Innovative Plumbing Design for Residential Buildings

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ABSTRACT

Building Services Engineers are responsible for the design, installation, and operation and monitoring of the mechanical, electrical and public health systems required for the safe, comfortable and environmentally friendly operation of modern building. The services team influences the architecture of a building and plays a significant role in the sustainability and energy demand of a building. A design team is fully responsible for delivering a fully coordinated functioning design, taking into account its unique nature and dealing with the changing requirements of clients and the external factors and also considering new areas like renewable energy, sustainability, low carbon technologies and energy management. With buildings accounting for around 50% of all carbon emissions, building services engineers play a significant role in combating climate change.

Sustainable development encompasses in its scope several aspects of construction. Amongst them water and waste management form an important discipline. Environmental and economic issues are driving plumbing engineers to design piping systems that use fewer resources and have minimal impact on our planet.

Role of Public Health Engineer in a design of a building had gained importance recently since they can contribute enormously to design a sustainable building. Among then various types of building, residential building has to be given more importance as the water consumption and waste water disposal from the building are high when compared to other buildings.Freshwater consumption is of major factor for the design of water systems in buildings. So the key factor in building design is the reduction of fresh water consumption.This can be done either by reducing the consumption levels or by augmenting alternative source for reducing fresh water consumption wherever possible

This paper deals with various aspects to be taken care during design by a Public Health Engineer, thevarious methods of safe waste water and solid waste disposal and storm water management including rainwater harvestingwhich will help to create a sustainable environment.

Keywords-***O**ptimization of **W**ater, **C**onservation of **W**ater, Disposal of waste water & solid waste, storm water management*.

INTRODUCTION

Building construction and operation have extensive direct and indirect impacts on the environment. As an Environmental Engineer, various design practices have to be implemented to improve the sustainable practices in building industry. Every time the trend in construction industry is to face inimitable challenges to meet demands for new and renovated facilities that are accessible, secure, healthy and productive while minimizing their impact on the environment. Building Designers are equally responsible for taking this challenge and help the owners to achieve the same. Recent answers to this challenge call for an integrated, synergistic approach that considers all phases of the facility life cycle. This approach, often called "sustainable design," supports an increased commitment to environmental stewardship and conservation, and results in an optimal balance of cost, environmental, societal, and human benefits while meeting the mission and function of the intended facility or infrastructure.

From sustainability perspective, total water system management may be the most critical feature of a building. Engineers should understand this importance and create designs that provide water-efficient solutions, while maintaining performance. Waste management system is also equally important to make a building more sustainable. Environmental engineers are involved with systems that overlap with the mechanical, civil, and chemical engineering disciplines and help influence the water efficiency, sustainable site, energy and pollution systems of a facility.

The reduction in consumption of water in buildings contributes to decrease in the volume of water extracted, treated and pumped in the public systems of water supply and in turn decreases the volume of effluents pumped and treated in public systems of drainage, consequently contributing to an increase of energy efficiency also at this level.

As a PHE engineer, the designer has to be involved from the concept itself in the design of residential buildings. Input has to be given to architects for space planning as well as choosing the right fixtures for the project so that the entire building can be designed from the sustainability point of view. Also, a PHE Engineer has an important role in space planning of utility structures and adopting the formed ground level of the site.

WATER USAGE IN BUILDING

Water in a building is commonly used for drinking, cooking, cleaning, personal hygiene, heat transfer and for landscaping. In addition to the above, some portion of water is used for recreation activities such as swimming pool, SPA etc.

Although water – consuming activities often remain similar, the sophistication of water infrastructure as well as the quantities and use patterns can vary significantly depending on the primary purpose of the building. For example, showers and toilets are important in

residential buildings, hostels and hotels. Toilets, HVAC systems are important in office buildings. Figure 1 shows a typical water use pattern in residential buildings.

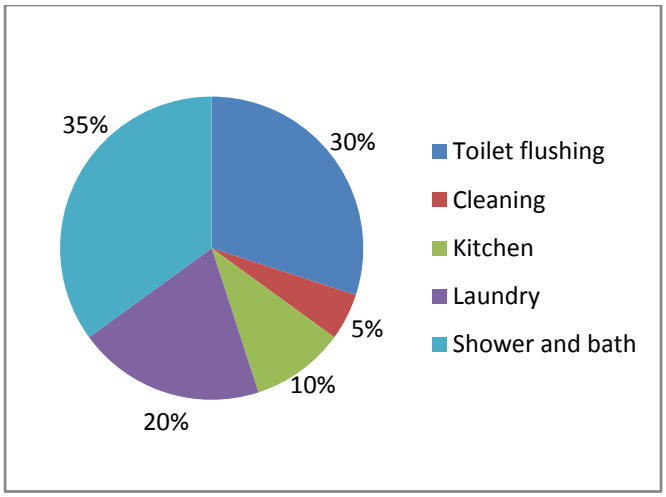

Figure 1.Typical water use pattern in Residential Buildings

COMMON WATER EFFICIENCY MEASURES FOR RESIDENTIAL BUILDING

There are numerous methods which can be adopted successfully to improve water efficiency in building. These improvements can be achieved through a combination of behavioural changes and technological fixes.

METERING

A common method to improve the water efficiency in buildings is linked to the tariff system adopted. In many of the countries, water used for different purposes for different types of buildings is not fully metered in accordance with the actual consumption rates. Instead it is implemented as fixed cost irrespective of the usage of water. So in order to achieve water efficiency, individual metering system can be adopted on individual users and rates shall be imposed based on the actual consumption rates. Since the charges are purely depending upon the consumption rate, the individual users will be enjoying the benefit in case they are using water efficiently. This awareness will make people use water efficient fixtures as well as change their habits in such a way that water is saved effectively.

Adoption of this individual metering system shall be brought out in the design stage itself. The PHE engineer should design space provision in consultation with architects in the beginning itself to fix these individual water meters. The accessibility to these meters shall be checked during the design stage itself so that later this issue will not arise. These meters can be integrated with Buildings Management system to read the meters without any difficulty. These details are to be co-ordinated with the BMS team so that the even if the meters are installed in the later stage, all the provision will be available in the beginning itself.

USAGE OF WATER EFFICIENT FIXTURES IN TOILETS AND KITCHEN

Reduction of fresh water consumption which in turn reduces the wastewater flow is achievable by adopting certain engineering practices such as modifications in plumbing, fixtures and water supply operating procedures.

Installing water-saving devices and repairing leaky pipes, faucets and toilets could save thousands of litres of water per person each year. Different engineering practices that can help residential users conserve water are listed below.

TOILETS

Dual-Flush Toilets

Dual-flush toilets employ a dual-action flushing cistern ie a two-button system; one for a full flush (6litres to eliminate solid waste) and the second button for a reduced flush (3litres for liquid waste). Some of the fixtures are designed for even lesser flow ie 4 litres to eliminate solid waste and 3litres for liquid waste.

Dual-Flush valve

Flush valve, toilets use water line pressure to flush waste into the sanitary sewer system. They consist of a valve and a toilet bowl fixture. Dual flush valve reduces the flow ie one for solid waste removal and another for liquid waste removal

Figure 2. Dual flush toilets

Figure 3. Dual flush valves

Bath Area

Bath tub and showers can be used for taking bath. If only hygienic requirements are only there, then people can be advised to use only showers which will reduce the water consumption to a limit. Bath Tubs can be used wherever therapeutic effect is required.

Showerheads

Showerhead replacement or modification represents another water efficiency area that is cost effective. Most conventional showerheads use 12 to 15 lpm at 3bar water pressure. Showerheads are available in current market which will restrict the flow to 9.5 lpm. These showers mix air jets along water flow to reduce the water consumptions.Water efficient showerheads also reduce energy consumption related to hot water generation.

Installing water flow/ timer in showers

By installing water restrictors and timer in shower reduces the water wastage to some extent. By introducing shower timers, the water can be saved while shampooing, applying soap and during head wash. Use of easily adjusted shower mixers reduces the time wasted for adjusting the mixers to arrive the comfortable levels, thus reducing the water wastage occurred during this time.

Figure4.Conventional type shower heads

Figure 5.Low flow shower heads

Faucets

Water efficiency in these areas can start from some behavioural changes like not letting the water drain during hand washing, tooth brushing or shaving. Washing razors in container reduces water consumption instead of washing in running water.

Figure 6.**Conventional type pillar cock**

Figure 7. **Sensor type pillar cock**

Older conventional faucet flow rates can range from 21lpm at 3 bar pressure. Sensor type water faucets depend on infrared sensors to trigger the wash flow. Such faucets should have a preferable respond time so that users will not get dissatisfaction. Faucets with automatic shut off valves will restrict the flow after a predetermined flow. This can reduce the water consumption rates to an extent. The flow rates can be restricted to 8.5lpm when compared with 21lpm of conventional type. Also push type faucet also reduces the water usage to some extent which is mainly lost during brushing, shaving etc.

Kitchens

Both domestic and industrial sector vegetables and fruits have to be washed before cooking/ consuming directly. Instead of washing directly under running water using a water container will be effective. Vessels shall be washed using water efficient dishwashers for reducing water consumption. The cycle time of dishwasher can be adjusted to reduce the water consumption. Where manual washing is the only option, measures should be taken to remove the food waste using napkin or other means. The dishes shall be soaked to a sufficient time for easy washing. Hot water can be used for washing so that it will be more effective than cold water, thus reducing total water consumption.

Design engineers have a major role in selecting the types of fixtures for the buildings. One can select the water efficient fixtures and can let the architects/ developers choose the final one from an aesthetic point of view from among the short listed options. This will help to reduce the water consumption as most of them will be ignorant about the same. Also flow restrictors shall be added while ordering for the fixtures. A pamphlet containing the same shall be circulated for awareness in case the fixture fixing is part of individual owner's scope.

LANDSCAPING

Water use in landscaping has a good potential for water reduction as it consumes a large amount of water. Three main approaches are effective in reducing the amount of water in landscaping.

Selecting the right plant species

Plant species hold the most important promise to reduce the water consumption. Exotic plant species that are not native in nature requires more water and demand maintenance. In semi-arid regions, the drought plant species are preferred as they can survive without water for a long duration. They require minimum water to supplement irrigation. They also need lesser maintenance in comparison with water needy plants. This practice is known as Xeriscaping. Also lawns shall be restricted to reduce the water consumption rates.

Optimization of Irrigation devices

While selecting the irrigation methods, suitable methods are also to be adopted to reduce the water consumptions. Drip irrigation system will consume less water in comparison with sprinkler irrigation. These will depend upon the type of species proposed. In addition to these, synchronizing moist sensors with irrigation equipment will reduce the water consumption rates. Similarly all irrigation devices shall be properly maintained to avoid the leakages.

Alternative water source for Irrigation

Alternative water sources such as grey water/ harvested rainwater can be used for irrigation purpose. This will reduce the direct consumption of fresh water sources.

Metering for Irrigation

By adopting the metering system, the water which is wasted can be restricted as the charges purely depend upon the consumption rates. This will indirectly force the owners to adopt the various water efficient technologies mentioned above for irrigation.

For adopting such techniques, Design engineer need to have provisions for meters, flow sensors in water supply system. Dual water supply lines should be designed and implemented, the treated water should be maintained as per the standards mentioned in CPHEEO manual for irrigation usages.

IMPLEMENTING DUAL WATER SUPPLY SYSTEM

Dual water supply systems are already implemented in most of the developed countries. After understanding the benefits and water scarcity in the urban developments, developing countries also have come forward to adopt the system. Along with adoption and implementation of the dual plumbing system to reuse the treated water system, developing standards for treated water for such system also arises.

Guidelines for non-drinking water supply stipulate a range of measures which permit the easy identification of drinking and non-drinking water supply lines. Some of them are:

- Give colour code for pipes for identification. As per international standards drinking water pipe should be blue in colour and non-drinking water line in purple.
- Warnings printed on non-drinking water supply lines.
- Use of marker tapes.
- Maintain minimum pipe separation.
- If the pipes are buried, there shall not be any crossing between the drinking and non-drinking water supply lines. Where there is a requirement for drinking water to supplement non-drinking water there should be an air gap with reduced pressure zone devices, acting as non-return valve. Installation of back flow preventers should be as per the standards. The back flow preventer should be located in well drained areas

For adopting the dual flushing system, the designer has to design the water storage tanks sizes accordingly. Also space provisions in ducts shall be made available for the additional water supply lines. Treatment technology for the sewage shall be suggested to achieve the standards for the treated water reuse. In some cases grey water can be collected separately and can be reused with minimum treatment.

RAINWATER HARVESTING

Rainwater harvesting is another alternative source to supplement the fresh water consumption. Rainwater harvesting is simply collection or storage of water through scientific techniques from the areas where the rain falls.

Rainwater can be harvested from the impervious surfaces (such as rooftops and other paved surfaces) of the building premises. The quality of the rainwater from rooftops is higher than from any other paved surfaces. Consequently rainwater collected from rooftops would require less treatment when compared with the rainwater collected from any paved surfaces exposed to people and vehicular traffic. The fig No: 8 mentioned below shows the pictorial representation of the same.

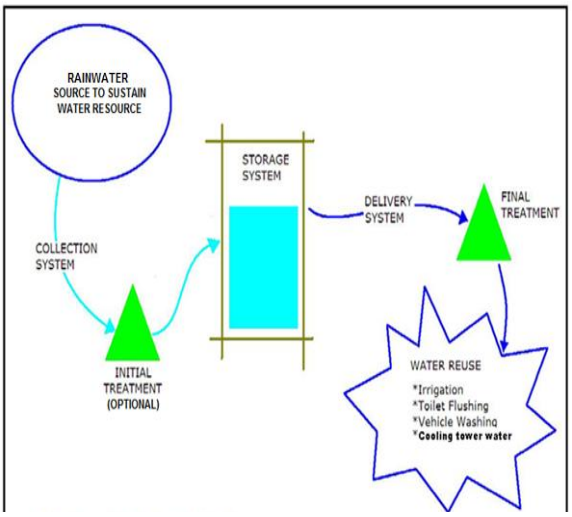

Fig 8.Pictorial representation of Rainwater harvesting

A rainwater harvesting system consists of three basic elements: collection areas, a conveyance system and storage facilities with necessary treatment units like first flush and filters. There are different types of harvesting methods

a. Roof water collection tank
b. Rainwater recharge pits
c. Rainwater percolation trenches
d. Rainwater harvesting ponds
e. Rainwater harvesting through existing open wells
f. Rainwater harvesting through existing abandoned bore wells within the site.

Before designing a rainwater harvesting system, following details need to be cross verified:

i. Catchment Area
ii. Soil report
iii. Annual rainfall pattern
iv. Reuse pattern
v. Existing elements in the site

For the rainwater harvesting system to be implemented in residential buildings, the designer has to plan an exclusive rainwater collection network separately. Separate balcony and podium water collection system has to be planned so that the water collected from these areas cannot be mixed with the roof water. As far as possible, the rainwater collection tank shall be planned near the domestic tank to avoid the pumping network. Pretreatment has to be planned for the roof water collected to reduce the load coming on the filters which is planned for the treatment of the domestic water.

SOLID WASTE MANAGEMENT

The solid waste collected in residential buildings will be more compared to other buildings.

A proper collection and management of the system will help to attain sustainable development. The solid waste generated has to be segregated at individual flat level itself. An exclusive area can be identified on each floor to collect the solid waste if manual collection is planned. Coloured bins can be given to the residents to segregate the solid waste at the source. In case garbage chute is planned, a chute with dual button option i.e. organic waste and inorganic waste has to be proposed during the designing itself. To treat the organic waste, location and space has to be identified. There are many methods available like composting, organic waste converter etc. Suitable methods can be adopted to get the desired outputs i.e. bio gas or manure which can be used for house hold applications and landscaping respectively.

CASE STUDIES

Rainwater harvesting storage tank

An effective RWH system was analyzed in the proposed residential town ship located near Chennai. After careful analysis of rainfall data, infiltration capabilities and the catchment area, the entire surface run off was collected in the storm water drains (SWD). Recharge pits are proposed at regular intervals within the storm water drains for percolating the water. This resulted in reducing the risk of flooding in the local area due to the huge development, improving the watershed quality and also reduced the burden on the local authorities in planning the SWD in the downstream areas. Also roof water is directly connected to the proposed rainwater harvesting sump with preliminary treatment and same is reused for domestic purpose.

Storage tank sizing:

Storage tank sizing by total annual rainfall

ST = A* CE* IA * (7.5%)== 4660 x 0.95 x 1300 x (7.5/100) = 432 cum

Provided Underground storage sump capacity = 400 cum

Total annual rainwater harvested volume (WH):

WH = A* CE* IA * percentage of harvesting (70%) =4660 x 0.95 x 1300x 70/100 = 4028 cum

Potable Water requirement per year (Wp) = 78475 cum

Total raw water requirement per year (W) = 78475 cum

Percentage of potable water saving through rainwater harvesting system/year

=(WH/Wnp)*100=4028/78475*100 =5.1 %

Potable water requirement:

Domestic water requirement per day = 255 cum

In the proposed scheme for rainwater harvesting, the reuse of rain water considered for potable water iefor domestic purpose and this reduced the consumption of fresh water to some extent in rainy season.

Adoption of Dual water Supply system

In order to reduce the fresh water consumption, Dual water supply system was adopted in one of the residential town ship in Bangalore where in water is reused for flushing and landscaping purposes. In this township, 4 types of blocks were there namely A, B, C & D. In this2 blocks namely B&C Blocks have been constructed and Municipal water supply mixed with bore well water is used for portable as well as non-portable uses. For the blocks which have yet to be constructed (Block A & D), due to the non-availability of Municipal water around 3000 tanker lorries have to be used per month which is costing around 5 lakhs per month. In addition to it, sanitary charges are also paid monthly as per BMWSSB Tariff. Due to the problem of less availability of water from BMWSSB for the future blocks, as well as the not getting permission for discharge in to the Municipal sewerage line, the developer has taken a step for implementing the Dual water supply system by adopting the treated water from STP as source of water for non-portable source ie for landscaping & flushing. For the new blocks D & A, non-portable water requirement is around 5500cum against the total requirement of 12350cum per month. The non-portable water is used for flushing and landscaping purposes. If only flushing water is reused then flushing water requirement is around 2900cum per month.

Sewage treatment plant of 800kld is constructedwhich caters for all the blocks. For using the treated water from STP for flushing, treated water from the STP is transferred to the flushing sump of respective blocks which is around 500m away from the blocks.

Total Non-Potable water demand - 5500cum per month

Total water demand -12350cum per/Month

Percentage of Total water supplied by alternative source= 5500/12350) X100

= 44.5%

So the water consumption is reduced by 44.5%

CONCLUSION

The demand for water is increasing every year due to the increase in population, increase in per capita consumption, increased activities of urbanization and industrialization taking place at a faster rate. Since residential buildings are one of the highest consumers of water, proper measures need to be taken to increase the water efficiency usage in these buildings. The design teams shall be made aware of the water scarcity problems and all the water efficiency measures shall be taken care in the beginning of the design phase itself. The consumers as well as the owners shall be made aware of advantages of adopting the water efficient measures and can be trained/ educated to follow the same.

Norms shall be proposed for all types of usages so that the treated waste water shall be as per norms and the treated water will be as per the quality standards. There statutory norms should insist on the water conservation techniques so that all will be forced to follow the same. Above all, by adopting the water efficiency measures, sustainable buildings can be built which in turn helps the developer/ owner to claim green building rating for the buildings.

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