Introduction to Infrastructural Engineering

Drainage & DESIGN OF DRAINAGE SYSTEMS

by

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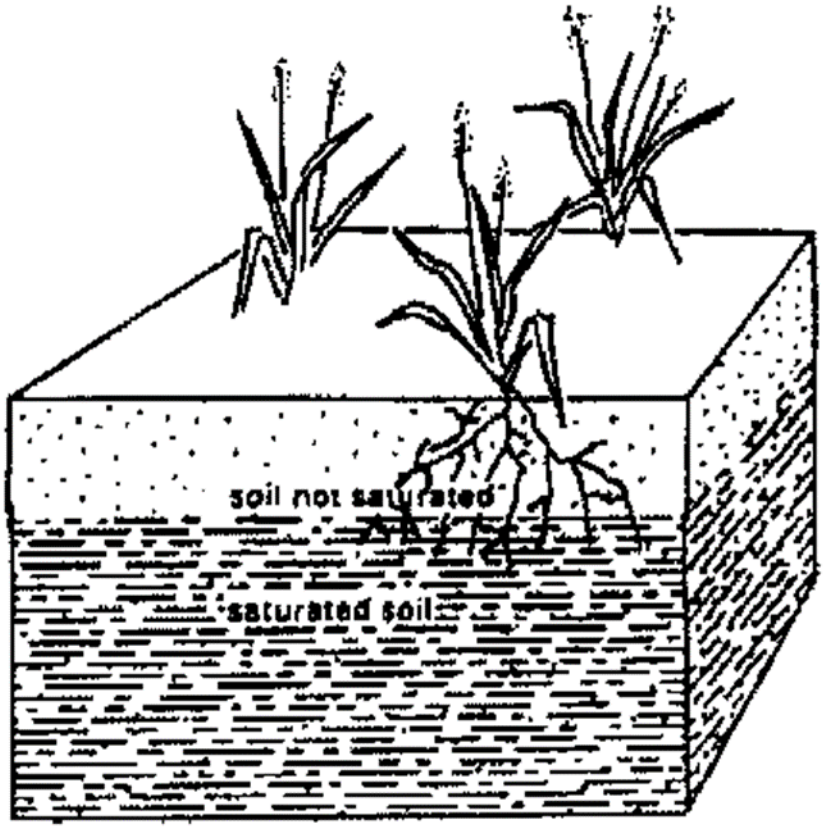
Introduction

- Drainage means the removal of excess water from a given place.
- Two types of drainage can be identified:
- **i) Land Drainage:** This is large scale drainage where the objective is to drain surplus water from a large area by such means as excavating large open drains, erecting dykes and levees and pumping. Such schemes are necessary in low lying areas and are mainly Civil Engineering work.

Field Drainage

- This is the drainage that concerns us in agriculture. It is the removal of excess water from the root zone of crops.

Water in Soil After Heavy Rain



Design of Drainage Channels or Ditches

- **Estimation of Peak Flows:** This can be done using the Rational formula, Cook's method, Curve Number method, Soil Conservation Service method etc.
- Drainage coefficients (to be treated later) are at times used in the tropics used in the tropics especially in flat areas and where peak storm runoff would require excessively large channels and culverts.
- This may not apply locally because of high slopes.

The Rational Formula

- It states that:
- qp = (CIA)/360
- where qp is the peak flow (m^3 /s);
- C is dimensionless runoff coefficient;
- I is the rainfall intensity for a given return period. Return period is the average number of years within which a given rainfall event will be expected to occur at least once.
- A is the area of catchment (ha).

Catchments

Diagram Showing Two Catchments

Using the Rational Method

- i) Obtain area of catchment by surveying or from maps or aerial photographs.
- ii) Estimate intensity using the curve in Hudson's Field Engineering, page 42.
- iii) The runoff coefficient C is a measure of the rain which becomes runoff. On a corrugated iron roof, almost all the rain would runoff so C = 1, while in a well drained soil, nine-tenths of the rain may soak in and so C = 0.10. The table (see handout) from Hudson's Field Engineering can be used to obtain C value. Where the catchment has several different kinds of characteristics, the different values should be combined in proportion to the area of each.

Runoff Coefficient, C

Table 3.3
Values of run-off coefficient C

Topography and vegetation	Soil texture		
	Open sandy loam	Clay and silt loam	Tight clay
Woodland			
Flat 0-5 per cent slope	0·10	0·30	0·40
Rolling 5-10 per cent slope	0·25	0·35	0·50
Hilly 10-30 per cent slope	0·30	0·50	0·60
Pasture			
Flat	0·10	0·30	0·40
Rolling	0·16	0·36	0·55
Hilly	0·22	0·42	0·60
Cultivated			
Flat	0·30	0·50	0·60
Rolling	0·40	0·60	0·70
Hilly	0·52	0·72	0·82
Urban areas	30 per cent of area impervious	50 per cent of area impervious	70 per cent of area impervious
Flat	0·40	0·55	0·65
Rolling	0·50	0·65	0·80

From Schwab, Frevert, Edminster, and Barnes,
Soil and water conservation engineering, Wiley, New York.

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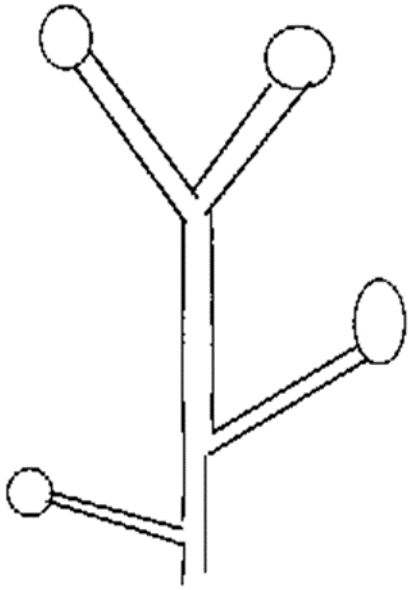
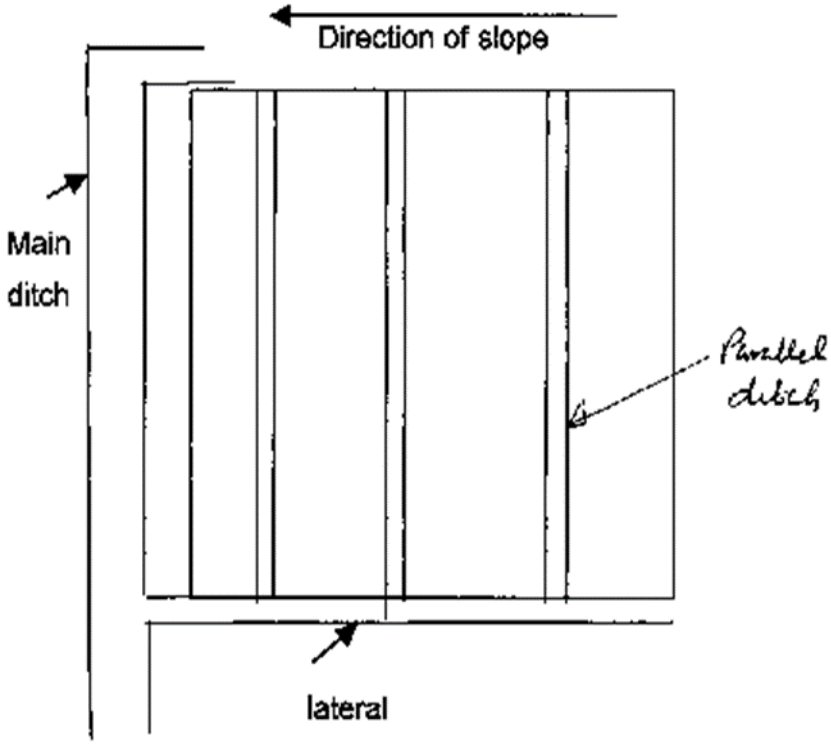
Cook's Method

- Three factors are considered:
- Vegetation,
- Soil permeability and
- Slope.
- These are the catchment characteristics.
- For each catchment, these are assessed and compared with Table 3.4 of Hudson's Field Engineering

Surface Ditch Arrangements



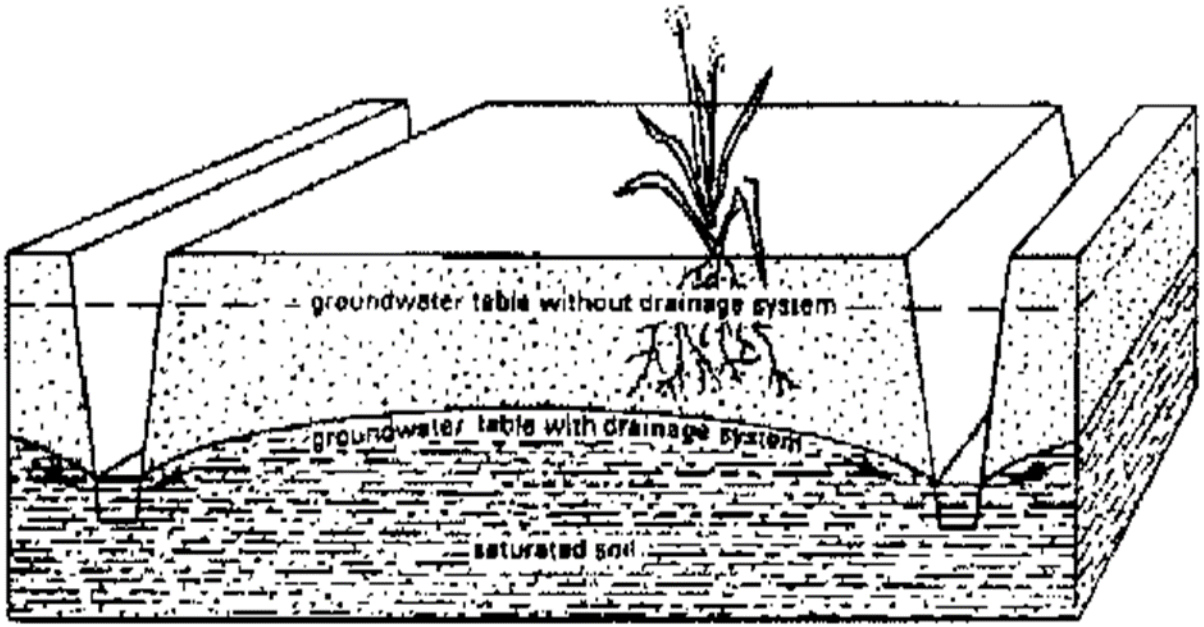
Random ditch system



Parallel ditch system.

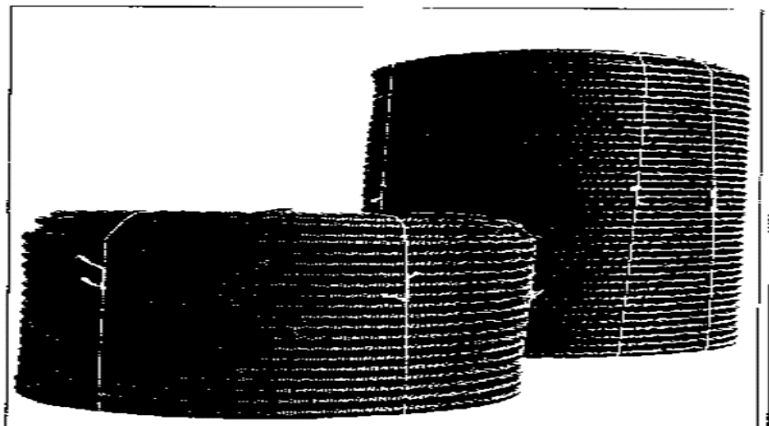
Sub-Surface Drainage Using Ditches

Fig. 99. Control of the groundwater table by means of deep open drains



Buried Drains

Land drainage and sub-surface irrigation pipes and fittings



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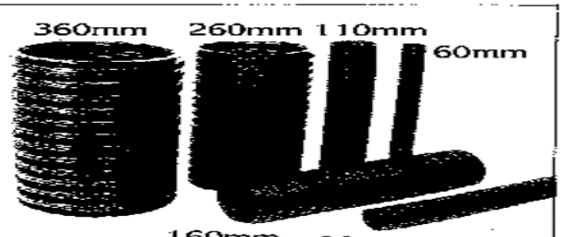

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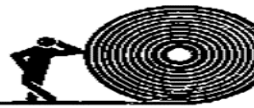

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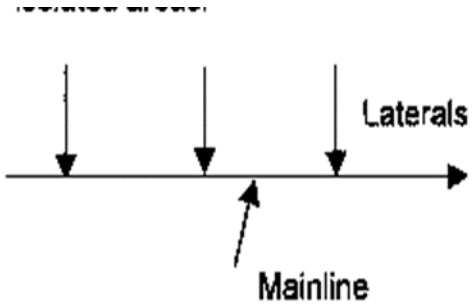
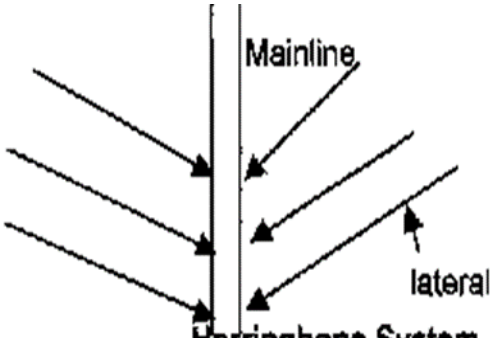
Technology

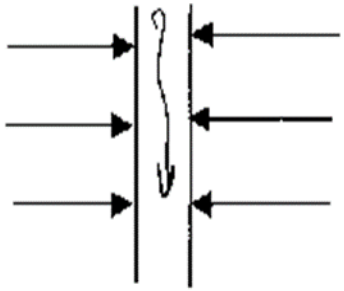
Arrangements of Sub-Surface Drains



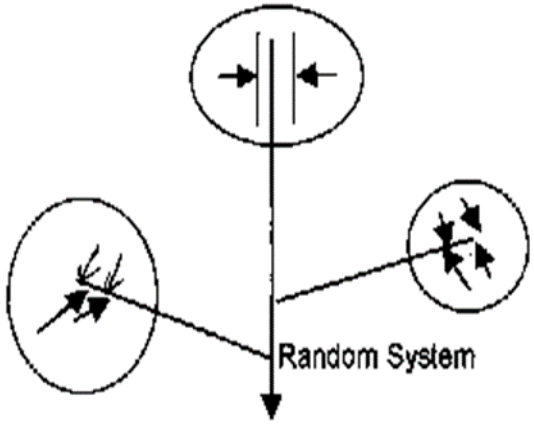
Parallel System



Herringbone System



Double Main System



Drainage Coefficient in Rain-Fed Areas

This is chosen from experience depending on rainfall. The following are guidelines.

- **A. Table 4.1 : Drainage Coefficient for Rain-Fed Areas***

Mean annual rainfall (mm/yr)	Drainage coefficient (mm/day) Ministry of Agric.	Hudson
2000	25	20
1950	25	19.5
1500	19	15
1000	13	10
875	10	10
< 875	7.5	10

- .....
- *From Ministry of Agric., U.K (1967) & Hudson (1975)

Other Methods For Obtaining Drainage Coefficient in Rain-Fed Areas

- **Note**: Hudson suggests that for MAR (mean annual rainfall) > 1000 mm, drainage coefficient is MAR/1000 mm/day and where MAR < 1000 mm, drainage coefficient is 10 mm/day.
- **B. From rainfall records**, determine peak rainfall with a certain probability depending on the value of crops or grounds to be protected e.g. 5 day rainfall for 1: 2 return period.
- **C. Divide the rainfall** of the heaviest rainfall month by the days of the month e.g. in St. Augustine, Trinidad, the heaviest rainfall month is August with 249 mm.
- i.e. Drainage discharge = 249/31 = 8.03 mm/day.
- Use this method as a last resort.