Water and wastewater system

CT 263

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Sanitary Engineering

Water — Wastewater

علم الهندسة الصحية:
هو علم فرعي عن علم أكبر يسمى هندسة البيئة وهو علم يختص بدراسة مشكلة تلوث الماء في الطبيعة ووضع الحلول الهندسية الخاصة بها حتى يمكن للإنسان استخدامها بأمان

1. Water supply

i. Collection works
ii. Treatment works
iii. Distribution works

Studies required for water supply systems (projects)

1-Area served:

a) Population
b) Water consumption
c) Location
d) Area properties of urbanization (مواصفات المنطقة ، طبوغرافية الأرض ، طبيعة التجمعات السكنية ، تخطيط المنطقة ، المياه الجوفية)

2-Sources of water

a) Surface water : 1- saline → sea
→ Ocean
→ Lakes
2- Fresh → Rivers
→ Canals
→ Drains
→ Lakes
→ Spring عيون المياه

b) Ground water: 1- saline (brackish)
2- fresh

c) Rain water : 1- Fresh
2- Acidic
3- Alkaline
4- Nuclear polluted ملوثة بغبار زرى

To study the source of water we have to study:

a) Quantity of water
b) Quality of water

3- Design Period: الفترة التصميمية للمشروع

Factors affecting the design period of water supply project:

a) Project components virtual age

Building	50 year
Tanks	30-50 year (concrete)
	15-30 year (steel)
Pipes	50-60 year (iron)
	50-80 year (concrete)
	100-180 year (plastic)
Pumps (motors)	10-20 year

(هذه الأرقام مبنية على أساس القيام بأعمال صيانة دورية)

b) material used
c) Population & Water consumption
d) Cost
e) execution program(stages)
f) labors (skill)
g) Scientific development

Population Studies

The prediction of future population is essential in connection with, planning, design and management of water supply works.

Sources of Data :

Population census and its characteristics are obtained from the official enumeration made by bureau of census.

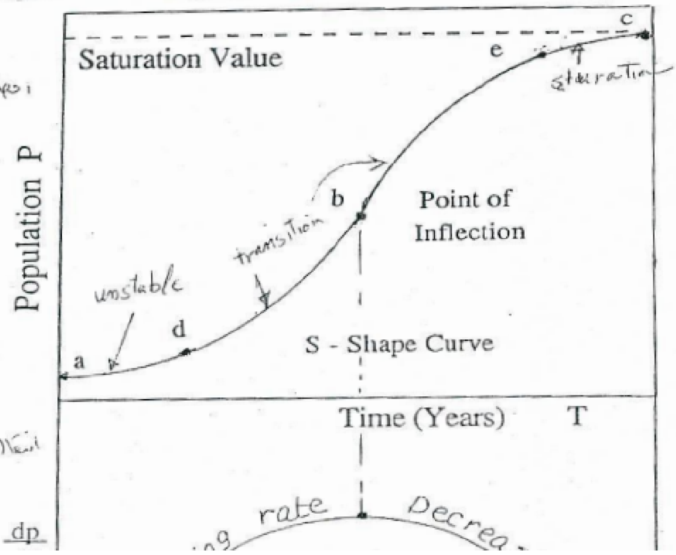
i - Factors affecting the rate of Increase of the Population

1 - Birth rate   2- Death rate.

3 - Immigration from other counties.

4 - Interstate migration of people.

ii - Curve of Population Growth



Plotting populations from each census period helps to provide a starting point for future population.

Stages of Growth

1 - Unstable growth (a - d) slow rate.

2 - Transition growth (d - e) rapid due to

iii - Methods of Population Prediction

1 - Arithmetic Increase Method

Growth is arithmetic if the population increase dp in the time internal dT is constant.

$$I_a = \frac{dp}{dT} = \text{constant}$$

let :

P_e = Population of earlier census

P_l = Population of later census

T_e = date of earlier census

T_l = date of later census

$I_a = \Sigma dP \; / (T_l - T_e)$

$$P_f = (P_l + \frac{\Sigma dP}{(T_l - T_e)} \times (T_f - T_l)$$

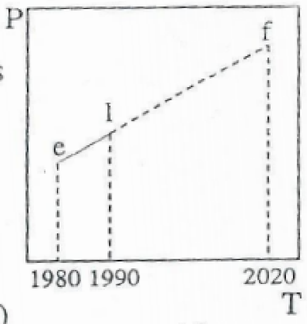


Fig. (6)

Example (1) :

Year	Population	Increase (dP)
1900	25 970	
1910	29 000	3030
1920	32 000	3000
1930	36 000	4000
1940	37 890	1890
1950	39 950	2060
1960	41 750	1800
1970	43 540	1790
1980	45 240	1700
		19270

I_a = 19270 / 80 = 241

2 - <u>Geometric Increase Method</u>

Growth is geometric if the population increase dp in the time internal dT is proportional to the size of population P i.e. $dp/dT = I_g \cdot P$

where I_g is the proportionately factor

$$I_g = \frac{\Sigma\, d\, \ln P}{T_l - T_e}$$

$$\ln P_f = \ln P_l + I_g (T_f - T_e)$$

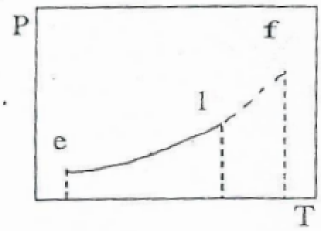


Fig. (7)

<u>Example (2)</u> :

Year	Population	ln P (log P)	Increase d ln P
1900	25 970	4.4145	
1910	29 000	4.4624	0.0479
1920	32 000	4.5123	0.0499
1930	36 000	4.5571	0.0348
1940	37 890	4.5785	0.0214
1950	39 950	4.6015	0.0270
1960	41 750	4.6206	0.0191
1970	43 540	4.6389	0.0183
1980	45 240	4.6554	0.0165
			0.2309

Average I_g = 0.2309 / 80 = 0 02884

$\ln P_{2020} = \ln P_{1980} + 0\ 02884 * 40$

$= 4.6554 + 0.11536$

$= 4.77076$

3 - Graphical Extension Method

4 - Comparison Method

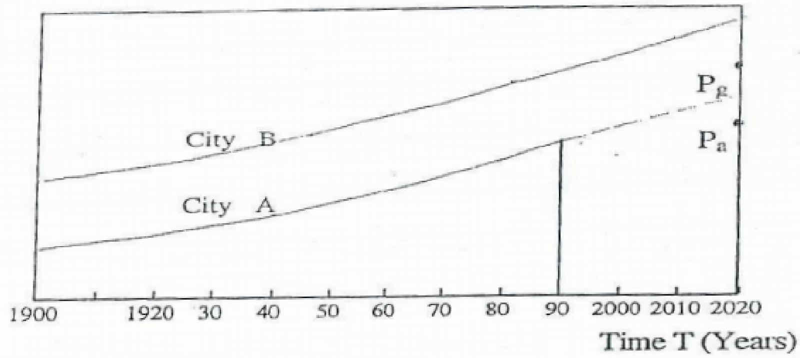


Fig. (8)

1) Plot the curve of population growth over the past years of census.
2) Plot the predicted population obtained by other methods as arithmetic & geometric methods.
3) Extend the curve following whatever tendencies the graph indicates.
4) The commonly used variant of this method includes comparison of the projected growth to that of other cities of larger size. The cities chosen for the comparison should be as similar as possible to the city being studied.

2.5. Population estimation by densities

This method of estimation depends on city planning, type of district, and type of housing. Table (2-2) shows the population densities to be used for estimation of the expected future population.

Table (2-2): Population Densities

Type of housing	Population Density capita/hectare
Palaces and villas (first level)	10
Villas second level	30 - 60
Small buildings	100 - 250
Medium buildings	250 - 700
High rise buildings	700 - 1000
Commercial areas	50 - 75
Industrials areas	20 - 30

2.6. Water consumption

In the design of any water works project it is necessary to estimate the amount of water that is required. This involves determining the per capita water consumption rate together with the number of people who will be served

i - Water Consumption Rate :

It is the amount of water in litre per capita per day. It is determined if the flows are measured at the consumer's house meter, or as it enters the distribution system.

For example, in Greater Cairo :

Total measured water consumption per day =

$= 5\ 000\ 000\ m^3$

Population = 16 650 000 capita.

Rate of water consumption = Total daily water consumption / Population

$= 5\ 000\ 000 \times 1000 / 16\ 650\ 000$

= 300 litre / capita /day

= 300 l /c/d

ii- Consumption for Various Purposes

The water furnished to a city can be classified according to its ultimate use. The uses are :

1. **Domestic Use** : drinking, washing, bathing and cooking, ... etc.
2. **Commercial Use** : commercial plants as : shopping centers, hotels, hospital, schools, governmental buildings, mosques, clubs. ... etc.
3. **Industrial Use** : for industrial plants. Industry usually has four water requirements :

b- Cooling.

c- Boiler water.

d- Potable water.

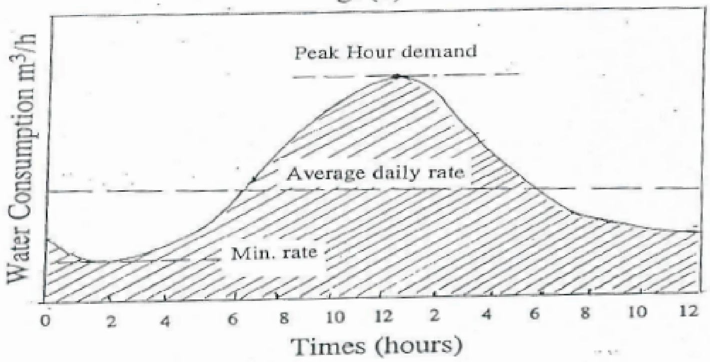
4. **Public Use** : as flushing streets, fire protection and irrigation of gardens.
5. **Loss and Waste** : Unaccounted water due to meter and pump slippage, Leakage in water mains and connections.

iii - Factors affecting water consumption

1. Climatic conditions (day and night, summer and winter seasons).
2. Size of city.
3. Standard of living.
4. Characteristics of the population.
5. Metering.
6. Pricing.
7. Water pressure.
8. Water quality.
9. Existence of sewerage system.
10. Efficiency of water administration.

Hydrograph of Water Consumption
and its Characteristics

Fig. (9)



1 - Area under the curve = total consumption / day
2 - Average rate of water consumption = Total consumption / day ÷ 24 = Area ÷ 24 m3 / hr
3 - For each hydrograph, there are two extremes of consumption Maximum & Minimum.
4 - Also there two extremes during the year, one in the summer and the other in the winter.
5 - Annual average water consumption (l/c/d) = Total water Consumption per year ÷ (365 * population)
6 - Max. water consumption = Max. consumption in summer / population.
7 - Max water consumption (l.c.d) ≈ 1.50 Annual average water consumption (l/c/d)
8 - Max hourly water consumption ≈ 2.25 Average hourly water consumption.

Average rates of water consumption in egyptian communities

The average daily per capita water consumption in Egyptian communities varies from 125 L in villages to 150 L in small cities to 200 L in capital cities and up to 280 L in the new cities.

In industrial areas the water consumption rate is 2 L/hectare/second up to 3 L/hectare/S in case of the new cities.

The average rates of water consumption for public buildings, hospitals, hotels, and schools are as given in table (2-3).

In addition, table (2-4) shows the projected consumption of water for various purposes in year 2000.

Table (2-3): Water Consumption Rates for Public

Type of use	Average water Consumption rate
1- public buildings, offices, schools	50 - 150 L /C/d
2- Hospitals	500 - 1000 L/bed/d
3- Hotels	180 - 500 L/bed/d

Table (2-4): Projected consumption of water for various purposes in the year 2000 .

Use	Liters per capita / day	Percent of total
Domestic	90	45
Industrial	40	20
Commercial	30	15
Public	20	10
Loss	20	10
Total	200	100

Comparison between metered and unmetered water supplies

There is a considerable difference between the water consumption per capita for metered supplies as compared to unmetered supplies. The average water demand of the city has been reduced by as much as 50% by installing meters on each service and charging customers for the water they use.

In Belgium and Canadian towns, Water Companies quoted 30 % of average annual demand was leakage. Leakage in the US are estimated to vary from 5 % to 45 % of the average flow. In Cairo and other Egyptian cities, the leakage was estimated to reach up to 45 % in the old water supply systems.

2.7. Fire demand

Although the actual amount of water used for fire fighting in a year is small, the rate of use is high during a fire. The Insurance Services Office calculates required fire flow from the formula

$$F = 18\, C\, (A)^{0.5}$$

in which F is the required flow in gal / min (L/min ÷ 3.78), C is a coefficient related to the type of construction as follow:

C = 1.5 for wood frame construction

C = 1.0 for ordinary construction

C = 0.8 for noncombustidle construction

C = 0.6 for fire resistive construction

Table (2-5): Residential fire flows

Distance between adjacent units		Required fire flows	
ft	m	gal /min	L/min
> 100	>30.5	500	1890
31-100	9.5-30.5	750-1000	2835-3780
11-30	304-902	1000-1200	3780-5670
> 10	>3.0	1500 -2000	5670-7560
For continuous construction		2500	9450

Table (2-6) : Required flow duration

Required fire flow		Duration h
gal/min	L/min	
< 1000	> 3780	4
1000 - 1250	3780-4725	5
1250-1500	4725-5670	6
1500-1750	5670-6615	7
1750-2000	6615-7560	8
2000-2250	7560-8505	9
> 2250	> 8505	10

Estimation of the maximum water demand during a fire

Example : A community of population 66,000 capita has floor of 1000 m^2 and a height of six stories. Estimate the maximum water demand during this fire.

Average domestic demand = 66000 × 200 = 13.2 × 10^6

Maximum daily demand = 1.8× average L/ day

= 23.76 × 10^6 L/ day

$F = 18\ (1)\ (1000 \times 10.76 \times 6)^{0.5}$ = 4574 gal / min .

= 24.89 × 10^6 L/ day.

Maximum rate = 23.76 × 10^6 + 24.89 × 10^6 =

48.65×10^6 L/day

From table (2-6) duration = 10 h

Total flow during this day = 23.76 + 24.89× 10/24 =

34.13 × 10^6 L

This represent an average per capita of 517 L/d.

Fire demand can be estimated according to the population of the community as shown in table (2-7).

Table (2-7) : Fire demand related to population

Population (capita)	Fire Demand (L/s)
up to 10000	20
25000	25
50 000	30
100 000	40
over 200 000	50

2.8. Design flows

The design flows for water pipe lines are estimated according to the planning of the pipe network. There are three methods for the planning of water distribution system :

1. Tree System .
2. Ring System .
3. Grid - Iron System .

a) In case of Tree or Ring system the following equation is applied $Q_{des} = Q_{av} \times P$

Q_{des} is the design flow of the community in l/s.

Q_{av} is the average flow which is equal to the average daily rate of water consumption multiplied by the design population.

P is the peak factor which depends on type of community rural or urban and population. Table (2-8) shows the recommended values of the peak factor .

Table (2 - 8) : Peak Factors

Population	urban	rural
up to 50 000	2.25	2.0
50 000-100 000	2.0	1.80
100 000 -500 000	1.80	1.60
500 000 -1.000 000	1.6 - 1.4	—
over 1000.000	1.4 - 1.2	

b) In case of Grid - Iron System

- For water carriers or transmission mains

$$Q_{des} = Q_{max - daily} + Q_{fire}$$

- For main and secondary pipes the design flow is the bigger value of

$$Q_{des (1)} = Q_{max - daily} + Q_{fire}$$
$$Q_{des} (2) = Q \text{ max hour/y}$$

-For distributor or laterals

$$Q_{des} = Q_{fire}$$

- For service connection

$$Q_{des} = Q \text{ max hourly}$$