"DESIGN STANDARDS FOR WATER SUPPLY SCHEMES IN PAKISTAN"

By

MR. IQBAL AHMAD BEG

Paper No. 418

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I. Introduction

Water is a basic necessity of life. It must be pure, palatable, wholesome and safe for human consumption. The water should meet the drinking water standards recommended by World Health Organization or national agencies with regard to its physical, chemical, bacteriological, biological and radiological quality of water. It is the responsibility of the Incharge Sanitary Engineer to see that various requisites for a good drinking water supply are met so that peoples' health and wellbeing is ensured. The quality and abundant supply of water is essential for a suitably designed water supply system. Therefore, the Sanitary Engineers, before selecting upon the source of water supply, should make a detailed survey of all the possible water resources—surface water and ground water and then decide as to which would be more suitable according to the site conditions and other factors affecting the choice.

Estimation of water requirements for a community is one of the fundamental and most important factors in the design of a water supply system. Hence it is necessary to make a proper estimate of the population to be served for calculating the expected water usage. The various design para-meters used in water supply are per capita water consumption, water demand, variation in water demand, fire demand, design period for various structures, machinery and other components of the water supply system. These para-meters are determined mainly by the economic conditions and water use habits of the community and obviously they are not generalized. It is, therefore, essential that while developing a design criteria for water supply project, the socio-economic condition of the peoples should be kept in view. Viewing in this context, the design criteria and more particularly the water demand recommended for Pakistan vis-a-vis those adopted in other countries are discussed here-in-under.

II. Various water uses

The water supply to a city is classified according to its ultimate use or end. The various uses are ;

(*a*) **Domestic Use** : This includes water supplied to houses, hotels etc. for sanitary, culinary, drinking, washing, bathing and other purposes. This use also covers air-conditioning of residences, irrigation and sprinkling of plants/trees of house gardens and lawns.

The domestic consumption varies according to the living conditions of the people. It is expected to be 30—75% of the total water demand in a community.

(*b*) **Commercial and industrial use** : Water so classified is the one furnished to industrial and commercial concerns. The figure for this use is about 20—45% of the total. Symon has proposed an average of about 300 gallons per day per 1000 sq. feet of floor area for commercial purposes.

(*c*) **Public use** : Public buildings such as schools, city halls, as well as public services—sprinkling and flushing streets and gardens and parks—require much water for which, usually the city is not paid. Such water consumption is 10—40% of the total.

(*b*) **Loss and waste** : This water is also sometimes classified as "unaccounted for" although some of the loss and waste may be accounted for in the sense that its cause and amount are approximately known. Unaccounted for water is the one which has been pumped or otherwise sent into the distribution system but has not been sold, measured or otherwise accounted for. Some of the non consumption uses falling in this category are-leakage from main and strong posts, unauthorised connections, flushing of main, cleaning of streets and at times water used for recreation purposes.

For practical purpose, the minimum of unaccounted-for water even in the most developed countries is in the order of about 5%. The unaccounted for water decreases when meter percentages are increased. Table—1 shows the unaccounted for water at different percentage of metered connection :—

Table—I **Estimate of Unaccounted for Water (New System)**

% of metered customers	Unaccounted for water (as % of total water production
0	40
50	35
75	30
100	25

In some of the cities in Pakistan, the magnitude of "Unaccounted for" water goes even higher than the figure shown in above table. However, effort should be made to reduce it to minimum and 15% is an accepted reasonable figure for developing counrties like Pakistan.

(*e*) **Domestic animals** : Ordinarily, water consumption by domestic animals is not taken into consideration in the design of a water supply system. However, for the system serving institutions and stockyard districts, the consumption by animals should be known. The approximate consumption by various animals are :

Horses — 5 to 10 Gallons
Cattre — 7 to 12 Gallons
Sheeps & Goats — 1 to 2 Gallons
Hogs — 2 Gallons

III. Design Parameters

The various design para-meters used in the water supply project are design period, per capita water consumption, variation in water demand, fire demand, storage capacity and distribution system etc. These are discussed hereafter.

(*f*) **Design period** : The economical period of design of a structure depends upon the various factors such as its useful life, capital cost, ease of future expansion and possibility of absolescence. The design period for the various components of water supply system are discussed below :

(*a*) **Water source** : The design period would depend upon the type of source e.g. ground water and surface water. For wells, the design period will be short and usually from

10—15 years provided it is easy to install new wells. However, the design period for a dam and impounding reservoir as source of water should be from 25—50 years. The design flow from a reservoir will be the annual average.

(*b*) **Pumping plant** : The design period is usually 10 years. Water demands needed are maximum hourly including fire demand.

(*c*) **Transmission main** : The design period for transmission main from source to city will depend upon length of life of the pipe used. Generally, design period of 25 years or more is used. It is designed for maximum hourly demand, though some of the authors recommend annual average.

(*d*) **Water Treatment Plant** : Design period is usually 10 to 25 years, as future extension can be made easily. Water demands required are usually maximum daily.

(*e*) **Distribution system** : The design period is indefinite and the capacity of the system is made adequate for the largest development of the city it serves. Maximum hourly water consumption, including fire demands will be needed.

(*ii*) **Per Capita water consumption** : It is defined as the average of water consumed by a person per day. It is to be determined by the ratio of water consumed throughout the year and the number of days in a year.

The per capita water consumption varies from place to place and is affected by the various factors which are mentioned below :—

(*a*) **Climatic conditions** : Water consumption is more in hot regions and in summer seasons.

(*b*) **Characteristics of the Population** : The more developed and civilised is a community, the greater will be the water demand.

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The per capita water consumption varies from place to place and is affected by the various factors which are mentioned below :—

(*a*) **Climatic conditions** : Water consumption is more in hot regions and in summer seasons.

(*b*) **Characteristics of the Population** : The more developed and civilised is a community, the greater will be the water demand.

(*c*) **Water pressure and quality** : The rate of use of water increases when the pressure is increased in the distribution system. Improvement of the quality of water supply will also result in the increased use of water, partly because of the availability of water for more uses and partly the feeling of safety on the part of the people in using.

(*d*) **Size of the city** : The effect of the size of the city is probably indirect. In a small town per capita water consumption is expected to be small due to the fact that there are only limited water uses. However, the presence of an important water using industry may result in high consumption.

(*e*) **Industry and commerce** : The water consumption is appreciably increased by the presence of industry and commercial establishments in a city.

(*f*) **Metering** : The installation of meter tends to reduce quite materially water wastage and thereby overall water used.

(g) **Other factors** : Some of other factors, affecting per capita consumption are water rates, type of service, presence of water-borne sanitation system, rain fall and the living conditions of the people.

(*iii*) **Percentage of connected population** : Needless to say the entire population in a community provided with water is not connected with the public water supply system. The percentage of directly connected population is a function of the economic standard of the people and the figure approximates to 100% for developed nations such as United States of America and other western countries. The percentage of directly connected population for both the developed and developing countries is given below :—

(*a*) Developed countries (both for urban & rural = 100%

(*b*) Rapidly developing countries = 80 to 90%

(*c*) United Nations—Decade Recommended measures for developing countries :

Directly connected	=	60%
Stand posts	=	40%

(*d*) Suggested measures for Pakistan :

The percentage of connected population in Pakistan at present is far below than the recommended limit for rapidly developing countries. Therefore, every end-eavour should be made to expand the existing water supply facilities so as to provide the drinking water to the vast majority of the people and bring the level to rapidly developing countries, Some of the water supply projects, recently completed by Public Health Engg. Department at Gujranwala, Sheikhupura, Multan and Hyderabad, envisage the percentage of connected population of the order of 85—90% and the same would be a good criteria for Pakistan.

(*ii*) **Fire Demand** : New water systems planned for urban areas of Pakistan should be provided with capacity to discharge the indicated fire flows at any time during the day or night over and above domestic demands. Whereever practical, emergency storage should be provided for four hours at these rates. The total amount of water used in a year for extinguishing fires is usually a negligible water use for all purposes. However, during fire the rate of demand and the volume of water used may be so great and is to be a deciding factor in medium sized communities in fixing the capacities of pumps, reservoir and distributing pipes.

Fire demand is a function of populalion with a minimum limit, because the greater the population, the greater the number of buildings and the greater the risk of fire. The minimum limit of fire demand is the amount and the rate of supply required to extinguish the largest probable fire that could be started in the community.

The Board of U.S. Under Writers requires provision for 5

hours flow in places of less than 2500 population and provision for 10 hours flow in larger cities. The pressure to be provided at the hydrant should not be less than about 20 P.S.I. where mobile fire pumping engines are used and 75 to 90 P.S.I. at other points. Table-II gives the recommendations of various authorities for estimating the fire demand for water works design.

TABLE—II Formulae For Estimation of Fire Demand

Name of authority	Formula	GPm for 100,000 population
Kuichling	$Q = 700\sqrt{P}$	7,000
John R. Freeman	$Q = 250\left(\frac{P}{5} + 10\right)$	7,500
National Board of Fire Under Writers	$Q = 1020\sqrt{P}\,(1-0.01\sqrt{P})$	9,180

where **Q**=Demand gpm.

P=Population in thousands.

It may be mentioned here that the general practice in our country has been and also continues in most of the newly planned water supply systems to base the design on domestic water consumption and other water uses with no specific provision for fire demand. As far as rural areas are concerned, the writer is of the opinion that because of the small size of rural communities and with scattered houses the chances of break out of big fires are negiligible and we may safely depend on the storage capacity of the system for extinguishing small fire, if any. However, the case of urban areas is different and we should start providing for the fire demand in the design of our water supply systems. General Advisory Services of Public Health Engg., Department designed and constructed the water facilities for Gujranwala, Sheikhupura, Multan and Hyderabad taking into consideration the fire demand.

It is suggested that the new water systems planned for urban areas of Pakistan should be provided with capacity to

discharge indicated fire flows at any time during the day or night over and above domestic demand. Whereever practical emergency storage should be provided for 4 hours at the rates mentioned in Table—1II.

TABLE—III **Required fire flow capacity**

Type of Urban Area	Required fire Demand (G.P.M.)	Cements
Population less than one (1) lac.	800	Interior urban areas only.
Population more than one (1) lac.	1200	Interior urban areas only.
All urban areas	400	Fringe of urban areas only.

(*v*) **Industrial water consumption** : The trend of most industries in the past has been to have their private water supply system. It is, therefore, recommended that no specific provision for industrial demand be provided unless it is specially required by some big industries. In such cases positive information for future industrial demand is to be estimated at the rate of 10 gallons per day per industrial worker. The number of workers can be estimated on following assumption :

(*i*) The adult male population would be equivalent to about 30% of total population during any given year.

(*ii*) In terms of adult male population, the population of industrial work force would be about 40%.

(*iii*) The effective work force would have the same relation to total work force as connected population would have to total population.

(*vi*) **Variation in water demand** : The rate of use of water varies from hour to hour, day to day and season to season. The various water demands which are used in fixing up the capacities of different units of a water supply system are :—

(*a*) **Average day demand** : It refers to the total quantity of water used in a given time period divided by number of days in that period. Unless otherwise stated the period of time is assumed to be one year.

(*b*) **Maximum—day demand** : It refers to the total water requirements during a 24—hours period of maximum.

(*c*) **Peak—hour demand** : It is defined as total water requirements to meet a one hour period of maximum demand during a maximum—day demand.

The range of variation is determined by a number of factors, notably the size of the community. In general the variation for a small town is much more than larger cities.

In the United States, the following factors are normally used for computing the maximum—day and peak—hour demand.

Max. Day	:	Ave.	Day	:	1.5	: 1
Peak hr.	:	Ave.	hour	:	2.5	: 1

General Advisory Services for Public Health Engg. Department had recommended that the maximum day water demand shall be considered to be 20% less than 1.5 time the production during an average day's demand unless higher historical figures are available for a water system of a city. Similarly the peak—hour water demand shall be considered to be not less than two times, the average rate of production required during a maximum day demand. For Lahore M/s. Nihonsuido Consulting Co. Japan has suggested the following figures :—

Max. Day	:	Ave.	Day	:	1.5	: 1
Peak hour	:	Max.	hr.	:	1.5	: 1

The Public Health Engg. Department have recently recommended the following factors for the towns and villages :—

Max. Day	:	Ave.	Day	:	1.25	: 1
Peak hour	:	Ave.	hr.	:	2.5	: 1

It is suggested that water supply system in Pakistan may be designed for maximum day and peak hour taken at the ratios mentioned below :—

Max. day	: Ave. Day	=	1.50	:	1
Peak hr.	: Ave. hr. of average day	=	2.25	:	1
i.e. Peak hr.	: Ave. of Max. day	=	1.50	:	1

IV. Prevalent Average per cptita Water Consumption in Various Countries

It may be relevant to mention the per capite capita water consumption of the various countries of the world. Table—IV shows per capita water consumption rates in various countries :—

Table—IV. Average per capita water consumption in various countries

Country	Water consumption (g.p.cd) U.S. Gallons
1. U.S.A.	150
2. Japan.	
Osaka (1965)	92
Tokyo (1965)	92
Jokohamn (1965)	67
Future	100
3. Egypt.	
Large cities	44 — 55
Small cities	22
4. Syria.	
Rural	7 — 17
Urban	22 — 55
5. Columbia.	
Industrial, commercial and residential (Temp. 20°C)	67
Industrial, commercial and residential (Temp. 20°C)	55
Others	44
6.Australia.	
Melbourne	87
Sydney	104
Future	142
7. India.	
Bombay	70 (Imp. Gallons)
Calcutta	42
Dehli	35
Madras	35
8. Kuwait	40

9. Thailand

Bangkok (1975) 115 U.S. Gallons

V. Average per capita consumption in Pakistan

Per capita water consumption as adopted in design of Pakistan is shown in Table V below :—

Table—V. Average per capita wate consumption in Pakistan (in Imp. Gallons)

City	Consumption
Gujranwala	40 gpcd (1975)
	50 gpcd (1990)
Sheikhupura	35 gpcd (1975)
	45 gpcd (1990)
Multan	40 gpcd (1975)
	50 gpcd (1990)
Hyderabad	30 gpcd (1975)
	45 gpcd (1990)
	50 gpcd (1991)
Jhang	30 gpcd
Sahiwal	35 gpcd
Sargodha	35 gpcd

VI. Break-up of water demand

It may be useful to know the break-up of per capita water consumption for different water uses. For United States where the water consumption is the highest in the World, the broad break-up is given in Table VI below, which is based on an average of many studies :—

Table—VI. Normal per capita water consumption for various uses in the U.S.

Uses	Average water consumption (g.p.c.d.) in U.S. Gallons
Domestic	50
Comm. & Ind.	65
Public	10
Unaccounted for	25
Total	150

In Pakistan as a result of various studies conducted in sixties, the analysis of water consumption as concluded by the General Advisory Services is shown in Table VII below :—

Table—VII. Break-up of Water Consumption, in Pakistan (in Imp. Gallons)

S. No.	Item	I	II	III
1.	Drinking	0.68	0.68	0.68
2.	Bathing	8.00	14.00	15.00
3.	Cooking	0.67	0.83	0.83
4.	Sanitary needs	3.00	8.00	9.00
5.	Ablution	1.30	3.50	10.50
6.	Utensils and house cleaning	3.34	3.90	4.00
7.	Lawn sprinkling	1.37	2.00	2.50
8.	Washing of clothes	2.90	4.00	5.00
9.	Hand washing	1.00	1.50	1.80
10.	Losses and miscellaneous	5.90	7.70	7.70
	Total	35.00	45.00	50.00

As has already been mentioned before, the per capita consumption depends upon a number of factors and as such it varies from place to place. It may be of interest to give here a comparison of the break-up of per capita water consumption (house hold) of various developed countries to enable better appreciation of our requirements. Table VIII below shows various house hold water uses in U.S.A., U.K. and Australia represented as percentage of total water demand :—

Table VIII. Break-up of household use (in percentage)

Category	Durfor & Beaker (For USA)	Howe, Russel & Young (For USA)	Sharp (For USA)	Melbourne (For Australia)
Toilet flushing	41	45	41	31
Washing & bathing	37	30	37	38
Kitchen Use	6	20	11	9
Household cleaning	3			
Clothes washing	4		11	
Drinking & cooking	5	5	—	6
Sundries	4	—	—	
	100	100	100	100

VII. Suggested Measures to Economise Water Use in Pakistan

In order to economise the water use for the optimum benefit of the people in Pakistan, the following measures are suggested :—

(*i*) Minimising wastage of water and thus reducing the percentage of un-accounted for water.

(*ii*) Using small capacity flushing cisterns. A maximum size of two gallons is recommended.

(*iii*) Developing special designs for squatting type water closets for urban and semi-urban areas which would require lesser quantity of water for flushing cistern.

(*iv*) Introducing improvised domestic latrine requiring only ½ Gallon of water for flushing.

(*v*) Providing water-meters for water supply system in urban areas, including metering of standpost connections.

VIII. Recommended Per Capita Water Consumption

After considering various factors discussed above with regard to our local conditions, it is suggested that the following rates of water consumption may be adopted for designing water supply systems in Pakistan according to the respective population as below :—

Population		Water consumption (gpcd)
Upto 1.00 lac	30	Imp. Gallons
From 1.00 to 10 00 lacs	35	
More than 10.00 lacs	40	

The break-up of the above suggested per capita water consumption is given in the Table IX below :—

Table IX. Analysis of proposed Per Capita Consumption

S. No.	Item	I	II	III
1.	Drinking	0.68	0.68	0.68
2.	Bathing	8.00	1.00	10.00
3.	Cooking	0.64	0.82	0.82
4.	Sanitary needs	4.75	6.00	6.00
5.	Ablution	1.50	1.50	2.00
6.	Utensils and house cleaning	3.33	3.88	4.00
7.	Lawn sprinkling	1.60	2.50	3.50
8.	Washing clothes	3.00	3.50	4.50
9.	Hand washing	1.00	1.50	1.80
10.	Losses and miscellaneous use	5.50	6.70	6.70
	Total :—	30.00	35.00 (Imp. Gallons)	40.00

IX. Storage & Source Capacity

Pumping capacity and elevated storage are related to each other in the inverse proportions *i.e.* if tubewell's capacity is more then storage required will be less and vice-versa.

Table X. Estimates of Source and Storage Capacity

S. No.	Source & Pumping capacity	Storage capacity
1.	Equal to the maximum day demand	1/6th the maximum day demand.
2.	Equal to the peak hour demand	Nil
3.	120% of max. day demand	7%
4.	130% of max. day demand	5%
5.	140% of max. day demand	3%

X. Distribution System

It is recommended that the distribution water main should not be less than 3" to 4" i/d. The terminal water pressure should be sufficient to serve the plumbing fixtures installed in a double storey building. A minimum of 40 ft. of head of water is recommended for communities with two storeyed buildings. The fire hydrants should be provided at suitable places. Their spacing should range between 1000' and 3000' depending upon the nature of the areas served.

XI. Concluding Remarks

The various suggestions for the design parameters of water supply system have been made keeping in view the economic conditions and water use habits of the people in Pakistan. It is possible that the various recommendations may no longer remain workable after some years depending upon the pace of development of the country, but with experience and the enormous work still to be done in this field, it is hoped that the recommendations made in this paper may remain applicable for a decade or so. It is, however, necessary that the various design standards may be reviewed from time to time to update and improve upon them.

The author is conscious of the magnitude of the topic but an effort has been made to briefly touch upon the various factors which are essential for designing a water supply system. It is also the intention of the author to invoke discussions and invite views of the learned professional experts to improve upon this modest attempt. It is, however, strongly urged to the planning and designners to follow a balanced pattern of design standards for drinking water supply schemes within the national frame work for the overall development.

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