Quantity and Population forecasting

Solved Numerical

Seismic Group UET LHR

Problems-Water Demand & Fire Flow

- Problem 1: Determine the average daily demand of water in cubic meter per day for a community having a population of 30,000 persons with average water consumption of 350 lpcd.
- Problem 2: A housing scheme has 50 plots with 5 persons per plot. Per Capita consumption is assumed to be 550 liter per capita per day. Calculate total average and maximum demand of scheme?
- Problem 3 :Estimate the peak hourly demand for the population of 68,000 persons, use a total amount of water 7,546,600 m^3 during 52 weeks.
- Problem 4: Estimate the average daily rate ,maximum daily rate, and peak hourly rate for the population of 58,000 persons , use a total amount of water 9,526,500 m^3 during 12 months.
- Problem 5: Calculate maximum daily flow and peak flow of a water use for a community having 1000 houses , 7 persons per house with an average water consumption of 350 l/c/d.
- Problem 6: Calculate minimum demand of water for a society having a population of 29,146 persons with a average water consumption of 400 l/c/d.

Problems-Water Demand & Fire Flow

- Problem 7 : City with present population 58000 persons used a total flow 9526600 m3 during last 12 months. On the day of maximum consumption 42000 m3 of water was used .Estimate Qavg, Q max , to be excepted in 10 years when the population is estimated to be 72500 persons.
- Problem 8 : Calculate average daily demand and peak hourly demand for a city having a 3000 houses, 5 persons per house, 3 schools , 1000 students per school , 2 commercial building with a floor area of 0.1 hector. The water consumption is assumed to be 300 L/person/d, 30 L/student/d, and 75 $L/m^2/d$.
- Problem 9: Determine the fire flow required for a three storey building with a planned area of 700 m2 and wood frame construction. If this building dictates a fire flow for the community of 78000 persons with the average water consumption of 350 Lpcd. What will be the maximum daily demand including fire flow.
- Problem 10 :Determine the fire flow required for the community of 22000 person has an average consumption of 600 lpcd. The fire flow is dictated by a building of ordinary construction with a floor area of 1000 m2 and height of 6 stories. Find total flow required during the day of fire.

Problems-Water Demand & Fire Flow

Problem 11: Determine the Peak hourly requirement of water and total flow for a community of population 30,000 persons and average consumption of 350 lpcd, during a peak hour flow , the fire demand flow is maintained for 3 hrs per day for the building of ordinary construction with floor area of 1000m^2 and the height is 3 stories.

Problem 12: A three storey wooden frame building has each floor area : a) 900 m2 b) 700 m2 c) 400 m2 .Determine fire flow and total daily amount of flow for maximum duration of fire flow.

Problem13: Community with a population of 50000 persons has an average consumption of 550 lpcd. Fire flow is dedicated by 2 storey building of wooden structure with a floor area of 1000m2 and 500m2 .Find the total flow required for this day.

Problem14: Estimate the water requirement for the following communities a) 20000 persons with 150 lpcd b) 55000 persons with 170 lcpd c) 120000 persons with 610 lpcd, having 7 storey building with a)Ordinary construction b)wood construction for each community (Each floor area=1000 m2.)

Problems-Water Demand & Fire Flow

Problem 15: Determine the required fire flow for a 3-storey wood frame building covering 700 m2 which connects with a 5- storey building of fire resistive construction covering 900 m2.

Problem 16: Calculate the required maximum daily demand , fire flow and total flow for a society having 5000 single storey houses covering 1000 m2 of area with 500 m2 of basement. Each house contains 10 persons wit average water consumption of 450 lpcd. (C=1)

Problem-Population Forecasting

Problem 18: A city had a population of 210000 in 1991 and 240000 in 2001.If the city is assumed to follow arithmetic rate of growth find the population of the city in 2018

Problem 19: Present (2015) population of city is 1350000 and it is expected to grow at a uniform rate of 3% per annum. Find its population in 2033.

Problem 20:A community has experienced the growth in population and water use as shown in table. Estimate the population ,per-capita water use and average daily water demand in the year 2030

year	1979	1980	1990	2000	2010	2030
population	8000	8990	11300	14600	18400	?
WC(m3/d)	2270	2720	3630	4970	6600	?

Problem 21:A community is expected to reach a population of 35000 in 20 yrs. It has present population of 28000 with average water consumption of 16×10^6 lit/day. The existing water treatment plant has a design capacity of 19000 m^3/day.

Assume an arithmetic rate of population growth. Determine in which year the existing plant will reach its design capacity.

Assume the plant to be designed on max. daily consumption.

Numerical

Prob 1

Data:

ADD in m^3/day = ?

Population = 30,000 persons

Avg water consumption = 350 lpcd

Sol.

1 lit = $1 dm^3$

ADD = Pop. × AWC

= 30,000 × 350 litres

$= \frac{30,000 \times 350}{1000}$

$= 10500 m^3/d$ ✓

Prob 2

Data:

Plots = 50, per plot = 5 persons

per capita consumption = 550 litre per capita per day

Total avg demand = ?

Max. demand = ?

Sol.

Pp. = 50 × 5 = 250

AWC = 550 lcpd

$ADD = \frac{250 \times 550}{1000} = 137.5 \text{ m}^3/\text{d}$

MDD = 1.5 × 137.5 = 206.25 m³/d

MDD = 1.5 × ADD
PHD = 1.5 × MDD
PHD = 2.25 × ADD

Prob 3

Data:

total days = 52 × 7 = 364 ≃ 365 days

peak hourly demand = ?

population = 68000 persons

Amount of water = 7546 600 m³

Sol.

$ADD = \frac{7546600}{365} = 20732 \text{ m}^3/\text{d}$

PHD = 2.25 × ADD

= 2.25 × 20732 = 46647 m³/d

Prob. 4

Data:

$$\text{Avg. demand} = \frac{9526500\ m^3}{12\ \text{month}}$$

$$= \frac{9526500}{365} = 26100\ m^3/d$$

$$\text{Avg. daily rate} = \frac{26100}{58000} = 0.45\ m^3/c/d \quad \checkmark$$

(max. daily rate)

$$MDR = 1.5 \times ADR$$

$$= 1.5 \times 0.45 = 0.675\ m^3/c/d \quad \checkmark$$

$$PHR = 2.25 \times ADR$$

$$= 2.25 \times 0.45$$

$$= 1.0125\ m^3/c/d \quad \checkmark$$

Prob 5

Data:

Max. daily flow = ?

Max. peak flow = ? = PHD = ?

No. of homes = 1000, No. of persons = 7 person per house

avg. water consumption = 350 l/c/d Population = 7000

Sol:

$$ADD = (350 \times 7000) = l/d$$

$$MDD = 1.5 \times (350 \times 7000) = 3675000\ l/d = 3.675\ m^3/d$$

$$PHD = 1.5 \times 3675000 = 5512500\ l/d = 5512.5\ m^3/d$$

Min. demand of water = 50% of ADD

~~ADD =~~

Prob. 6

Data:

Min. demand of water = ?

Pop = 29146 persons

WC = 400 l/c/d

~~Min. demand~~

$$ADD = \frac{29146 \times 400}{1000} = 11658.4 \text{ m}^3/\text{d}$$

Min. demand = 0.5 × 11658.4

= 5829.2 m³/d

Prob. 1

Data:

Population = 58000 persons

Total WC = 9526600 m^3

time = 12 months

MDD = 42000 m^3

In 10 years Find

1) ADD (Q_{avg}) For Pop = 72500 pers

2) MDD (Q_{max})

Sol:

~~ADD = Q_{avg} = $\frac{9526600}{365}$ = 26100 m^3/d~~ ✓

ADD = $\frac{9526600}{365}$ = 26100 m^3/d

AWC = $\frac{9526600}{365 \times 58000}$ = 0.45 $m^3/p/d$

As

$MDD = x \ ADD$

$x = \frac{MDD}{ADD} = \frac{42000}{26100}$

$x = 1.61$

Now for 10 years:

$ADD = Pop. \times AWC$

$= 72500 \times 0.45 = 32625 \ m^3/d$

$MDD = x \ ADD$

$= 1.61 \times 32625 = 52526 \ m^3/d$

1 hectar = 10,000 m²

Prob. 8

Data: ADD = ?

PHD = ?

Houses = 3000 | Persons per house = 5 | WC are as follows

School = 3 | students in school = 1000 | 300 l pcd

Building = 2 | Area of floor = 0.1 hectar | 30 l pcd

75 l/m²/d

Sol.

$(Pop)_H = 15000$

$(Pop)_S = 3000$

Total area of buildings = $(0.1 \times 10{,}000) \times 2 = 2000\ m^2$

$ADD = Pop. \times W.C$

$(ADD)_H = 15000 \times 300 = 4500\ m^3/d$

$(ADD)_S = 3000 \times 30 = 90\ m^3/d$

$(ADD)_B = 75 \times 2000 = 150\ m^3/d$

Total ADD = 4500 + 90 + 150 = 4740 m³/d

PHD = 2.25 ADD = 10665 m³/d

Prob 9

Data:

F = ?

3 story building

A = 700 m²

Wood construction

Population = 78000

AWC = 350 lpcd

MDD = ? (including F.F)

Sol:

C = 1.5

A_T = (700 × 3) = 2100 m²

$$\Rightarrow F = 223.18\, C\sqrt{A}$$

$$= 223.18 \times 1.5 \sqrt{2100}$$

F = 15341 l/min

F = 15341 × 60 × 24 / 1000

= 22091 m³/d

Min. storage = 4 hrs = 4/24 day

$$F = 22091 \times \frac{4}{24} = 3681.8 \text{ m}^3/\text{d}$$

$$\Rightarrow ADD = Pop. \times AWC$$

= 78000 × 350 = 27300 m³/d

MDD = 1.5 ADD = 1.5 × 27300 = 40950 m³/d

$$\Rightarrow \text{Total flow} = MDD + F$$

= 44631.8 m³/d

Prob.10

Data:

F = ?

Pop = 22000

AWC = 600 lpcd

Ordinary construction (C=1)

A = 1000 m²

Height of building = 6 storeys

Total flow = ?

Sol:

$A_T = 1000 \times 6 = 6000\ m^2$

$\Rightarrow F = 223.18\, C\sqrt{A}$

$= 223.18 \times 1\sqrt{6000}$

$= 17287.4\ L/min$

$= 17287.4 \times 24 \times 60 = 24893926\ l/day$

$= 24894\ m^3/day$

Min. storage = 4 hrs = 4/24 day

$F = 24894 \times \frac{4}{24} = 4149\ m^3/d$

$\Rightarrow ADD = Pop \times AWC$

$= 22000 \times 600 = 13200000\ l/day$

$= 13200\ m^3/day$

$MDD = 1.5 \times ADD$

$= 1.5 \times 13200 = 19800\ m^3/d$

$\Rightarrow$ Total flow = 4149 + 19800

= 23949 m³/d

Prob 19

Data:

PHD = ?
Total flow = ?
Pop = 30,000
AWC = 350 lpcd

During Peak hr flow
t = 3 hrs per day
C = 1
A = 1000 m²
Storeys = 3

Sol:

Total Area = A_T = 3000 m²

$F = 223.18 C\sqrt{A}$

$= 223.18\sqrt{3000}$ = 12224 l/min

= 17602560 l/day

= 17602.56 m³/d

F.F for 3 hrs = 3/24 day

$F = 17602.56 \times \frac{3}{24}$ = 2200.32 m³/d

ADD = Pop. × AWC

= 30,000 × 350 = 10500 m³/d

PHD = 2.25 × ADD = 23625 m³/d

Total flow = 23625 + 2200.32

= 25825.32 m³/d

Prob. 12

Data:

Wooden construction $C = 1.5$

3 storeys

a) $A = 900 m^2$ b) $= 700 m^2$ c) $400 m^2$

Sol.

$F = 14462.064 m^3/d$ $F = 12754.4 m^3/d$ $F = 9641.376 m^3/d$

Total F = 14462.064 + 12754.4 + 9641.376

= 36857.84 m^3/d

For max flow = $36857.84 \times \frac{10}{24}$

= 15357.4 m^3/d

Prob 13

Data.

$P_{op} = 50000$

AWC = 350 lpcd

2 storeys (wooden) $\Rightarrow C = 1.5$

$A_T = 1000 + 500 m^2$

Total flow = ?

Sol:

$F = 18670.44 m^3/d$

F.F for 4 hrs = $3111.74 m^3/d$

$ADD = P_{op.} \times AWC = 17500 m^3/d$

Total flow = $30611.74 m^3/d$

Prob. 14

Data:

a) ~~20000~~ Pop. = 20000 WC = 150 lpcd

b) Pop. = 55000 WC = 170 lpcd

c) Pop. = 120000 WC = 610 lpcd

~~Ordinary~~ Building storeys = 7 $A = 1000\ m^2$

$A_T = 7000\ m^2$

a) Ordinary b) Wood

Solution Only for (a)

$$ADD = Pop. \times AWC$$
$$= 20000 \times 150$$
$$= 3000\ m^3/d$$

For ordinary For wood

$F = 26888.513\ m^3/d$ $F = 40332.76\ m^3/d$

Prob = 15

Data:

F.F = ?

$A_T = 2100 m^2$ ⇐ 3 storys = 3 (Wood) $A = 700 m^2$

$A_T = 4500 m^2$ ⇐ 5 story = 5 (resistive) $A = 900 m^2$

Find F.F for both and add.

Prob 16

Data:

MDD = ?

FF = ?

Total flow = ?

Houses = 5000

A = 1000 m2 each 500 m2 basement

Pop. = 10 each home

AWC = 450 lpcd C = 1

Sol:

Total Population = 50000

ADD = pop × AWC = 22500 m3/d

MDD = 1.5 ADD = 33750 m3/d

Total Area = 5000 × 1000 = 5000 000 m^2

FF = 718625.74 m3/d

For 10hrs = 299427.4 m3/d

Total = 33750 + ↓

= 33177.4 m3/d

Prob 1.7

Date:

$K = \frac{P_2 - P_1}{t_2 - t_1}$ (Arithmetic)

$K = \frac{\ln P_2 - \ln P_1}{t_2 - t_1}$ (Geometric)

Year	Pop. thousands	Arithmetic K per year	Geometric
1901	60	-	-
1911	65	0.5	8×10^{-3}
1921	63	-0.2	-3.1×10^{-3}
1931	72	0.9	13×10^{-3}
1941	79	0.7	9.3×10^{-3}
1951	89	1	12×10^{-3}
1961	97	0.8	8.6×10^{-3}
1971	120	2.3	21.3×10^{-3}

Arth

$K_{avg} = \frac{0.5 - 0.2 + 0.9 + 0.7 + 1 + 0.8 + 2.3}{7}$

$= 0.857$ /year

Geom

$K_{avg} = 0.0098$

Predict for 1981, 1991, 1994, 2001

Arithmetic

$P_f = P_0 + K(t_f - t_0)$

$P_{1981} = P_{1971} + 0.857 \times (1981 - 1971)$

$= 128.57$

$P_{1991} = 137.14$

$P_{1994} = 139.711$

$P_{2001} = 145.71$

Geometric

$P_f = P_0 e^{K(t_f - t_0)}$

$P_{1981} = P_{1971} e^{0.0098 (1981 - 1971)}$

$= 132.3$

$P_{1991} = 146$

$P_{1994} = 150.8$

$P_{2001} = 161.7$

Prob. 18

Year	Pop.	Arth.
1991	210000	—
2001	240000	K = 3000

$$P_f = P_o + K(t_f - t_o)$$
$$= 240000 + 3000(2018 - 2001)$$
$$= 291000$$

Prob. 19

Year	Pop.
2015	1350000
2033	?

Rate of change = 3% per annum

$$K = \frac{3}{100} = 0.03$$

$$P_f = P_o e^{K(t_f - t_o)}$$
$$= 1350000\, e^{0.03(2033-2015)}$$
$$= 2316609.264$$

Prob 20

Data:

Population = ?

lpcd = ?

ADD = ?

in 2030

year	Pop.	WC m³/d	K	mpcd WC/Pop. c
1979	8000	2270	–	0.284
1980	8990	2720	0.117	0.303
1990	11300	3630	0.023	0.321
2000	14600	4970	0.026	0.340
2010	18400	6600	0.023	0.386
2030	?	?		

~~Avg = 0.0316~~

population will be calculated by Geometric

$$K_{avg.} = \frac{0.117 + 0.023 + 0.026 + 0.023}{4} = 0.04725$$

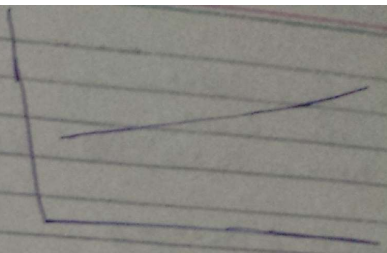
$$P_f = P_o e^{K(t_f - t_o)}$$

$$P_{2030} = 18400\, e^{0.04725(2030-2010)}$$

$$= 47339.8$$

In 2010 $\frac{WC}{pop} = 0.36$ m³/c/d

In 2030 $\frac{WC}{Pop} = 0.38$ m³/c/d



lpcd

284
303
321
340
360
x

Arithmetic

$$K = \frac{x - 360}{2030 - 2010}$$

$$1 = \frac{x - 360}{20}$$

$$x = 380 \text{ lpcd}$$

$$= 0.38 \text{ mpcd}$$

$$ADD = \text{Pop.} \times \text{AWC}$$

$$= 47339.8 \times 0.38$$

$$= 17989.124 \text{ m}^3/\text{d}$$

Prob 21

Data,

Let 2036 $P_{20} = 35000$

2016 $P_0 = 28000$

$AWC = 16 \times 10^6$ l/d $= 16000$ m³/d

Capacity $= 19000$ m³/d

Arithmatic rate

Sol:

At 2016 $mpcd = \frac{16000}{28000} = 0.571$ mepcd

Population required to use full capacity of plant is

$$Pp. = \frac{m^3/d}{m^3/c/d}$$

$$= \frac{19000}{0.571} = 33274.956 \text{ phons}$$

$$K = \frac{P_2 - P_1}{t_2 - t_1} = \frac{35000 - 28000}{2036 - 2016} = \in 350 \text{ person/ye}$$

$$P_f = P_0 + k(t_f - t_0)$$

$$33275 = 28000 + 350(t_f - 2016)$$

$$\boxed{t_f = 2031}$$