

Lecture Note – 7

Infiltration

The vertical movement of water through the soil surface is known as infiltration.

Importance of infiltration

1. It affects the timing, distribution, and magnitude of surface runoff.
2. It is the primary step in the natural groundwater recharge.

Infiltration capacity (f_c)

The maximum rate at which the ground can absorb water at a given time is its infiltration capacity.

If f is the actual rate of infiltration then,

$$f = f_c \quad \text{when } i > f_c, \text{ and}$$
$$f = i \text{ when } i < f_c$$

Where, i = Intensity of rainfall

The infiltration capacity of a soil is high at the beginning of a storm and has an exponential decay as the time elapses, and finally settles down to a constant value.

Factors affecting infiltration capacity

Characteristics of soil

A loose, permeable, sandy soil will have a larger infiltration capacity than a tight, less permeable, clay soil.

A dry soil can absorb more water than the one whose pores are already full.

A forest soil will have a higher value of f_c than the soil in an urban area under identical conditions. It is because of the fact that the urban soil is subjected to compaction.

Surface of entry

A surface covered with vegetation has higher value of f_c than a barren soil.

Fluid characteristics

Heavy suspended particles in water can clog the fine pores in the soil and reduce infiltration capacity.

Infiltration capacity equation

$$f_{ct} = f_{cf} + (f_{co} - f_{cf})e^{-K_h t} \quad 0 \leq t \leq t_d \rightarrow \text{Horton's equation (1930)}$$

Where,

f_{ct} = Infiltration capacity at any time t from the start of rainfall

f_{co} = Infiltration capacity at $t = 0$

f_{cf} = Final steady state value

t_d = Duration of rainfall

K_h = Constant depending on soil characteristics and vegetative cover

Typically,

For a bare sandy soil, $f_c = 1.2$ cm/hr

For a bare clay soil, $f_c = 0.15$ cm/hr

A good grass cover or vegetation increases this value by **as much as 10 times**.

Infiltration index

In hydrological calculations, it is convenient to use a constant value of infiltration rate for the duration of the storm. The **average infiltration rate** is called infiltration index.

ϕ -index

It is the **average rainfall** above which the rainfall volume is equal to the runoff volume.

The ϕ -index is derived from the rainfall hyetograph with the knowledge of resulting runoff volume. In this case, the **initial loss** is also considered as infiltration.

$$\phi - index = \frac{P - R}{t_e}$$

Where,

P = Total storm precipitation

R = Total storm runoff

t_e = Duration of rainfall excess, i.e. the total time in which the rainfall intensity is greater than ϕ -index

Now,



if $i < \phi$ -index, then infiltration rate (f) = i (No runoff case)



if $i > \phi$ -index, then infiltration rate (f) = ϕ -index, and the difference between rainfall and infiltration in an interval of time represents the runoff volume in that time.

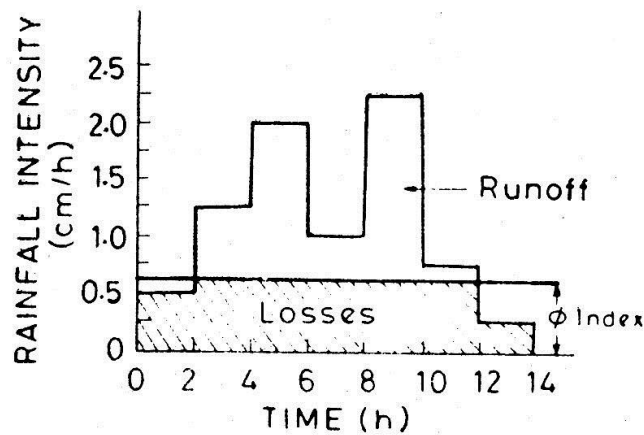


Fig. 3.13 ϕ Index

EXAMPLE 3.5: A storm with 10.0 cm precipitation produced a direct runoff of 5.8 cm. Given the time distribution of the storm as below, estimate the ϕ index of the storm.

Time from start (h)	0	1	2	3	4	5	6	7	8
Incremental rainfall in each hour (cm)	0	0.4	0.9	1.5	2.3	1.8	1.6	1.0	0.5

$$\text{Total infiltration} = 10.0 - 5.8 = 4.2 \text{ cm}$$

Assume t_e = time of rainfall excess = 8 h for the first trial.

Then

$$\phi = \frac{4.2}{8} = 0.525 \text{ cm/h}$$

But this value of ϕ makes the rainfalls of the first hour and eighth hour ineffective as their magnitude is less than 0.525 cm/h. The value of t_e is therefore modified.

Assume t_e = 6 h for the second trial

In this period,

$$\begin{aligned} \text{Infiltration} &= (10.0 - 0.4 - 0.5 - 5.8) \\ &= 3.3 \text{ cm} \end{aligned}$$

$$\phi = \frac{3.3}{6} = 0.55 \text{ cm/h}$$