Toppersnotes
Unleash the topper in you

IES/GATE

Civil Engineering

Volume - 6

Environmental Engineering

SIERRA INNOVATIONS

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CHAPTER

1

WATER DEMAND & RESOURCES

THEORY

1.1 | WATER DEMAND

1.1.1 Domestic Water Demand

The total domestic water consumption usually vary from 50% to 60% of the total water supply to a city. The IS code list down a limit of water consumption between 135 to 225 ltr/capita/day (LPCD). Under ordinary condition (as per IS code) the domestic water demand for a town or a city with full flushing system should be taken as 200 LPCD. Although it can be reduced to 135 LPCD for economical weaker section and LIG colony.

1.1.2 Industrial Water Demand

This quantity varies with number and type of industries present in the city. This consumption under ordinary condition is 50 LPCD. Some industries influence a high water demand like : Paper industry, Textile industries etc.

1.1.3 Institutional and Commercial Water Demand

On an average demand is 20 LPCD. It may be as high as 50 LPCD.

1.1.4 Demand for Public Use

This includes water requirement for parks, gardening washing of roads etc. On this account a normal amount not exceed 5% of consumption may be provided.

1.1.5 Fire Demand

The quantity of water require for fire is not very large. The city upto 50 lakh population hardly amount is 1 LPCD. But this water should be easily available and kept always stored in storage reservoir.

1.1.6 Water Demand for Losses & Theft

This may be as high as 15% of total demand.

1.2 | FACTORS AFFECTING WATER DEMAND

(a) Size of city

(b) Climate condition

(c) Industrial and commercial activities

(d) Habits of people

(e) Quality of water supply

(f) Pressure in the distribution system.

(g) Development of sewage facility.

(h) Cost of water and method of charging.

1.3 | Population Forecasting Methods

Methods are based on laws of probability and growth curve. Following are population forecasting methods :

(a) Arithmetic increase method
(b) Geometric increase method
(c) Incremental increase method
(d) Decreasing rate of growth method
(e) Simple graphical method
(f) Comparative graphical method
(g) Master plan method or zoning method
(h) The ratio method or apportionment method
(i) The logistic carve method

Methods are Discussed Below:

(a) Arithmetic Increase Method

This method assumes that the population increases at a constant rate :

$$\frac{dP}{dt} = \text{constnat}$$

Forecasted population (P_n) after 'n' decades

$$P_n = P_0 + n\bar{x}$$

where,

P_0 = Population at last known census.

$\bar{x}$ = Average (Arithmetic mean) of population increase in last decades.

n = No. of decades between last census and future.

(b) Geometric Increase Method

It is also known as 'uniform increase method'.

Forecasted population,

$$P_n = P_0 \left(1 + \frac{r}{100}\right)^n$$

where,

P_0 = Population at last known census.

r = Growth rate (%)

$$r = \frac{\text{Increase in population}}{\text{Orginal population}} \times 100 \text{ for each decade.}$$

Knowing as r_1, r_2, r_3, r_4 .... r_n for each decade.

The average value of r can be found by

(i) Arithmetic average method

$$r = \frac{r_1 + r_2 + r_3 + \ldots\ldots\ldots\ldots r_n}{n}$$

(ii) Geometric average method

$$r = (r_1 \times r_2 \times r_3 \ldots\ldots\ldots\ldots \times r_n)^{\frac{1}{n}}$$

Note: *Engineers adopt arithmetic average method since it gives more value than the geometric avg. Method. However GOI manual on water supply recommends 'Geometric mean method'.*

(iii) Incremental increase method:

Rate of growth is not assumed constant.

Population

$$P_n = P_0 + n\bar{x} + \frac{n(n+1)}{2}\bar{y}$$

where,

P_0, n, $\bar{x}$ are as usual.

$\bar{y}$ = Average of Incremental increase of the known decades.

Note: (i) *Geometric mean method suitable for younger cities expanding of faster rate.*

(ii) *Incremental increase method suitable for both old and new cities.*

Example: The population of 5 decades from 1930 to 1970 are given below in table. Find out the population after '3' decades beyond the last known decade, by using

(i) Arithmetic mean method (ii) Geometric mean method (iii) incremental increase method

Year	1930	1940	1950	1960	1970
Population	25000	28000	34000	42000	47000

Solution:

Col (1)	Col (2)	Col (3)	Col (4)	Col (5)
Year	Population	Increase in population	Growth rate (r) %	Incremental increase
1930	25000			
		3000	$\frac{3000}{25000} \times 100 = 12$	
1940	28000			6000-3000 = 3000
		6000	$\frac{6000}{28000} \times 100 = 21.4$	
1950	34000			8000-6000 = 2000
		8000	$\frac{8000}{34000} \times 100 = 23.5$	
1960	42000			5000-8000 = -3000
		5000	$\frac{5000}{42000} \times 100 = 11.9$	
1970	47000			
Total		Σ = 22000		Σ = 2000

(i) Arithmetic mean method:

$$\bar{x} = \frac{\sum col(3)}{4} = \frac{22000}{4} = 5500$$

$$P_{2000} = P_{1970} + n\,\bar{x}$$

$$= 47000 + 3 \times 5500 = \mathbf{63500}$$ **Ans.**

(ii) Geometric mean method :

(a) $$r = \frac{r_1 + r_2 + r_3 + r_4}{4} = \frac{12 + 21.4 + 23.5 + 11.9}{4} = 17.2\%$$

$$P_{2000} = P_{1970}\left(1 + \frac{r}{100}\right)^n$$

(b)

$$r = (r_1\ r_2\ r_3\ r_4)^{1/4}$$
$$= (12 \times 21.4 \times 23.5 \times 11.9)^{1/4}$$
$$= 16.37\%$$

So,

$$P_{2000} = 47000\left(1+\frac{16.37}{100}\right)^3$$
$$= 74066.62 \simeq 74067$$

(iii) Incremental Increase method :

$$\bar{y} = \frac{\sum col(s)}{3} = \frac{2000}{3} = 666.67$$

$$P_{2000} = P_{1970} + n\bar{x} + \frac{n(n+1)}{2}\bar{y}$$
$$= 47000 + 3 \times 5500 + \frac{3(3+1)}{2}\left(\frac{2000}{3}\right)$$
$$= \mathbf{67500}$$ ***Ans.***

1.4 | WATER RESOURCES

Mainly there are two types of water resources:

1. Surface water resources
2. Ground water resources

1. Surface water resources

- ❖ It consist river, lake, water fall etc.
- ❖ Among all the surface water resources rivers are main.
- ❖ The source of water in river is either rain or melting of ice.

2. Ground water resources

- ❖ The main ground water resources are well and tube-well.
- ❖ The possibility of ground water occurance depends upon (a) Porosity (b) Permeability
  - (a) ***Porosity :*** Indicates voids in which water will be accumulated.
  - (b) ***Permeability :*** It represent ability to pass water to itself. Only if permeability is large enough than only water can be taken out from the pores.

1.5 | DARCY'S LAW

As per Darcy the velocity of flow in soil is directly perposonal to hydraullic gradient.

$\Rightarrow$ $$V \propto i$$

$\Rightarrow$ $$V = K\ i$$

$\Rightarrow$ $$Q = KiA$$

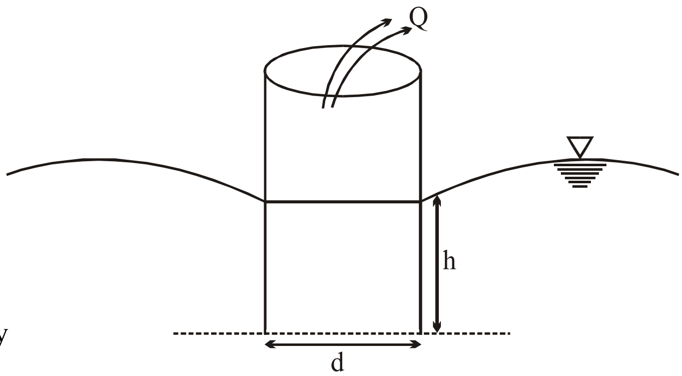
Where,

Q = Discharge rate

i = Hydraullic gradient

A = Area of flow

K = Permeability of soil



⇒ In general

$$A = \pi d h$$

But, Area available for flow of the water is only void present in soil mass.

So,

$$A_{actual} = \eta A$$

where, η = Porosity

⇒ For the continuity equation,

$$VA = V_{act} A_{act}.$$

$$V_{act} = V\left(\frac{A}{A_{act}}\right)$$

⇒

$$\boxed{V_{act} = V_{seepage} = \frac{V}{\eta}}$$

Co-efficient of permeability depends upon pores medium as well as fluid properties.

Co-efficient of permeability is given as

$$K = \frac{Cd^2 g}{\nu}$$

where,

C = shape factor

ν = kinematic viscosity of fluid

g = gravity acceleration

d = main or effective size of particle.

The component of permeability which represents only the properties of pores medium is called Intrinsic permeability / Absolute permeability. Given as

$$K_0 = Cd^2$$

$$K_0 = \frac{K\nu}{2}$$

$$\boxed{K_0 = \frac{K\mu}{r}}$$

The unit of Intrinsic permeability is "m^2" Or "Darcy"

$$\boxed{1\ \text{darcy} = 9.87 \times 10^{-13} m^2}$$

1.6 | TYPE OF GROUND LAYERS

On the basis of porosity and permeability the following types of layers are given.

1. ***Aquifuse :*** Neighter pores nor permeable. ***Example :*** Granite.
2. ***Aquitard :*** Its permeability is less. It does not yield ground water freely, but seepage is possible through it. ***Example :*** sandy clay.
3. ***Aquiclude :*** Highly pores but not permeable. ***Example :*** Clayey soil.
4. ***Aquifer :*** High pores and enough permeable. ***Example:*** sand deposits

1.7 | GROUND WATER YEILD

All water in the pores cannot be drained out under gravity. Some water can be retain due to molecular attraction. It is called "Pellicular water"

$$\text{Specific yield} = \frac{\text{Volume of water drain out under gravity}}{\text{Total volume of soil being drain out}}$$

$$\text{Specific retention} = \frac{\text{Volume of water retain}}{\text{Total volume of soil being drain out}}$$

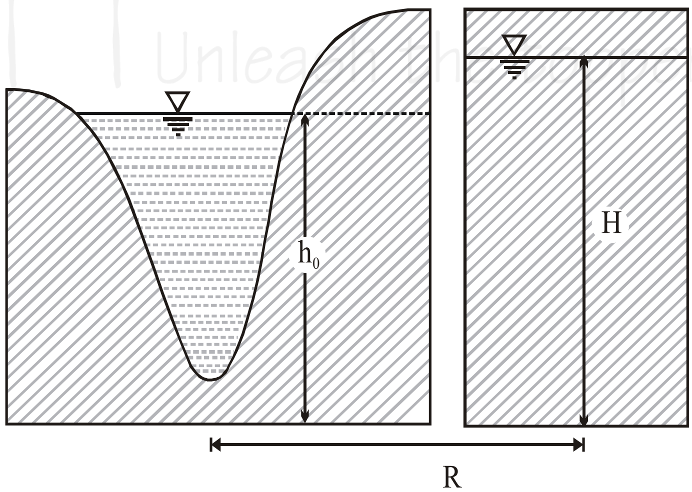
$$\boxed{\text{Specific yield} + \text{Specific retention} = \eta}$$

Smaller the particle size larger will be retention.

1.8 | SPECIFIC CAPACITY

It is a rate of flow from well per unit drawdown. *Various form of under ground source and there exploration:*

1. **Infilteration Gallery**



infilteration gallery

$$\text{Discharge } Q = \frac{K(H^2 - h_0^2)L}{R}$$

where,

K = Permeability of soil

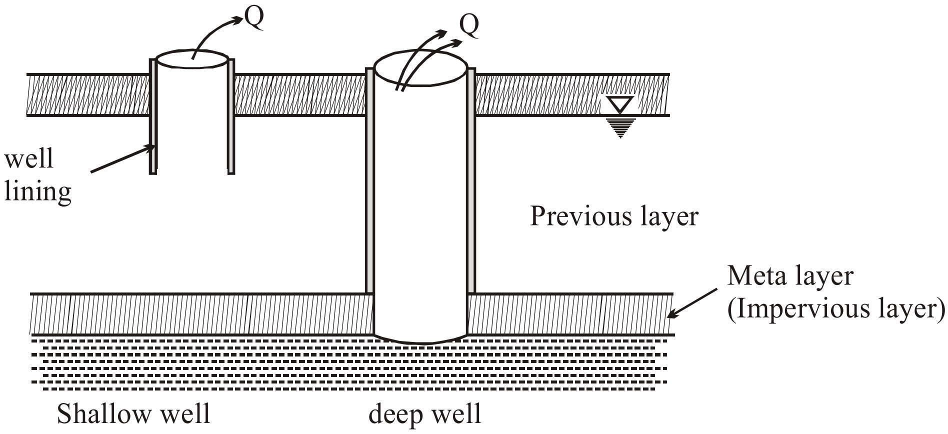
H = Height of water table

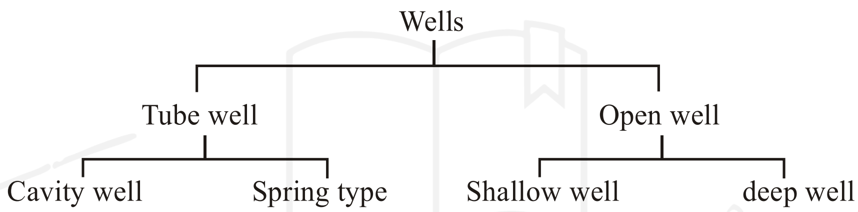
h_0 = height of Infilteration gallery

L = Length of Infilteration gallery

R = Distance between water levels

2. Wells

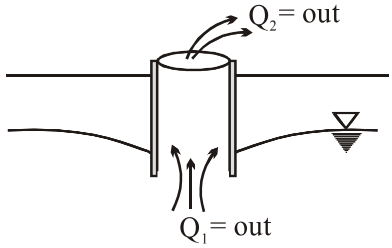




- ***Shallow well :*** Well lining are resisted by soil friction. It may be deeper than deep well.
- ***Deep well :*** Well lining rest on the first impervious layer.
- ***Cavity Formation :*** Due to large discharge from the deep well, upward velocity of flow become more than the critical velocity of flow and hence fine sand is get lifted along the water. More lifting of fine sand cause a cavity below the meta layer.
- It increase the flow area approx 4/3 times.
- Cavity formation is dangerous in shallow well, as well lining may sink. hence discharge from shallow well is limited.

1.9 | YIELD OF OPEN WELL

Yield at open well correctly calculated by pumping test in the field.



$Q_1 = Q_2$ = water level maintain

$Q_1 > Q_2$ = water level increases

$Q_1 < Q_2$ = water level decreases

1.10 PUMPING TEST

Pumping causes drawdrown thus it is adjucted to make water level constant. Under this equilibrium condition rate of pumping will be equal to rate of yield from the well

$$Q = CAS$$

where,

Q = Discharge

C = Specific capacity per unit area of well

S = Drawdown

A = Area of well (Bottom area)

$$= \frac{\pi}{4}d^2 \text{ (Shallow well)}$$

$$= \frac{4}{3}\times\frac{\pi}{4}d^2 \text{ (for deep well)}$$

If C and A are constant than

$$\frac{Q}{S} = \text{constant.}$$

$$\boxed{\frac{Q_1}{S_1} = \frac{Q_2}{S_2}}$$

The value of 's' for which the velocity become equal to critical velocity (for sand comes out) is called "Critical dispression head". Working head = $\frac{1}{3}$ critical dispression head (generally).

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