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.

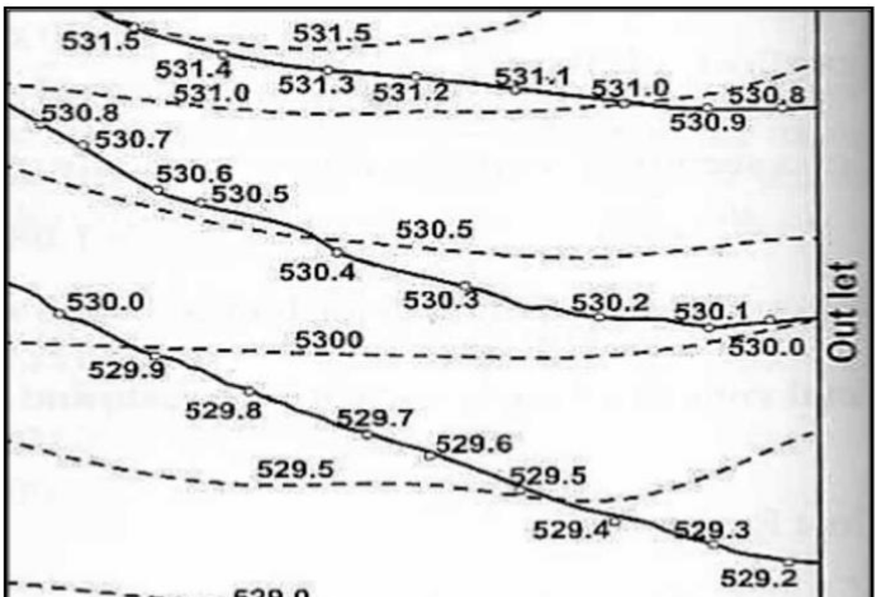

Figure 2-11: Planning of graded bunding on contour map

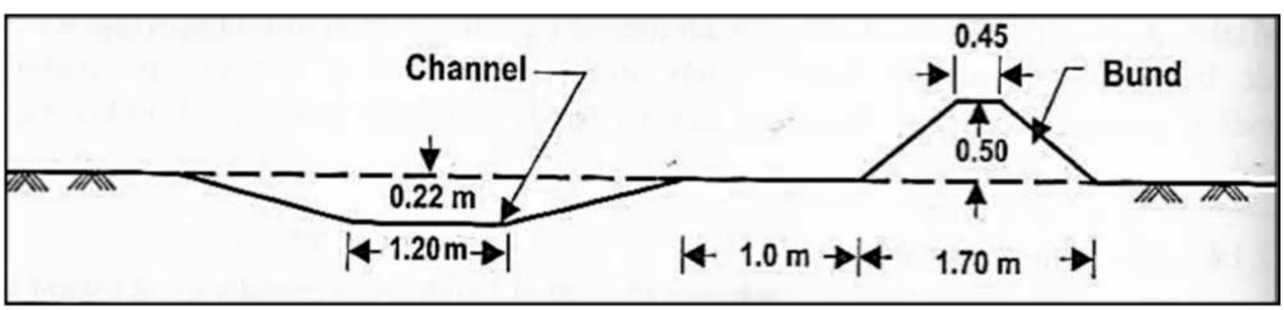

Figure 2-12: Details of graded bund

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