfall of 600 mm and above and in soils having poor permeability or those having crust forming tendency (black soils), and in the lands having slopes between 2 and 6%. These bunds are provided with a channel if necessary. Uniformly graded bunds are suitable where the length of bund is less and the discharge behind the bund or in the channel is not much. Variable grades are provided in different sections of the bund. For uniform graded bund, a grade from 0.1% to a maximum of 0.4% is adopted and for variable graded bund the grade will vary with the length of the bund. The required capacity of the channel can be determined by using the rational method.

The spacing between two graded is based on the formula

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

where,

V.I – vertical interval (m)

S – slope (%)

a – constant value ranging from 3 to 4; b = 2

GRADED BUND SPECIFICATION

Type of soil	Bottom width (m)	Top width (m)	Height (m)	Side slope
Shallow soil	1.1	0.3	0.4	1: 1
Red and alluvial soil	1.5	0.5	0.5	1: 1
Heavy soil	2.1	0.5	0.5	1.5: 1

For graded bunds, the horizontal interval, length per hectare and cost estimation are similar as that of contour bunds.

Broad Base Terrace

A broad base terrace is a broad surface channel or embankment constructed across the slope of the rolling land for reducing runoff erosion and for moisture conservation. The broad base terrace has a ridge of 25 to 50 cm high and 5 to 9 m wide gently sloping on both sides and a channel along the upper side, constructed to control erosion by diverting runoff at a non-erosive velocity. It is classified as graded *i.e*. channel type terrace and leveled or ridged type terrace.

Narrow base terrace is similar to a board base terrace in all respects except the width of ridge and channel. The base width of a narrow base terrace is usually 1.2 to 2.5 m. These terraces are made in the lands having a slope above 6% and upto 10%.

Design of board base terrace

1. Horizontal Interval (H.I.) in meters

$$\text{H.I} = \frac{200}{\text{S}} + 10 \text{ where S is slope in \%}$$

2. Vertical Interval (V.I) in meters

$$\text{V.I} = 2 + \frac{\text{S}}{10}$$

3. Length of the terrace per hectare

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

4. Channel design

The channel capacity is calculated by using the rational formula and the dimensions of the channels are predicted by using the Manning's formula and the permissible velocities.

Contour Stone Wall

In this, cut stones of size around 20 cm are dry packed across the hill slope to form a regular shape of random rubble masonry without mortar. After construction it should be stable enough so that a man can walk on it. They are constructed in lands having slopes between 10 and 16% and above.

The spacing between two successive stone walls is 10 to 15 m. A longitudinal slope of 1 in 500 or 0.2% is provided towards the safe outlet. The top portion of the stone wall should be straight. As in the case of contour bunding vertical deviation of plus or minus 25 cm is permitted for laying the stonewalls along the boundaries to suit the convenience of the land owner. Each stone wall must end in an outlet either natural or artificial. Besides conserving moisture and controlling erosion, these stone walls are constructed to form bench terraces in a gradual manner.

Design of contour stone wall

1. Vertical Interval (V.I) in meters

$$\text{V.I.} = \frac{S}{8} + 4$$

2. Horizontal Interval (H.I) in meters

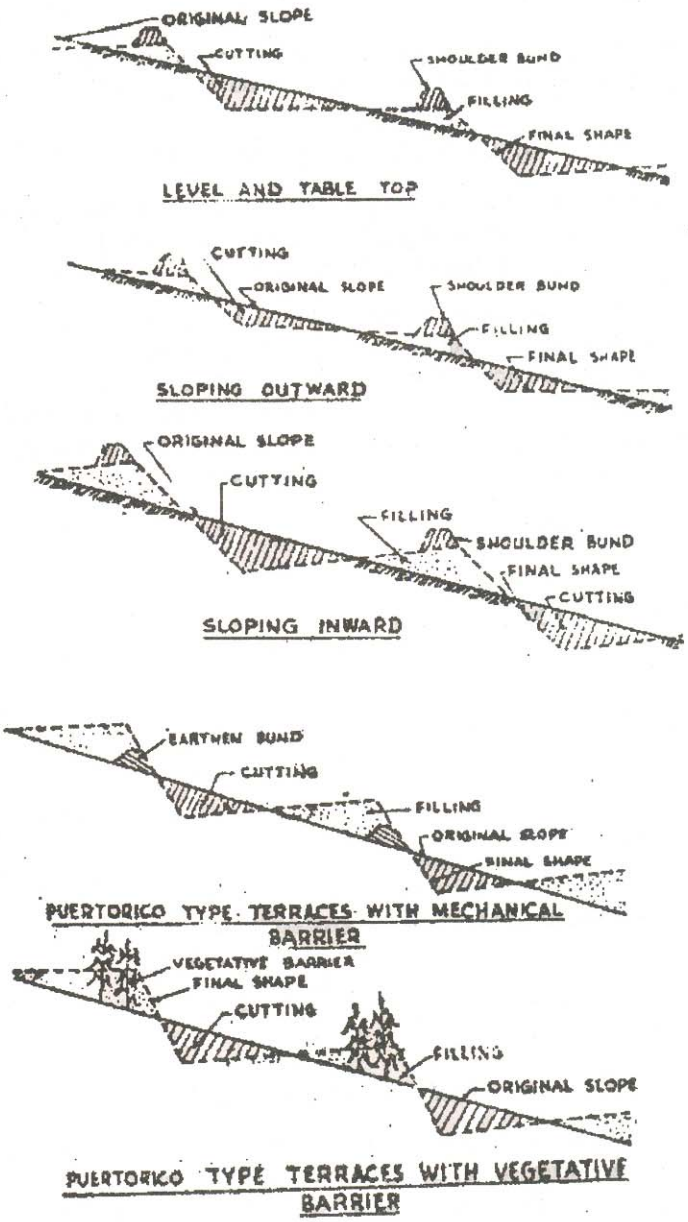
$$\text{H.I} = \frac{\text{V.I}}{S} \text{x} 100$$

3. Length per hectare

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

4. Volume of stones required (m^3 ha^{-1})

V = Cross sectional area of the stone wall x Length per hectare



Bench Terracing

Bench Terracing

Bench terracing is one of the most popular mechanical soil conservation practices adopted by farmers of India and other countries for ages. On sloping and undulating lands, intensive farming can be only adopted with bench terracing. It consists of construction of step like fields along contours by half cutting and half filling. Original slope is converted into level fields and thus all hazards of erosion are eliminated. All the manure and fertilizers applied are retained in the field. In sloping irrigated lands, bench terracing helps in proper water management. Bench terraces are normally constructed in lands having slope between 16 and 33%.

Type of bench terraces and their adaptability

1. ***Level Bench Terrace:*** Paddy fields require uniform impounding of water. Level bench terraces are used for the same and to facilitate uniform impounding. Sometimes this type of terraces are termed as table top, or paddy terraces, conveying the same that such bench is as level as top of the table.
2. ***Inward Sloping Bench Terrace:*** Crops like potato are extremely susceptible to water logging. In that case the benches are made with inward slope to drain off excess water as quickly as possible. These are especially suited for steep slopes. It is essential to keep the excess runoff towards hill (original ground) rather than on fill slopes. These inwardly sloping bench terraces have a drain on inner side, which has a grade along its length to convey the excess water to one side, from where it is disposed-off by well stabilized vegetated waterway. These are widely used in Nilgiri hills of Tamilnadu state as well as on steep Himalayan slope in Himachal Pradesh and North-Eastern hill regions. Longitudinal slope of 1 in 120 and inward slope of 1 in 40 is adopted in Nilgris.
3. ***Outward Sloping Bench Terraces:*** Farmers many a times carry out the leveling process in phases, doing part of the job every year. As such outward sloping bench is usually a step towards construction of level or inward sloping bench terraces. In places of low rainfall or shallow soils, the outwardly sloping bench terraces are used to reduce the existing steep slope to mild slope. In this type of terraces constructed on soils not having good permeability, provision of graded channel at lower end has to be kept, to safely dispose off surplus water to some

water way. In very permeable soils a strong bund with arrangement may take care for most of the rainfall events, while during heavy rainfall storm, the excess water may flow from one terrace to another. Attempt is usually made to dispose-off this to some waterway at an earliest possible spot.

4. ***Puertorican or California Type of Terraces****:* In case of Puertorican type of terrace, the soil is excavated little by little during every ploughing and gradually developing benches by pushing the soil downhill against a vegetative or mechanical barrier laid along contour. The terrace is developed gradually over years, by natural leveling. It is necessary that mechanical or vegetative barrier across the land at suitable interval has to be established.

Design of Bench Terraces

1. Type of Bench Terrace

It is selected among the three types and depends upon rainfall, soil conditions, land use etc.

2. Terrace Spacing and Width

It is normally expressed in terms of the vertical interval at which the terraces are constructed. It depends upon factors like slope, soil and surface condition, grade and agricultural use.

Steps for terrace spacing design

i. Find the maximum depth of productive soil range

ii. Having the above consideration in view, find out the maximum admissible cutting (d), for the desired land slope (S) and the crops to be grown.

iii. Having fixed the depth of cutting, the width of the terrace (W) can be computed for the slope (S) by using the formula *ie.* for vertical cut

$$W = \frac{200d}{S}$$ where W and d are in meters and S in %

and $$d = \frac{D}{s}$$ where D – vertical interval

iv. For a batter slope of 1: 1 riser, the vertical interval is

$$D = \frac{WS}{100 - S}$$

and for a batter of 0.5: 1 riser, the vertical interval is

$D = \frac{2WS}{200 - S}$ and the width of the terrace will vary suitably.

3. Terrace Gradient

In high rainfall areas, for quick disposal of the excess water, a suitable gradient has to be provided for newly laid out terraces.

4. Terrace Cross Section

The design of terrace cross section involves the batter slope, cross section area of the shoulder bund, inward or outward slope of the terrace field.

Trenches

Contour or staggered trenches are adopted in high rainfall hilly areas of lands with slope steeper than 33% or nay slope with badly eroded soil. Length of staggered or contour trench will be 3 to 3.65 m while the inter space between trenches in the same row will be only 2.4 to 3 m. The trenches will be trapezoidal in cross section with 0.3 to 0.45 m bottom width, side slopes of 0.5: 1 or 1: 1.

In addition for stabilization of soil, steps are to be taken to plant the area with fast growing tree and grass species. Plants are put on the trench side of the bunds along the berms.

Example

On a 20% hill slope, it is proposed to construct bench terraces. If the vertical interval is 2 m, calculate (i) length per hectare, (ii) earthwork, and (iii) area lost both for vertical cut and batter slope of 1: 1. The cut should be equal to fill.

Solution:

For vertical cut,

$$W = \frac{100 * D}{S} = \frac{100 * 2}{20} = 10\,m$$

$$\text{Length per hectare} = \frac{10{,}000}{10} = 1000\,m$$

$$\text{Earthwork} = \frac{1}{2} * 5 * \frac{2}{2} * 1000 = 2500\,m^3$$

Since it is vertical cut, no area is lost for cultivation, except the area for shoulder bund.

When the batter slope 1: 1

$$W = \frac{100(100 - S)}{S} = \frac{2(100 - 20)}{20} = 8\,m$$

$$\text{Length per hectare} = \frac{10{,}000}{8 + 1 + 1} = 1000\,m$$

$$\text{Earthwork per hectare} = \frac{1}{2} * 4 * 1 * 1000 = 2000\,m^3$$

Area lost for cultivation = 21.57%