Water Efficiency and Management in Green Building: A Review

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Abstract: ***Water is the most important compound worldwide for life support and other varied human activities. The shortage for these specific activities demands the need for air, river, waste and water disposal, reservation and transportation to produce portable water. These studies were planned to assess the value of water conservation and quality, and the level of distribution of criteria and points through green building ranking systems. When groups, criteria and distribution of points were evaluated for ranking schemes. The analysis reveals that water is a significant category because it is included in all rating schemes and within the rating schemes have appreciable criteria and the allocation level. The difference in rank, criteria, and points distribution is focused on the social, cultural, and environmental interests of all stakeholders of the different countries. The Green Ship and Green Star SA 's highest parameters and points indicate the need for effective water production and delivery throughout the society as well as the house. While in Green Mark and BEAM is due to lack of enough fresh water for daily activities as well as building construction. As a consequence of developments in renewable water production and delivery in the respective countries, the lowest in the BREEAM, Green Star NZ and LEED has been. The study harmonized criteria included the whole sustainable building environment evaluation in terms of water supply, delivery, and use for countries establishing ranking schemes.***

Keywords: ***Construction, Green Building, Water Efficient Technologies, Water Management, Water Efficiency***
(Article history: Received: 6 th February 2021 and accepted 20 th March 2021)

I. INTRODUCTION

Growing population followed by certain water stressors places stress on water supplies around the globe. Buildings in the United States consume significant volumes of potable water as well as pollution disposal which lead by rain water drainage to polluting costs. As our population rises and expands, our water demand often increases, and our infrastructure stretches as well. Growing demand on water supplies contributes to greater involvement in more effective usage of energy, both in terms of decreased quantity and efficiency. The issues associated with rising water usage may be alleviated by introducing water storage techniques such as water reclamation, recycling, or localized water reuse. Water conservation is an energy saving principle which is very much required. Conserving resources for current and future generations is a huge need.

Some wastewater is used either for agricultural purposes or for washroom washing. It saves a great deal of energy and is a simple activity that can be applied in everyday life. Designers often agree that rainwater should not be diverted, so to maximize the usage of drinking water so avoid water pollution should be collected for washing purposes or for other domestic jobs.

A. Green Building

Green architecture includes a construction system built to be environmentally sustainable to make use of renewable capital nominally to effectively. These houses, beginning from design to removal, are resource-efficient and environmentally sustainable over the entire lifetime.

A Green building design largely emphasizes on making effectual use of natural resources like water, energy, etc. while reducing several bad effects on the environment and the occupant’s health during its use.

Green building is interpreted in many ways, common opinion that they should be designed and operated to reduce the overall impact of the built environment on human health and the natural environment by:

1) Efficiently using energy, water and other resources
2) Protecting occupant health and improving employee Productivity
3) Reducing waste, pollution and environmental degradation
4) Site and Design Efficiency
5) Reduced Energy Usage
6) Reduced Water Consumption
7) Environmentally Safe Construction Materials
8) Better Air Quality

B. Water Efficiency

As the name suggests, here we will be looking at ways to make water use more efficient. This includes domestic water use (drinking, cooking, washing, flushing) and irrigation.

Water is a precious resource that needs to be conserved and reused so we don't run out. Strategies for doing this include:

1) Proper selection of landscape plant materials and irrigation systems.
2) Use of High efficiency plumbing fixtures.
3) Water reuse and treatment systems.

The three key components of water efficiency in green buildings according to the USGBC (U.S. Green Building Council) are:

1) Reduce Indoor Potable Water Use
2) Reducing Water Consumption to Save Energy
3) Improve Environmental Well-Being

C. Salient Water Features in Green Building

1) Minimum Water Discharge
2) 100% Waste water recycling
3) Rain water harvesting
4) Water efficient landscaping
5) Highly efficient water fittings
6) Innovative waste water technology
7) Reduction of Potable water use

D. Typical Water Use at Home

The following Fig.1. shows typical water use at home.

Fig.1. shows typical water use at home

E. Cost Effective Strategy for Water Efficiency

The following Fig. 2 shows cost effective strategy for water efficiency

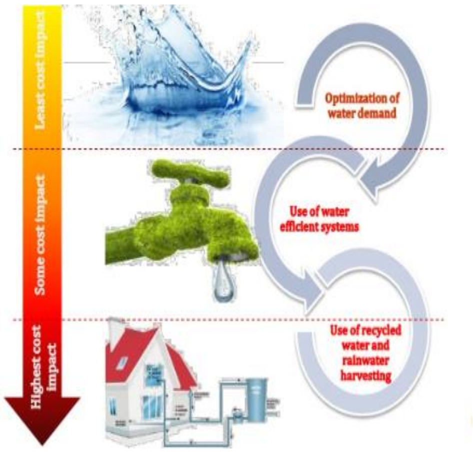


Fig.2. shows effective cost strategy for water efficiency

F. Fundamentals of Green Building

A green building is one which uses less water, optimizes energy efficiently, conserves natural resources, generates less waste and provides healthier space for occupants, as compared to a conventional building." (IGBC, 2008).

Green Architecture is a design definition that combines a wide range of best practices and approaches. While green building is viewed in several respects, popular consensus is that it should be planned and managed to minimize the total effect of built infrastructure on human health and the natural infrastructure by:

1) Efficiently using energy, water and other resources
2) Protecting occupant health and improving employee productivity
3) Reducing waste, pollution and environmental degradation

G. Green Building Guidelines

Anyone involved in designing a safe and green designing are created to include a set of standards and metrics. This was agreed that in order to gain a clear understanding of the elements of a green building and then design this, a detailed collection of instructions should be needed to direct the involved party towards the construction of a green building with the necessary techniques and processes.

H. Green Building Rating System in India

Many Green Building ranking systems have been established around the globe by various countries to evaluate green buildings based on their degree of environmental targets they have accomplished. In India the major water quality certifying companies are:

1. *Green Rating for Integrated Habitat Assessment (GRIHA)*

GRIHA is the ranking framework in our own nation that was jointly established by the Ministry of New and Renewable Power, the Government of India and TERI. This method of ranking comprises of 34 separate divisions under 4 major parts i.e., Site discovery and preparation, resource management and productive usage, construction and preservation of structures, and creativity.

GRIHA is a ranking device that helps individuals to measure their building's efficiency against other standards that are appropriate nationwide. This must holistically measure a building's environmental efficiency across its whole life cycle, thereby establishing a clear benchmark on what constitutes an 'urban house.'

GRIHA criterion for evaluation is based on some of the following points: Site selection and site planning, building planning and construction stage, Building operation and maintenance, Innovation.

2. *Indian Green Building Council (IGBC*)

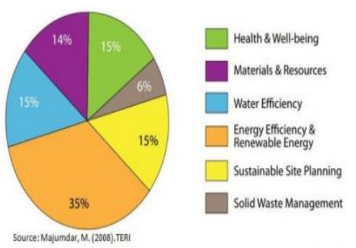
IGBC is the non-profit research institution formed by the Confederation of Indian Industry (CII). IGBC facilitates India’s green structures to become one of the green rated buildings.

3. *Leadership in Energy and Environmental Design (LEED, INDIA)*

LEED, India Green Building Certification Framework is a common reference point for the architecture, development and service of high-performance green buildings both in India as well as around the world. It is one of the major bodies offering a construction system with green scores, whether it's an office, a private residence or a commercial house.

I. *Rating Criteria for Green Building*

The following Fig. 3 shows rating criteria of GRIHA



Points achieved	GRIHA Rating
50-60	★
61-70	★★
71-80	★★★
81-90	★★★★
91-100	★★★★★

Fig. 3. Weighting of various criteria as per GRIHA

J. *Role of Water Efficiency*

The most important elements of understanding water efficiency are the diversification of water terms in green building practices.

LEED standard identifies four key types:

1. *Potable Water*

LEED standard expresses potable water as meeting quality standards for human consumption by local and/or state authorities. LEED standard discourages the use of potable water in non-potable applications such as landscaping or indoor plumbing needs.

2. *Grey water*

To protect the unnecessary use of potable water, green building practices under LEED emphasize the use of grey water for a variety of non-potable applications such as landscaping and indoor plumbing. Defined as untreated wastewater that has not come into contact with water closet waste, grey water emanates from bathtubs, showers, and bathroom wash basins. The high applicability of grey water on a LEED project in meeting landscaping requirements or limiting potable water use for water closets and urinals is the main element of its importance to green building practices.

3. *Black water*

Black water is both the antithesis to drinking water and brown water, because it is not ideal for any human touch. Kitchen drains, and bathtubs are called black water. The LEED norm discourages the usage of black water to supplement the use of drinking water and is usually assumed to be prohibited in use until it is handled.

4. *Process Water*

Due to its usefulness in cooling towers, chillers, and boilers, the usage of process water, particularly in LEED rating systems, is not controlled for water efficiency processes. However, the most significant aspect of process water is the restricted usage of fresh water to be used as process water, as the LEED principle essentially discourages the use of liquid water for non-drinking purposes.

K. *Integrated Building Water Management Modelling*

Overview- Design of the first iteration of the IBWM was based on a conventional market design, but with the University of South Florida's Patel Center for Global Solutions in mind. The original iteration of the IBWM model (Version 1) was built in a construction environment from the concrete quantities and flows of water. The extent of influence includes the house and the surrounding landscaping. Within the system, Drainage was deemed a significant area; and as such, a green roof alternative and low impact construction (LID) approaches such as minimal impermeable surfaces were included for review. Equations and theories were intuitively established. Regardless of that, it is important to doubt the quality of the empirical tests; nevertheless, the model has worked in monitoring the various flows and preserving a mass equilibrium, as well as producing similar outcomes for specific water management alternatives. Equations and assumptions are estimated values with the exception of mandated flows given in the Energy Policy Act of 1992.

The second and current iteration of the model was built to fit a nearby children's school's water flows and management choices. Version 2 borrowed extensively from version 1 since essentially the water mapping is the same. Water is also obtained from the same outlets (drinking water, filtered water) and sent to the same sinks (toilets, watering). New equations and assumptions were taken directly from the LEED NC Reference Manual so that attainable LEED points for the 26 projects could be determined from the improved model. Although the assumptions may not accurately represent the water usage for a specific building, this model allows users to alter the assumptions to values they feel more accurately portray water usage for their site. Sectors of the model not included in the Reference Manual, such as green roofs or cooling, are generally turned off in the Version 2 framework because:

1) They do not contribute to attainable LEED credits
2) Acceptable equations and assumptions for these sectors have not been developed. However, these sectors are built-in and prepared to be linked when proper assumptions can be established. The current IBWM model consists of various flows and volumes that can be separated into individual sectors.

Irrigation - Irrigation around a house would create the single largest need for water on the property. Including normal rainfall, the usage of activities of native or modified plants greatly reduces or removes the need for water sources. Rainwater storage provides extra drainage assistance, particularly from a conventional or green roof. Water obtained from low impact development (LID) design strategies may be stored in a retaining pond and drained when demand determines, whereas filtration can allow 29 to prevent possible clogging of piping systems. All fresh water and green water are appropriate for agricultural purposes in addition to the cooling and toilet flushing. The sum of all inflows for irrigation is the total flow for irrigation.

Bathroom Sinks **-** The bathroom sinks stock does not accumulate volume; therefore, the volume within the stock is 0. The only inflow is assumed to be potable water because of the possibility of human consumption. Water exiting from bathroom sinks is sent directly to the sewer in the baseline case. The model provides the opportunity for grey water exiting the fixtures to be routed to treatment before being reused within the building.

Kitchen Sinks **-** Unlike the sinks in the shower, the stock of kitchen sinks will not generate space: the space within the stock therefore is 0. Thanks to the probability of human use the only inflow is believed to be potable water. In the reference scenario, water leaving the bathroom sinks is sent straight to the drain. The model provides the opportunity for grey water exiting the fixtures to be routed to treatment before being reused within the building.

Showers - The stock of the centre shower does not collect quantity; thus, the stock capacity is 0. This is presumed that the main inflow is potable water. In the standard scenario, water escaping from the bathroom sinks is sent directly to the drain. The model calls for the grey water escaping the fixtures to be redirected through care before being collected within the house.

Toilets - There are various alternate sources of water that can be added to flushing toilets as it should not be of sufficient quality (potable water) for sewage conveyance. Alternate water supplies include filtered grey water from sinks and toilets, rainwater captured, storm water captured, or waste water. In the standard case, water used for the flushing is sent directly to the drain. In the construction scenario, black water leaving the fixtures may be submitted to storage in usage inside the building as a different potential recyclable source. For male and female, the toilets are divided into two parts. The separation is necessary because the number of applications for a male and female toilet differ if urinals are present in the building. The number of applications for a male toilet will be less due to utilization of urinals.

Urinals - Inside the form the same system used with toilets applies to that of urinals. The alternate approachable sources of water are the same: recycled black water from sinks and toilets, collected rainwater, recorded storm water, or waste water. Flushed water is sent through the container, in the normal situation. The case construction provides the recovery of black water entering the urinals for certain uses. The urinals are split into parts male and female. If urinals are placed in the house, the male portion may see a need for water. There's no competition going to be in the female section.

II. LITERATURE REVIEW

According to **Caryssa Joustra et al. (2010)** recycled and reused of water is also compartmentalized; each water-saving strategy is suggested ahead of another. The holistic strategy, though, measures the outcomes of different water control strategies or, most specifically, a mixture of the strategies. This knowledge is essential for making water-based decisions and such decisions are taken by people interested in the construction. [1]

According to **William J Rhoads et al. (2015)** plumbing, management techniques implemented at each green building provided both hot and cold-water temperature profiles that are conducive to growth of OPPP during stagnation. Strategies for maintaining goal temperature profiles in buildings reliably need to be discussed. Green building construction with water efficiency characteristics will reduce average water age and remove wasted water. [4]

According to **Oindrila Das et al. (2015)** highlight the rising need for water conservation in today’s world and its importance as a part of green building designing and construction. The necessity for water conservation has become so much significant that recently LEED rating system has doubled the points under the water efficiency category to ten from the previous quantity of five. Several countries around the world have already started devising green building designs in all their construction works with special emphasis on water conservation and are encouraging their citizens to use water efficient technologies. [2]

According to **R. Sivasankar et al. (2016)** drawn attention to the growing need for water protection in today's environment, and its significance as part of the design and development of green buildings. The need for water management has been so important that the LEED ranking scheme just increased the points from the previous quantity of five in the energy quality group to ten. [3]

III. MODEL SIMULATIONS

Assumptions - A sample run of the IBWM model for a hypothetical green office building in Tampa, FL was conducted using the following assumptions.

FTE - The full-time occupant equivalent (FTE) is calculated assuming that the office building employs 85 full-time workers and 30 part-time workers. The total FTE is calculated as 100.

Irrigation - All landscape factors are assumed to be average values. Sprinklers are used to provide water to the plants, yielding an irrigation efficiency (IE) of 0.625. The water consumption required to irrigation incorporates the average evapotranspiration rate averaged from data collected for Odessa, FL from 2004 to 2006 (USGS, 2010).

Fixtures- The green office building contains toilets, urinals, bathroom sinks, kitchen sinks, and showers for employees. The baseline parameters for these fixtures are based on the LEED values.

Rainfall Collection - In this scenario, the feasibility of a rainwater collection system is being evaluated. The building has a total roof collection area of 10,000 square feet. The collection efficiency of the system is 90%, and the first flush volume is 5 gallons for every 500 square feet of catchment area. If all 10,000 square feet of catchment are utilized, the first flush volume is 100 gallons. The cistern volume can be varied. Daily rainfall values collected by a personal weather station in Lutz, FL (KFLLUTZ5) for 2009 were used for the simulations.

Wastewater Treatment **-** Wastewater disposal and reuse are another solution necessary for the house. The wastewater recovery system is capable of holding up to 5,000 gallons of water for building use. Water should be obtained from drains, pools, toilets and urinals, and used for conveying drainage or waste.

Model Runs **-** The IBWM model was run using different scenarios. Each model run lasted a full year from June 1 to May 31. Percent reductions in both total water and potable water were determined from the LEED baseline case. The scenarios analysed by this IBWM simulation is:

Scenario 1: Conservation measures are in place. The building installs toilets that use 1.28 gpf, urinals that use 0.5 gpf, and sinks with 1.8 gpm flow rates.

Scenario 2: The same conservation steps are in effect as those listed in Scenario 1, as are low-flow showerheads that use 1.8 gpm. Aerators are mounted on the sinks in the bathroom to reduce the time from 15 to 12 seconds. In all landscaping, drip irrigation is built and increases the irrigation capacity from 0.625 to 0.90.

Scenario 3: All conservation measures mentioned above are in place. Grey water from kitchen sinks, bathroom sinks, and showers are used to flush toilets.

Scenario 4: All conservation measures are still in place. Grey water from kitchen sinks, bathroom sinks, and showers is used for flushing urinals first and then toilet flushing.

Scenario 5: All conservation measures are in place. Greywater from kitchen sinks, bathroom sinks, and showers is used for irrigation.

Scenario 6: All conservation measures are in place. Greywater from kitchen sinks, bathroom sinks, and showers is used for flushing urinals and toilets. Rainwater is collected in a 5000-gallon cistern for irrigation use.

Scenario 7: Same as Scenario 6, but the cistern size is 1000 gallons.

The following Fig. 4 shows total potable water savings for each scenario.

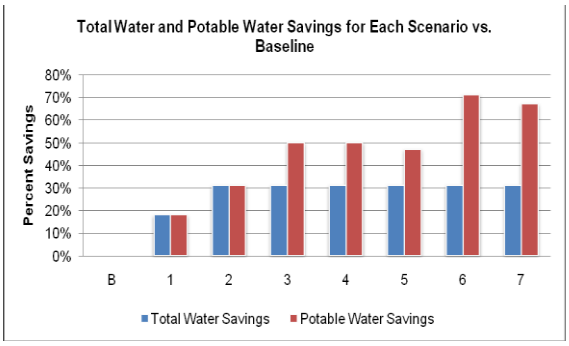


Fig. 4. Total water savings Vs Baseline

Maximum water savings rely solely on the building efficiency steps taken. In scenarios 2 and 7, the reduction strategies in the case of low-flow fixtures are the same, so all situations provide the same percentage reductions in gross water usage. Implementing new water supplies, though, reduces the amount of potable water that is provided in each case. Just shifting the water source to satisfy demand won't change the net sum of water savings, moving the water source combines potable water with an additional access point.

The IBWM model differentiates between overall water consumption and consumption of drinking water and addresses certain characteristics to the consumer. LEED already grants points to minimize the consumption of drinking water; furthermore, potential versions will discuss the elimination of the overall demand for energy. The IBWM model also allows consumers a description on where water is being used for the construction site. Again, scenarios 2 through 7 have the same values because water to meet 65 demand is only being substituted; the amount of water still needed for each fixture does not change.

Resolution - The IBWM model will display annually, weekly, or regular patterns. Figure maps the percentage reduction in use of potable water for the criteria set out in scenario 7. The percentage declines reported are measured as an average, weekly average, and hourly average for the year.

The following Fig. 5 shows potable water savings daily, monthly and annually.
The overall annual drop in drinking water for scenario 7 is 69%. The figure above indicates that, owing to the difference in rainfall and evapotranspiration, the main factors influencing irrigation, the percentage savings differ by month and day. The plot follows a recommendation from the LEED to examine water use during the year.

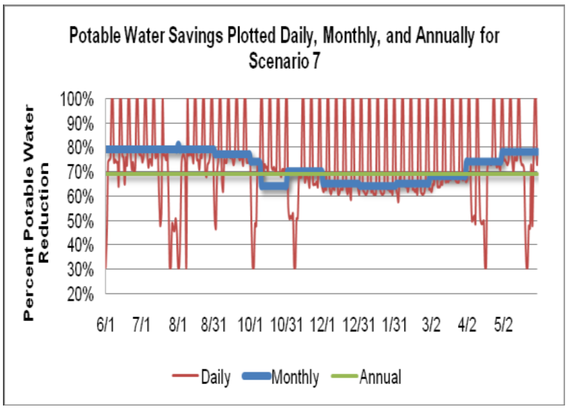


Fig. 5. Potable water savings Vs Reduction

However, providing resolution down to the monthly or daily level allows users to evaluate how the effects of water management are dynamic with respect to time. Plotting daily water consumption captures trends such as workday consumption vs. weekday consumption, and seasonal changes for irrigation. Figure presents the daily water consumption for irrigation, sewage conveyance, water fixtures, and the total building over the simulation year for scenario 7.

The following Fig. 6 shows daily water consumption.

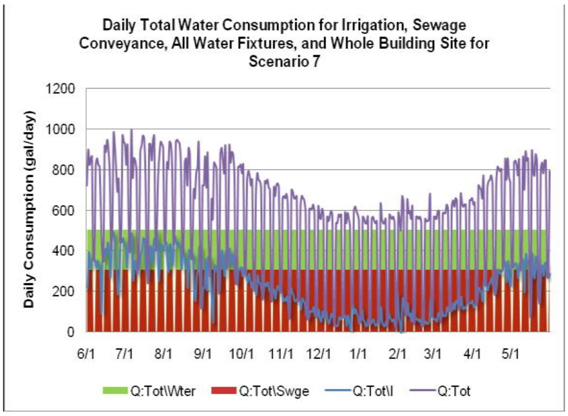


Fig. 6. Daily consumption of water

The trends in interior versus exterior water consumption for the building are seen in the above figure. The colored bars represent interior water usage by building fixtures. Water consumption by all fixtures is around 504 gal/day (306 gal/day for toilets and urinals) when the building is occupied during the weekdays; interior consumption goes to zero during the weekends when the building is not occupied. Total water consumption for the site is the sum of the demand by all water fixtures and irrigation. The graph shows that irrigation drives the changes in overall demand; more water is consumed in the summer when irrigation demand is high, while less water is consumed in the winter when irrigation demand is low.

July Baseline Case - LEED estimates for water fixtures include a yearly average; however, LEED NC's landscaping section requires initiatives to measure drinking water benefits using the July month as the benchmark. The fundamental expectation is that evapotranspiration would be the lowest in July; thus, the water required for irrigation would be the maximum and would be tougher to reach alternate sources of water.

The following Fig. 7 shows comparison of available rainfall to irrigation demand.

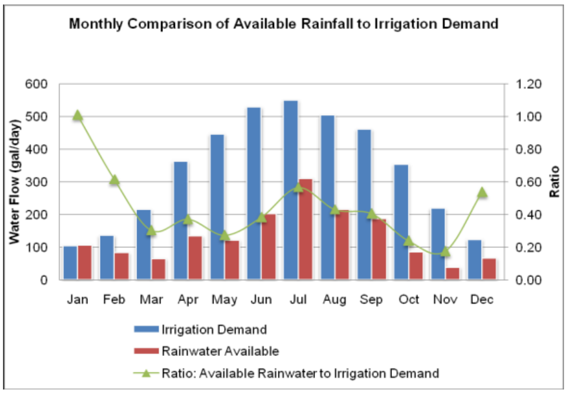


Fig. 7. Demand Vs Water flow

For each month the triangles describe the ratio of accessible rainwater to the irrigation requirement: higher ratios mean that rainwater will satisfy further requirement. If more rainwater is used for drainage, the percentage is the total gain in potable water. November providers-case month to offset potable water for landscaping because it has the lowest ratio of 0.17. Although July has the highest demand for irrigation, there is also a fair amount of rainfall available to offset potable water. The ratio for July is 0.56; if all rainwater is collected and applied to irrigation, 56% of potable water would be saved. However, the annual average ratio is 0.40 or 40% possible potable water savings. In this scenario, the July baseline assumption overestimates the potential potable water reduction by 16 percentage points. The difference in this scenario affects Water Efficiency credit 1: Water Efficient Landscaping. The July baseline calculates a 56% potable water reduction, which would earn the project two points for exceeding the 50% reduction threshold. However, measuring the reduction over the year would show that the average savings of 40% does not meet the 50% goal. The end result is that the building is perceived as more water-efficient than it really is. Doing so not only overestimates water savings, but also the potential economic savings and payback associated with it.

IV. COST COMPARISON OF GREEN BUILDING AND CONVENTIONAL BUILDING

Table I: Site Development

Description	Cost
Total Cost Without Sustainable Features	1611564
Total Cost with Sustainable Features	2232444

Table II: Summary Civil and Electrical Work

Description	Green Building	Conventional building
A) Civil Work	127664007	126338122
Sanitary Installation and Water supply	6084200	5584200
Sewerage and Drainage	1923738	1923738
Rain Water Harvesting	297972	-
Bore well	248615	-
Total Civil Work	136218532	133846060
B) Electrical Work	11474400	7653000
C) Consultancy Fees	2266871	1714814
Grand Total Of A+B+C	**149959803**	**143213874**

Cost of Green Building Rs. 149959803/-

Cost of Conventional Building Rs. 143213874/-

Extra Cost of Construction of Green building 4.5%

V. LEARNING GATE COMMUNITY SCHOOL

Overview - Learning Gate Community College, a member of the Hillsborough County School District, is an environmentally-themed K-8 high school. The school began as a private college in 1983 and was charged with an estimated student body of 500 in 2000. Our curriculum services incorporate the natural environment into the practices and topics of instruction. Learning Gate Community School is eligible for registration with LEED Platinum. In the LEED award program for classrooms, recently built concrete buildings on the campus received platinum status. Owing to the comprehensive preparation and engineering development conducted to conserve water on campus, Learning Gate offers an ideal test site for water expenditure study. There are two cisterns for the existing buildings to store rainwater, for a minimum of 10,000 gallons. For the new buildings which are already plumbed for this reason, captured water from cisterns is used to flush the toilets. The school is also studying how more rainwater may be stored in two drainage ponds situated on the campus' north side. Currently the ponds collect storm water runoff for the school which quickly infiltrates and recharges the groundwater supply. Therefore, any retention attempt would require that the ponds be lined to halt the high infiltration that occurs naturally. Learning Gate plans to install an on-site natural wastewater treatment machine (Eco Machine), where all wastewater produced on campus is sent for treatment and reused to replace the need for toilet flushing. Recycled water may also be used inside the Eco-Machine to meet the demand on the campus or to support a fish or plant crop. All the aforementioned technologies provide excellent educational opportunities for students to learn and be a part of the water treatment and reuse process.

A. Water Efficient Technologies

1. Rain Water Harvesting

It is the intensive storage and application of rainwater that is brought into use in everyday life, rather than heading to the sewer. Usually, rainwater is collected from the rooftops, stored in a filtrated tank. Upon purification of the water, it may be used for agriculture, planting and other domestic purposes. Another of rainwater harvesting's main applications is in drier areas where rainfall levels are smaller. We will store this water and then purify it to render it useable, or drink it to wash or cool plants. Water harvesting is considered an significant feature of water quality in Green classification.

The following Fig. 8 shows rain water harvesting system.

Fig. 8. Rain water harvesting system

2. Grey Water Recycling

Gray water can be described as untreated waste water that has not come into touch with the waste from the water closet. It emanates essentially from toilets, kitchens, wash basins, washing machines, and dishwasher. Gray water treatment may include: washing, solid deposition, flotation and lighter material separation, aerobic or anaerobic digestion, chemical or UV disinfection.

Then, whatever the procedure, this water is rarely healthy to consume then may be used for toilet flushing, laundry washing and irrigation purposes. One of the big advantages of treating grey water is that it's a massive supply of low organic matter content.

The following Fig. 9 shows grey water recycling system

Fig. 9. Grey water recycling system

3. Pressure Reduction

In high-rise residential and industrial buildings, pressure-reducing valves are very frequently designed to help ensure a constant water pressure at the water fittings in the whole building from top to bottom. Higher pressures could crack pipes and destroy fixtures which in household settings could contribute to much greater water wastage.

The following Fig. 10. shows pressure reduction valve.

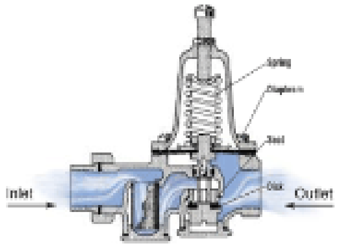


Fig. 10. Pressure reduction valve

4. Cooling Towers

Green buildings use evaporative refrigeration devices to conserve on resources. These devices refrigerate with water. Bearing in mind the tremendous need to save energy, the energy used in these cooling towers is non-potable water and the same is not pumped out but filtered and reused time and time again.

The following Fig. 11. shows cooling tower system.

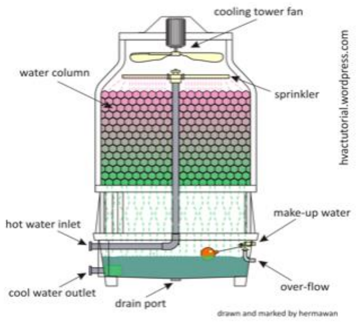


Fig. 11. Cooling tower

5. Low-Flow Plumbing Fixtures

Low-flow plumbing fixtures such as faucets, shower heads and toilets have been an extremely popular function nowadays, and with good cause, in green houses. The usage of plumbing fixtures which are built to work with fewer water saves vast amounts of energy. Toilets were once designed to run using 7 gallons per wash, but nowadays they can function effectively using just 1.3 gallons – this clearly means water savings of over 80 percent.

The following Fig. 12. shows low plumbing fixtures.

Fig. 12. Low plumbing fixtures

VI. CONCLUSIONS

From the extensive literature review following conclusions can be drawn.

1) The key goal is to highlight the growing need for water protection in today's environment and its significance as part of the design and development of green buildings.
2) Applying Green practices can help resolve national issues like water efficiency.
3) To achieve sustainable built environment, green buildings are best options. Green building has potential to save 40% of water consumption with reduction of operating cost and enhance good health.
4) In India GRIHA, IGBC and LEED are prime three rating tools available for access building parameters like water efficiency, energy efficiency, waste management etc.

ACKNOWLEDGMENT

I thankful to Prof. (Dr.) I. N. Patel, Principal, BVM Engineering College, Vallabh Vidyanagar, Gujarat, Prof. (Dr.) L. B. Zala, HOD, Civil Engineering Department, BVM Engineering College, Vallabh Vidyanagar, Gujarat and Dr. Jayeshkumar R. Pitroda, Associate Professor, PG Coordinator Construction Engineering and Management, Civil Engineering Department, BVM Engineering College Vallabh Vidyanagar, Gujarat for their motivation and support for the research work.

REFERENCES

[1] Caryssa Joustra "An Integrated Building Water Management Model for Green Building", July 1, 2010

[2] Oindrila Das, Priyanka Bera, Sanjib Moulick, "Water Conservation Aspects of Green Buildings", Volume: 04 Special Issue: 13, ICISE-2015, Dec-2015

[3] R. Sivasankar, C. Sivasubramanian, J. Malarvannan, M. Jeganathan and M. Balakumari "A study on Water Conservation Aspects of Green Buildings" ISSN: 2454-1354 Year – 2016s

[4] William J. Rhoads, "Survey of green building water systems reveals elevated water age and water quality concerns" 5th November 2015

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