RPSC 2024

Rajasthan Public Service Commission

Assistant Engineer

CIVIL ENGINEERING

Environmental Engineering

MADE EASY PUBLICATIONS

CONTENTS

WATER DEMAND

1

Following Operations are Necessary for a Water Supply Scheme

- Water Collection
  - (i) Assessment of water demand.
  - (ii) Precipitation and design of surface reservoirs.
  - (iii) Ground water development.
- Water Transportation
- Water Treatment
  - (i) Water quality parameters
  - (ii) Control of Water quality parameters
- Water Distribution

WATER DEMAND

(A) Domestic Water Demand

- The total domestic water consumption usually amounts to *50 to 60% of the total water* consumption.
- The I.S. Code lays down a limit of water consumption between 135 to 225 litre per capita per day (lpcd).
- Under ordinary conditions (as per I.S. code) the minimum domestic water demand for a town or a city with full flushing system should be taken at *200 lpcd*. Although it can be reduced to *135 lpcd for economically weaker sections and LIG colonies* (Low Income Group) depending upon prevailing conditions.

(a) Minimum domestic water Consumption (Annual Average) for Indian Towns and Cities with Full Flushing Systems as per 1172-1993

Use	Consumptions (lpcd)
Drinking	5
Cooking	5
Bathing	75
Washing of clothes	25
Washing of utensils	15
Washing and cleaning of houses and residences	15
Lawn watering and gardening	15
Flushing of water closets, etc.,	45
Total	200

(b) Minimum domestic water Consumption (Annual Average) for Weaker Section and LIG Colonies in Small Indian Towns and Cities

Use	Consumptions (lpcd)
Drinking	5
Cooking	5
Bathing	55
Washing of clothes	20
Washing of utensils	10
Washing and cleaning of houses and residences	10
Flushing of water closets, etc.,	30
Total	135

(B) Industrial Water Demand

- The industrial water demand represents the water demand of industries which are either existing or likely to be started in future, in the city for which water supply is being planned.

- This quantity varies with the number and types of industries present in the city. This consumption, *under ordinary conditions is 50 lpcd.*

Water Demand of certain Important Industries:

1. Petroleum Refinery — 1 to 2 k*l* per tonne of crude oil
2. Sugar Industry — 1 to 2 k*l* per tonne of crushed cane.
3. Fertilizer Ind. — 80 to 200 k*l* per tonne of Textile Industry product.
4. Paper Industry — 400 to 1000 k*l* per tonne of paper
5. Automobile and Industry production — 40 k*l* per tonne of Leather.

(C) Institutional and Commercial Water Demand

- The water requirements of institutions such as hospitals, hotels, restaurants, schools and colleges, railway station etc. should also be assessed and provided for in addition to domestic and industrial water demands discussed above.
- On an average, a per capita demand of 20 lpcd is usually considered to be enough to meet such commercial and institutional water requirements. Although this demand may be as high as 50 lpcd for highly commercialised cities.

Water demand of certain commercial establishments:

(i) Offices 45 *l*pcd
(ii) Schools 45 to 135 *l*pcd
(iii) Hostels 135 *l*pcd
(iv) Hotels 180 *l*pcd
(v) Hospitals 450 *l*pcd
(vi) Cinema halls 15 *l*pcd

(D) Demand for Public Uses

- This includes water requirement for parks, gardening, washing of roads etc. On this account a nominal amount not exceeding *5%* of the total consumption may be provided.

(E) Fire Demand

- The quantity of water required for extinguishing fire is not very large, the total amount of water consumption for a city of 50 lakh population hardly **amounts to 1 lpcd.** But this water should be easily available and kept always stored in storage reservoirs.
- Three jet streams are simultaneously thrown from each hydrant; one on the burning property, and one each on adjacent property on either sides of the burning property. The discharge of each stream should be about 1100 litres/minute.
- The minimum water pressure available at fire hydrants should be of the order of 1 to 1.5 kg/cm^2 and should be maintained even after 4 to 5 hours of constant use of fire hydrant.
- Rate of fire demand is worked out by following formulas

1. **Kuichling's Formula:**

$$Q = 3182\sqrt{P}$$

Where,

Q = Amount of water required in litres/minute

P = Population in thousands.

2. **Freeman Formula:**

$$Q = 1136\left[\frac{P}{5}+10\right]$$

3. **National Board Formula:**

(A) For a central congested high valued city:

(i) When population ≤ 2 lakhs:

$$Q = 4637\sqrt{P}\left[1-0.01\sqrt{P}\right]$$

(ii) When population ≥ 2 lakhs:

A provision for 54600 litres per minute may be made with an additional provision of 9100 to 36400 litres/minute for a second fire.

(B) For a residential city:

(i) For small or low buildings:

Q = 2200 litres/minute.

1. Arithmetic Increase Method

- This method assumes that the population increases at a constant rate.

$$\frac{dp}{dt} = \text{constant}$$

Forecasted population (P_n) after 'n' decades from the last known census is given by

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

Where,

P_0 = Population at last known census.

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

n = Number of decades between last census and future.

2. Geometric Increase Method

- This is compounding rate method also called *'uniform increase method'*.
- The forecasted population (P_n) after n decades is given by

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

Where,

P_0 = Population at last known census

r = Assumed growth rate (%)

r can be calculated by following methods.

(i) $r = \left(\frac{P_n}{P}\right)^{\frac{1}{n}} - 1$

(ii) $r = \frac{\text{increase in population}}{\text{Original population}} \times 100$ for each decade

Knowing r_1, r_2, r_3 ... r_n for each decade the average value of r can be found by

(a) Arithmetic average method:

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

(b) Geometric average method:

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

Do you know?

The Field Engineers adopt arithmetic average method since it gives more values than the geometric average method. However, GOI manual on water supply recommends 'geometric mean' method.

3. Incremental Increase Method: (The Method of varying increment)

- The rate of growth is not assumed constant. Whereas it was assumed constant in arithmetic and geometric methods.
- The population after n decades from present (i.e. last known Census) is given by

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

Do you know?

The geometric progression method, gives highest values of forecasted population, evidently gives higher results for developed cities which do not expand in future at compound rate, although it may be suitable for new younger cities expanding at faster rates. For old cities, the arithmetic method may be better, although, incremental method is considered to be the best for any city, whether old or new.

4. Decreasing Rate of Growth Method

- Since the rate of increase in population goes on reducing as the cities reach towards saturation, this method is suitable. In this method, the average decrease in the percentage increase is worked out, and is then subtracted from the latest percentage increase for each successive decade.

Do you know?

- *This method is applicable only when the rate of growth shows a downward trend.*
- In this method calculations are made for each successive decade.

Steps:

(i) Find increase in population.

(ii) Find % increase (r) for last count P_o

(iii) Find decrease in the % increase in population. (r_1) is actually decreasing then it is taken +ve and If r_1 is increasing it is –ve.

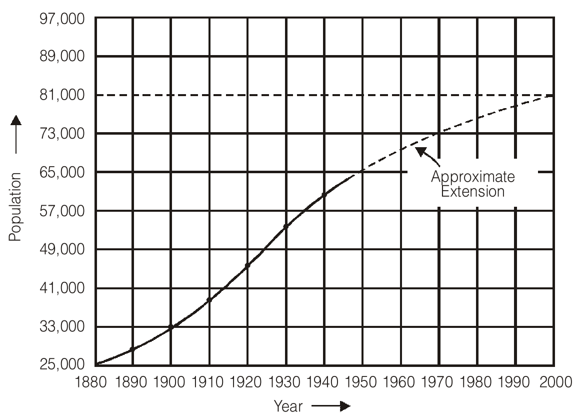
(iv) The expected population

$$P_1 = P_o + \frac{r - r_1}{100} \times P_o$$

$$P_2 = P_1 + \frac{(r - r_1) - r_1}{100} \times P_1$$

5. Simple Graphical Method

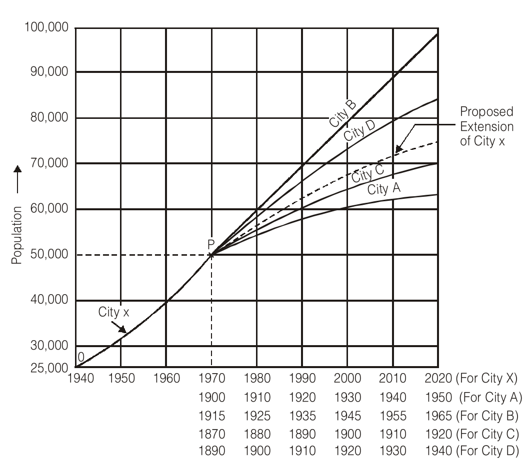
- A graph is plotted from the available data between time and population, the curve is then smoothly extended up to the desired year.



Graph between population and time for example 2.11

6. Comparative Graphical Method

- Cities of similar conditions and characteristics are selected which have grown in similar fashion in the past, and their graph is plotted, and then mean graph is also plotted. This method gives quite satisfactory results.



7. Master Plan Method or Zoning Method

- Big and Metropolitan cities are generally controlled by development authorities in a planned manner, only those expansions are allowed which are permitted or proposed in the master plan of that city and the populations are also fixed.

  Say for (example) 5 persons living in a flat etc.

8. The Ratio Method or Apportionment Method

- In this method the city's census population record is expressed as the % of the population of the whole country, in order to do so, the local population and the countries population for last 4-5 decades is obtained from the census records. The ratios of local population to national population is worked out a graph is then plotted between those ratios and time and extended up to the design period and then ratio is multiplied by expected national population at the end of design period.
- This method does not take into consideration abnormalities in local areas.

9. The Logistic Curve Method

- This method is given by P.F. Verhulst. This method is mathematical solution for logistic curve.
- The population at any time t from the start is given by

$$P = \frac{P_s}{1 + m.\log_e^{-1}(nt)}$$

Where,

P_s = Saturation population

P = Population at any time t from start point

P_o = Population at the start point of the curve

$$m = \frac{P_s - P_0}{P_0} = \text{constant}$$

$$P_s = \frac{2P_0P_1P_2 - P_1^2(P_0 + P_2)}{P_0P_2 - P_1^2}$$

$$n = \left(\frac{1}{t_1}\right)\log_e\left[\frac{P_0(P_s - P_1)}{P_1(P_s - P_0)}\right]$$

P_o, P_1, P_2, are population at times $t = t_0$, t_1 and $t_2 (= 2t_1)$.

Practice Questions : Level-1

Q.1 Which one of the following method gives the best estimate of population growth of a community with limited land area for future expansion?
(a) Arithmetical increase method
(b) Geometrical increase method
(c) Incremental increase method
(d) Logistic method

Q.2 If the average daily water consumption of a city is 24000 cum, the peak hourly demand (of the maximum day of course) will be
(a) 1000 cu m/hr (b) 1500 cu m/hr
(c) 1800 cu m/hr (d) 2700 cu m/hr

Q.3 The suitable method of forecasting population for an old developed large city, is
(a) arithmetic mean method
(b) geometric mean method
(c) comparative graphical method
(d) None of these

Q.4 The suitable method for forecasting population for a young and a rapidly developing city is
(a) arithmetic mean method
(b) geometric mean method
(c) comparative graphical method
(d) None of these

Q.5 A compared to the geometrical increase method of forecasting population, the arithmetical increase method gives
(a) lesser value
(b) higher value
(c) equal value
(d) may vary, as it may depend on the population figures

Practice Questions : Level-2

Q.6 The growth of population can be conveniently represented by a curve, which is amenable to mathematical solution. The type of this curve is
(a) semi-log curve (b) straight line curve
(c) logistic curve (d) exponential curve

Q.7 If the population of a city is 2 lakh, and average water consumption is 200 lpcd, then the capacity of the pipe mains, should be
(a) 108 MLD (b) 72 MLD
(c) 60 MLD (d) 40 MLD

Q.8 If the population of a central congested high valued city in 2,00,000 and the fire demand is computed to be 45,000 litres per minute, the formula used for the calculation must have been
(a) Freeman's formula
(b) National Board of Underwriters formula
(c) Kuichling's formula
(d) Buston's formula

Q.9 If the average water consumption of a city is 300 lpcd, and its population is 4,00,000 the maximum hourly draft of the maximum day will be
(a) 120 Mld (b) 216 Mld
(c) 324 Mld (d) None of these

ANSWERS

1. (d)	2. (d)	3. (a)	4. (b)	5. (a)
6. (c)	7. (b)	8. (c)	9. (c)	

Hints & Solutions

1. (d)
Since the area is limited and there is no time period specified for population estimation, such as young or old city. Therefore, logistic curve method will be best.

2. (d)

$$\text{Peak hourly demand} = \frac{2.7 \times 24000}{24}$$
$$= 2700 \text{ cum/hr}$$

7. (b)
Average water consumption per day
$$= 200 \times 2 \times 10^5$$
$$= 40 \times 10^6$$
∴ Max. water consumption per day
$$= 1.8 \times 40 \times 10^6$$
$$= 72 \text{ Mld}$$