1. WATER DEMAND

FIRE DEMAND

Rate of fire demand is sometimes treated as a function of population and is worked out on the basis of empirical formulas:

(i) **Kuichling's Formula**

$Q = 3182\sqrt{P}$ where, Q = Amount of water required in liters/minute.
P = Population in thousand.

(ii) **Freeman Formula**

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

(iii) **National Board of Fire Under Writers Formula**

(a) For a central congested high valued city

(i) Where population < 200000

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

(ii) Where population > 200000

Q = 54600 lit/minute for first fire

and Q = 9100 to 36,400 lit/minute for a second fire.

(b) For a residential city.

(i) Small or low building,
Q = 2,200 lit/minutes.

(ii) Larger or higher buildings,
Q = 4500 lit/minute.

(iii) High value residences, apartments, tenements
Q = 7650 to 13,500 lit/minute.

(iv) Three storeyed buildings in density built up sections,
Q = 27000 lit/minute.

(iv) **Buston's Formula**

$$Q = 5663\sqrt{P}$$

The probability of occurrence of a fire, which, inturn, depends upon the type of the city served, has been taken into consideration in developing a above formula on the basis of actual water consumption in fire fighting for Jabalpur city of India. The formula is given as

$$Q = \frac{4360R^{0.275}}{(t+12)^{0.757}}$$

where, R = Recurrence interval of fire i.e., period of occurrence of fire in years, which will be different for residential, commercial and industrial cities.

$(R)_{minimum}$ = 1 year

t = Duration of fire in minutes,

$t_{minimum}$ = 30 minute.

PER CAPITA DEMAND (q)

$$q = \frac{\text{Total yearly water requirement of the city in litre}}{365 \times \text{Design population}}$$

ASSESSMENT OF NORMAL VARIATION

(i) Maximum daily demand = 1.8 × Avg daily demand

(ii) Maximum hourly demand = 1.5 × maximum daily demand

(iii) Maximum hourly demand or peak demand = 2.7 × Avg daily demand

(iv) $\frac{\text{Maximum daily demand}}{\text{Avg daily demand}} = 180\%$

(v) $\frac{\text{Maximum weekly demand}}{\text{Avg weekly demand}} = 148\%$

(vi) $\frac{\text{Maximum monthly demand}}{\text{Avg monthly demand}} = 128\%$

POPULATION FORECASTING METHODS

(i) Arithmetic increase method

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

where, P_n = Prospective or forecasted population after n decades from the present (i.e., last known census)

P_O = Population at present (i.e., last known census)

n = Number of decades between now & future.

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

(ii) Geometric Increase Method

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

where, P_O = Initial population.

P_n = Future population after 'n' decades.

r = Assumed growth rate (%).

$$r = \sqrt[t]{\frac{P_2}{P_1}} - 1$$

where, P_2 = Final known population

P_1 = Initial known population

t = Number of decades (period) between P_1 and P_2.

$$r = \sqrt[t]{r_1 r_2 \ldots r_t}$$

(iii) Incremental Increases Method

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

where, $\bar{x}$ = Average increase of population of known decades

$\bar{y}$ = Average of incremental increases of the known decades.

(iv) Decreasing rate of growth method

Since the rate of increase in population goes on reducing, as the cities reach towards saturation, a method which makes use of the decrease in the percentage increase, in many a times used, and gives quite rational results. In this method, the average decrease in the percentage increase is worked out, and is then subtraced from the latest percentage increase for each successive decade. This method is however, applicable only in cases, where the rate of growth shows a downward trend.

(v) Logistic Curve Method

(a) $$\log_e\left(\frac{P_s - P}{P}\right) - \log_e\left(\frac{P_s - P_o}{P_o}\right) = -kP_s t$$

where,

P_o = Population of the start point.

P_s = Saturation population

P = Population at any time t from the origin.

k = Constant.

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

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

(d) $$m = \frac{P_s - P_o}{P_o}$$

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

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