Construction of Environmentally Friendly Buildings: A Review

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ABSTRACT

Eco-friendly building basically refers to a building and the construction process involved that are resource-efficient and environmentally friendly throughout the life-cycle of the building. (Parashar and Parashar, 2012). The advancement in technology in recent times has brought forth the idea of incorporating the construction of the sustainable building in the construction of the green building to create greener structures with the aim of reducing the overall impact on the health of human as well as the environment by improving employee productivity; the efficient use of water, reducing waste, environmental degradation and pollution; reducing waste, environmental degradation and pollution; energy and other resources. This paper considers some of the various studies conducted with the objective of converting standard buildings into green buildings as well as the environment at large. Some of the various methods or approaches adopted in the creation of an eco-friendly environment were considered. These methods were critically examined and gaps identified were high-lighted. Suggestions were made in relation to the correction of these gaps as identified.

Keywords: *Eco-friendly, resource-efficient, life-cycle, greener structures, sustainable building.*

INTRODUCTION

Eco-friendly building refers to a structure and the construction process involved that are environmentally friendly and resource-efficient throughout the building's life-cycle beginning from site to its design, construction, operation, maintenance, renovation and demolition (Parashar and Parashar, 2012). This can be realized through the combined effort of the team of engineers and the client at all project stages. The approach to eco-friendly construction takes into consideration factors such as the climate which has a significant impact on the environment making the process comprehensive in nature. Eco-friendly building is mostly concerned with renewable resources rather than non-renewable resources. One of the parameters that significantly influence the climate system is solar radiation. The intensity of the sunlight and its associated heat through open apertures and building envelope can impair vision and increase room temperature causing occupant discomfort. Subsequently, higher energy consumption will be required as a result of the increasing demand for mechanical ventilation. Again, this introduces the concept of daylighting. The introduction of light into the interior part of a building and dispersing it under a controlled manner to produce desirable and better-quality illumination than that of the artificial light source is termed as day-lighting. This cuts down the cost of electricity since it reduces the demand of electrical or artificial light sources.

"Urban Heat Island (UHI) is the general phenomenon which brings into light the reason why the increasing in the number of concrete structures in urban or metropolitan areas significantly increases temperature making these areas warmer than the surrounding areas. This is a result of the reduction in the green surface due to the rapid increase in population and human activity (Aram et al., 2019)".

Eco-friendly building is a source of financial reward for occupants, operators and building owners. The annual cost of an eco-friendly building is mostly relatively lower than that of standard building in terms of energy, maintenance/repair, water, churn, and other operating cost. The first cost of an eco-friendly building can either be the same, slightly higher or higher than a standard or traditional building through the advent of integrated design and eco-friendly equipment.

The payback period for the incremental investment of an eco-friendly buildings may be short and the lifer cycle cost is mostly lower than that of a standard or the traditional buildings. Eco-friendly building also provide indirect cost to both the owner and the society in that sustainable buildings promote good health, well-being and comfort increase productivity of occupants. Eco-friendly building also reduce cost by recycling waste materials which in turn reduce cost from air pollution, creation of landfills, wastewater treatment plants, transmission/distribution lines and power plants.

METHOD

Introduction of Energy efficient equipment: Introducing energy efficient equipment into standard buildings and making efficient use of the non-renewable resources they access makes them more environmentally friendly and increase occupants comfort. The rate of energy consumption is a problem to the entire world. Energy is conserved by

i. Using LED light
ii. Proper installation of light emitting equipment
iii. Using energy management systems
iv. Ensuring proper maintenance
v. Using CFL (compact fluorescent lamp) instead of incandescent lamps.
vi. The use of efficient lamps, luminaries, controls (e.g. *energinet*), ballasts (act as the central device for dissipating the required amount of energy to the various devices) and coordinating them with daylight as well as the interior colour of the open space to give the desired level of light.
vii. Solar photovoltaic equipment.

Maintenance of good thermal comfort in the interior of the building: The introduction of urban green space (UGS) with the aim of creating eco-friendly environment as well as reducing environmental pollution. UGS reducing greenhouse gases in the atmosphere and subsequently improves indoor environmental temperature. Benefits of green building to especially developing countries.

Control daylight entering into building: Intensive daylight entering a building may result in pollution and can even cause visual impairment to the occupants. The benefits of controlled daylight include improvement in visual quality, mitigate adverse solar effect and heat gain, gives better lighting-colour, increase productivity and improves visual performance.

Building Orientation

The building will be oriented using *sketchup* software. The visible light transmitted (VLT) through the facades and the glass is determined using the *skeptchup* software. The area between 60-70% is considered as a good daylight office space. Nonetheless, any mission within the range of 50-75% is considered good. In temperate regions, the orientation should be done in a way to minimize solar gain. Wind direction is purposefully for ventilation of room.

Simulation Phase

Simulation may be done every hour on a peak day to determine the lux level of the glass. The measure of the amount of light received on the surface is called illuminance. It is expressed in lux (lm/m^2). Based on the local weather condition, the simulation may be done. Luxmeter may be used to measure the amount of light available in the interior. Luminance meter may be used to determine the various values of all light emitting elements.

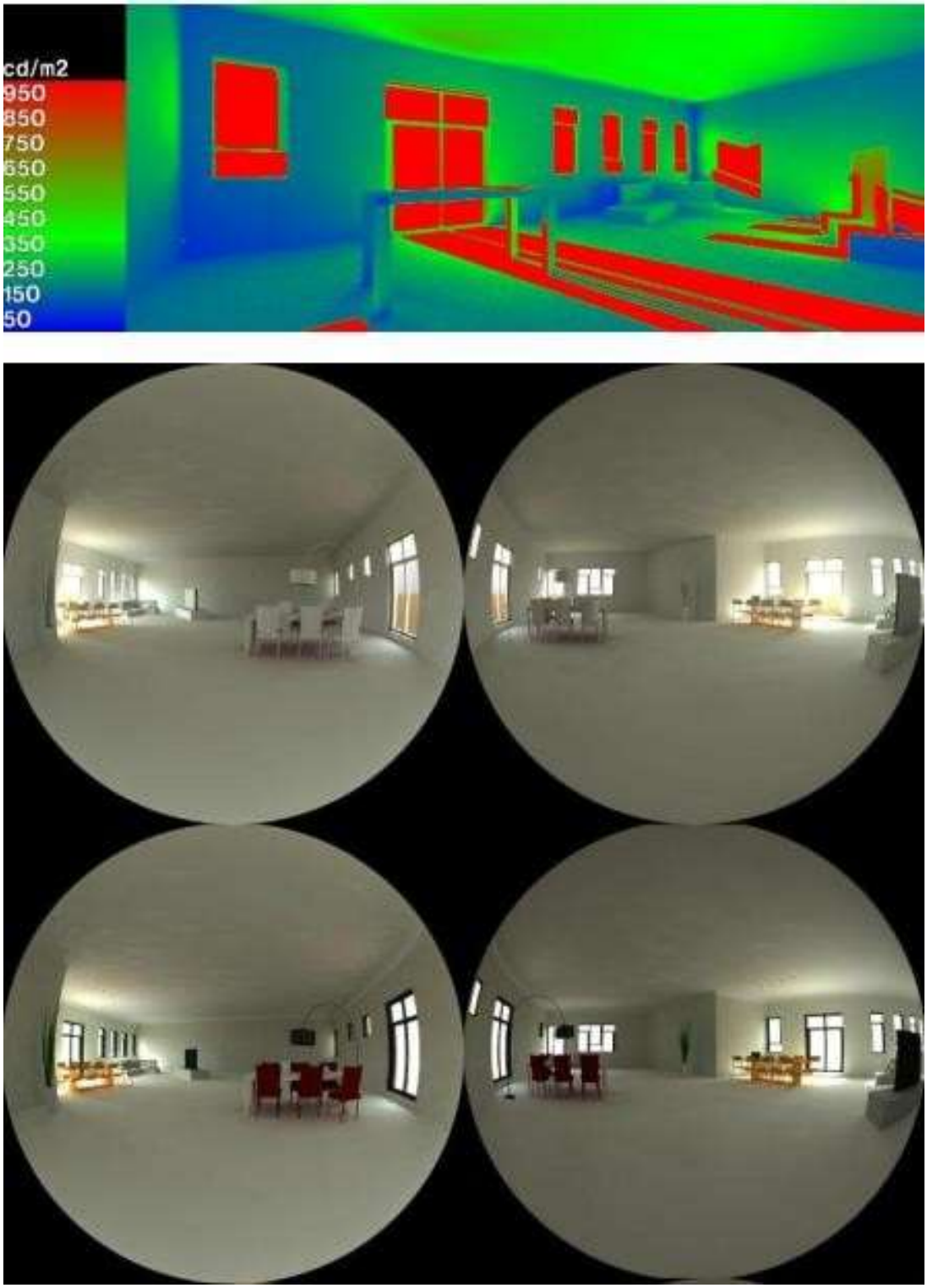

Fig 1 Luminance Image and Map

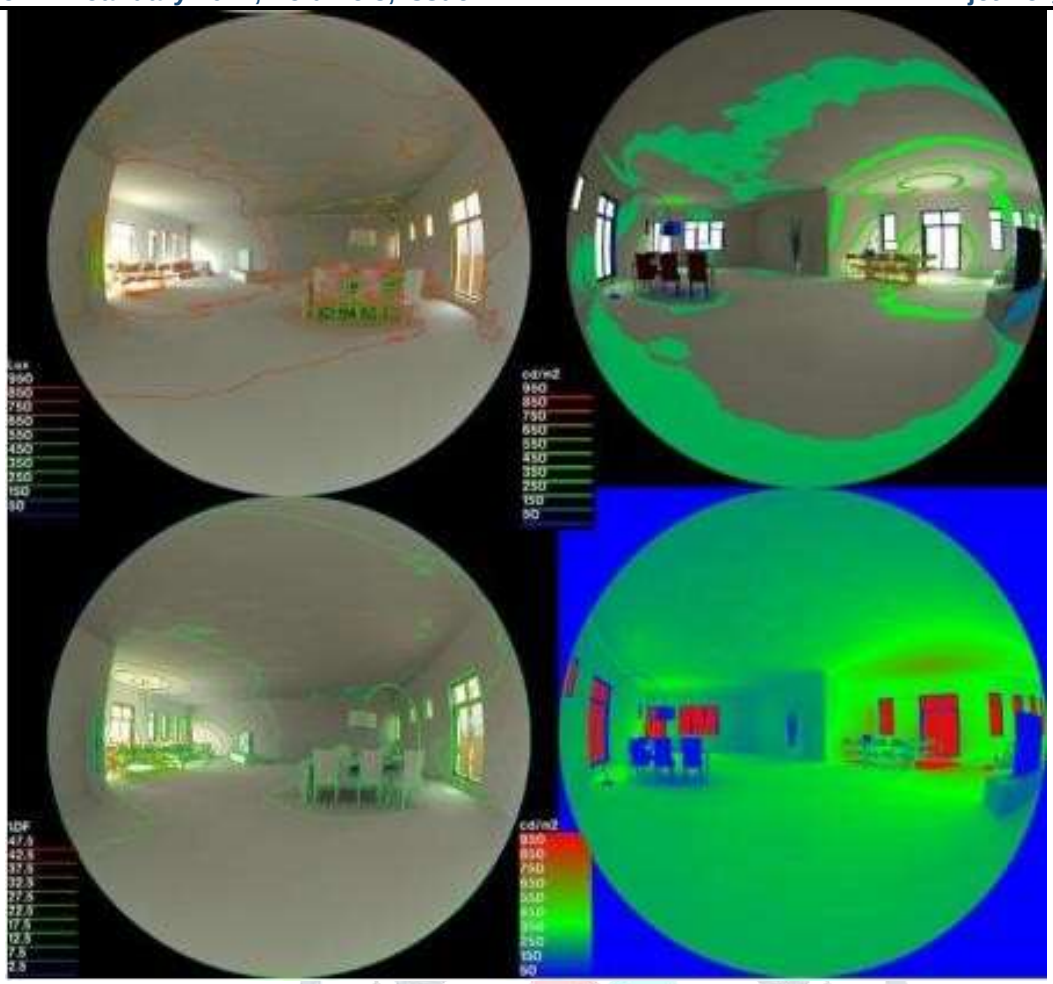

Fig 1 Luminance Image and Map (*continue*) (Amtmann, *et al.*, 2012)

Google Sketchup

The new version of SketchUp do not allow the user to import AutoCAD files.

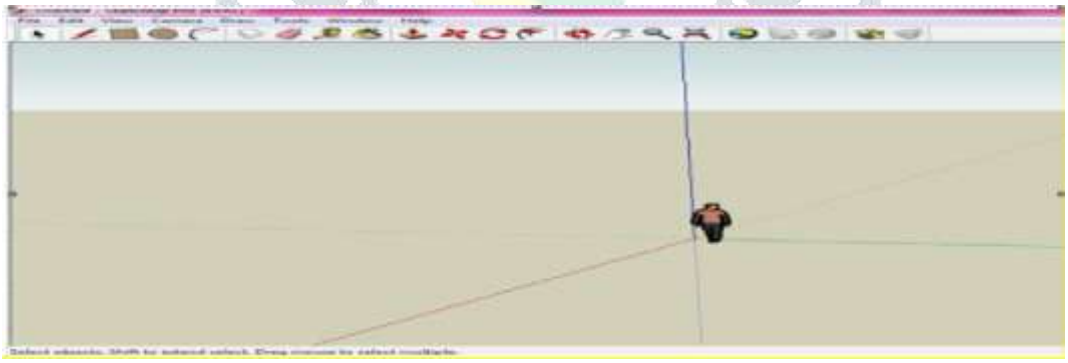

Fig 2 Google Sketchup Platfrom (Amtmann, *et al.*, 2012)

In order to commence with the simulation, the plug in must be displaced as shown above.

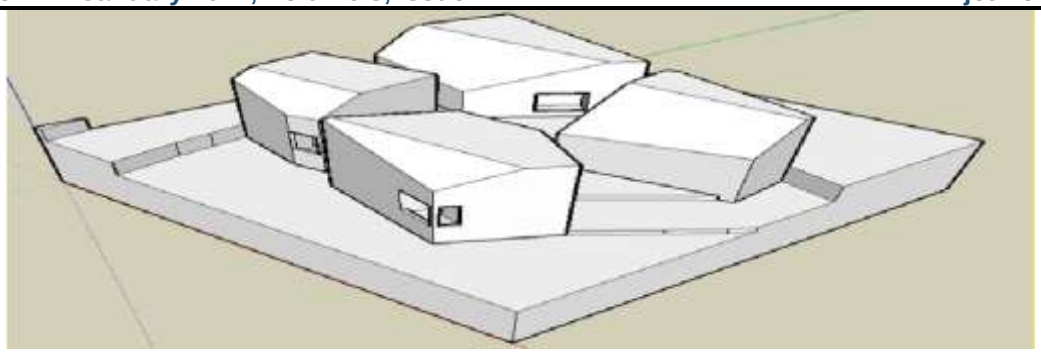

Fig 3 A model in Google (Amtmann, *et al.*, 2012)

In order to perform a solar energy analysis, the model should be displaced in a blue frame after importing it in an energy plus zone. A coloured version of the model signifies that solar energy analysis can be performed. If the model is not displayed colours, it signifies that the object is not in EnergyPlus, and energy analysis can therefore not be performed.

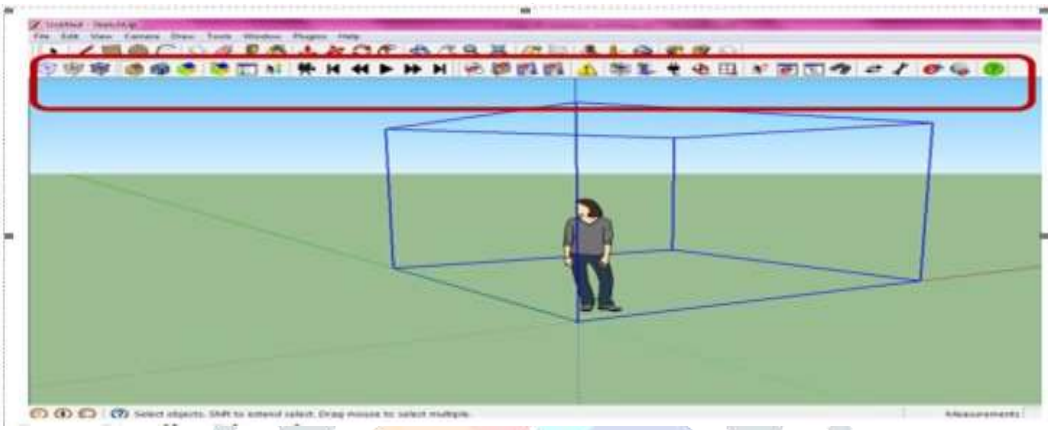

Fig 2 Open Studio Plug-in (Amtmann, *et al.*, 2012)

Fig 4 Coloured model in SketchUp (Amtmann, *et al.*, 2012) OpenStudio

plug-in gives the opportunity to perform the following:

- Create, edit and view EnergyPlus input files within Sketchup.
- Include internal gains and outdoor air (an example is the natural ventilation) for load calculations.
- Also gives the opportunity to add ideal HVAC system for load calculations.
- Add illuminance map and daylighting controls.

Programming Phase (energy used-pattern)

The daylight performance objectives and requirement is determined. This may include cooling-load reductions, views to the outside, lighting-energy costs and visual quality. The illumination levels is established using the *energinet* software in order to meet the desire of the occupants. The objective is to maintain optimum performance.

Mitigating Urban Green Island Effect: In most cases, the green parameters of buildings are measured on the basis of how they make efficient use of energy and water. More importantly, the effect of UGSs on UHI of the environment is also considered. Onsite parameters such as the trees, grass, harden ground, buildings and water body are measured. The ENVI-met is been fed with the measured value as input to predict the temperature of air (Ta), Mean Radiant Temperature (MRT), Wind speed (WS) and Relative Humidity (RH), The simulated parameters (Ta, RH, WS and MRT) will be compared with that measured on the field using linear regression algorithm. The tree, grass, harden ground, water body and building together with the simulated parameters by ENVI-met will be used as input in RayMan to predict the physiological equivalent temperature (PET) or standard efficient temperature (SET). This will serve as a training set for the RayMan. Now, the simulated parameters from ENVI-met will be directly used without considering the tree, grass, harden ground, water body and buildings in RayMan to predict the SET or PET.

The Rayman software is configured as follows: 1.75 m (height), 35 years (age), 75 kg (weight), 0.9 (clothing index), male (gender) and 80 W (activity). As already said, the simulated data of WS, T_a, MRT and RH generated by the ENVI–met was fed into the RayMan to compute the PET values. The corresponding set of data (PET_0) will now serve as the control group data set. The ΔPET values is then computed as

$$\Delta PET = PET_0 - PET \quad (1)$$

PET - Physiological Equivalent Temperature (it defines thermal comfort of the park); PET_0 – the

control data set of PET;

ΔPET difference between PET and PET_0.

$$\Delta PETm = \sum \frac{\Delta PET_{i,j}}{i_{max} \times j_{max}}, \quad (2)$$

$\Delta PET_{i,j}$ - the sum total of all ΔPET values at each cell grid with (i,j) coordinate of the ENVI-met model in each of the sub-area;

(i_{max}, j_{max}) - are the total number of cells in each sub-area.

Sun *et al*., 2017 also considered a park in a specific area to determine the impact of the park on UHI. The degree of thermal comfort as provided by the park was determined by computing the physiological equivalent temperature (PET) (The PET refers to normal body temperature 37 deg. Celsius). A research work as conducted by Aram *et. al.*, 2019 gives some specific characteristics of the individual green spaces in the environment and shows the impact of their combined effect on the UHI of the environment. The study investigated the impact of UGSs on UHI based on the sizes of the parks in the cities. He considered various methods as adopted by other researchers to determine the effect of the UGSs on the UHI. Skoulika *et al* 2014 conducted a research in the Athens, Greece, on one park which is surrounded by commercial and medium size residential buildings. Skoulika *et al.*, 2014 conducted a field measurement to obtain values from the nine fixed temperature and humidity stations. The mobile sensors was used; Cohen *et al.*, 2012 used the information obtained from the meteorological station and relative humidity sensors together with RayMan and PET calculation to determine the impact of the UGSs on Tel Aviv, Israel.

RESULT AND DISCUSSION

Energy efficient equipment

According to Kodnikar *et al*., 2018 CFL lamps saves more energy than Incandescent lamps and LED tubes saves more energy than Fluorescent tubes. A total of 10-12% of the energy consumed in the building can be safe. Solar Photovoltaic systems save electrical energy since it stores heat energy from the sun and converts it into electrical energy. Thus, reducing the amount of energy as required from the usual source in the building. Energy management systems regulates the total amount of energy required

Thermal Comfort in the Interior of the Building

Sun *et al.*, 2017 found out that comfort was found to occur within 14:00 h - 16:00 h taken into consideration the ENVI-met modelling and the actual circumstance. It was found out that all the regions covered by the PET values were comparatively lower than the surroundings. Thus, the cooling effect on the UHI is as a result of the combined effect of the landscape parameters which include the river, tree, grass, manmade features, and other shading devices.

Again, it can also be deduced from the range of comfort as discovered by Sun *et al*., 2017 that the hourly temperature difference within the day, the weather, the season and the local condition contribute to the effect on the UHI. Furthermore, the research conducted by He *et al*., 2015 gives a knowledge on when or at what time within the day or the season that a particular city generally experience thermal comfort taken into consideration the local condition.

Building Orientation and Simulation

SketchUp is designed in such a way that the platform can be used to perform solar path analysis which gives an idea of the various position of the sun in relation to the object on the ground. The direction of the incident rays from the sun to the structure on the ground can be determined. This helps to position the building a way to receive the required sunlight which will be needed in the interior of the building. The type of glass to be selected is determined after conducting a series of simulation for different glasses. The glare part above 1000 lux (this may result in glare issue) is considered too much of light Winterbottom and Wilkins (2009).

CONCLUSION

Most researchers consider the technique of integrating the conventional energy-efficient device with passive design element. It will therefore be suggested that researchers also consider the technique of using solely solar energy during the sunny hours of the day in order to make maximum use of the solar energy especially in the temperate regions. It was found that most researchers adhere to simulation in order to determine the PET values areas. Nevertheless, the use of aerial maps and field observations for green space placement gives the most accurate result. The approach adopted by He *et al.*, 2015 will be suggested to researcher as one of the optimum procedure to determining the ranges of the thermal sensation of the inhabitants of a city.

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