

## I. RUN OFF COMPUTATION

- Computation of runoff depend on several factors
- Methods available
  - Rational method
  - Cook's method
  - Curve number method
  - Hydrograph method
  - Many more Rational Method
- Computes peak rate of runoff
- Peak runoff should be known to design hydraulic structures that must carry it.

### Rational Method

- Computes peak rate of runoff
- Peak runoff should be known to design hydraulic structures that must carry it

= Peak runoff rate ( $\text{m}^3/\text{s}$ )

C = runoff coefficient

I = rainfall intensity (mm/h) for the duration equal to the time of concentration

A = Area of watershed (ha)

**Runoff coefficient** – Ratio of peak runoff rate to the rainfall intensity – No units,

0 to 1 – Depend on landuse and soil type – When watershed has many land uses and soil types, weighted average runoff coefficient is calculated

## Runoff coefficient for Rational Method

S.No.	Land use and topography	Soil type		
		Sandy loam	Clay and silt loam	Tight clay
1.	Cultivated land			
	(i) Flat	0.30	0.50	0.60
	(ii) Rolling	0.40	0.60	0.70
	(iii) Hilling	0.52	0.70	0.82
2.	Pasture land			
	(i) Flat	0.10	0.30	0.40
	(ii) Rolling	0.16	0.36	0.55
	(iii) Hilling	0.22	0.42	0.60
3.	Forest land			
	(i) Flat	0.10	0.30	0.40
	(ii) Hilling	0.30	0.50	0.60
4.	Populated land			
	(i) Flat	0.40	0.55	0.65
	(ii) Rolling	0.50	0.65	0.80

### Time of concentration (T<sub>c</sub>)

Time required to reach the surface runoff from remotest point of watershed to its outlet

- Have to compute the rainfall intensity for the duration equal to time of concentration –
- Several methods to calculate T<sub>c</sub> – Kirpich equation

L = Length of channel reach (m) S = Average channel slope (m/m)

### Assumptions of Rational Method

- Rainfall occur with uniform intensity at least to the T<sub>c</sub>
- Rainfall intensity is uniform throughout catchment

### Limitations of Rational Method

- Uniform rainfall throughout the watershed never satisfied
- Initial losses (interception, depression storage, etc). are not considered
- Cook's Method Computes runoff based on 4 characteristics (relief, infiltration rate, vegetal cover and surface depression)

### •Numerical values are assigned to each Step in calculation

- Step 1 –Evaluate degree of watershed characteristics by comparing with similar condition

S. No.	Range	Numerical values assigned for runoff producing watershed's characteristics			
		Relief (10 to 0)	Soil infiltration (5)	Vegetal cover (5)	Surface storage (5)
1.	Low	(10 to 0) Land is relatively flat, average slope ranges from 0 to 5%.	(5) Infiltration rate is more than 2 cm/hour, soil contains high sand and loamy sand.	(5) About 9% of total area is covered under good vegetation either by forest or equivalent.	(5) Land consists of high surface depression, drainage system is not very well.
2.	Normal	(20 to 10) The land is rolling in shape and slope ranges from 5% to 10%.	(10) Infiltration rate varies from 0.75 to 2 cm/ hour, the soil is in normal and deep permeable nature.	(10) About 50% of total area is under good grass land or any other equivalent cover.	(10) Considerable depression, lakes, ponds and marshes are less than 2% of entire drainage system.
3.	High	(30 to 20) Lands are hilly in nature, average slope ranges from 10% to 30%.	(15) Infiltration rate ranges from 0.25 to 0.75 cm/hour, the soil is relatively hard such as clay soil.	(15) Vegetal cover varies from poor to fair, less than 10% of total area is under grass cover.	(15) Surface depression is very low and area is well drained.
4.	Extreme	(40 to 30) Lands are steep and rugged terrain, slope ranges upto 30%.	(20) Infiltration rate is less.	(20) Land is bare, no effective grass cover.	(10) Surface depressions are negligible, drainage of land is very well, and no ponds or tanks are available.

- Step 2 Fig. (2) Numerical values for Cook's Method –Assign numerical value (W) to each of the characteristics
- Step 3 –Find sum of numerical values assigned

$\Sigma W$  = total numerical value R, I, V, and D are marks given to relief character, initial infiltration, vegetal cover and surface depression respectively

- Step 4 –Determine runoff rate against  $\Sigma W$  using runoff curve (valid for specified geographical region and 10 year recurrence interval)
- Step 5 –Compute adjusted runoff rate for desired recurrence interval and watershed location =
- **P.R.F.S**= Peak runoff for specified geographical location and recurrence interval (m<sup>3</sup>/s) P = Uncorrected runoff obtained from step 4 R = Geographic rainfall factor F = Recurrence interval factor S = Shape factor

H<sub>2</sub> = downstream water surface elevation measured above weir crest n = for rectangular weir  
n = 1.5

## 1.2 CATEGORIZATION OF HYDRAULIC STRUCTURE

- (a) Thin plate structures
- (b) Long base weirs [ broad crested structures]
- (c) Flumes [made of concrete, masonry, metal sheets etc]

### SLOPE AREA METHOD

- Manning's formula is used to relate depth at either section with the discharge.
- Knowing the water surface elevation at the two section, it is required to estimate the discharge. Applying the energy equation to sections 1 and 2,
- $Z_1 + Y_1 + \{V_1^2 / 2g\} = Z_2 + Y_2 + \{V_2^2 / 2g\} + h_L$
- $h_L = h_e + h_f$  where  $h_e$  = eddy loss and  $h_f$  = frictional loss.
- $h_f = (h_1 - h_2) + \{(v_1^2 / 2g) - (v_2^2 / 2g)\} - h_e$
- If  $L$  = Length of the reach then  $h_f / L = S_f = Q^2 / K^2$  = Energy slope
- $K$  = conveyance of the channel  $= (1/n)A(R^{2/3})$
- $n$  = manning's roughness coefficients
- In non uniform flow  $k = \{k_1 k_2\}^{1/2}$
- $h_e = K_e [(v_1^2 / 2g) - (v_2^2 / 2g)]$  where  $K_e$  = eddy loss coefficient

### Stage Discharge Relationship

- The stage discharge relationship is also known as rating curve.
- The measured value of discharges when plotted against the corresponding stages gives relationship that represents the integrated effects of a wide range of channel and flow parameters.
- The combined effects of these parameters is known as control.
- If the (G-Q) relationship for a gauging section is constant and does not change with time, the control is called permanent.
- If it changes with time, it is called shifting control

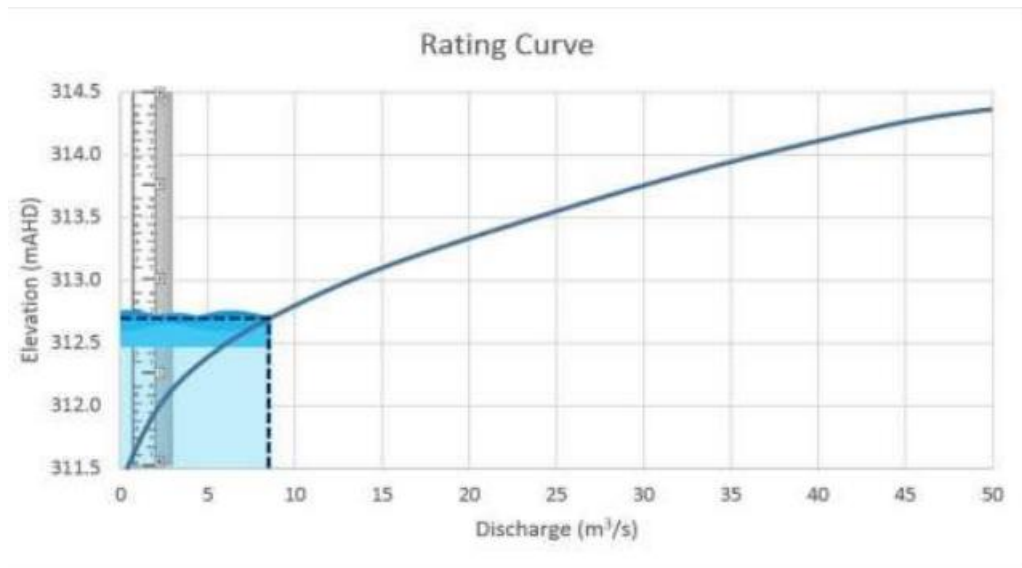


Fig (5) Rating Curve

