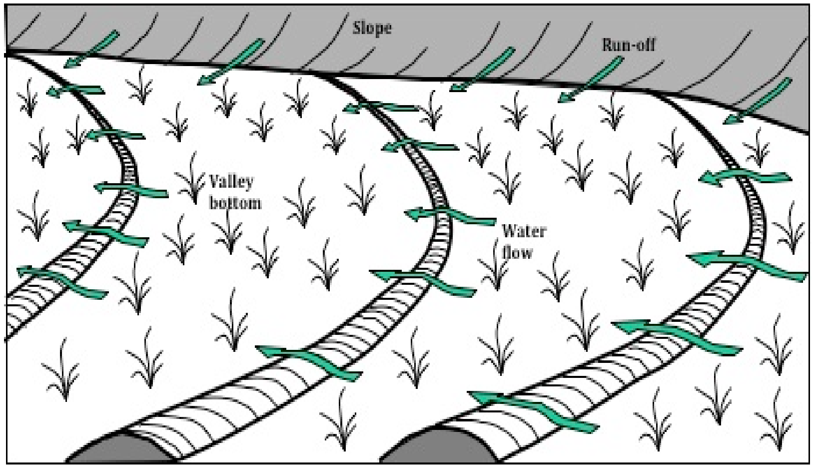
Bunding

It is an engineering soil conservation measure, used for retaining water, creating obstruction, and thus controlling soil erosion or soil loss. When they are constructed on the contour of the area, are called **contour bund** and when grade is provided to them, then they are known as **graded bund**. In bunding practice, the entire area is divided into several small parts, thereby the effective slope length of the area is reduced. The reduction in slope length causes not only to reduce the soil erosion but also retain the runoff water in the surrounded area of the bund. Contour bunds are used in low rainfall areas for the purpose to control the soil erosion and to store rain water, while the graded bunds are constructed in relatively medium to high rainfall area for the same purpose as the contour bunds.

Contour Bunding

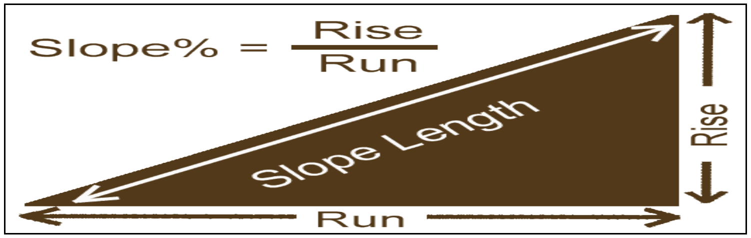
What?

The bunds passing through the points of equal elevation (i.e. on contour) of the land are known as contour bunding



Why?

- It reduces the length of slope, which in turn to reduce soil erosion



- Impounds the water at u/s portion, and permits more water to get recharged into the soil that is utilized for crop cultivation

Where?

- In all types of soils except deep black cotton soils
- In areas where annual rainfall does not exceed 800 mm
- In arid and semi-arid areas where soils are of high infiltration and permeability
- It is commonly used on agricultural land up to 10% slope

What are the structural Components?

- Borrow pit
- Berm
- Weir
- Main Bund

Let us understand design of contour bunding by example

1 Hectare = 10,000 square meters 1 Hectare = 2.471 acres

Problem: A piece of land measuring 1350 m along the slope and 250 meters across the slope has a uniform slope of 2 %.The maximum 24 hour rainfall for 10 years recurrence interval is 200 mm. The soils are sandy loam in texture and having a good infiltration rate. Design the cross section of the main bund if the top width of the bund is 0.5m. The side bunds are to be taken up to the slopes of 0.5 m above the main bund line. Find the earth work of bund.

Solution:

(1) Area to be brought under construction of contour bunding: 1350 m x 250m = 337500 square meters = 33.75 hectares = 83.40 acres

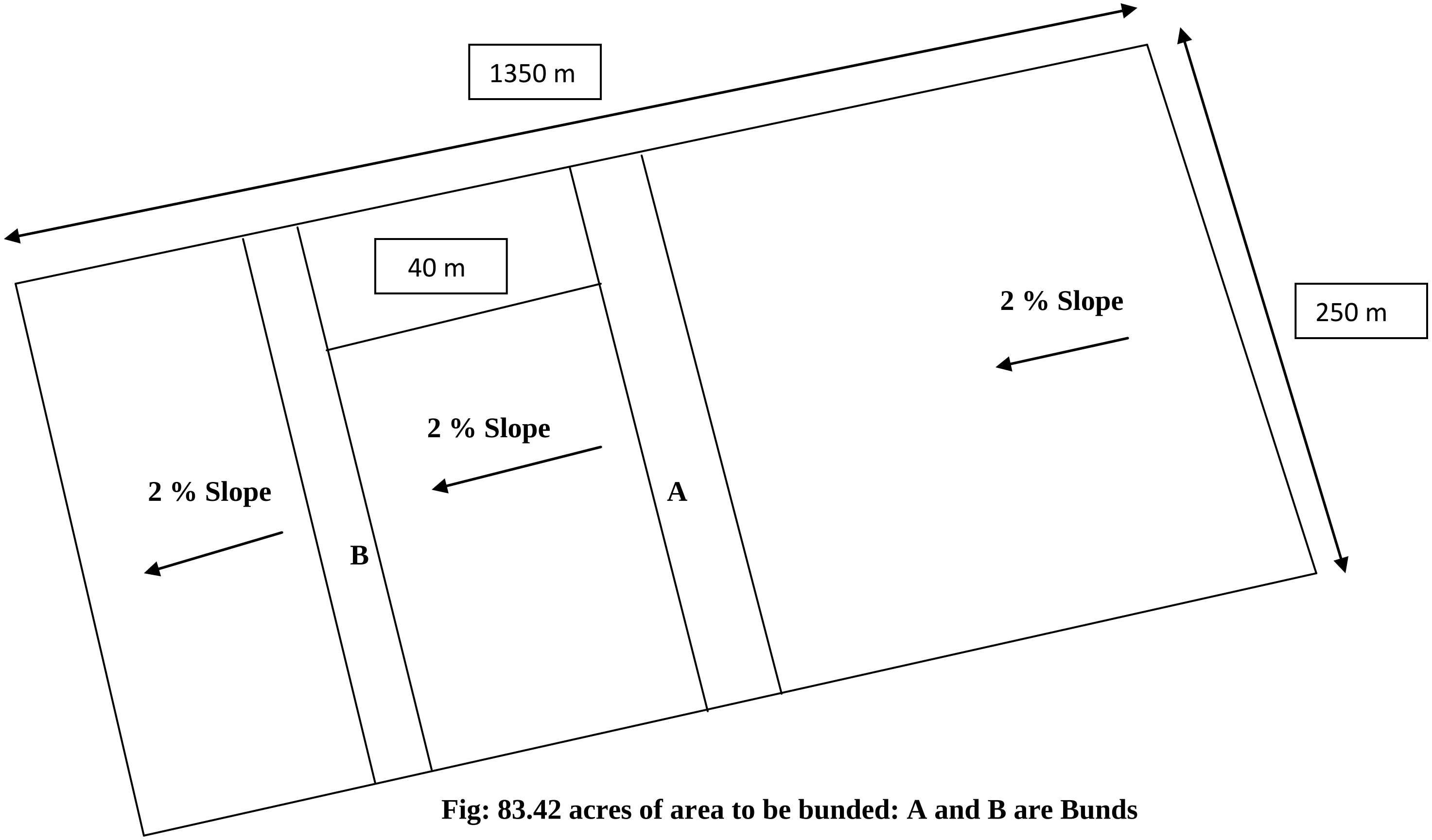


Fig: 83.42 acres of area to be bunded: A and B are Bunds

(2) Now we have to determine following parameters

- Volume of earth work for the main bund

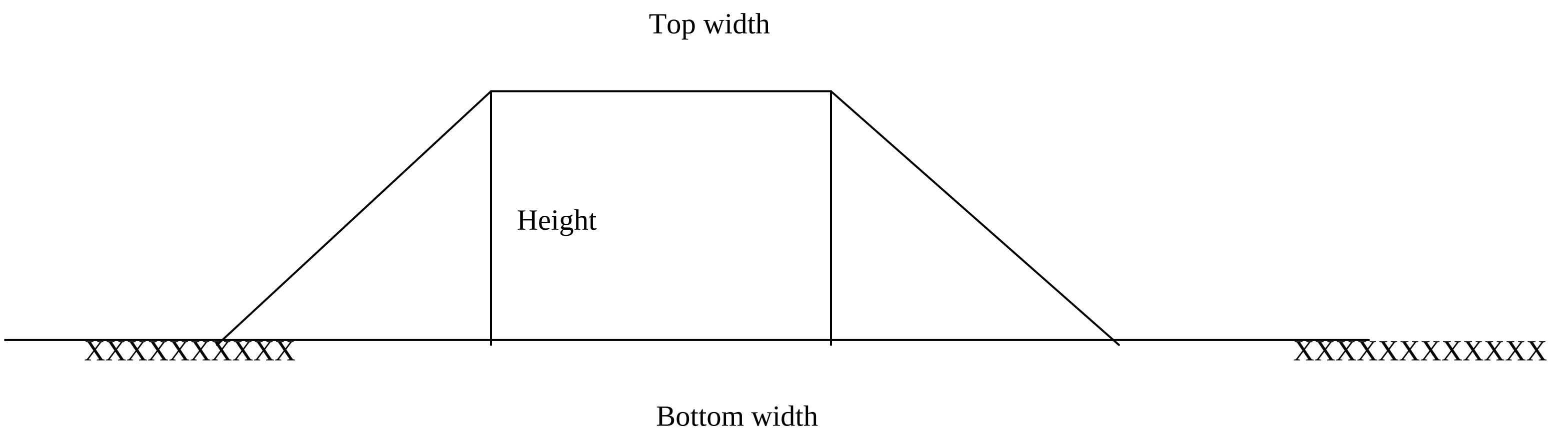
Volume of earth work for the main bund = Total length of the bund for the area to be bunded x Cross sectional area of bund

- Total length of the bund for the area to be bunded

Total length of the bund for the area to be bunded = Length of the bund per hectare x Total area to be bunded (in hectares)

- Cross-sectional area of bund

Cross-sectional area of bund =((Top width + Bottom width) / 2) * Height



Note: In general, a minimum of 0.3 to 0.6 m width is kept to facilitate planting of grasses on the top of the bund.

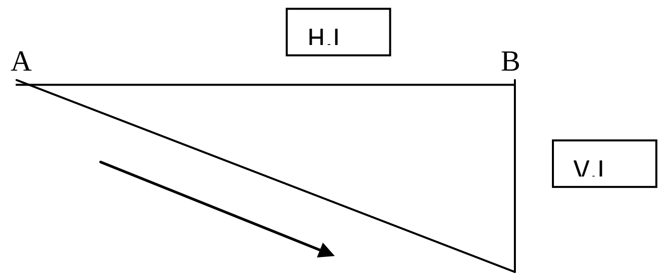
Stylosanthes Hamata grass is grown on the bund

- **Height of bund (h)**

Height of the bund (h) is decided for a 30 cm depth of impounding which is a usual practice in many states. The design of bund for 30 cm depth of impounding is an arbitrary design. The height of bund to impound run off from 24 hours storm is calculated as follows

$$h = \sqrt{Re \times VI/50}$$

Where, Re is 24 hour rainfall for 10 years recurrence interval and VI = Vertical Interval



Vertical Interval (V.I) = 0.3 (S/a + b)

Where, S is the land slope, a & b are constants. Where “b” is taken as 2

For soils with good infiltration rates, the value of “a” is taken as 3 and for soils with low infiltration rates, the value of “a “is taken as 4.

Infiltration rate

Low infiltration rate less than **15 mm/hour;** medium infiltration rate **15 to 50 mm/hour;** high infiltration rate more than **50 mm/hour.**

- **Obtain rainfall data from nearest Rain Gauge Station and find out the maximum - 24 hour rainfall occurred in 10 years recurrence interval.**

- **Horizontal Interval**

  H.I = 100 V.I/S

- **Number of Bunds (N)**

  N = Length of the field / H.I

- **Freeboard (f)**

  Minimum of 10 cm is provided as free board.

- **Bund side slopes**
- **Cross section of Bund**

Cross-sectional area of bund =((Top width + Bottom width) / 2) * Height

Given value in the problem

Side slope ratio for sandy loam soils is 1.5:1

Height of the bund (h) = $\sqrt{\text{Re x VI/50}}$

Vertical Interval (V.I) = 0.3 (S/a + b)

S = 2%

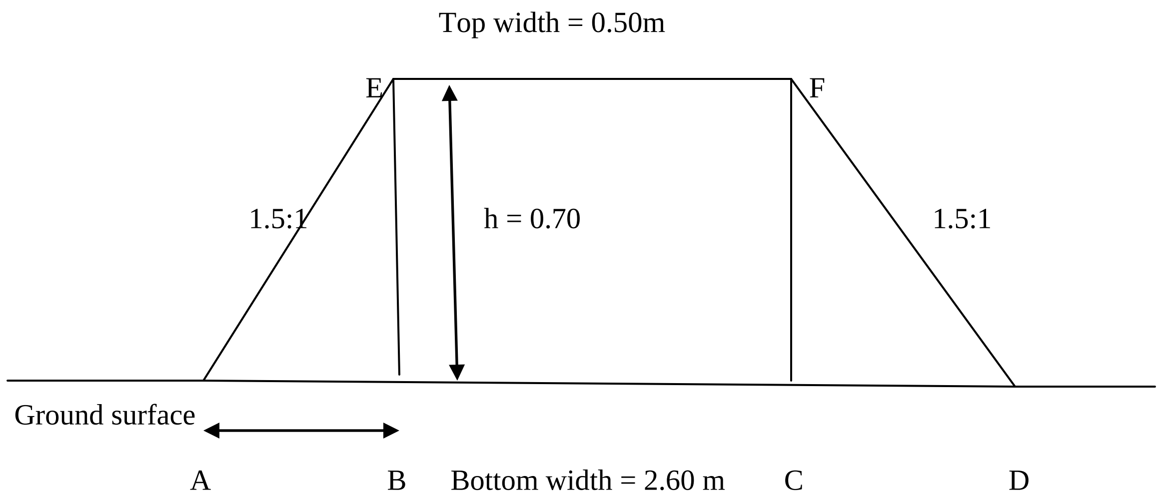
Since the given soils are having good infiltration rate, value of “**a”** = 3 and **“b” = 2**

V.I = 0.3(2/3 + 2) = 0.80 m

Re is given as 200mm = 20cm

h = $\sqrt{20\text{x}0.80/50}$ = 0.57 m

Actual height of bund after adding freeboard = 0.57 + 0.10 = 0.67 = 0.70m



Bottom width = AB + BC + CD

Here EF = BC = 0.50 m

AB = h x 1.5 = 0.70 x 1.5 = 1.05 m

CD = h x 1.5 = 0.70 x 1.5 = 1.05 m

Bottom width = AB + BC + CD = 1.05 + 0.50 + 1.05 = 2.60 m

Cross-sectional area of bund = ((Top width + Bottom width) / 2) * Height

= ((0.50 +2.60)/2) * 0.70

= (3.10/2)*0.70 = 1.55 *0.70 = 1.085 m2

Total length of the bund for the area to be bunded = Length of the bund per hectare x Total area to be bunded (in hectares)

Length of the bund per hectare = 100 S/VI = 100x2/0.80 = 250 m

Total area = 33.75 ha

Total length of the bund for the area to be bunded = Length of the bund per hectare x Total area to be bunded (in hectares)

= 250 x 33.75 = 8437.5 m

Volume of earth work for the main bund = Total length of the bund for the area to be bunded x Cross sectional area of bund

= 8437.50 m x 1.085 m2 = 9154.6875 m3 = 9155 m3

- **Volume of earth work for side bunds = Total length of side bunds x cross sectional area of side bund**

Number of Contour Bunds (N)

N = Length of the field / H.I = 1350/40 = 34 No.s

Number of side bunds = 2x 34 = 68 No.s

Length of side bund = 100 x d/2

Where d is the elevation difference between the end point of side bund and contour bund

Given value of "d" = 0.5 m

= 100 x 0.5 /2 = 25 m

Total length of all side bunds = 68 x 25m = 1700 m

Cross sectional area of side bund is usually taken as 2/3 rd of the main bund

= 2/3 x 1.085 m2 = 0.7233 m2

Volume of earth work for side bunds = Total length of side bunds x cross sectional area of side bund

= 1700 m x 0.7233 m2 = 1299.61 m3 = 1230 m3

Total volume of earth work for main and side bunds = 9155 + 1230 = 10385 m3

Construction steps

- Layout for construction should be started from top of the catchment.
- A horizontal line along the slope is marked at one end of the field.

- Using a pipe level, contour line is demarcated up to the end of the field.
- Next line for contour bund is demarcated on the line with elevation difference equal to vertical interval.
- Soil for construction of bunds should be taken from burrow pits of suitable chosen size.
- Size of burrow pits should be as per required volume of earth required for bund.
- Normal size of burrow pit is 3 x 3 x 0.3 m or 3 x 3 x 0.45 m.
- Burrow pit should not be continuous, but interrupted with a gap of 0.6 m.
- A space of 0.3 m is provided as the gap between the bund and burrow pit which is called as berm.
- All bunds from the top are constructed to their full sections.
- All the burrow pits should be uniform in size and the berm gap should be uniform.
- Ramps are provided for the free passage of cattle, implements etc. on the bund.
- Suitable vegetation protection must be provided to ensure stability of the bund.

Contour Bunds: DO's and DONT's

i. Always provide a berm (distance from excavated portion to bund) of minimum 30 cm.
ii. Always provide a settlement allowance of 10-15% depending on soil type.
iii. Exit must be provided in sloping land and in impermeable soils, depending on site conditions.
iv. In impermeable soils increase the cross section area of bunds.
v. Do not start the lay-out of bunds from the shorter section. Always begin from the longest section within the largest area of uniform slope.
vi. Do not make bunds on slopes higher than 10%. On relatively high slopes do not make bunds closer than 30 m.
vii. On low slopes do not make bunds farther than 60 m.
viii. Do not construct bunds where there is already dense vegetation.
ix. Do not excavate if roots of a tree are encountered
x. Do not excavate soil continuously in permeable soils.

GRADED BUNDING

Graded bunds are laid along a predetermined longitudinal grade instead of along the contour for safe disposal of excess runoff.

a) Suitability:

Graded bunding is recommended in situations where the rain water is not readily absorbed either due to high rainfall or low intake rates of the soils. It is adopted in medium to high rainfall areas where annual rainfall exceeds 800 mm in low permeable soils and particularly in clayey soils (infiltration rate <8mm/hr.) even with lesser rainfall.

b) Planning and design of graded bunding:

The design of the graded bund involves the selection of the vertical interval and the provision of grades and suitable cross-section for the bund and channel. A typical bund and channel section is shown in Figure 2.12. By and large graded bunds of 0.3 to 0.50 m2 cross section are constructed.

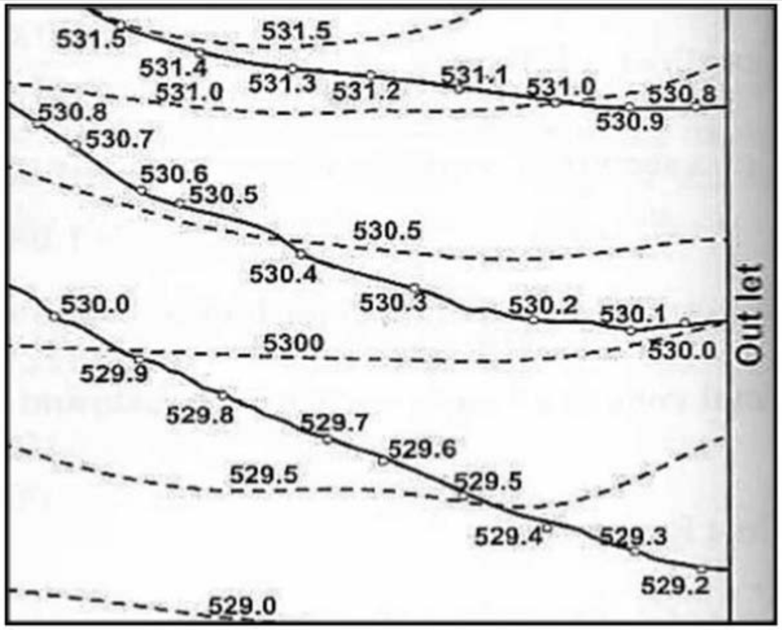


Figure 2-11: Planning of graded bunding on contour map

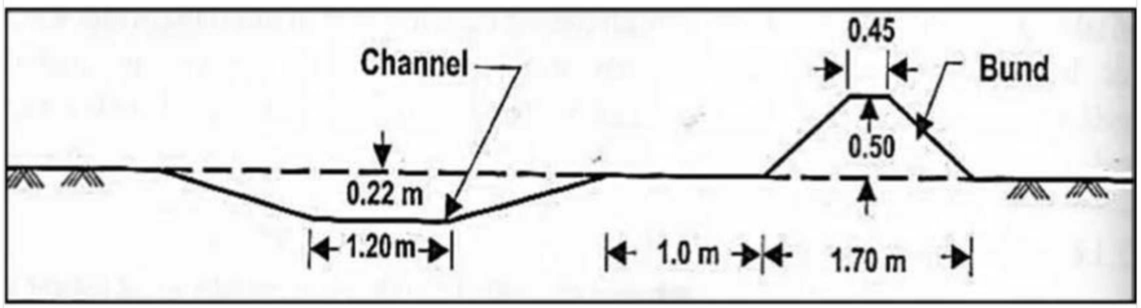


Figure 2-12: Details of graded bund

Graded bunds are spaced at the same vertical interval as that of contour bunds. The following vertical intervals have been arrived at by using an arbitrarily fixed formula.

VI = (S/6+2)*0.3 for the area where rain fall is > 800 mm.

Slope (%)	**VI (m)= 0.3x(S/6 +2)**	**HI (m)= VI/S x100**
1	0.3 x (1/6 + 2)= 0.6498 or 0.65m	0.65/1 x=
2	0.3 x (2/6 + 2)= 0.6999 or 0.70m	0.70/2 x=

VI = (S/4+2)*0.3 for the area where rainfall is <800 mm.

Slope (%)	**VI (m)= 0.3x(S/4 +2)**	**HI (m)= VI/S x100**
1	0.3 x (1/4 + 2)= 0.6750 or	0.70/1 x=
2	0.3 x (2/4 + 2)= 0.7500 or	0.75/2 x=

- **Grade:**

In general a grade of 0.20 to 0.40% is provided depending upon the soil type. In permeable soils the grade may vary from 0% at the upper end to 0.5% at the outer end. In case of impervious soils, it may start with 0.2% at the upper end and increase to 0.4% at the outlet.

- **Channel cross-section:**

- The main requirements of satisfactory channel cross-section are adequate channel

capacity to discharge the flow and the channel side slopes flat enough to permit farming operations without causing damage to cross-section.

- Usually the channel depth of a settled terrace from bottom of terrace to the top of ridge

should be at least 0.45 m. usually, a minimum cross-section of 1 sq. m is provided to the channel.

- The capacity of the channel of terraces depends on cross-section and velocity. The

velocity should be non-erosive.

The permissible velocity in different type of soil is as follows:

Bare Soil: 0.50 m/ sec

Sandy Soil: 0.30 m/sec.

Clayey soil: 0.75 m/sec.

-The channel is designed for handling a peak discharge of 10 year frequency for the inter-bunded area using rational formula while manning's formula is used for deciding the cross-sectional area and flow velocity. The channel side slopes are kept as 5:1 or flatter to facilitate cultivation. Generally the shape and size of the channel remain same throughout the length while the gradient may be varied to take care of the increasing quantity of runoff as the length of bund increases.

-The availability of channel with good vegetation for disposing off the excess water from

the graded bunds is essential.

For designing channel, formulas used are:

Rational formula, $Q = \frac{CIA}{360}$ **.... (2.10)**

Where,

Q = Design peak rate of runoff, m^3/s,

C = Runoff coefficient,

I = Intensity of rainfall, mm/hr for the duration equal to time of concentration (T_c) of watershed and design RI, and

A = Area of the watershed, ha.

Manning's formula for velocity of flow in channel

V = 1/n R2/3 S1/2 **.... (2.11)**

Where,

V = velocity of flow in the channel (m/sec),

R = hydraulic radius (m)’

S = hydraulic Slope (M/m) and

n = the manning’s roughness coefficient.

c) Construction:

Starting from the ridge, the site of the first bund is located at desired/designed vertical interval aligned along the predetermined grade avoiding sharp bends through the permissible deviations mentioned under the contour bund. A channel of suitable width is marked leaving 1.2 m from the inner edge of the bund on the upstream side. Bund and channel are trapezoidal in shape with channel size depending on the size of the bund as the bund has to be formed from the soil excavated for making the channel. The waterways are to be protected with stone/vegetative checks and drops at suitable interval for providing stability. The channels and the channel grade need to be maintained once in 2 to 3 years for their effective functioning since cropping is done in the channel portion also.

d) Example:

Case study: Graded bunding in Manneguda watershed (A.P.) Design the graded bund for the following parameters:

Maximum length of terrace, L = 340 m

Average slope of watershed S = 2%

Vertical interval, VI = 1.2 m as per the field situation

Solution:

Average width of terrace, W (HI) = VI/S * 100

= 1.2/2 * 100 = 60 m

Inter-terrace area A = 340 * 60 = 20400 Sq.m = 20400/10000 = 2.04 ha

Runoff coefficient, C = 0.25

Longitudinal gradient = 0.4 %

Length of run = 340 + 60 = 400 m

Fall = (0.4/100 * 340) + 12 = 1.36 + 1.20 = 2.56 m

Time of concentration (Tc) = 15 min

$Tc = 0.0195K^{0.77}$

Where $K = \sqrt{L^3/H}$,

L= Maximum length of flow of water (m),

H = Difference in elevation between the most remote point and the outlet (m) Design intensity (I) for 10 years frequency and duration of 15 Min

(From the intensity – duration – frequency formula)= 96.40 mm/hr.

Peak discharge Q	=	CIA/360 = 0.25 x 96.40 x= 0.137m3/sec
Top width	=	0.30m
Assumed height	=	0.60m
Side slopes	=	1:1
Bottom width	=	1.50m
Slope in channel	=	0.4%
Area of cross-section	=	$\frac{(1.5+0.3)}{2}$ 0.60 = 0.54m^2

Assuming a water sheet flowing along bund with 0.15 m depth,

The flow area (A) becomes 0.57 m2

The wetted perimeter for the section will be 7.57 m and hydraulic radius will be 0.075 m the longitudinal grade of bund is 0.4%

According to Manning's formula. V = (R2/3S1/2) /n

Where,

V = Velocity m/sec

R = Hydraulic radius, m

S = Slope, m/m

n = Manning's coefficient

$$V = \frac{(0.075)^{2/3} \times (0.004)^{1/2}}{0.04} = 0.28 \text{ m/sec}$$

This velocity is within safe limits.

Discharge = Q = A * V = 0.57 * 0.28 = 0.16 cu.m / sec

E/W Estimate.

Length of bund per ha = 100 * S/VI = 100 * 2/1.20 = 167 m

Where, S = Land slope % = 2 %

VI = Vertical Interval in m = 1.2 m

Cross Section of Bund = 0.54 sq.m

Volume of E/W per ha = 167 * 0.54 = 90.18 cu.m