Environmental Comparative Study of Conventional Green Residential Building

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Abstract- *A green building uses less energy, water and natural resources, creates less waste and is healthier for the people living inside compared to a standard building. There is a rapidly expanding market for green building materials. Green building provide suitable environment by controlling solar radiation temperature, energy efficiency, water conservation using domestic treatment plant and indoor air quality. The main aim of green buildings is to reduce the environmental impact of new buildings. The sustainability in the environment can be well achieved by reducing the energy emission and consumption by the buildings. Sustainability means using the energy efficiently. Green Building refers to a structure that is environmentally responsible and resource-efficient throughout a building's life-cycle. The aim of this project is to conduct a environmental comparative study on conventional green residential building. Data regarding temperature details are represented in energy simulation software – Energy 2D. A study on various green building rating system is to be conducted. Rate of water consumption and electricity consumption, waste generated in the selected building were collected for grading the building using LEED certification. A model showing all elements of green building such as rainwater harvesting plant, biogas plant, grey water filter, cooling tunnel, etc. were made.*

I. GREEN BUILDING

Green building refers to both a structure and the using of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. In other words, green building design involves finding the balance between homebuilding and the sustainable 12 environment. This requires close cooperation of the design team, the architects, the engineers, and the client at all project stages. The Green Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Leadership in Energy and Environmental Design (LEED) is a set of rating systems for the design, construction, operation, and maintenance of green buildings which was Developed by the U.S. Green Building Council. Other certificates system that confirms the sustainability of buildings is the British BREEAM (Building Research Establishment Environmental Assessment Method) for buildings and large scale developments. Currently, World Green Building Council is conducting research on the effects of green buildings on the health and productivity of their users and is working with World Bank to promote Green Buildings in Emerging Markets through EDGE Excellence in Design for Greater Efficiencies Market Transformation Program and certification. Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective of green buildings is to reduce the overall impact of the built environment on human health and the natural environment by: Efficiently using energy, water, and other resources • Protecting occupant health and improving employee productivity • Reducing waste, pollution and environmental degradation

RAIN WATER HARVESTING

It is the collection and distribution of rainwater for using in daily life, rather than allowing it to run off. Rainwater is generally accumulated from roof tops. Then it is deposited in a reservoir with percolation. It is used for gardening, cultivation and domestic uses. The harvested water can also be used as ground water recharge. Water shortage is caused by climate change, lack of planning of water uses, rapidly increasing water pollution and increasing population. So, under such conditions some serious steps towards conservation of water must be taken. Rain is a natural source of water. So, if it can be collected and treated, it can be used as potable water. It is a cheap and simple technology, so it can be easily installed in normal households and a lot of water can be saved.

BIOGAS PLANT

Biogas typically refers to a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste.

Biogas is a renewable energy source and in many cases exerts a very small carbon footprint. Biogas can also be produced by anaerobic digestion with anaerobic organisms, which digest material inside a closed system, or fermentation of biodegradable materials. 30 Biogas is primarily methane and carbon dioxide and may have small amounts of hydrogen sulfide, moisture and siloxanes. The gases methane, hydrogen, and carbon monoxide can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel.

Energy Calculation for Cooking For cooking

For cattle dung maximum gas production per kg = /0.05 m^3 Total gas = Total dung in kg * 0.05 Medium stove uses 9 MJ of energy per hour. For 3 animals each producing 8 kg dung, Amount of fuel to run the stove = 8 * 3 = 24 kg dung = 1.2 m^3 Duration to run the stove of 1.2 m^3 dung = 1.2 * 19 MJ (1m^3 = 19 Mega Joules) = 22.8/9 = 2.5 hours Manure of 3 animals (24kg manure) is used as fuel to run the stove for 2.5 hours.

Grey Water Recycling and Reuse

Grey water refers to the domestic waste water which is drained out excluding the waste water from kitchen sink and the water closet as they have high concentration of organic matters. In order to conserve water this water cannot be just drained out but should be recycled and reused. The benefit of using recycled grey water is that it is a large source with low concentration of organic matter.The bathroom grey water consists of waste water from showers, bathtubs and wash basins. It has a very low concentration of organic matter. The other sources of grey water are from washing of clothes, car washing, etc. According to various studies, an average household produces 140 liter of grey water per day. The various sources and their contribution is categorized in Table 5. Table 5: Sources of Grey Water and their Contributions Sl. No. Source Quantity/day/person 1 Shower 20-30 lit 2 Washing cloth 15-20 lit The grey water from all these sources are collected and then treated to make them safe for nonpotable use. These treatments include passing the grey water through sand filters or by using natural coagulating agents or by electro-coagulation techniques. Also other biological and chemical treatments. It has been found that using recycled grey water can support the quantity of water required for water closets, car washing and garden watering. Although it is normally slightly contaminated with a range of chemicals, such as soap or detergent, grease and microbes, it can be successfully reused for a range of purposes which do not require drinking water quality purity, including: • Watering the garden 34 • Flushing toilets • Car-washing Anything other than the most simple of methods - manually emptying your bath tub with a bucket, for example - will require a separate plumbing system to be installed to collect the grey water, and the detail and extent of this will depend on the intended use and the level of sophistication desired. 4.4.2

Design of Grey Water Filter As per Manual for Design, Construction Operation and Maintenance. Following layers are present I. 25 cm gravel layer at bottom II. 10 cm gravel layer at top III. Two 10 cm M sand IV. Two 10 cm charcoal layer V. 60 cm sand at middle Thickness of layer = 10 + 25 + (2 * 10) + (2 * 10) + 16 = 1.35 m ≈ 1.4 m As per guidelines for greywater reuse in sewered, single household residential premises. For 3 persons per household approximately 339 litres of grey water produce per house per day. In order to accommodate 339 litres a portion of 0.8 m * 0.7 m *0.7 m is required. Therefore total depth of the tank = thickness of layers + 0.7 = 1.4 + 0.7 = 2.1 m Length of tank = 0.8 m Width of tank = 0.7 m

Determination of Alkalinity

Pipette 50 ml of sample into a clean Erlenmeyer flask (V). Add 1 drop of sodium thiosulphate solution, if residual chlorine is present. Add 2 drops of phenolphthalein solution, if the pH is above 8.3, colour of solution becomes pink. Titrate against standard sulphuric acid in the burette, till the colour just disappears. Note down the volume (V1). Then add 2 drops of methyl orange indicator, the colour turns yellow. Again titrate against acid until the colour turns to orange yellow. Note down the total volume (V2).

Determination of Hardness

Dilute 25 ml of sample (V) to about 50 ml with distilled water in an Erlenmeyer flask. Add 1 ml of ammonia buffer solution. Add 2 drops of Erichrome Black T indicator. The solution turns wine red in colour. Add the standard EDTA titrant slowly, with continuous stirring until the last reddish tinge disappears from the solution. The colour of the solution at the end point is blue under normal conditions. Note down the volume of EDTA added (V1).

Determination of Sulphate

Measure 100 ml or suitable portion of the sample into a 250 ml Erlenmeyer flask. Add 5 ml of conditioning reagent and mix it. Add a spoonful of barium chloride crystals. Stir at constant speed exactly for 1 minute. After stirring pour some of the solution into the absorption cell of the photometer and measure the turbidity at 30 seconds intervals for 4 minutes. Usually maximum turbidity occurs within 2 minutes and the reading remains constant thereafter for 3 to 10 minutes. So take reading with maximum turbidity occurring in within 4 minutes.

The standards are prepared at 5 mg/l increments in the 0 to 40 mg/l sulphate range and their turbidity or absorbance read. Absorbance versus Sulphate concentration is plotted and curve is obtained. Finding the absorbance for a given sample, the concentration of sulphate in the solution is determined with the help of calibration curve.

Determination of Chlorides

Take 10 ml of sample (V) and dilute to 100 ml. If the sample is coloured add 3 ml of aluminium hydroxide, shake well, and allow to settle, filter, wash and collect filtrate. Sample is brought to pH 7-8 by adding acid or alkali as required. Add 1 ml of indicator (Potassium chromate). Titrate the solution against standard silver nitrate solution until a reddish brown precipitate is obtained. Note down the volume (V1). Repeat the procedure for blank and note down the volume (V2).

Determination of Dissolved Oxygen

Add 2 ml of manganous sulphate solution and 2 ml of alkali-iodide azide reagent to 300 ml sample taken in the bottle, well below the surface of the liquid. Stopper with care to exclude air bubbles and mix by inverting the bottle at least 15 times. When the precipitate settles, leaving a clear supernatant above the manganese hydroxide floc, shake again. After 2 minutes of settling, carefully remove the stopper, immediately add 3 ml concentrated sulphuric acid by allowing the acid to run down the neck of the bottle. Restopper and mix by gentle inversion until dissolution is complete. Measure out 203 ml of the solution from the bottle to an Erlenmeyer flask. Titrate with 0.025 N sodium thiosulphate to a pale straw colour. Add 12 ml starch solution and continue the titration to the first disappearance of the blue colour and note down the volume of sodium thiosulphate solution added (V), which gives directly the D.O .

PASSIVE DESIGN

Passive Design regards the particular way to construct a building using the natural movement of heat and air, passive solar gain and cooling in order to maintain a good internal comfort.

Through the use of passive solutions it is possible to eliminate, or at least reduce, the use of mechanical systems and the energy demand by 80% as well as the CO2 emissions.
Building a passive house takes careful planning, which includes the introduction of five basic principles:

- orientation
- overhangs and shadings
- insulation
- thermal mass

The Passive House Concept is defined as follows: "A Passive House is a building in which thermal comfort can be guaranteed by post-heating or post cooling the fresh-air mass flow required for a good indoor air quality". There has been a drastic increase in the use of air conditioning system for cooling the buildings all around the world. The last two decade has witnessed a severe energy crisis in developing countries especially during summer season primarily due to cooling load requirements of buildings. Increasing consumption of energy has led to environmental pollution resulting in global warming and ozone layer depletion. Passive cooling systems use non-mechanical methods to maintain a comfortable indoor temperature and are a key factor in mitigating the impact of buildings on the environment. Passive cooling techniques can reduce the peak cooling load in buildings, thus reducing the size of the air conditioning equipment and the period for which it is generally required.

Orientation

The first basic principle in a passive house is the orientation, in which the southern façade of the building should be oriented towards the equator in the northern hemisphere (and the northern façade towards the north in the southern hemisphere. By facing the longer axis of the building in the east/west direction, the longer dimension of the home faces will be more likely to gain the maximum solar radiation. For that reason, areas which are most frequently used, such as the kitchen and the living room, must be located into this part of the building. This orientation is also advantageous for summer cooling conditions because it minimizes the east-west façades to morning and afternoon sunlight.

Overhangs and Shading

Overhangs and shadings are important devices in a passive house because they help in reducing overheating during the summer season. Therefore, it is very important that the devices are properly sized. The southern façade through which the sun mostly comes inside must be correctly shaded, or equipped by sized overhangs, in order to prevent overheating and to keep the house cool during summer months. However, a careful design of the device must be made in order to guarantee that the size and sloped can meet the need to let the sun in during the winter and to shade the building during the summer. The type of shade and its degree is always linked with the position of the sun and the geometry of the building. For instance, simple overhangs are very efficient for shading the building in the south façade during the summer when the sun is high in the sky. However, this type of shading device is not efficient for the south-west façade at blocking the sun entering inside during morning and afternoon hours, when the sun is low in the sky. It is very important to understand that in summer the peak sun angles comes in June on the 21st during the solstice, but peak temperature and humidity come mostly in August. Therefore, include a fully shade south façade during the summer will also shade the window in autumn and spring, when actually the passive solar heat is needed for heat up the building and keep the house with a comfort temperature. Having say that, for designing a proper shading device it is necessary to understand how the sun moves along the year which effect its angles have on the building. The altitude and azimuth angles represent the position of the sun in the sky. Because shading devices can have a huge impact on the building appearance as well as reducing the cooling demand, they must be considered and evaluated at the early stage of the design process, in order to be effective for both technical and visual aspect for being well integrated.

There are several type of shading devices, but it is very difficult to make a generalization of their design. However, some general recommendations have been listed just below:

- to control direct solar radiation in the south façade use fixed overhangs limit the number of east and west windows because they are very difficult to shade
- compared to the south side. Maybe some consideration of the surrounded landscape, such as type of tree that might be used to shade
- north façade can be out of shading as it receives very little direct solar radiation
- interior shading devices, such as Venetian blinds or vertical louvres, might be used in order to control glare, however exterior shadings must be included since the interior ones have already admitted the solar gain in.

Thermal Mass

The concept of thermal mass regards a solid or liquid material which absorbs and store warmth and releases it when is needed. By means that, the excess solar heat gain can be stored and used when the sun is not shining or where there is no sun at all, as during the night. It actually works as a battery because during the summer season it absorbs heat keeping the house comfortable, while in winter it stores the heat gained and gives it back at night keeping the house warm. Basically in a passive house a thermal mass can work in two ways: by direct solar gain or by indirect solar gain.

A thermal mass could moderate the temperature of internal spaces, reducing the need for mechanical cooling and winter heating requirements and the most cost effective method normally is to take advantage of thermal mass in the building structure.

Cooling Tunnels

The cooling tunnel enhances indoor air quality. By using a single exhaust fan the hot air entrapped inside the closed room of residence is circulated out and with the help of approximately 14 cooling tunnels (for normal room) it circulates fresh air in to the room, keeps the room cool and increase the comfort level. This system requires a maximum of 2hrs working for effective cooling. This technique is successively implemented in Kerala. There is no need to use mechanical ceiling, hence consumes less energy.

II. CONCLUSIONS

Coped with production of bio waste which can be converted to bio gas, thus reducing the burning of other fossil fuels. Effective treatment of grey water that can be used for gardening, flushing etc. Harvesting rain water in order to reduce deal with water scarcity in dry period. Effective cooling system that provides air conditioning similar to that provided by an electric air conditioner. Passive design which increases internal air flow and provides sufficient ambient light. Solar panels help to produce necessary amount of electricity for household purposes. Thermal variation is represented using energy-2D simulation software. A model representing all elements of green building were made. LEED point increased after converting the selected residential building into green building.

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