International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.01, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

WATER SUPPLY SYSTEMS AND HIGH RISE BUILDINGS

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ABSTRACT

Along with constant rise of land prices in densely populated cities, high rise buildings continuously are gushing out. This high rise housing trend increases energy required for water supply & corresponding green gas emission. Therefore it is necessary to evolve methods which result into energy savings. This paper addresses the issue of appropriate water supply system to be employed for high rise buildings in India. Optimizing energy requirement of water supply systems in high rise buildings is a way towards sustainable development. This paper brings out a case study of a 11 to 24 floor residential building wherein the gravity system and Hydropneumatic system and intermediate tank system methods of water supply schemes are compared on energy consumption profile, all systems being sized as per National Building Code 2005 guidelines. The result shows that the corresponding annual electricity energy can be saved via intermediate tank system than gravity system for scenario considered.

Keywords: High rise buildings, Water supply systems, intermediate tank system, energy consumption profile.

I. INTRODUCTION

Along with constant rise in land prices in densely populated cities high rise buildings are continuously gushing out. This high rise housing trend across our great nation increases energy required for water supply. Reducing energy consumption of water supply system in buildings is a way of reducing carbon emission now days.

As the water pressure head at the government water mains is insufficient to supply whole building (or to reach topmost floor of building), gravity tank system and Hydro pneumatic systems are designed, for water distribution through pipes [1].

Although energy consumption is a major concern for sustainable high-Rise developments, there is no existing measure that systematically addresses the issue with respect to the optimal design and operation of high rise water supply systems. Design solutions which integrate effective energy use into water planning and supply process should be developed so as to save energy, reduce waste & protect our environment.Energy efficiency of many existing high rise water supply systems was about 0.25 and could be improved to 0.26-0.37 via intermediate tank [2].

It was reported that the water supply system consumes 1-4% of electricity & was the largest single consumer over a city. Energy consumption in water distribution systems takes an important part of energy use in urban water supply cycle. The specific energy the water supply system varies from 1.1 to 1.4 Kwh/m^3 in some Asia Cities. The pumping efficiencies evaluated from a survey of 20 high-rise water supply systems were presented as a function of installation time and better performed pumps got longer suggested service period.[3].

This paper investigates the energy consumption of three water supply systems which are used in high rise buildings.

II. NEED AND OBJECTIVE OF STUDY

High rise buildings pose a huge challenge when it comes to design of efficient water supply systems. This high rise housing trend increases energy required for water supply & corresponding green gas emission.

Therefore it is necessary to evolve methods which result into energy savings and Optimizing energy requirement of water supply systems and is a way towards sustainable high rise development.

Objective of study:

1. To study and design gravity system, hydropneumatic system and intermediate tank water supply systems.
2. To evaluate annual energy consumption and energy cost of three water supply systems for high rise buildings.
3. Comparison of three systems based on energy consumption profile.
4. To suggest most economical system among three systems on the basis of annual energy consumption profile.

III. METHODOLOGY

Gravity, Hydropneumatic method and intermediate break tank systems were designed for four residential buildings as per NBC code which is given below and annual energy consumption profile of three systems were found out for designed four buildings located in India.

Three systems were compared on energy consumption profile.

3.1 WATER SUPPLY SYSTEMS AND DESIGN

3.1.1 Water demand calculation and water storage

For calculating the water demand per person per day for a residential project following figures need to be considered as per NBC domestic (drinking + non drinking): 45+45 = 90 litters per capita per day (lpcd+ Flushing): 45 lpcd. [4]

For a project the underground storage to be provided for is 50% to150% of one day (daily) water demand. For the Overhead tank it is equal to 33% to 50% of the daily water demand. Generally UGT (1.5) plus OHT (0.5) equal to 2 day water demand.

3.2 Gravity system and their design

This is the most common of the distribution systems adopted by various types of buildings. The system comprises pumping water to one or more overhead tanks placed at the top most location of the hydraulic zone. Water collected in the overhead tank is distributed to the various parts of the building by a set of pipes located generally on the terrace. From the tank, gravity ensured a natural downwards flow and sufficient pressure. Roof tanks allow the users to have both water pressure and water supply in situations where there is no electrical power. In this model the some upper floors require a separate booster system in order to create sufficient pressure. The static pressure there is too low due to the insufficient geometric height to the roof tank.

3.2.1 Rising Main Details

a) The water requirement to be considered for designing the rising main: The Daily Water Demand of the project.

b)The operating hours of the pump, to pump this demand from UGR to OHT need to be decided for each compartment, in consultation with the client: Typically 3 to 8 hours in a day are considered.

c)From this we can get the discharge (Q) (in liters/hour) required = Daily Water Demand (in liters)/No of Hours of pumping.

d) Assume required diameter of pipe.

(A) (insqm) = Pi (3.142) * [Diameter (D^2) (in m)] / 4……….equation (1)

e) Find out the total length of pipe.

f)Using Hazen Williams formula friction head loss in pipes is calculated as below

$PL = 6.05 \times 10^{5} \times L \times Q^{1.85} / (c^{1.85} \times d^{4.87})$ ……….equation (2)

Where,

PL=Pressure loss in Bars per meter length of pipe.

Q= Flow in Liter/min.

d=Nominal diameter of the pipe in m

L=Length of the pipe in meter.

C=Friction Coefficient.

g) Based on the formula

Q(in cum/s) = A (in sqm) x V (in m/s) ……… equation (3)

From the above calculations we can find out the velocity (V) in (m/s)

3.2.2.Down take Details

For designing of a pipe diameter for the down take the following shaft wise and floor wise method is adopted:

a)Find out the number of Fixtures on each down take.

b)Finding out the Discharge from the fixture value obtained above floor wise, determine the Discharge (in LPM) from the table.

c)Assume the required Pipe Diameter.

d)Find out the total length of pipe.

e)Using Hazen Williams Formula Friction head Loss in pipes is calculated.

3.2.3. Head calculation and Pump selection

To select pump two duty parameters are decided by design which are total head and discharge for pump. From the discharge and total head pump is decided by following formula

Pump power in kw = $\gamma * Q * H / \eta$.

Following table shows which head are taken into account to calculate total head and how to calculate discharge.

Table1: *Pump Selection*

Pumping Rate Calculation	
Total water demand of all Building tanks to be served	(From OHT Drawings)
Pumping Hours/day	2-8 hours
Rate of flow in lps	
Pump Selection	
Calculation of Head	
Suction Head = Height of UGR	H1
Static Head (From UGR top to OHT top)	H2
Residual Head	H3
Frictional Head (assumed initially)	H4(Equal to 35% of static head)
Total Head	Sum of above 4 values
	H
Pump required ……Lps	
Power required ……..HP/kw	

3.3 Intermediate tank system design

In this system whole building is divided into number of zones and one intermediate tank is introduced as break tank only or this intermediate tank can serve the floor below that tank at mid height of building and one tank at roof. So working and design of gravity system and intermediate tank system is same but intermediate tank system has one extra tank at mid height.

3.4 Hydro pneumatic System

Design For the hydro pneumatic system instead of down takes we have risers directly going to the individual toilets. For hydro pneumatic system also zoning can be done.

3.4.1. The design flow is as follows

a)Find out the number of Fixtures on each Riser

Start with the shaft farthest from the UGR and start from the highest floor. To determine the number of fixtures on a single riser, consider the number of toilets connected to the riser on one floor and for each toilet decide the maximum fixture value of that toilet. Calculate the fixture value floor wise connected to riser. Sum up these fixtures values for each floor and the number of floors connected to that riser to derive on the total number of fixtures on that riser.

b)Find out FU after diversity.

c)Finding out the Discharge from the fixture value obtained above floor wise, determine the Discharge (in LPM) from the table.

d)Assume the required Pipe Diameter:

e)Find out the total length of pipe.

f)Using Hazen Williams Formula Friction Loss in pipes is calculated

g)Based on the formula Q (in cum/s) = A (in sqm) x V(in m/s) we can find out the velocity(V) in (m/s).

3.4.2.Hydropneumatic System pump selection:

Now sum all the fixtures for different zones (as calculated in the Hydro pneumatic system design) which will be catered to by this pump. Based on this fixture number find out the Discharge required to cater to all the fixtures in LPSFor determining the head of the Pump:

a.Static Head: Difference in meters in the FL of the Highest Fixture and the FL of the Delivery Header of the pump or to be safer the FL of the bottom of the UGR.

b.Residual Head

c.Suction Head

d.Frictional Head: Again calculate the Frictional head loss per unit length from Hazen Williams formula.

Frictional Head = Frictional head loss per unit length xLongest Length of Pipe

e.Pump selection depends upon two parameters which are total head and discharge.Pump power in kw = $\gamma * Q * H / \eta$

IV. WATER SUPPLY SYSTEMS DESIGN AND ENERGY CONSUPMTION

According to above design procedure four buildings of story ranging from 11 to 24 located in India were designed for three water supply systems and as per design the annual energy consumption profile is found out for these buildings which is given in table below. The consumption profile shows that intermediate tank system consumes less energy than gravity and hydropneumatic system.

IJARSE
ISSN: 2319-8354

Table 2: Monthly Energy Consumption of Four Buildings

No. Of Storeys In Building	Monthly Energy Consumption In Units		
	Gravity System	Hydropneumatic System	Intermediate Break Tank System
11	576	750	565.2
17	1242.9	1500	1197
21	1440	1800	1368
24	1953	2310	1836

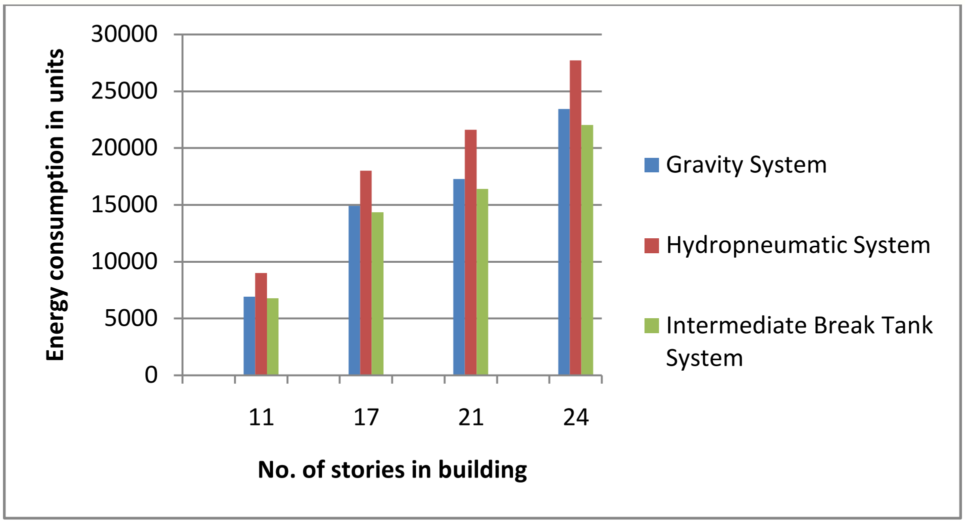
From this monthly energy consumption profile probable estimated annual energy consumption profile is calculated which is given below

Table3: Annual Energy Consumption of Four Buildings

No. Of Storeys In Building	Annual Energy Consumption In Units		
	Gravity System	Hydropneumatic System	Intermediate Break Tank System
11	6912	9000	6782.4
17	14914.8	18000	14364
21	17280	21600	16416
24	23436	27720	22032

V.RESULT AND DISCUSSION

Table 5 **Energy consumption requirement vs No of stories in building**



The above two table and graph shows that the energy consumption profile for intermediate tank system is less than gravity and hydropneumatic pressured system. From these tables it is clear that energy consumption profile of intermediate system is less than two systems so it is necessary to carry out the detailed overall cost analysis of three systems to get clear picture.

VI.CONCLUSION

Traditionally there has been great focus on initial cost of systems but now day's energy consumption of system is also important. So it is necessary to adopt the system which will save the energy against the initial cost. Energy saving of water supply systems in high rise buildings is a way towards sustainable development. Intermediate break tank system claims annual electricity saving against other two systems and as number of story in building increases saving units also increases. The Intermediate tank system can definitely become the turning point in the field of water supply systems and thus the water management in high rise buildings will become more efficient and economical.

ABBREVIATIONS AND ACRONYMS:

A-Area (m^2)

Q-Discharge

V- Velocity

H-Pressure head of water column (m)

η- Overall transmission efficiency (70%)

γ - Specific weight of water (9.81 KN/m^3)

Lpcd-Litters per capita per day

OHT- Over head tank

UGT-Under ground tank

FL–Floor Level

FU-Fixture Unit

DG- Diesel generator

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