PRCATICAL MANUAL

Course Title	:Soil and Water Conservation Engineering
Credit	: 2(1+1)
Course Code	:CC-AGL-210
Prograamme	:B.Sc. (Hons.) Agriculture

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INDEX

PRACTICAL NO. 1

TITLE: GENERAL STATUS OF SOIL CONSERVATION IN INDIA

Objective: To study about soil conservation status in India

Activities: study status of soil conservation and identify soil conservation structures

Skill obtained: can able to describe soils erosion and its effects, identify soil conservation structures

Introduction: Soil degradation in India is estimated to be occurring on 147 million hectares of land which includes; 94 Mha from water erosion, 16 Mha from acidification,

- **14 Mha** from flooding,
- **9 Mha** from wind erosion,
- **6 Mha** from salinity, and
- **7 Mha** from a combination of factors.

The causes of soil degradation are both natural and human-induced. Natural causes include earthquakes, tsunamis, droughts, avalanches, landslides, volcanic eruptions, floods, tornadoes, and wildfires. Human-induced soil degradation results from land clearing and deforestation, inappropriate agricultural practices, improper management of industrial effluents and wastes, over-grazing, careless management of forests, surface mining, urban sprawl, and commercial/industrial development. Inappropriate agricultural practices include excessive tillage and use of heavy machinery, excessive and unbalanced use of inorganic fertilizers, poor irrigation and water management techniques, pesticide overuse, inadequate crop residue and/or organic carbon inputs, and poor crop cycle planning. Some underlying social causes of soil degradation in India are land shortage, decline in per capita land availability, economic pressure on land, land tenancy, poverty, and population increase.

Effects of Soil Erosion in India

- Soil erosion results in huge loss of nutrients in suspension or solution, which are washed away from one place to another, thus causing depletion or enrichment of nutrients.
- Besides the loss of nutrients from the topsoil,
- There is also degradation through the creation of gullies and ravines.
- Water causes sheet-wash, surface gullies, tunnels and scours banks in rivers.
- In hot and dry climate of India, wind blowing is the main cause of soil erosion.

Indian government is adopting adequate measures to reduce the unpleasant effects of soil erosion in India particularly in the states like Punjab, Maharashtra, Karnataka.

Introduction to Soil Conservation:

Soil and water conservation is essential to protect the productive lands of the world. In our country, where droughts, famines and floods cause crop damage almost every year, soil conservation will not only increase crop yields but also prevent floods and further deterioration of land.

Broad objectives of these Centre's are:

(i) To identify erosion problems and conservation of land and water resources under different land use systems, (ii) To evolve mechanical and biological methods of erosion control under different land use systems, (iii) To evolve methods of control of erosion and reclamation of ravines stabilization of landslides and hill torrents, (iv) To evaluate hydrological behavior and evolve techniques of watershed management , (v) To set up demonstration projects for popularizing soil and water conservation measures,

(vi) To impart specialized training in soil and water conservation to gazetted and non-gazetted officers of State Governments.

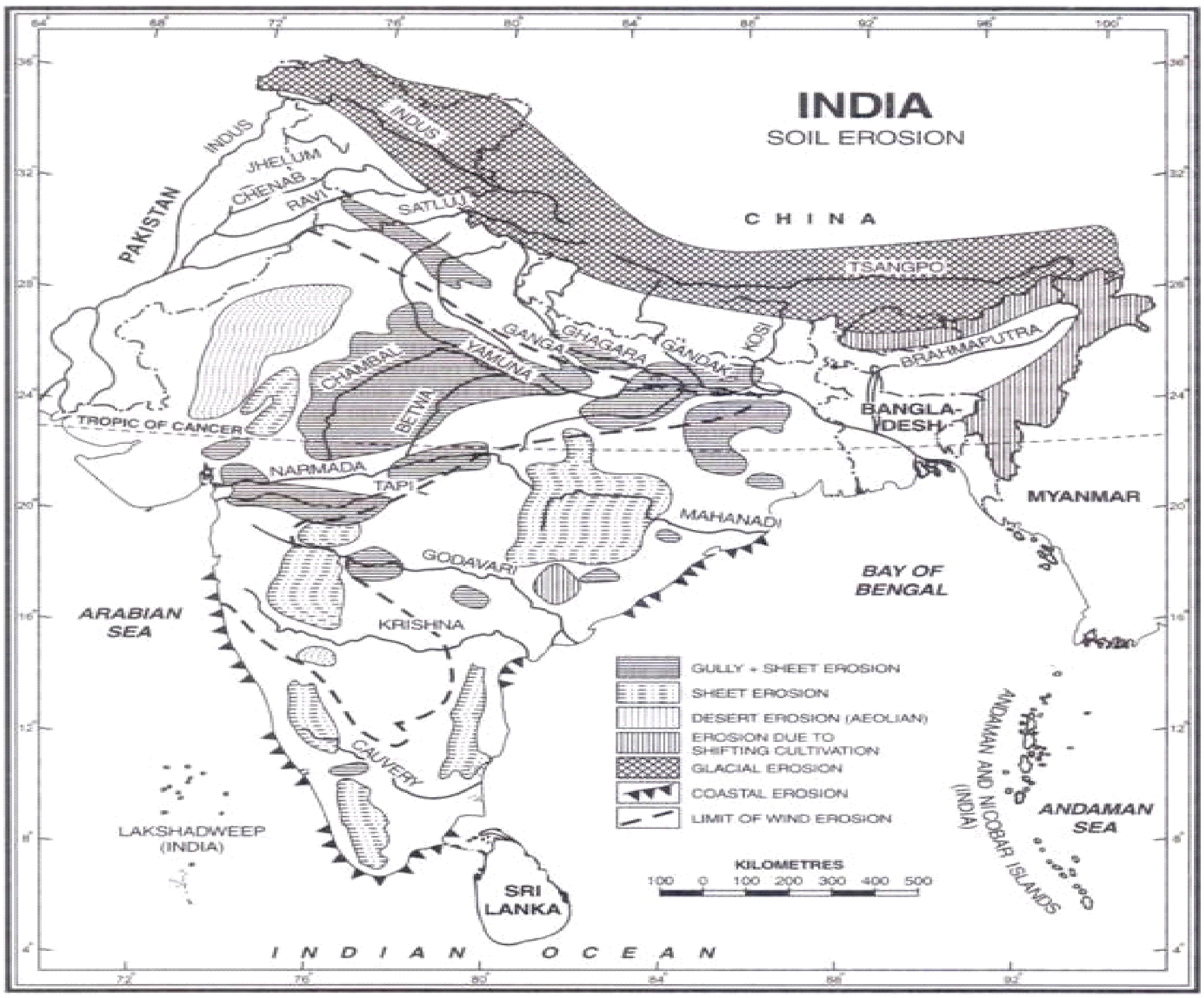


FIG. 7.2. India : Soil Erosion

Table 12.1

Central Soil and Water Conservation Research Demonstration and Training Centres in India (Tejwani, 1980)

Location	Region/major problems	Date of start
(1)	(2)	(3)
Dehradun	North-western Himalayan region. Erosion control in Himalayas; training of torrents; stabilisation of landslides; development of techniques for crop production; establishment of pastures and forestry.	28.9.1954
Chandigarh	Sub-montane tracts in the north-western region of India with special reference to Shiwalik hills. Erosion control in Shiwaliks; training of chos.	28.9.1954
Ootacamund	Southern hill high rainfall region/soil and water conservation in the Nilgiris hills; development of techniques for crop production; establishment of pastures and forestry.	10.10.1954
Bellary	Semi-arid black soil region. Soil and water conservation in the black soil region.	20.10.1954
Kota	Along the Chambal river in Rajasthan. Ravine problem on the banks of Chambal river and its tributaries; survey, classification and reclamation of ravines for forage production and forestry.	19.10.1954
Vasad	Along the rivers of Gujarat State. Ravine problem specifically along the banks of Mahi river system; survey, classification and reclamation of ravines forage production and forestry.	11.5.1955
Agra	Along the Yamuna river and its tributaries. Ravine problems specifically on the banks of Yamuna river; survey, classification and reclamation of ravines for forage production and forestry.	22.7.1955
Hyderabad	Red soil, semi-arid region. Soil and water conservation in the red soils under low to medium rainfall regions.	10.1.1962
Chattra	North-eastern Himalayan region. Erosion control in the Kosi river catchment.	19.12.1956

Important Soil and Water Conservation Programmes implemented by state and central Govt.

- Soil conservation in catchments of river valley project (RVP).
- Integrated Watershed Management in the catchments of flood Prone Rivers (FPR).

- Centrally Aided Drought Prone Area Development Program (DPAP), (as per 1995 guidelines) implemented by Government and NGO. Desert Development Programme (DDP)
- National Watershed Development Program for Rain fed Area (NWDPRA) implemented by Dept. of Soil Conservation & Watershed Management, Gov.M with financial support from Department of Agriculture, Gov.I
- Operational Research Projects on Integrated Watershed Management (ICAR)
- World Bank Project on Watershed Development in Rain fed Area.
- Council for Peoples Action & Rural Technology (CAPART) supported 38 Watershed Development Programs in Maharashtra
- DPAP & IWDP projects (of 2001 guidelines) in Satara, Sangali& Nasik Districts of Maharashtra state.
- NABARD Holistic Watershed Development Programme
- Vasundhara Watershed Development Project
- Maharashtra government has launched a new programme named 'Jalyukta Shivar Abhiyan' in a state on January 26, 2015. The programme aim to make 5000 villages free of water scarcity every year and to conserve and protect the soil from further degradation. This Abhiyan aims at initiating permanent measures to make the state drought free by 2019 and to harvest rain water within the village boundary thereby increasing ground water levels.

Video link :

1. https://youtu.be/TWm5tOAD-sE

Answer the following questions

1. List out some important state and central Govt. implemented Important Soil and Water Conservation Programmes

Answer:

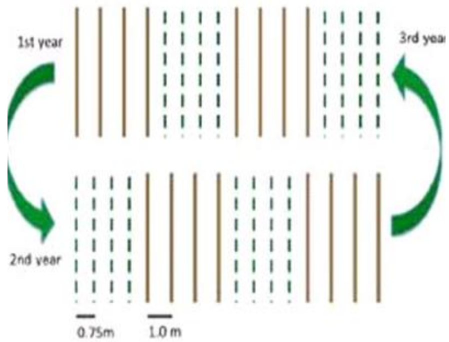
2. List out and write their important functions of Central Soil Conservation Research Demonstration and Training Centers in India

Answer:

3. Write short note on Importance of Soil Conservation and effect of soil erosion

Answer:

4. Identify the figure and write their functions in soil conservation

Fig:			
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PRACTICAL NO. 2

TITLE: CALCULATION OF EROSION INDEX

Objective: To find out erosion index using different parameters

Activities: Solving problems on estimation of erosion index by considering and incorporating values of different parameters influencing the soil loss

Skill obtained: Can able to estimate erosion index for different soils under different crop conditions and watershed conditions which will be further helpful for design of soil and water conservation structures

Introduction: The rainfall erosivity factor ‘R’ is the sum of individual rainstorm erosivity value, EI30, over a time period, usually a year (USDA). Here ‘E’ is the total kinetic energy of a rainstorm and I is the maximum 30 minute intensity of rainstorm. Storms with rain amount less than 13 mm and separated from other rain period by more than 6 h are not included in the computation unless 6 mm of rainfall occurs in 15 min. Mathematically, R is the annual.

The rainfall erosivity is related to the kinetic energy of rainfall. The following two methods are widely used for computing the erosivity of rainfall.

1. EI30 Index method and

2. KE > 25 Index method.

1. EI30 Index Method

This method was introduced by Wischmeier (1965). It is based on the fact that the product of kinetic energy of the storm and the 30-minute maximum rainfall intensity gives the best estimation of soil loss. The greatest average intensity experienced in any 30 minute period during the storm is computed from recording rain gauge charts by locating the maximum amount of rain which falls in 30 minute period and later converting the same to intensity in mm/hour. This measure of erosivity is referred to as the EI30 index and can be computed for individual storms, and the storm values can be added over periods of time to give weekly, monthly or yearly values of erosivity.

The rainfall erosivity factor EI30 value is computed as follows:

$$EI_{30} = KE \times I_{30} \quad EI_{30} = KE \times I_{30}$$

where KE is rainfall kinetic energy and I30 is the maximum rainfall intensity for a 30-minute period. Kinetic energy for the storm is computed from Eqn.

$KE=0.119+0.0873 \log I$ for $I \ll 76$ mm/hr

$KE=0.283$ for $I > 76$ mm/hr

Where I =Intensity of rainfall (mm/hr)

KE= Rainfall kinetic energy per unit depth of rainfall (MJ/ha mm)

The EI30 index method was developed under American condition and is not found suitable for tropical and sub-tropical zones for estimating the erosivity.

2. KE > 25 Index Method

This is an alternate method introduced by Hudson for computing the rainfall erosivity of tropical storms. This method is based on the concept that erosion takes place only at threshold value of rainfall intensity. From experiments, it was obtained that the rainfall intensities less than 25 mm/h are not able to yield the soil erosion in significant amount. Thus, this method takes care of only those rainfall intensities, which are greater than 25 mm/h. That is why the name is K.E. > 25 Index method. It is used in the same manner as the EI30 index and the calculation procedure is also similar.

Calculation Procedure

The estimation procedure is same for both the methods. However, K.E. > 25 method is more advantageous, because it sorts out many data less than 25 mm/h, hence uses less rainfall data. For both the methods, it is important to have data on rainfall amount and its intensity.

The procedure involves the multiplication of rainfall amounts in each class of intensity to the computed kinetic energy values and then all these values are added together to get the total kinetic energy of the storm. The K.E. so obtained, is again multiplied by the maximum 30-minute rainfall intensity to determine the rainfall erosivity value.

Video link:

1. https://youtu.be/9Y_8ZvNbP7c

Problem1. Find out the total kinetic energy of rainfall and also its erosivity using EI30 and K.E.> 25 index methods for the following given rainfall amount and intensity values.

Cumulative time (min)	Cumulative rain fall depth (mm)	Duration (mm)	Rainfall depth (mm)	Rainfall intensity (mm/hr)	KE per unit depth of rainfall (MJ/ha mm)	Total KE (MJ/ha)	Summation of all total KE (MJ/ha)
0	0						
20	1						
27	4						
36	12						
50	27						
57	30						
65	35						
80	40						
90	40						
110	44						
130	50						
150	55						

Calculation

EI30 index:

KE>25 index:

Conclusions:

PRACTICAL NO. : 3

TITLE: ESTIMATION OF SOIL LOSS BY UNIVERSAL SOIL LOSS EQUATION

Objective: To find out the soil loss by using different parameters

Activities: Solving problems on estimation of soil loss by considering and incorporating values of different parameters influencing the soil loss

Skill obtained: Can able to estimate the soil loss for different soils under different crop conditions and watershed conditions which will be further helpful for design of soil and water conservation structures

Introduction: The universal soil loss equation (USLE) developed by Wischmeier & Meyer; & the same was published in the year 1973 by Wischmeier & Meyer. This equation was designated as Universal Soil Loss Equation, and in brief it is now as USLE. Since, simple & powerful, tool for predicting the average annual soil loss in specific situations. The associated factors of equation can be predicted by easily available meteorological & soil data.

The term 'Universal' refers consideration of all possible factors affecting the soil erosion/soil loss; and also its general applicability. The USLE is given as under:

$$\mathbf{A = R\ K\ LS\ C\ P}$$

Where,

A = computed soil loss, expressed in t/ha/y for a given storm event.

R = rainfall erosivity factor, which is the measurement of the kinetic energy of a specific rain event or an average year's rainfall.

K = soil erodibility factor. It is the soil loss rate per erosion index unit for a given soil as measured on a unit plot. (22.1 m long with 9 % slope in continuous clean –tilled fallow)

L = slope length factor. It is the ratio of soil loss from the field plot under existing slope length to that from the 22.1 m slope length (Unit plot) under identical conditions.

S = slope gradient factor. It is the ratio of soil loss from the field slope gradient to that from the 9% slope (unit plot) under identical conditions.

C = cover or crop rotation (management) factor. It is the ratio of soil loss from the area under specified cover and management to that from an identical area is tilled continuous fallow (unit plot).

P = erosion control practices or soil conservation practices factor. It is the ratio of soil loss under a support practice like contouring, strip cropping or terracing to that under straight – row farming up and down the slope.

Rainfall Erosivity Factor (R): It refers to the rainfall erosivity index, which expresses the ability of rainfall to erode the soil particles from an unprotected field. It is a numeral value. From long term field studies, it has been observed that the extent of soil loss from a barren field is directly proportional to the product of two rainfall characteristics: 1) kinetic energy of the storm; and 2) its 30- minute maximum intensity.

Soil Erodibility Factor (K): This factor is related to the various soil properties, by virtue of which a particular soil becomes susceptible to get erode, either by water or wind. Physical characteristics of the soil greatly influence the rate at which different soils are eroded. In general, the soil properties such as the soil permeability, infiltration rate, soil texture, size & stability of soil structure, organic content and soil depth, affect the soil loss in large extent.

Slope Length and Steepness Factor (LS): The LS factor represents the erosive potential of a particular soil with specified slope length and slope steepness. This factor basically affects the transportation of the detached particles due to surface flow of rainwater, either that is the overland flow or surface runoff. And accordingly affects the value of soil erosion due to any given rainfall. The capability of runoff/overland flow to detach and transport the soil materials gets increased rapidly with increase in flow velocity. On steep ground surface the runoff gets increase because of increase in runoff rate. The factors- L and –S are described as under:

Slope Length Factor (L): The slope length is the horizontal distance from the point of origin of overland flow to the point where either the slope gradient gets decrease enough to start deposition or overland flow gets concentrate in a defined channel.

Slope Steepness Factor (S): Steepness of land slope influences the soil erosion in several ways. In general, as the steepness of slope increases the soil erosion also increases, because the velocity of runoff gets increase with increase in field slope, which allows more soil to detach and transport them along with surface flow.

Crop Management Practices Factor (C): The crop management practices factor (C) may be defined as the ratio of soil loss from a land under specific crop to the soil loss from a continuous fallow land, provided that the soil type, slope & rainfall conditions are identical. The crop & cropping practices affect the soil erosion in several ways by the various features such as the kind of crop, quality of cover, root growth, water use by growing plants etc.

Soil Conservation Practices Factor (P):

It may be defined as the ratio of soil loss under a given conservation practice to the soil loss from up and down the slope. The conservation practice consists of mainly the contouring, terracing and strip cropping in which contouring appears to be most effective practice on medium slopes ranging from 2 to 7 per cent.

Video link:

1. https://youtu.be/lMAq2nQLyuw

Solve the Problem:

Example 1: Calculate the annual soil loss from a given field subject to soil erosion problem, for the following information: Rainfall erosivity index = 1000 m.tonnes/ha, Soil erodibility index = 0.20, Crop management factor = 0.50, Conservation practices factor = 1.0, Slope length factor = 0.10. Also explain how the soil loss is affected by soil conservation practices.

Solution:

Example 2: A field is cultivated on the contour for growing maize crop. The other details regarding USLE factors are as follows:

K = 0.40

R = 175 t/acre

LS = 0.70

P = 0.55

C = 0.50

Compute the value of soil loss likely to take place from the field. Also, make a comment on soil loss when same field is kept under continuous pasture with 95 percent cover. Assume the value of factor- C for new crop is 0.003

Solution:

PRACTICAL NO. 4

TITLE: MEASURMENT OF SOIL LOSS (MULTI SLOT DIVISOR)

Objective: Estimation of soil loss from the field by using multi slot divisor.

Activities: Study about multi slot divisor and measurement of soil loss in filed

Skill Obtained: can able to estimate soil loss for different soils under watershed conditions which will be further helpful for design of soil and water conservation structures

Introduction: Multi slot divisor is useful for measuring runoff from small plots. It can measure quantity of runoff and can estimate soil loss from field. Its design and application is very simple. Mostly used for experiment purpose. It has mainly three parts:

- ✓ Collection tank
- ✓ Slot divisor (spout)
- ✓ Cistern tank

1. **Collection tank:** The collection tank is used to collect the runoff water from the plot. The water is diverted from the plot and discharged into the collect
2. ion tank. The tank has four compartments of different dimensions. The dimension of the collection tank varies according to the size of the plot and probable runoff to be collected. The probable runoff is calculated considering the plot size and maximum daily rainfall of the area. The collection tank is provided with roof cap to avoid rain water falling into the tank. The tank is provided with a provision to attach slot divisor.

2. Slot Divisor: The slot divisor with number of slots is used for experimentation, in which one slot is connected to the cistern tank. The divisor is always provided with the odd number of slots. The number of slot are decided as per the volume of water is to collected from the experimental plot. Larger the quantity of runoff, more are the slots and vice versa. It is also covered with cap on its top. The middle slot connected to the cistern tank, to collect excess runoff.

3. Cistern tank: It is the tank connected to the slot divisor to collect the runoff water for final measurement. The capacity of the cistern tank is decided as per the probable runoff and number of slots.

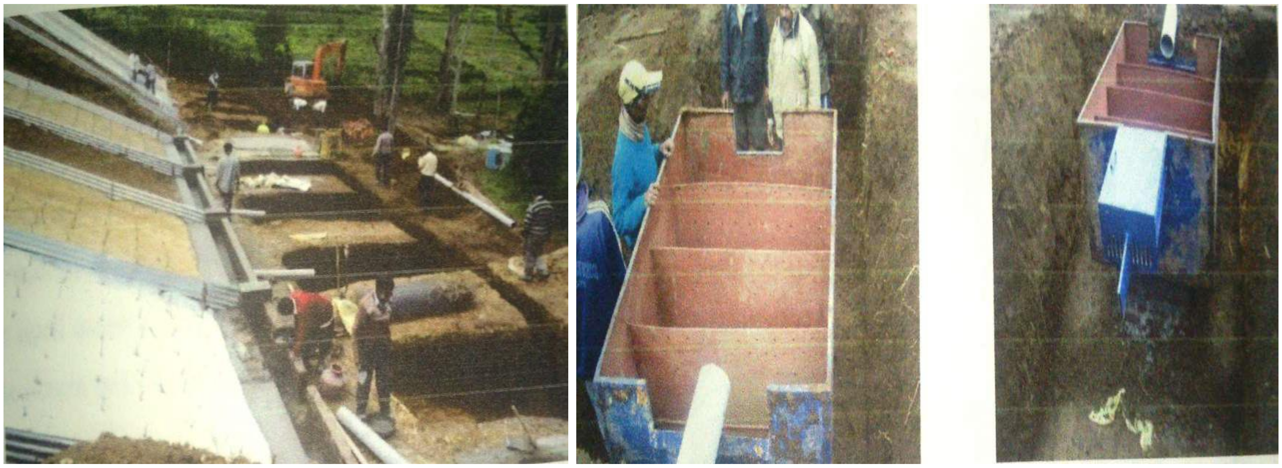

Fig. a) Multislot field setup b) Collection tank

Procedure:

1. Select the particular field from where soil loss is to be measured.
2. Generally, the dimensions of the field are selected as 15 x 4 m
3. Mark the plot boundary by erecting GI sheets along the boundary of plot such that no runoff water will enter into the experimental field Soil & Water Conservation Engineering
4. The runoff collection channel is constructed to divert the runoff water towards collection tank.
5. Pipe is used to convey the runoff water into the tank.
6. At the end of the plot pit is excavated to install the multi slot assembly to collect runoff water and runoff samples.

Calculation of runoff volume and soil loss:

Runoff volume: The runoff water collected in the **Cistern** tank is measured by using following formula

Where, V = volume of runoff water, m3

r = radius of cistern tank, m

h = height of tank, m

This is the volume of runoff water collected through one slot. Convert it into total volume of water collected from the plot considering the number of slots of the divisor. Then, calculate total volume of runoff water collected from one hector of land.

Estimation of Soil loss:

1. The runoff samples are collected from the collection tank in the bottles with continuous stirring of water.
2. Add alum to the water samples to allow the settlement of sediment in the sample bottles.
3. Keep it for 24 hrs for settlement.
4. Remove water from bottles.
5. Keep the soil/sediment for 24 hrs at 105 0C in oven dryer.
6. Then take dry weight of soil.
7. Calculate the soil loss in kg per hector.

Video link:

1. https://youtu.be/wAqrRdNtrh0

2. https://youtu.be/UUV5UQ-kv4U

Calculation:

PRACTICAL NO. 5

TITLE: MEASUREMENT OF LAND SLOPE (S) BY HAND LEVEL AND ABNEY LEVEL

Objective: To measure land slope for the given area

Activities: Measure the eye level of the observer.

Skills obtained: Can able to measure land slope for different topographies of land

Introduction: Determination of land slope is a necessary for all soil erosion studies as well as for implementing soil and water conservation programmes. In Universal Soil Loss Equation, the degree of slope parameter (S) is very important in soil loss estimation. Similarly for land capability classification (an important component for developing watershed management programmes), land slope is an important attribute of mapping unit, which forms the basis of determining class and subclass. Besides, for implementing soil conservation programmes, such as laying of contour bunds, designing of other mechanical structures such as check dams, spillways and other gabion structures measurement of land slope is important. Slope is expressed in percent, meaning the number of units the land falls (or rises) in 100 units of horizontal distance. The higher is the percent, the steeper will be the slope. Example: a slope that drops 10 vertical meters in 100 horizontal meters is a 10% slope (vertical drop/horizontal distance times 100). Two commonly used instruments for slope estimation:

Hand level: A hand Level is used for rough determination of elevations. It consists of a metal sighting tube with a bubble tube mounted on it. The bubble is located on the top of the instrument and its image is reflected by means of 45° mirror or prism inside the tube so that the user can see the bubble at the same time as the terrain. If the bubble is centered between the horizontal lines in the tube while sighting, the line of sight is horizontal. Hand level is satisfactory for laying out contour lines and for measuring slopes 8%

Fig.: The Abney level for slope measurement

Procedure

1. Measure the eye level of the observer.

2. Keep another person of same eyelevel as the target
3. Sight at the eye level of target and move the index arm over the scale of Abney level until the bubble image, cross wire and eye level of target come in the same line. At this stage the line of sight will be parallel to slope of land.

4. Read the degrees and minutes of the angle Φ on the scale in this position.

5. Slope % of land = tan Φ *100

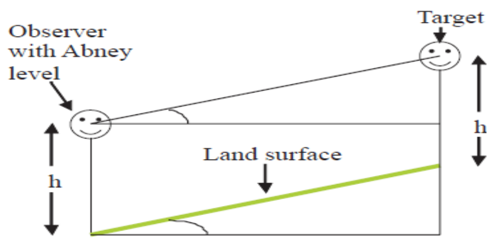

Fig.: Using an Abney Level to measurement slope

1. Sight at the tree tip and move the index arm over the scale of Abney level until the bubble image, cross wire and tree tip come in the same line

2. Read the degrees and minutes of the angle È on the scale in this position

3. Height of tree = Y+H = X Tan È + H

where, H is the eye level of the observer and X is the horizontal distance between the feet of observer and base of tree.

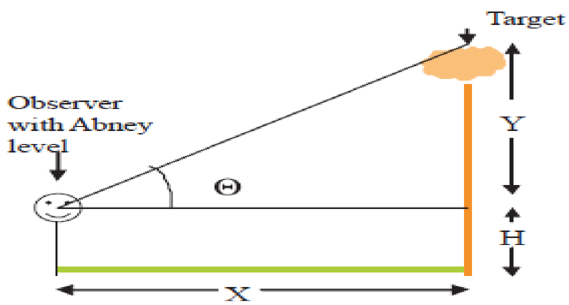

Fig.: Using an Abney Level to determine tree height

Video link:

1. https://youtu.be/Knob0zezPz8

2. https://youtu.be/ZQm5ReBqoGg

Calculation:

PRACTICAL NO. 6:

TITLE: STUDY OF LEVELLING USING DUMPY LEVEL

Objective: To study different leveling concepts and practical utility in agriculture

Activities:

1) Studying about leveling techiniques
2) Study of dumpy level and using it field to record reduced levels of the given field
3) Study of Leveling staff

Skills obtained:

1) Can able to take reduced levels of the field to prepare contour maps

Instruments Required: **Dumpy level with stand, levelling staff, chain, or tape and a level field book** for recording staff readings, distances etc.

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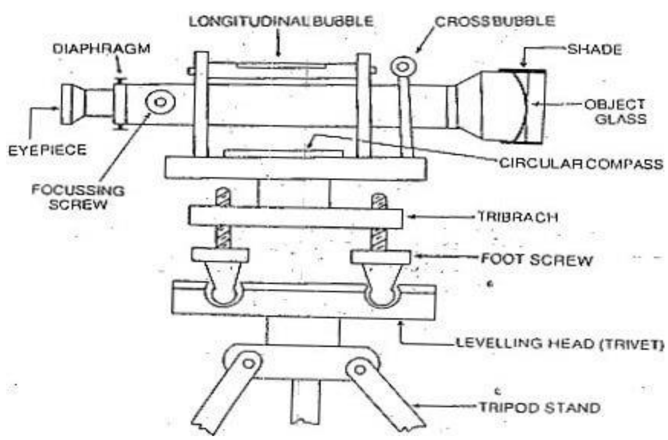
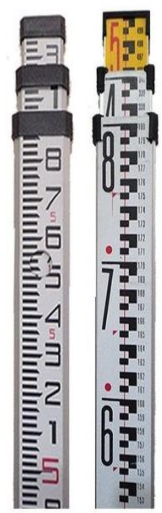
Dumpy level: It is the most commonly used level. This instrument is short and stout, hence the name as dumpy.





Parts of Dumpy level: Telescope, Bubble tubes, Compass, Vertical spindle, Tribrach screws, Foot screws, Leveling head, Tripod

Levelling Staff: A level staff, also called levelling rod, is a graduated wooden or aluminium rod, used with a levelling instrument to determine the difference in height between points or heights of points above a vertical datum, usually 4m long when fully extended. Each metre is subdivided into 200 divisions, each division being 5 mm. The metre numeral is in red and marked to the right and the decimeter numeral in black and marked into the left.

Adjustments of the level: Two kinds **1.Temporary** and 2**. Permanent**

Temporary Adjustments: The temporary adjustments are those, which have to be performed at each set up of the level. They are **a) Setting up the level and b) Focusing the eyepiece and object glass.**

Procedure of Dumpy Level Surveying

The procedure of dumpy level surveying starts with some temporary adjustments which are:

- Setting up of instrument
- Leveling up
- Focusing

Setting up of Dumpy Level

The instrument is fixed to the tripod stand using clamp screws. Spread the tripod legs and position the instrument at convenient height. Firstly fix the two legs in the ground at a point and centering of bubble in the bubble tubes is done by adjusting third leg.

Leveling up

The leveling up of an instrument is done using foot screws or leveling screws. In this case, the telescope is arranged parallel to the any two leveling screws and the bubble in the tube is centered by turning both the screws either inwards or outwards. When it is centered, then the telescope is turned 90^o and the third screw is turned until the bubble come to center. Repeat the process until the bubble in the tube always stays at the middle in any position of telescope.

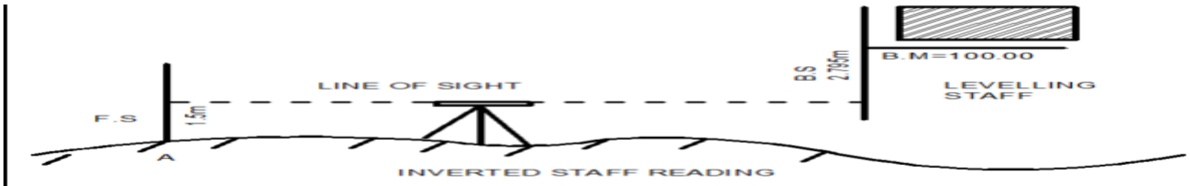
Focusing

Focusing is done by adjusting eye piece and focusing screw. Eye piece is adjusted until the cross hairs of diaphragm are clearly visible. To eliminate the parallax error, a white paper is used to obtain sharp vision of cross hairs. Focusing screw is adjusted to view the clear image of the objective or staff. Focusing is said to be done when the cross hairs bisect the objective or staff with clear vision

Procedure:

1. Set-up the level at point ‘P’ near to the Bench Mark (BM) (the R.L of BM assume as 100.000 m)
2. Focus the telescope towards BM and bisect the staff correctly and take the back sight (BS) on it and record the reading in the Levelling book.
3. Keep the levelling staff at a convenient intermediate point(S) and take the intermediate sight (IS) and enter the reading.
4. Before shifting the instrument to the next station enter the last staff reading in the FS column.
5. Shift the instrument to the next station ‘Q’ and follow the steps from 3 to 4.

6. Calculate the Reduced levels by Height of Instrument Method and also by Rise and Fall Method which can be shown in the below Table 6 & 7 respectively.



The results are tabulated as below:

B.S.	I.S	F.S	H.I	R.L	Remarks
-2.795			97.215	100.000	B.M.Staff inverted
		1.500		95.715	Point A

Observations and Calculations:

1. **Collimation System** (Height of instrument method):

a) Height of Instrument Method:

Height of Instrument (H.I.)	=	R.L. of A.B.M. + B.S.
R.L. of a station	=	H.I. – I.S. or F.S.
Height of Instrument at C.P. (H.I.)	=	R.L. of C.P. + B.S.
R.L. of a station	=	R.L. of C.P. – I.S. or F.S.
CHECK : Sum of B.S. – Sum of F.S.	=	First R.L. – Last R.L.

Arithmetical Check

The difference between the sum of the back sights and the sum of the foresights should be equal to the difference between the first and last reduced level.

B.S.- F.S. = Last R.L. - First R.L.

2. Rise and Fall System-

It consists in determining the difference of level between consecutive points by comparing each point after the first with that immediately preceding it. The difference between their staff reading indicates a rise or a fall according as the staff reading at the point is smaller or greater than that at the preceding point. The reduced level of each point is then found by adding the rise to, or subtracting the fall from the reduced level of the preceding point.

Arithmetical Check -

There are three checks on the accuracy of the reductions. The difference between the sum of the back sights and the sum of the foresights = the difference between the sum of the rises and that of the falls = The difference between the first and last reduced levels.

B.S. F.S. = rise - fall = Last R.L. - First R.L.

Example:

The following readings were taken successively with a level and levelling staff. 0.250, 0.500, 0.300, 1.565, 2.150, 3.560, 0.450, 1.260. The level was shifted after 3rd and 6th reading. Record these readings in the table and find out the reduced levels (RL) of different points. Assume RL of the first point as 100 m. Apply usual checks.

Solution:

1. The Collimation System (Height of instrument method)

Station	Staff Reading B.S	I.S	F.S	H.I	R.L.	Remarks
1	0.250			100.250	100.00	B.M.
2		0.500			99.750	
3	1.565		0.300	101.515	99.950	C.P
4		2.150			99.365	C.P.
5	0.450		3.560	98.405	97.955	
6			1.260		97.145	L.P
∑	2.265		5.12			

Arithmetical Check

The difference between the sum of the back sights and the sum of the foresights = he different between the first and last reduced levels

B.S. F.S. = Last R.L. - First R.L.

2.265-5.12 = = 97.145 -100.00

2.855 = 2.855

2. Rise and Fall System-

Station	Staff Reading B.S	I.S	F.S	Rise	Fall	R.L.	Remarks
1	0.250					100.00	B.M.
2		0.500			0.250	99.750	
3	1.565		0.300	0.200		99.950	C.P
4		2.150			0.585	99.365	C.P.
5	0.450		3.560		1.410	97.955	
6			1.260		0.810	97.145	L.P
∑	2.265		5.12	0.200	3.055		

Arithmetical Check

The difference between the sum of the back sights and the sum of the foresights = the difference between the sum of the rises and that of the falls = The difference between the first and last reduced levels

B.S. F.S. = rise - fall = Last R.L. - First R.L.

2.265-5.12 =0.200- 3.055 = 97.145 -100.00

2.855 = 2.855 = 2.855

Video link:

1. https://youtu.be/Ghj654KptnQ
2. https://youtu.be/xKfb6wOeoc4?t=61
3. https://youtu.be/1zW_mEx0E9w

Calculation :

PRACTICAL NO. 7:

TITLE: STUDY OF LEVELLING USING AUTO LEVEL

OBJECTIVE: To find out reduced levels of given points using Auto level

Activities:

1) Studying about leveling techiniques using auto level
2) Study of auto level and using it field to record reduced levels of the given field
3) Study of Leveling staff

Skills obtained:

1) Can able to take reduced levels of the field to prepare contour maps

Instruments Required: Auto level with stand, levelling staff, chain, or tape (30m) and a level field book for recording staff readings, distances etc.

Auto level: An Autolevel machine is a professional tool generally used for accurate levelling. It is also used for measuring Horizontal distance at the site. The method used to find the horizontal distance is known as 'Stadia Method. A typical optical level consists of a tripod, a bubble or circular level and a telescope with a magnifying glass, and it is generally used in combination with a marked stadia rod. The telescope contains crosshairs and a series of horizontal stadia marks, much like the marks on a ruler. The crosshairs establish the level point on a targeted area, with one long horizontal line marking the horizontal plane, and the stadia marks allow for the calculation of distances. Stadia marks often have a scale of 100:1, meaning 0.5 meters between these stadia marks represents a distance of 50 meters to the target.

Parts of Dumpy level: Eye piece, object glass Bubble tubes, Compass, Vertical spindle, Tribrach screws, Foot screws, Leveling head, Tripod

procedure of surveying on Auto Level: The auto level is a two-man procedure, one may require at least an assistant to proceed with the operation.

Setup a Benchmark [BM]:- The process of surveying starts from a specified benchmark with already known height concerning Mean Sea Level (MSL). This previous data of benchmark can be acquired from previous surveys. Benchmark data is usually found on churches, govt buildings, municipal offices, Railway station boards, etc. If data is not available, one may choose an arbitrary point (temporary benchmark like fence post etc) with an assumed height.

Location and Position of auto level: Select a place where you have a clear sight of the benchmark. It is recommended to set up the instrument in the centre of the land where you can see all the site including benchmark.

Setting up auto level on Tripod:- The Tripod has to be placed firmly on the ground so that it can efficiently hold the dumpy level. In general, the tripod height must be adjusted up till eyesight. One must ensure the legs of the tripod stand are wide enough to hold the instrument properly and legs are properly inserted into the ground.

The auto level is to be firmly and securely fixed with the tripod stand through the foot screws. One must ensure that the device is tightly fixed with a tripod. Since the level head is very sensitive, and the instrument is very costly, special care should be taken while handling it.

Observations and Readings:-

Backsight [BS] Reading: The first reading which surveyor needs to take is back sight. The second man (assistant) should hold the staff "vertically" on the benchmark. The operator begins the surveying operation by viewing through the eyepiece of the telescope and rotate the dump level until the crosshairs are lined up with the E staff. Then look and focus to see the numbers on E Staff. The staff comprises of both metric and imperial measurements. The "E" marking on the staff signifies 5 cm as of metric scale.

Height of the Instrument (H.I.) or Height of the Level: To find out the height of the level, you must know the height of the backsight which we have noted in the previous step. Now add the benchmark height to the backsight height which will give you the height of the instrument.

Height of the level = Bench Mark(BM) height + Back Sight Reading

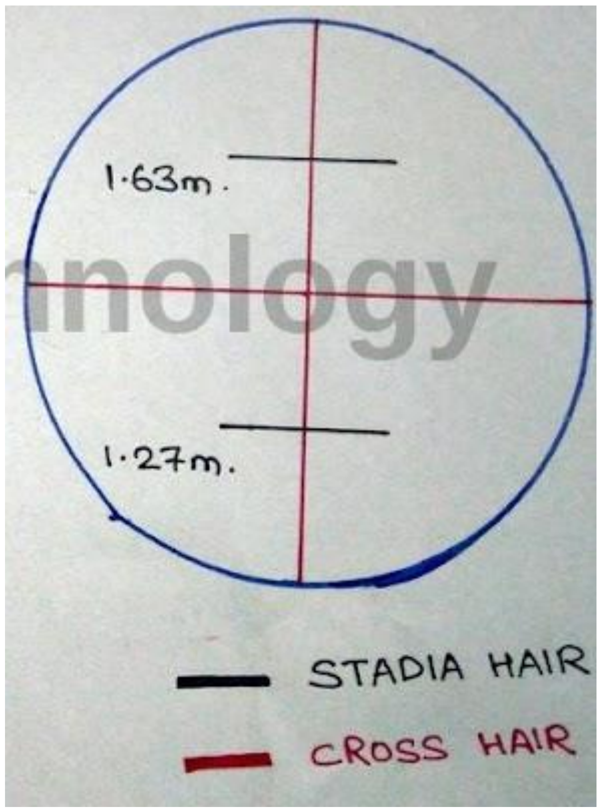
Foresight readings: Locate and mark the points (A, B, C) on the ground at which you intended to find out the level. Place the E Staff on the selected point (Suppose 'A') and hold it vertically. Repeat the same procedure of taking readings from E Staff which we performed to find out the backsight height. Record the readings from E staff and find out the foresight height of (Point 'A').

The results are tabulated in the below table

Reading No.	Identification point	Benchmark Height	Backsight	Height of Instrument	Reduced Level
1.					
2.					
3.					
4.					
5.					
6.					

7.					
8.					

calculate the horizontal distance: A circle is provided where two red lines intersect with each other and that it's known as a crosshair. The two lines intersect the red line and it is known as stadia hair. The horizontal distance in the construction site will be calculated with the help of stadia hair.



Example of horizontal distance calculation:

Say Upper Stadia Hairs = 1.63 meter
Lower Stadia Hairs = 1.27 meter
Now Difference between Upper Stadia and Lower Stadia = 1.63 – 1.27 = 0.36 meter
Now convert the 0.36 meter into cm i.e, 0.36 x 100 = 36 cm.
In Autolevel machine, the scale of the difference of Upper Stadia and Lower Stadia is designed in such a manner that it says,
1 cm = 1 m
So, we can say The horizontal distance is 36 meter.

Video link

1. https://youtu.be/vKqhV4wS3PU

2. https://youtu.be/xy5cFNf8DB8

PRCTICAL NO. 8

TITLE: PREPARATION OF CONTOUR MAPS

Objective: To prepare contour maps for the given area

Activities: Preparation of contour maps by interpolation method

Skills obtained: Can able to prepare contour maps for different topographies of land viz. hill, valley, canal, plain land etc.

Introduction: Contour mapping, the delineation of any property in map form by constructing lines of equal values of that property from available data points.Contour line is the lines drawn on a map connecting points of equal elevation. Contour intervals are the vertical spacing between two different contour line.Contour Index is define as when not possible to label the elevation of each contour line, make level to every fifth contour, which make the map easier to read. Contour map is a common tool used by a hydro-geologist to indicate water flow directions.Elevation are measured to a common datum such as sea level.

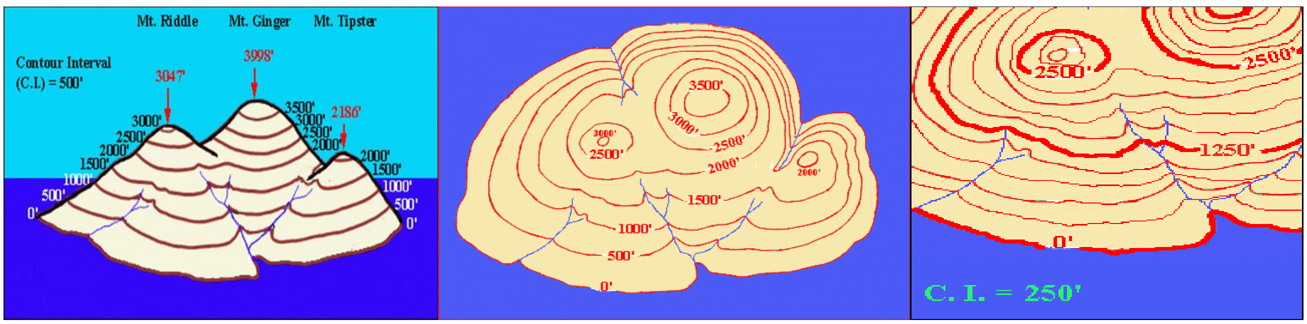


Fig. a) Contour line b) Contour map c) Contour Index

Purpose of contouring: 1. To locate the alignment of a canal so that it should follow a ridge line. 2. To mark the alignment of roads and railways so that the quantity of earthwork both in cutting and filling should be minimum. 3. For getting information about the ground whether it is flat, undulating or mountainous. 4. To find the capacity of a reservoir and volume of earthwork especially in a mountainous region. 5. To locate the physical features of the ground such as a pond depression, hill, steep or small slopes.

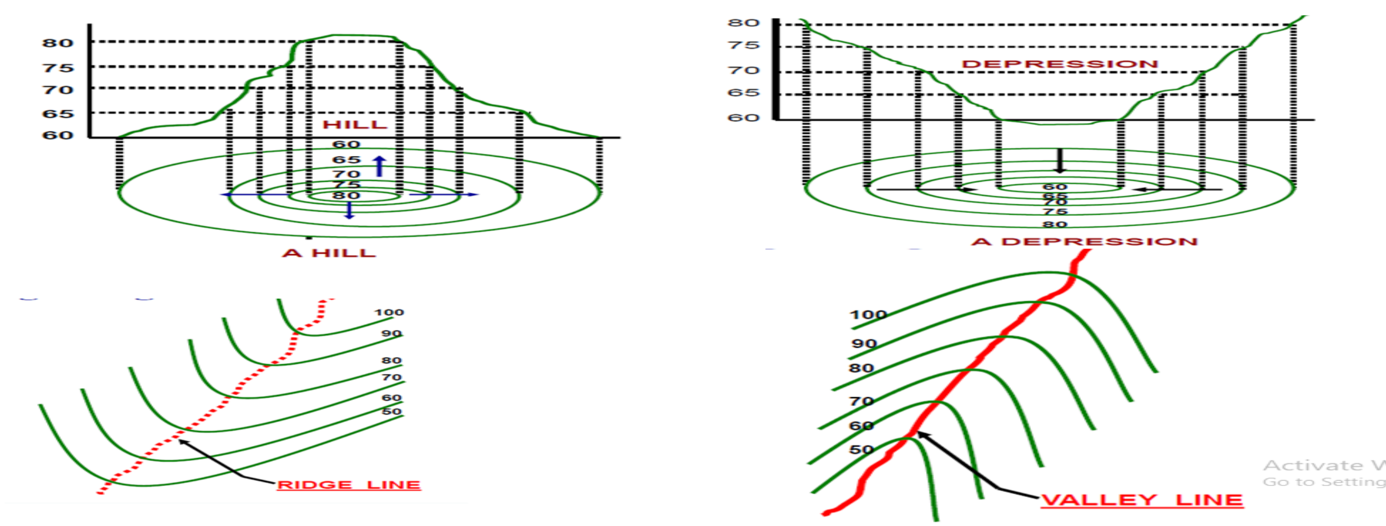


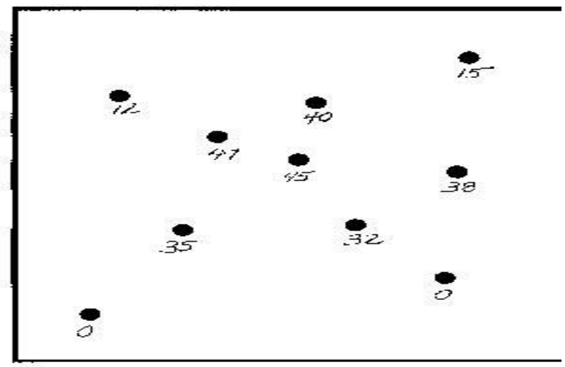
Fig. Contour map a) Hill b) Depression c) Ridge line d) Valley line

How to make a contour map:

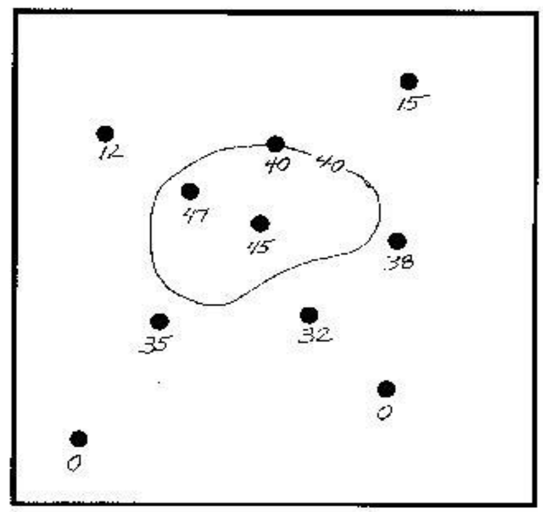
1) “spotting,” or drawing, all the elevation on a section of land. You need to know the distance of each elevation point from a common boundary.

2) write the Depth of levels, are measured to a common datum such as sea level.

3) Start contouring with the highest elevation values. Use a pencil. Start with a “contour interval” that is slightly less than the biggest values.



[In this case, the first line drawn is the 40-foot contour. As you draw your line, look carefully when you pass between two elevations. Try to use your eye like a “ruler,” and position the line at the proper distance between the two wells. Notice the well with a footage of “38.” Since 38 is very close to 40 (the contour we are drawing), you should “pull” the 40-foot contour over close to the 38-foot line, like see the fig.].

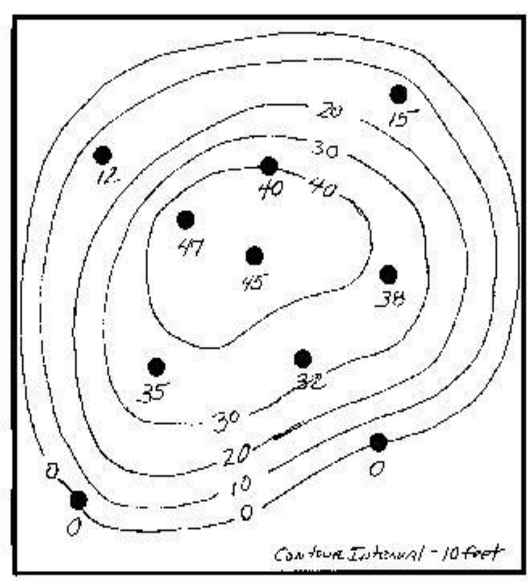


4). Now draw the 30-foot contour (contour lines are usually at some even interval, like 10 feet, 20 feet, 50 feet)

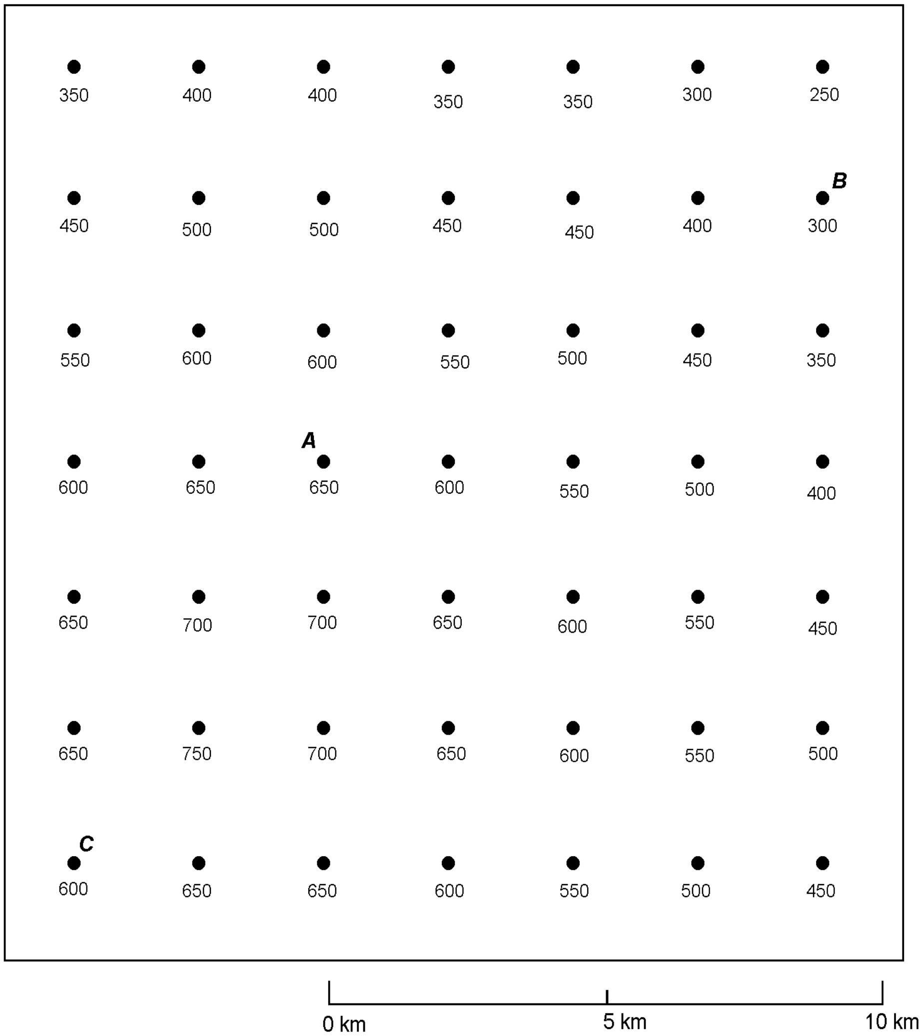
5). Finish the map by drawing the 10-foot, and zero contour lines. Label the “contour interval” you used at the bottom of the map.

6) Calculate the gradient difference by using the formula

$$\text{Gradient} = \frac{\text{change in field value}}{\text{distance}}$$



Example problem: Draw in contour lines at the following elevations (all numbers are given in feet above sea level): 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750 and Find the gradient difference between point A and B , point B and C



Video link:

1. https://youtu.be/L6FbV0LiA_k
2. https://youtu.be/ZbKUkSW7_DQ

Calculation:

PRACTICAL NO. 9

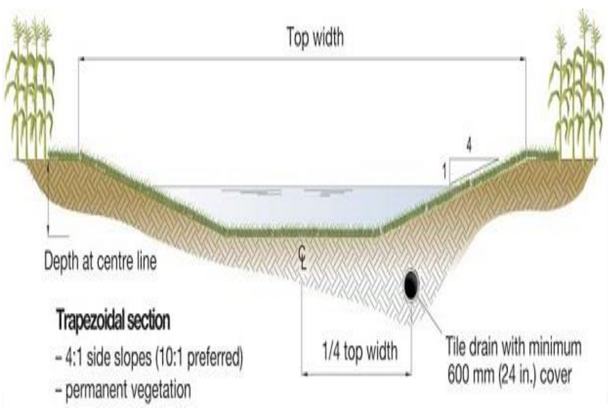
TITLE: DESIGN OF GRASSED WATERWAYS

Objective: To design a grassed way for the given rainfall in the given area

Activities: Solving design problems on grassed waterways

Skills obtained: Can able to design a grassed way for the given condition of the watershed for different soil conditions and rainfall conditions

Introduction: Grassed waterways are broad, shallow and typically saucer-shaped channels designed to move surface water across farmland without causing soil erosion. The vegetative cover in the waterway slows the water flow and protects the channel surface from the eroding forces of runoff water. Left alone, runoff and snowmelt water will drain toward a field's natural draws or drainage ways. It is in these areas that grassed waterways are often established.
If properly sized and constructed, grassed waterways safely transport water down natural draws through fields. Waterways also provide outlet channels for constructed terrace systems, contour cropping layouts and diversion channels. Grassed waterways are a good solution to the erosion caused by concentrated water flows when the watershed area generating the runoff water is relatively large



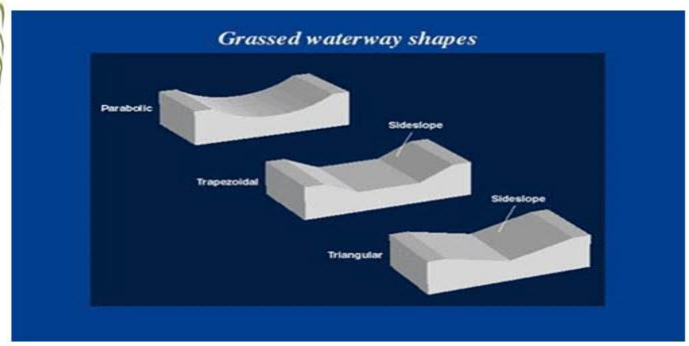


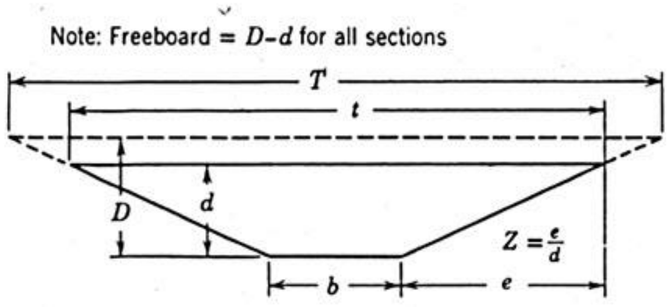
Fig. a) Recommended location of subsurface drainage tile beneath a grassed waterway b) **Grassed waterways shapes**

Design of Grassed Waterways

In cases, where the shape of the waterway, the carrying capacity, and the slope of the bed are known, the procedure for the design of the channel parameters comprises of the following steps. This procedure is an iterative one.

Step 1: Assume the value of flow depth and calculate the channel cross sectional area (A), wetted perimeter (P), hydraulic radius (R) and top width (T):

For trapezoidal channel section (Fig. 25.3),



$$Cross\ sectional\ area(A) = bd + Zd^2 \qquad (m^2)$$

$$Wetted\ perimeter(P) = b + 2d\sqrt{Z^2+1} \qquad (m)$$

$$Hydraulic\ radius(R) = \frac{A}{P} \qquad (m)$$

$$Top\ width(t) = b + 2dZ \qquad (m)$$

Fig. 25.3. Trapezoidal grassed waterways. (Source: Schwab et al., 1993)

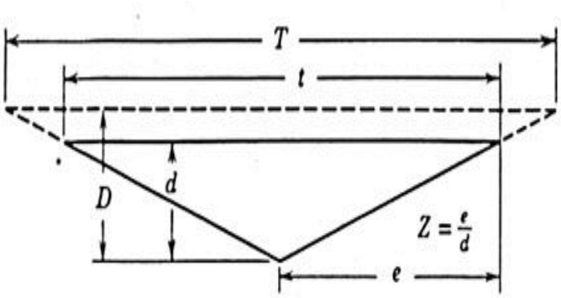
Where,

b = bottom width (m)

d = channel depth (m)

Z = e/d =side slope (horizontal: vertical) of trapezoidal channel

For Triangular channel section (Fig. 25.4),



$$Cross\ sectional\ area(A) = Zd^2 \qquad (m^2)$$

$$Wetted\ perimetre(P) = 2d\sqrt{Z^2+1} \qquad (m)$$

$$Hydraulic\ radius(R) = \frac{A}{P} \qquad (m)$$

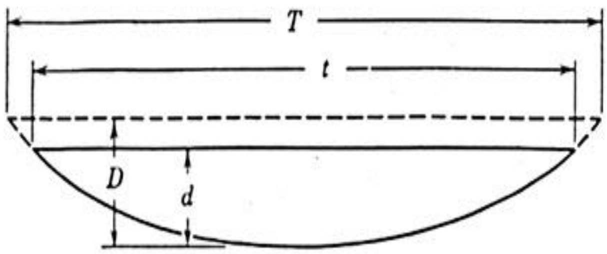
$$Top\ width(t) = 2dZ \qquad (m)$$

Fig. 25.4. Triangular grassed waterways. (Source: Schwab et al., 1993)

Where,

d = depth of channel (m)

For parabolic channel section (fig. 25.5),



$$Cross\ aectional\ area(A) = \frac{2}{3}td \qquad (m^2)$$

$$Wetted\ perimetre(P) = t + \frac{8d^2}{3t} \qquad (m)$$

$$Hydraulic\ radius(R) = \frac{A}{P} \qquad (m)$$

$$Top\ width\ (t) = \frac{A}{0.67d} \qquad (m)$$

Fig. 25.5. Parabolic grassed waterways. (Source: Schwab et al., 1993)

Where,

d = depth of channel section (m)

Step 2: Determine the mean velocity of flow by using manning's formula which states that

$$v = \frac{R^{\frac{2}{3}}S^{\frac{1}{2}}}{n} \qquad \left(\frac{m}{s}\right)$$

Where, R= hydraulic radius of the channel section (m), S = channel grade, n = Manning's roughness co-efficient (for vegetated waterways, n= 0.04)

Table 27.3. Recommend Velocities of Flow in a Vegetated Channel.

Type of vegetation cover	Flow velocity, (m/s)	
	Type	Magnitude
Spare green cover	Low velocity	1-1.15
Good quality cover	Medium velocity	1.5-1.8
Excellent quality cover	High velocity	1.8-2.5

Step 3: Determine the discharge rate Q = Av (m3/s) through the channel.

Step 4: Check if the velocity is safe, and the carrying capacity of the channel is within the permissible range.

Step 5: If it is observed that the velocity is unsafe, and the carrying capacity is not within the permissible range, and then repeat the process with another set of assumed value in step (1), till the carrying capacity is found to be within the permissible range.

Step 6: A free board of 15 cm is then added to the assuming channel depth as

$$Channel\ depth(D) = (d + 0.15) \qquad (m)$$

$$Channel\ top\ width\ after\ adding\ free\ board(T) = \frac{D}{d}t \qquad (m)$$

Video link:

1. https://youtu.be/ohKIrRHNY_A

2. https://youtu.be/QQf4I6RVznA

3. https://youtu.be/yt5ORwQH378

Example Problem 1: Design a grassed waterway of parabolic shape to carry a flow of 2.6 m^3/s down a slope of 3 percent. The waterway has a good stand of grass and a velocity of 1.75 m/s can be allowed. Assume the value of *n* in Manning's formula as 0.04.

Example Problem 2: Design a grassed waterway to carry a discharge of 3.5m3/sec, through a slope of 3%, the waterway has good grass cover with maximum permissible velocity 1.8 m/sec. Assume mannings roughness coefficient is 0.04 and side slope at the cross section is 4:1.

PRACTICAL NO. 10

TITLE: DESIGN OF CONTOUR BUNDS

Objective: To design contour bunds for the given soil, rainfall and topographical conditions

Activities: Solving design problems on contour bunds

Skills obtained: Can able to design contour bunds for the given conditions of rainfall, type of soil and land slope in given watershed

Introduction: Bunding is an engineering soil conservation measure used for retaining water and creating obstruction to the surface runoff for controlling soil erosion. Bunds are simple earthen embankments of varying lengths and heights, constructed across the slope. When they are constructed on the contour of the area, they are called as contour bunds and when a grade is provided to them, they are known as graded bunds. For bunding, the entire area is divided into several small parts; thereby the effective slope length of the area is reduced. Contour bunds are constructed in relatively low rainfall areas, having an annual rainfall or less than 600 mm, particularly in areas having light textured soils. For rolling and flater lands having slopes from 2 to 6% contour bunding is practiced, in red soil.

Design of Contour Bund: The design parameters required for contour bunds are
(1) Vertical interval
(2) Horizontal interval
(3) Bund cross-section
(4) Earth work due to bunding
Height of the contour bund should be enough to store the expected peak runoff for a 10 years recurrence interval. A free board of about 20% should be provided for the settlement of height.
(1) Calculation of Vertical Interval (V.I) and Horizontal Interval (H.I)
For low rainfall areas

$VI = 0.15s + 0.6 \quad (m)$ $and \quad \frac{s}{100} = \frac{VI}{HI}$ $then, \quad HI = \frac{VI \times 100}{s} \quad (m)$	Where, VI = Vertical interval, m HI = Horizontal interval, m s = Original land slope, %

(2) Calculation of Storage Required for Runoff Volume

$P_e = P - I \quad (m)$ $A = HI \times L \quad (m^2)$ $So, runoff\ volume\ to\ be\ stored (R_V)$ $R_V = P_e \times A \quad (m^3)$	Where, P = Precipitation, m Pe = Excess rainfall depth or surface runoff, m I = infiltration depth, m H.I = Horizontal interval, m L = Length of bund behind which the runoff is stored, m A = Area of watershed behind two bunds, m^2. R_V = Runoff volume to be stored, m^3.

(3) Calculation of Storage Volume

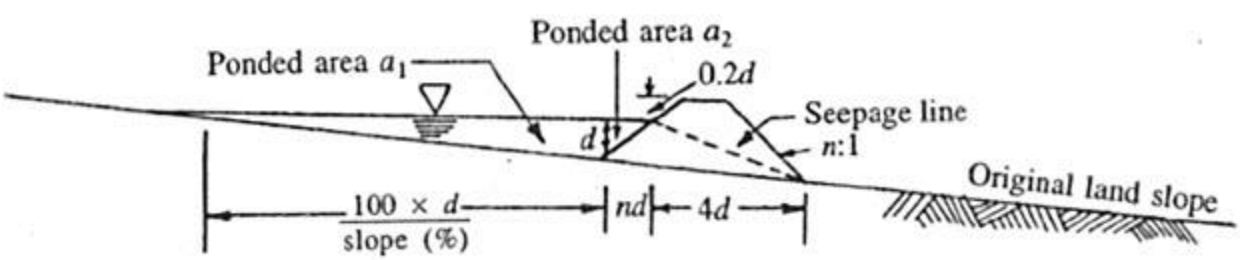


Fig. 24.3. Layout of contour bund. (Source: Das, 2002)

From the above layout of contour bund (Fig. 24.3),

$$Ponded\ area\ (a_1) = \frac{1}{2} \times \frac{100d}{s} \times d \qquad (m^2)$$

$$Ponded\ area\ (a_2) = \frac{1}{2} \times nd \times d \qquad (m^2)$$

$$Area\ of\ water\ stored\ behind\ the\ bund = (a_1 + a_2) \qquad (m^2)$$

Storage volume (SV) = area of water stored behind the bund × length of bund (m3)

Where,

d = depth of water stored behind the bund (m)

n : 1(H:V) = side slope of the contour bund

4:1 (H:V) = Seepage line slope of the bund

(4) Calculation of Depth of Water Stored Behind Bund For total runoff absorbed by the bund,

Runoff volume (RV) = Storage volume (Sv)

Using this relationship, the depth of water stored behind bund is calculated.

(5) Calculation of Bund Cross Section

$$Total\ height\ of\ the\ bund\ (H) = (d + 20\%\ of\ d\ as\ freeboard) \quad (m)$$

$$Base\ width (B) = (nd + 4d) \quad (m)$$

$$Top\ width (T) = (B - 2nH) \quad (m)$$

(6) Calculation of Earth Work due to Bunding

$$Lengh\ of\ contour\ bund\ per\ ha\ (L) = \frac{10^4}{HI}\ \ for\ main\ bund$$

$$= \frac{10^4}{HI} \times 1.3\ for\ main\ bund\ with\ side\ and\ lateral\ bund$$

$$Earthwork\ per\ ha = cross\ sectional\ area\ of\ bund \times length\ per\ ha$$

$$= \left[\frac{1}{2} \times (B + T) \times H\right] \times L \qquad \left(\frac{m^3}{ha}\right)$$

Video link:

1. https://youtu.be/d_Xe42J9BFk

2. https://youtu.be/IUCI5tBJzuA

PRACTICAL NO. 11

TITLE: SOLVING DESIGN PROBLEMS ON CONTOUR BUNDS

Example Problem: Design a contour bund a contour bund for a land having 4% slope and laomy soil, the distance between the bund is 60 m, the expected rainfall based on 10 years reoccurrence interval is 15 cm, out of which 40 % is lost due to abstraction, assume slope of the seepage line for the given soil is 5:1.

PRACTICAL NO. 12

TITLE: DESIGN OF GRADED BUNDS

Objective: To design graded bunds for the given soil, rainfall and topographical conditions

Activities: Solving design problems on graded bunds

Skills obtained: Can able to design graded bunds for the given conditions of rainfall, type of soil and land slope in given watershed

Introduction: 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 form agricultural fields. Function of graded bund is act primarily as drainage channel to regulate and conduct runoff at non erosive velocity and to make the runoff water to trickle rather than to rush out. The limitations of the system are: Due to crossing of farm implements, the bunds are disturbed and some soil is lost, Proper maintenance is required at regular interval.

Design of Graded Bund: Graded bund is designed based on 1h rainfall intensity for desired recurrence interval. In general, a grade of 0.2 to 0.3% is provided in graded channel. In graded bund free board of 15 to 20% of desired depth is provided.

Recommended Dimension

Height of bund $\leq$ 45 cm

Top width = 30 to 90 cm

Velocity of runoff should be less than critical velocity.

Table 24.1 Recommended side slope for graded bund (Source: Das,2002), Table 24.2 Recommended seepage line slope for graded bund (Das, 2002)

Type of soil	*Side slope (horizontal : vertical)*
Clayey	1 : 1
Loamy	1.5 : 1
Sandy	2 : 1

Type of soil	*Seepage line slope (horizontal : vertical)*
Clayey	3 : 1
Sandy loam	5 : 1
Sandy	6 : 1

(1) Calculation of Vertical Interval (VI) and Horizontal Interval (HI)

For medium to high rainfall areas:

$$VI = 0.1s + 0.6 \quad (m)$$

$$and \ \frac{s}{100} = \frac{VI}{HI}$$

$$then, \qquad HI = \frac{VI \times 100}{s} \qquad (m)$$

Where, V.I = Vertical interval, m; H.I = Horizontal interval, m; s = Original land slope, %

(2) Calculation of Peak Runoff Rate:

$$Q_P = \frac{CIA}{360} \qquad \left(\frac{m^3}{s}\right) \qquad\qquad by\ Rational\ formula$$

Where, QP = Peak runoff rate (m3/s)' ; C = Runoff coefficient ; I = Rainfall intensity (mm/h) for duration equal to time of concentration.

$$t_c = 0.0195\left(\frac{L}{\sqrt{S}}\right)^{0.77} \qquad in\ minute$$

Where, tc = Time of concentration (min); L =Length of water flow = (length of bund + distance between two bunds) in (m); S = H/L = gradient or slope causing water flow; H = Elevation difference causing water flow = (elevation difference causing length of bund + elevation difference of land)

= (L X g + HI X s) (m)

g = grade of channel (%); A= Drainage area (ha) = (L X HI)

(3) Calculation of Discharge Capacity of Graded Bund

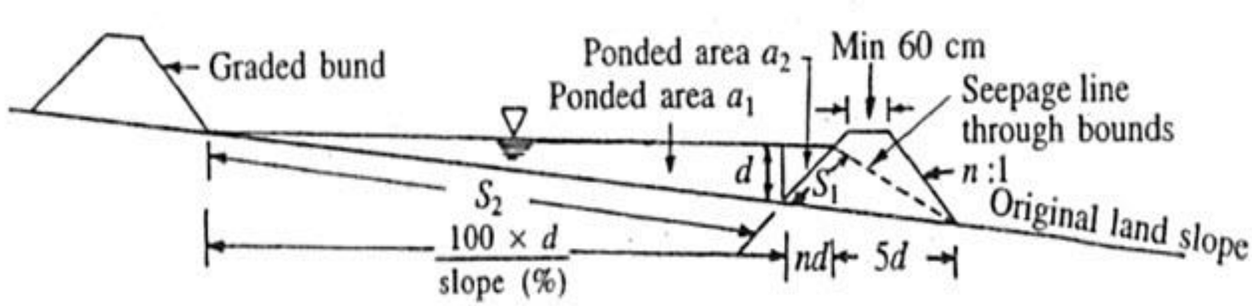


Fig. 24.4. Design layout of graded bund. (Source: Das, 2002)

From the design layout of contour bund (Fig. 24.4),

$$Ponded\ area\ (a_1) = \frac{1}{2} \times \frac{100d}{s} \times d \qquad (m^2)$$

$$Ponded\ area\ (a_2) = \frac{1}{2} \times nd \times d \qquad (m^2)$$

$$Area\ of\ water\ ponded\ behind\ the\ bund = (a_1 + a_2) \qquad (m^2)$$

$$wetted\ perimeter\ of\ ponded\ water\ (P) = (P_1 + P_2) \qquad (m)$$

$$P = \left[\sqrt{\left(\frac{100d}{s}\right)^2 + d^2} + \sqrt{(nd)^2 + d^2}\right] \qquad in\ (m)$$

Where, d = depth of water stored behind the bund (m); n:1(H:V) = side slope of the graded bund; 5:1 (H: V) = Seepage line slope of the bund for sandy loam soil

$$\text{Hydraulic radius } (R) = \frac{A}{P} \qquad (m)$$

$$Mean\ velocity(v) = \frac{1}{n} \times R^{\frac{2}{3}} \times g^{\frac{1}{2}} \quad in\ \left(\frac{m}{s}\right) \qquad by\ Mannings\ equation$$

where,

n = Manning's roughness coefficient

$$Discharge\ capacity(Q) = (a_1 + a_2) \times v \quad in\ \left(\frac{m^3}{s}\right)$$

$$if\ \ Q > Q_P \quad then\ the\ design\ is\ proper$$

(4) Calculation of Bund Dimension

$$Total\ height\ of\ the\ bund\ (H) = (d + 20\%\ of\ d\ as\ freeboard) \quad (m)$$

$$Base\ width(B) = (nd + 5d) \quad (m)$$

$$Top\ width(T) = (B - 2nH) \quad (m)$$

(5) Calculation of Earth Work due to Bunding

$$Lengh\ of\ contour\ bund\ per\ ha\ (L) = \frac{10^4}{HI}$$

$$Earthwork\ per\ ha = cross\ sectional\ area\ of\ bund \times length\ per\ ha$$

$$= \left[\frac{1}{2} \times (B + T) \times H\right] \times L \qquad \left(\frac{m^3}{ha}\right)$$

Video link:

1. https://youtu.be/hp-YyL0P3J4

2. https://youtu.be/DYTu9RmwKRE

PRACTICAL NO. 13

TITLE: SOLVING DESIGN PROBLEMS ON GRADED BUNDS

Example Problem: A 350 m long graded bund has been proposed to be constructed on a land of 3% slope. The type of soil is sandy. The rainfall intensity of the area was recorded as 18 cm/h for the duration equal to time of concentration. A uniform grade of 0.18% is to be marinated along the bund. (Assume Vertical Interval (VI) as 1.25m and runoff coefficient C as 0.35). Using the above given data determine the dimensions of the bund.

PRACTICAL NO. 14

TITLTE: DESIGN OF BENCH TERRACING SYSTEM

Objective: To study about the Terraces and their Design

Activities: Solving problems on terraces and their design by considering different factors influencing on it.

Skills obtained: Can able to solving problems on Terraces and their Design by using different factors

Introduction: Terrace is an earth-embankment, constructed across the slope, to control runoff and minimize soil erosion. A terrace acts as an intercept to land slope, and divides the sloping land surface into strips. It has been found that soil loss is proportional to the square root of the length of slope; i.e. by shortening the length of run, soil erosion is reduced. The soil eroded by the runoff scour and the raindrop splash flows down the slope, and gets blocked up by terraces. The original bench terrace system consists of a series of flat shelf-like areas that convert a steep slope of 20 to 30 percent to a series of level, or nearly level benches (Fig. 5.2). In other words, bench terracing consists of construction of series of platforms along contours cut into hill slope in a step like formation. In several hilly areas bench terraces have been used for the purpose of converting hill slopes to suit agriculture. Bench terraces have also been adopted for converting sloping lands into irrigated fields or for orchard plantations.

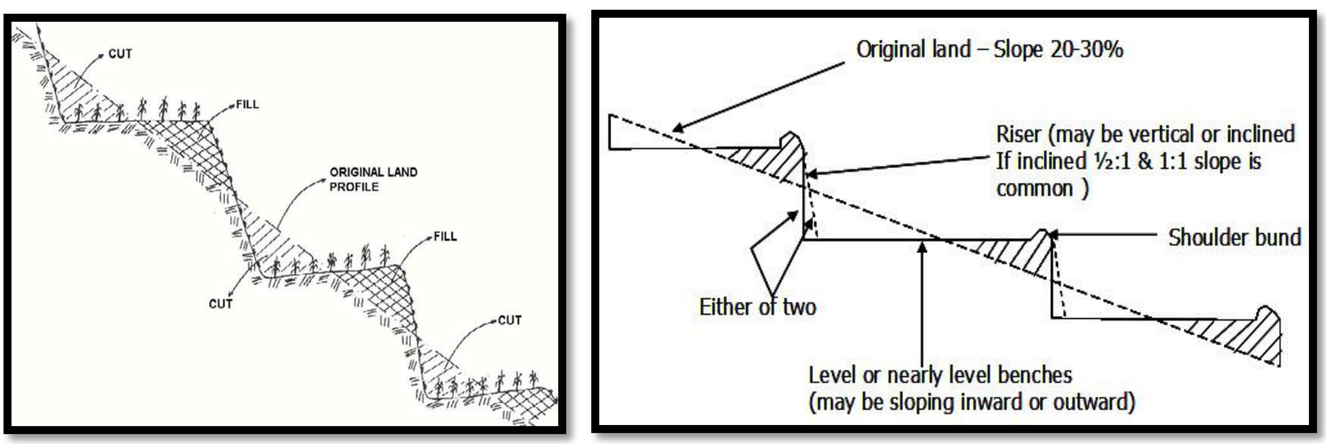


Fig. Bench terrace and its different components.

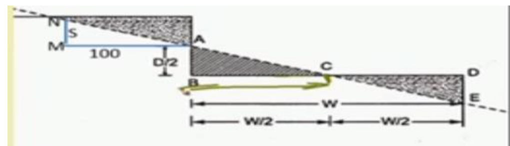
Design of Bench Terraces: The design of bench terraces consists of determining the (1) type of the bench terrace, (2) terrace spacing or the depth of the cut, (3) terrace width, and (4) terrace cross section.

Terrace spacing is generally expressed as the vertical interval between two terraces. The vertical interval (D) is dependent upon the depth of the cut and since the cut and fill are to be balanced, it is equal to double the depth of cut. The factors that limit the depth of cut are the soil depth in the area and the slope. The depth of cut should not be too high as to expose the bed rock which makes the bench terraces unsuitable for cultivation. In higher slopes greater depth of cuts result in greater heights of embankments which may become unstable.

The width of the bench terraces (W) should be as per the requirement (purpose) for which the terraces are to be put after construction. Once the width of the terrace is decided, the depth of cut required can be calculated using the following formulae.

Case 1: When the terrace cuts are vertical

$$D = \frac{WS}{100} \tag{5.1}$$

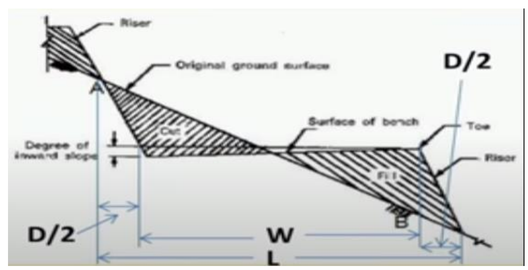


S is the land slope in percent; D/2 is the depth of cut and W is the width of terrace.

Case 2: When the batter slope is 1:1

$$\frac{D/2}{W/2 + D/2} = \frac{S}{100}$$

$$D = \frac{WS}{(100 - S)} \tag{5.2}$$



Case 3: When the batter slope is ½: 1

$$\frac{D/2}{W/2 + D/4} = \frac{S}{100}$$

$$D = \frac{2WS}{(200 - S)} \tag{5.3}$$

After deciding the required width, the depth of cut can be calculated from one of the above formulae.

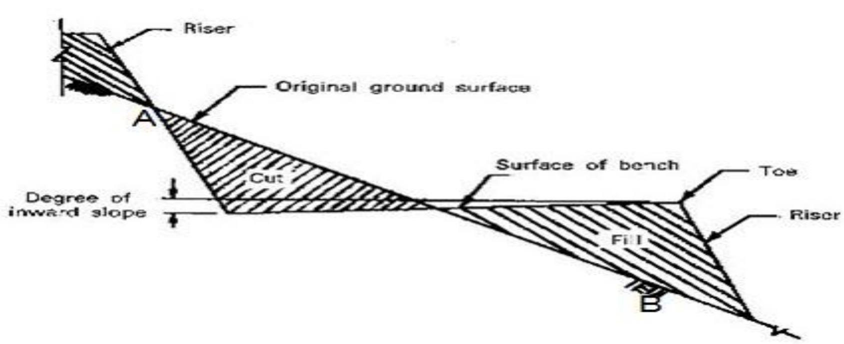


Fig: 5.3 Cross section of bench terraces.

The design of the terrace cross section consists of deciding (1) the batter slope, (2) dimensions of the shoulder bund, (3) inward slope of the terrace and the dimensions of the drainage channel in case of terraces sloping inward, and (4) outward slope in case of terraces sloping outward (Fig. 5.3). The batter slope is mainly for the stability of the fill or the embankment. The flatter the batter slope, the larger the area lost due to bench terracing. Vertical cuts are to be used in very stable soils and when the depth of the cut is small (up to 1 m). Batter slopes of ½: 1 can be used in loose and unstable soils. The bund cross section depends upon the terrace width and soil conditions.

Area Lost for Cultivation due to Bench Terracing: The area lost for cultivation due to bench terracing of a slope can be calculated as follows.

Consider a batter slope of 1:1. Let D be the vertical interval of the benches to be laid out on a land with a slope of S %, along AB in Fig. 5.3 and the batter of the risers is 1:1. L is the horizontal interval between the benches i.e., projected length of AB on horizontal plane. Actual distance of AB is given by:

$$\begin{aligned} \mathrm{AB} &= \sqrt{L^2 + D^2} \\ &= L\left[1 + \frac{D^2}{2L^2} + \frac{D^4}{8L^4} + \ldots\ldots\right] \end{aligned} \qquad (5.4)$$

$$\mathrm{AB} = L + \frac{D^2}{2L}$$

$$L = \frac{100D}{S}$$

$$\begin{aligned} AB &= \frac{100D}{S} + \frac{D^2}{2} \cdot \frac{S}{100D} \\ &= \frac{100D}{S} + \frac{DS}{200} \end{aligned} \qquad (5.5)$$

If W is the width available for cultivation after terracing:

$$W + D = L = \frac{100D}{S}$$

$$W = \frac{100D}{S} - D = \frac{100D - DS}{S} \qquad (5.6)$$

Width not available for cultivation after terracing (from equations 5.5 and 5.6)

$$= AB - W$$

$$= \frac{100D}{S} + \frac{DS}{200} - \frac{100D}{S} + \frac{DS}{S}$$

$$= \frac{DS}{200} + \frac{DS}{S}$$

Width loss in percentage of original inclined width AB

$$= \frac{\frac{DS}{200} + \frac{DS}{S}}{\frac{100D}{S} + \frac{DS}{200}} * 100$$

$$= \frac{\frac{S}{200} + 1}{\frac{100}{s} + \frac{S}{200}} * 100 = \frac{(S+200)S}{20000 + S^2} * 100$$

By dividing the numerator and the denominator by 100 width lost in percentage of the original width

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

The percentage width lost can be taken as the percentage area lost. When the batter is vertical, the length of bench terrace per hectare in metres will be 10000/W where W is in metres. When the batter slope is 1:1 the length per hectare in metres will be 10000/W + D; D and W being in meters.

Video link:

1. https://youtu.be/ahQD_VfdqlY
2. https://youtu.be/93QMqXxHoJw

PRACTICAL NO. 15

TITLTE: SOLVING DESIGN PROBLEMS ON BENCH TERRACING SYSTEM

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

Solution: Using the equation for vertical cut, and estimating the width of bench terrace (W)-

PRCATRICAL NO. 16

TITLE: PROBLEM ON WIND EROSION

Objective: To study about the wind erosion, its estimation process and the distance of full protection (m) behind shelter belt

Activities: Solving problems on wind erosion estimation by considering different factors influencing wind erosion

Skills obtained: Can able to estimate soil loss due to wind erosion by using wind erosion estimation models

Wind Erosion

Wind erosion is a serious environmental problem. It is in no way less severe than water erosion. High velocity winds strike the bare lands (having no cover), with increasing force. Fine, loose and light soil particles blown from the land surface are taken miles and miles away and thereby, causing a great damage to the crop productivity. It is a common phenomenon occurring mostly in flat, bare areas; dry, sandy soils; or anywhere the soil is loose, dry and finely granulated and where high velocity wind blows. Wind erosion, in India, is commonly observed in arid and semi-arid areas where the precipitation is inadequate, e.g. Rajasthan and some parts of Gujarat, Punjab and Haryana.

Estimation of Soil Loss Due to Wind Erosion

An equation in the form of universal soil loss equation has been developed and can be used for estimating soil loss by wind. However, the evaluation of the constants in the equation for wind erosion is comparatively difficult than the universal soil loss equation. The equation is of the form,

$$E = IRKFCWDB \qquad (14.1)$$

Where, E is soil loss by wind erosion, I is soil cloddiness factor, R is surface cover factor, K is surface roughness factor, F is soil textural class factor, C is factor representing local wind condition, D is wind direction factor, and B is wind barrier factor, W is field width factor.

Another model of wind erosion estimation used in USA is as follows:

$$E = f(I, K, C, L, V) \qquad (14.2)$$

Where, E is estimated average annual soil loss (t/ha/yr), I is soil erodibility index (t/ha-yr), K is ridge roughness factor, C is climate factor, L is unsheltered length of eroding field (m), and V is vegetative cover factor.

The soil erodibility index (I) can be estimated as given below

$$I = 525(2.718)^{-0.05F} \tag{14.3}$$

Where, F is % of dry soil fraction greater than 0.84 mm, K is ridge roughness factor; a measure of ridges made by tillage implements on wind erosion and can be estimated as given below

$$K_r = \frac{0.16h^2}{d} \tag{14.4}$$

Where, Kr is ridge roughness, h is ridge height in mm, d is ridge spacing in mm, and K can be estimated as a function of ridge roughness.

$$K = 0.35 + \frac{12}{(K_r + 18)} + \left(6.2 * 10^{-6} K_r^2\right) \tag{14.5}$$

The climatic factor (C) depends on wind velocity and soil surface moisture. The mean wind velocity profile above the soil surface is estimated as given below.

$$U_z = \left(\frac{U_*}{k}\right) \ln\left(\frac{z-d}{z_o}\right) \tag{14.6}$$

$$\text{Where, } U_* = Frictional\ Velocity = \frac{\tau_0(shear\ stress\ at\ boundary)}{\rho(airdensity, 1.2kg/m^3)} \tag{14.7}$$

$$k = vonKarman's constant = 0.4\ (usually\ taken)$$

$$Z_0 = a\ roughness\ parameter$$

$$d = effective\ surface\ roughness\ height$$

$$\log d = \log h - 0.15$$
$$\log z_0 = \log h - 0.09$$

$$c = crop\ height$$

Wind Erosion Control

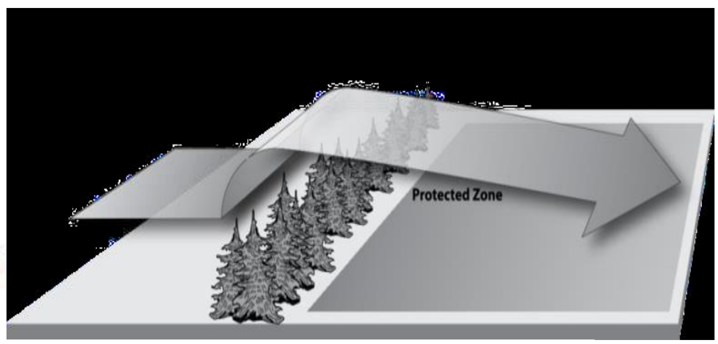
Wind Breaks: This is a permanent vegetative measure which helps in the reduction of wind erosion. It is most effective vegetative measure used for controlling severe wind erosion. The term wind break is defined as any type of barrier either mechanical or vegetative used for protecting the areas like building apartments,

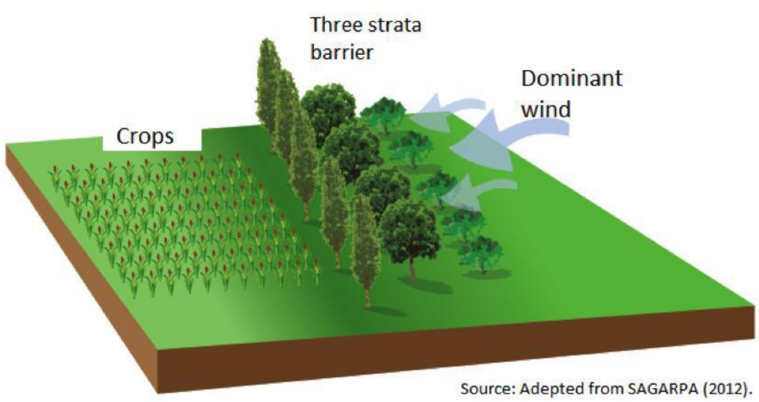
orchards or farmsteads etc. from blowing winds. The wind break acts as fencing wall around the affected areas, normally constructed by one row or maximum up to two rows across the prevailing wind direction.
A further use for "windbreaks" or "wind fences" is for reducing wind speeds over erodible areas such as open fields, industrial stockpiles, and dusty industrial operations. As erosion is proportional to the cube of wind speed, a reduction in wind speed by 1/2 (for example) will reduce erosion by over 80%. The largest one of these windbreaks is located in *Oman* (28 m high by 3.5 km long).

Shelter Belts: A shelterbelt is a longer barrier than the wind break, is installed by using more than two rows, usually at right angle to the direction of prevailing winds. The rows of belt can be developed by using shrubs and trees. It is mainly used for the conservation of soil moisture and for the protection of field crops, against severe wind erosion.
Shelterbelt is more effective for reducing the impact of wind movement than the wind break. Apart from controlling wind erosion, it provides fuel, reduces evaporation and protects the orchard from hot and cold winds.

Relationship between the distance of full protection (d) and the height (h) of wind break or shelter belt:

$$d = 17h\left(\frac{v_m}{v}\right)\cos\theta$$





Where, *d* is the distance of full protection (m), *h* is the height of the wind barrier (wind break or shelter belt) (m), *vm* is the minimum wind velocity at 15 m height required to move the most erodible soil fraction (m/s), *v* is the actual velocity at 15 m height, and θ is the angle of deviation of prevailing wind direction from the perpendicular to the wind barrier.

This equation may also be adapted for estimating the width of strips by using the crop height in the adjoining strip in the equation. The value of *vm* for a bare smooth surface after erosion has been initiated and before wetting by rainfall and subsequent surface crusting is about 9.6 m/s.

Solve Problem:

Problem 1: Find out the wind velocity at 10 and 15 m height from ground surface over a wheat cropped field of plants height 1.3 m and friction velocity of 6 m/s.

Solution: The mean wind velocity above the soil surface is estimated as-

Problem 2: Determine the spacing between windbreaks that are 15 m high. 5 year return period wind velocity at 15 m height is 15.6 m/s and the wind direction deviates 10° from the perpendicular to the field strip. Assume a smooth, bare soil surface and a fully protected field.

Solution:

Problem 3: Determine the full protection strip width for field strip cropping if the crop in the adjacent strip is wheat, 0.9 m tall, and the wind velocity at 15 m height is 8.9 m/sec at 90° with the field strip.

Solution:

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