A DESCRIPTIVE STUDY OF DIFFERENT PARAMETERS REQUISITE IN THE GREEN BUILDING

A Project Report Submitted in Partial Fulfilment of the Requirements for the Degree of

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in

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by

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A DESCRIPTIVE STUDY OF DIFFERENT PARAMETERS REQUISITE IN THE GREEN BUILDING

FINAL YEAR PROJECT REPORT

Batch: Civil Engineering 2021

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CERTIFICATE

This is to certify that Pranaya Patel, Prashant Rahi, Prakhar Singh, Sonali Madhesia, Nitin, Rahul Shukla have carried out the project work entitled "**A DESCRIPTIVE STUDY OF DIFFERENT PARAMETERS REQUISITE IN THE GREEN BUILDING**" for the partial fulfilment of the award of Bachelor of technology in Civil Engineering from Institute of Engineering and Technology, Lucknow an autonomous constituent college of Dr. A.P.J. Abdul Kalam Technical University, Lucknow under my supervision. The report embodies result of original work and studies carried out by my students themselves and the content of the report do not form the basis award of any other Degree to the candidate or anybody else.

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DECLARATION

We, the undersigned, declare that the project entitled "**A DESCRIPTIVE STUDY OF DIFFERENT PARAMETERS REQUISITE IN THE GREEN BUILDING**" being submitted in partial fulfilment for the award of Bachelor of Technology Degree in Civil Engineering, from Institute of Engineering and Technology, Lucknow an autonomous constituent college of Dr. A.P.J. Abdul Kalam Technical University, Lucknow is the work carried out by us under guidance of Er. V.K. Singh. We further declare that the work reported in this project has not been submitted and will not be submitted for the award of any other degree or diploma in this institute or any other institute or university.

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ABSTRACT

Green building technology is one of the most trending topics all over the world which is been put forward to reduce the significant impact of the construction industry on the environment, society and economy. The globe is in an urgent need of sustainable and a smart development as the problem of pollution and global warming is rapidly increasing all over the world. A drastic climatic change also been noticed and being experienced all over the world due to increase in the Green House Gases (GHG's). In the developed countries like United States of America, Russia, Australia, United Kingdom, there are already strict measures been taken to achieve a sustainable development and also rules and regulations are been made by their respective governments to support and achieve a sustainable and an eco-friendly development of their nations. However, in the developing countries like India, China, Sri Lanka, Pakistan, etc., they are far behind in achieving a sustainable development and eco-friendly constructions. Also, there is a lack of awareness amongst the people about this global issue in these developing countries. The studies and the research work in these countries is also way far behind as compared to the developed nations in the world. This paper presents the need of sustainable development all over the globe especially in the developing countries like India and China which have a huge land mass and also developing rapidly and heading towards becoming the new super powers of the world soon in the future. Also, it includes the sustainable and economic studies with references to the Indian contexts with a supporting live recent case study of a newly designed and constructed luxurious residential bungalow in a small town in India. The case study is specially selected as a residential bungalow which is designed and constructed as a sustainable and a green structure in a small town in the state of Maharashtra in India as India is also known as a country of villages with a second largest population in the world. According 20 the 2011 census of India, 68.84% of Indians i.e. around 833.1 million people live in 6,40,867 different villages. This paper will help Indian villages and their residential buildings develop sustainable and green by implementing easy, simple and economic techniques. Furthermore, the most emphasised advantage is reduced energy and water use. Contractors are more familiar with traditional materials than green materials and professionals do not have sufficient experience in green building materials/concepts, resulting in a low growth rate of green building construction.

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CHAPTER 1: INTRODUCTION

Green building is a vital step towards a healthy, sustainable built environment. In india, the green building movement has swelled in recent years with the proliferation of third-party rating systems, technologies and strategies to achieve high performing, sustainable buildings. Regulators are recognizing the promise of better building performance for mitigating environmental impacts like carbon emissions while also realizing human health benefits through improved indoor environmental quality in green buildings. These factors include a lack of high performance standards and financial incentives, low energy and water prices, and an unfavourable political climate over the past decade.

For the purpose of this article, the following terminology applies:

Green materials – building materials that are environmentally friendly, renewable, biodegradable and recyclable, e.g. carbon, polyurethane.

Traditional/natural materials – materials that are found naturally in a specific place and used by inhabitants to build, e.g. grass, bamboo, thatch, straw bales, dry stone, mud (plaster). Conventional materials – materials specified mostly by designers, e.g. brick, concrete, glass, steel.

The concept of Green Building basically stands on four main points which are

I. Reduction of the effects or rather the side effects of the structure on the environment.
II. Improving and enhancing the health conditions of the occupants in a structure.
III. Savings and returns on investments to the investors and the community.
IV. Life cycle considerations during the planning and development process.
V. Construction industry is one of the most rapidly developing industries all around the world

A ‘green building’ is defined by the Green Building Council of South Africa (GBCSA) as “a building which is energy-efficient, resource-efficient and environmentally responsible” (GBCSA, 2010). Green building is also known as “a sustainable or high performance building” (US Environmental Protection Agency, 2010: online). Van Wyk (n.d.) argues that green buildings are now a universally accepted principle that promotes the construction of environmentally friendly buildings; they can be Buys & Hurbissoon • Green buildings 83 defined as buildings that minimise their impact on the environment while improving their indoor environmental quality.

CHAPTER-2: LITERATURE REVIEW

2.1. The first green building

According to Freed (2008: 10), the first truly green buildings dated from AD 1. These were the stone dwellings of the Anasazi Indians (Meinhold, 2009: online). The best examples of these buildings appeared around the 700s and consisted of apartment-house-style villages which had beautiful stone masonry. Freed (2008: 10) mentioned that the reason for considering those buildings as green buildings was that the Anasazi understood the sun and heating, natural ventilation, how to capture water, while the only materials used were stone, mud and wood. It is important to note that the 'Anasazi buildings' were completely free of toxins and were healthy.

2.1.1 *Features of Green Building*

i. Dependence on renewable energy and energy efficient.
ii. Efficient use of water
iii. Environmental friendly construction materials.
iv. Minimum waste output from the operation of green building.
v. Minimum Toxics output from the operation of green building.
vi. Enhanced Indoor Air Quality.
vii. Overall Growth with Sustainable Development

2.2 Criteria For Green Building Certification

Sustainable sites Site selection and design play important roles in both reducing greenhouse gas emissions and helping projects adapt to the effects of climatic change. When planning a green building project, design and construction professionals will consider strategies to maintain an environmentally appropriate site. Strategies for sustainable sites include encouraging the development of an environmentally friendly transport plan, protecting and restoring the natural habitat, controlling storm water and reducing heat island effect

Restore Habitat: Green building can promote biodiversity by promoting and restoring surrounding habitats or conserve existing natural areas. Areas to avoid include prime farmland, flood plain, critical habitat, public parks etc.

Storm Water Control: Stormwater runoff can cause flooding, pollution, and significantly, soil erosion. Thus, storm water management is an important feature of green building construction. It is a process to treat, collect, reduce stormwater runoff using plants, soils, microbes and engineered systems like underground detention tanks.

Heat Island Effect: It is the absorption of heat by hardscapes and it is radiated to the surroundings altering microclimate and wildlife habitats. A microclimate is a local atmospheric zone where the climate differs from the surrounding area [18]. These changes can affect native species and biodiversity. To avoid these outcomes, green building construction projects can implement strategies like shading, vegetation and installing surfaces with high solar reflectance indexes etc. Use of high albedo roofing material or heat resistant paint or china mosaic or white cement tiles or any other highly reflective materials over the roof to cover atleast 50% of the exposed roof area is essential. Shade-giving trees are to be planted to cover atleast 75% of the open parking areas

Water Efficiency We are going to face a Global water crisis in the near future according to U.S. Geological Survey. Urbanization, high population growth rates, climatic changes, lower precipitation amounts, higher temperature are the most important reasons behind ground water depletion. A hydrological study conducted by University of Arizona Cooperative Extension assess that, by harvesting rainwater, we will be able to minimize the devastating effects of droughts, rainfall runoff and non point source pollution

Climate approach passive design: Passive strategies such as shading, natural ventilation can reduce the demand on active mechanical systems. After observing that which part of the building receives sunrays during afternoon and incorporate shading strategies is an usual practice. Applying window film with an solar heat gain coefficient less than 0.3 helps in blocking the Sun‘s heat. Selecting light colors for roofing and exterior painting helps to reflect heat from Sun as dark color absorbs heat.

Renewable Energy: Onsite generation of Renewable Energy through Solar power, Wind power, Hydro power can reduce the impact on resources [27]. Substituting renewable energy for conventional energy can substantially reduce emissions of GHGs (Green House Gases) and other pollutants. Obtaining electricity from on-site sources can produce significant cost savings [8]. Through IGBC Green Buildings rating system, buildings can reduce energy consumption through energy efficient - building envelope, lighting, air conditioning systems, etc

Reuse and Recycling of materials to reduce waste production: Green buildings emphasize on the resource usage efficiency and also press upon the three R's - Reduce, Reuse and Recycle . Reusing elements of a previously constructed building can help in sustainable development and in waste management. Vintage brick salvage, wood wastes, materials from abandoned buildings, old docks etc. can be reused in construction of new building. Some building materials include a number of ingredients where certain components may come from recyclables (e.g. of materials with recycled content include cement, rebar, paint etc.

Rapidly Renewable Materials: Extracting certain raw materials can have an impact on biodiversity of the area. The renewable materials have the ability to grow back, but it takes time to re-establish ecosystems. In the meantime it may increase green house emissions and affect the other species. For this reason, it is important to use rapidly renewable materials that mature in 10 years or shorter life cycle such as bamboo, wool, cotton insulation, linoleum, wheat board, straw board, cork etc.

Durable materials: Products should stand for a long time and require little maintenance. This will save time, money and energy on repairs at a later date.

Water efficient materials: Water Conservation can be obtained by utilizing products, materials and systems that help to reduce water consumption in buildings and landscaped areas, and increase water recycling and reuse [6]. Other materials that should be used are high reflective paints, high performance glass, low VOC adhesives, ecofriendly chemicals, solar water heaters, efficient pumps & motors, timer based control on lawn sprinklers, LED lighting fixtures, efficient BEE labelled air conditioners and refrigerators etc. Equipments used in the building are to be free from CFCs, Halons or any other ozone depleting substances.

2.3 Misconceptions regarding Green Buildings

Green Building is a relatively new idea, so there are quite a few misconceptions that keep people from pursuing the development of a green building or home. They are listed as below:

Green Building is a Fad: The upcoming generation of homebuyers is more concerned about their carbon footprint than any previous generation. The debate over climate change continues and industry experts expect more regulatory stipulations on building materials and methods. Consumers will always look for ways to save on energy cost, regardless of whether the fuel is nuclear energy, coal-fired plants or natural gas.

Green buildings are expensive: There are some additional costs during the construction phase of building green. But the operational and maintenance cost of a green-built home are significantly less. A building designed with passive solar and high-efficiency windows require less 40 energy to heat and cool, less workload on units also results in lower repair cost and a more years of service

Green building is all about landscaping: While this may not be entirely wrong, landscaping is only a part of the whole green building concept. Integrating landscaping in site development provides shading for homes and buildings to help reduce energy. Plants inside homes and offices can help reduce carbon dioxide, thus improving indoor air quality. Large open green spaces help reduce urban heat island effect caused by too much concrete surfaces.

Green homes are less appealing: The components used in green construction are engineered to last longer and require less maintenance. Building green also involves leaving more trees on the lots and less modification to terrain. When sustainability and environmental considerations are implemented in the design of a home, the result is a more harmonious and comfortable design that blends with its surroundings

CHAPTER 3: MATERIALS AND METHODOLOGY

3.1. Techniques used in Green Buildings

3.1.1 *Structural Techniques*

Insulated wall :-

All of us pay to heat and cool our homes and wish we could pay much less than we do. In a typical home, space conditioning and comfort bills can account for up to one-half of a home's energy bills with the remaining portion due primarily to water heating, lighting, and appliances. Installation of the cost-effective level of insulation is extremely important. Homeowners can affect their energy usage, save money, and help the environment all at the same time. Investing in energy-efficient options, such as insulation, will provide a continued payback to the homeowner and a more enjoyable and comfortable living environment for many years, as well as a reduction in emission of greenhouse gases.

Types**:-** 1. Air gap insulation 2. Cotton insulation 3. Mineral wool insulation 4. Plastic Fibre insulation.

*Green Cement***:-**

Green Cement is a combinations incorporating limestone, fly ash or ground. granulated blast-furnace slag can be specified and, in some exposure conditions, may be more appropriate. The cement industry is actively recovering the energy from wastes by increasing the use of non-fossil fuels such as waste solvents; refuse derived fuel (RDF), certain non-recyclable paper and plastics, sewage pellet, and meat and bone meal. Using these alternative fuels not only reduces the need for landfill sites or disposal by incineration but also helps preserve our finite reserves of fossil fuels.

*Fly ash brick***:-**

This is a fine, glass-powder recovered from the gases of burning coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. When mixed with lime and water the fly ash forms a cementations compound with properties very similar to that of Portland cement. Because of this similarity, fly ash can be used to replace a portion of cement in concrete, providing some distinct quality advantages. Adding fly ash to stabilized soil bricks or ordinary bricks can increase their compressive strength. Other benefits include: 1) Low water absorption 2) Less consumption of mortar 3) Economical & eco-friendly 4) Low energy consumption 5) No emission of green house gases 2.2.1.4.

Transparent roof / sustainable day lighting

Lighting accounts for around 15% of the energy bill in most homes, and around 25% in commercial buildings. The most sustainable lighting is natural daylight. It is not only a free renewable resource but it also has well-documented health benefits. Careful architectural design is required to maximize natural light in a building while maintaining indoor temperature regulation and reducing direct light glare. The strategic placement of windows, skylights, light shafts, atriums and translucent panels in harmony with other building components, such that light is reflected evenly throughout internal spaces, is known as day lighting design.

3.2. Green Roof Technology

A Green Roof is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It also includes additional layers such as a root barrier and drainage and irrigation systems. The use of term green refers to the growing trend of environmentalism and does not refer to roofs which are merely colored green, as with green roof tiles.

The term "green roof" is generally used to represent an innovative yet established approach to urban design that uses living materials to make the urban environment more livable, efficient, and sustainable.

3.2.1 *Advantages of Green Roof*

I. Roofs represent a large percentage of impervious surfaces; placing vegetation on them can substantially reduce storm water runoff.

II. Green roofs can manage much or all of the runoff that would otherwise be generated by a building's roof area.

III. Green roofs cover normal roofing materials, shielding them from wear and prolonging their life.

IV. Rooftop vegetation adds to the insulation of a building, reducing cooling and heating requirements.

V. The collective effect of several buildings with green roofs can reduce the ―heat island‖ effect of urban areas, improve the air quality, and reduce dust and other airborne particle.

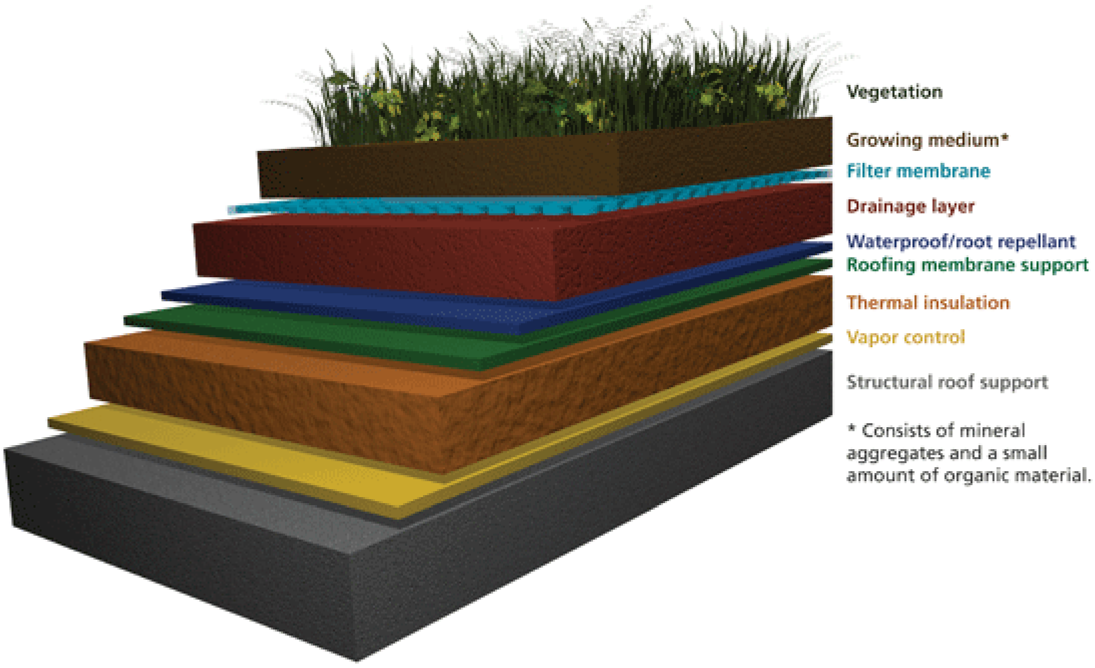

Figure 1- Different layers of Green roof.(source: www.igbc.in)

3.3 Electrical Techniques

3.3.1 *Conservation Techniques*

i. Optimum use of natural light.
ii. Replacing incandescent lamps by compact fluorescent lamps (CFLs).
iii. Replacement of conventional fluorescent lamp by energy efficient fluorescent lamp.
iv. Replacing of mercury/sodium vapour lamp by halides lamp.
v. Replacing HPMV lamps by high pressure sodium vapour lamps.
vi. Replacement of luminaries by more energy efficient luminaries.
vii. Replacement of conventional ballast by energy efficient ballast.
viii. Obtain flexibility in light control circuit by using sensors, microprocessors.

3.3.2 *Generation Techniques*

Solar Lighting:

The system is provided with battery storage backup sufficient to operate the light for 10-11 hours daily. The system is provided with automatic ON/OFF time switch for dusk to down operation and overcharge / deep discharge prevention cut-off with LED indicators. The solar street light system comprise of :-74 W Solar PV Module 12 V, 75 Ah Tubular plate battery with battery box Charge Controller cum inverter (20-35 kHz)11 Watt CFL Lamp with fixtures 4 meter mild steel lamp post above ground level with weather proof paint and mounting hardware. The SPV modules are reported to have a service life of 15-20 years. Tubular Batteries provided with the solar street lighting system require lower maintenance; have longer life and give better performance as compared to pasted plate batteries used earlier. .

i. SPV Module
ii. Battery Box
iii. Lamp with charge controller
iv. Lamp Post Other Green Techniques in Electrical Field includes Energy Conservation in the appliances like Refrigerator, Oven, Air Conditioners etc.

Solar-Wind Hybrid:

Hybrid systems are usually a combination of photovoltaic with wind turbines and/or generators running on diesel or biofuels. Power generated by the PV array during the day is stored in the battery bank through an energy manager, which controls the complete system. Hybrid systems make optimal use of sunlight and wind speeds - the two main resources readily available in the South Asian sub-continent. When the solar resource is low during the monsoon, the wind is quite strong and vice versa. The resultant hybrid system thus offers an optimal solution at a substantially lower cost. It is ideal for electrification of remote villages in India.

3.4 Constructing Eco-Friendly Building With Green Building Aspects

3.4.1. *Foundation*

Figure 2- Foundation in normal soil. (source: www.geostru.eu)

Though much cannot be done about this part of the construction as everything depends on the soil conditions and Fig.2. 1 Green Roof Building Fig.2. 1 Green Roof Building safety of the structure being the priority consideration, it is recommended to adopt a foundation depth of 0.6 m for normal soil like gravely soil, red soils etc., and use the un-coursed rubble masonry with the bond stones and good packing. Similarly the foundation width is rationalized to 0.6m. To avoid crack formation in foundation the masonry shall be thoroughly packed with cement mortar of 1:8 boulders and bond stones at regular intervals.

3.4.2.*Plinth*

Figure 3- Plinth slab.(source: www.google/leed.org)

A plinth of height 0.2 m above ground level was adopted, constructed with 1:6 cement mortar. The plinth slab of (100-150) mm which is conventionally provided, was avoided and in its place, in order to take necessary precaution, impervious blanket like concrete slabs or stone slabs was provided all round the building to reduce erosion of soil and thereby avoiding exposure of foundation surface and crack formation.

3.4.3. *Rat trap bond walling*

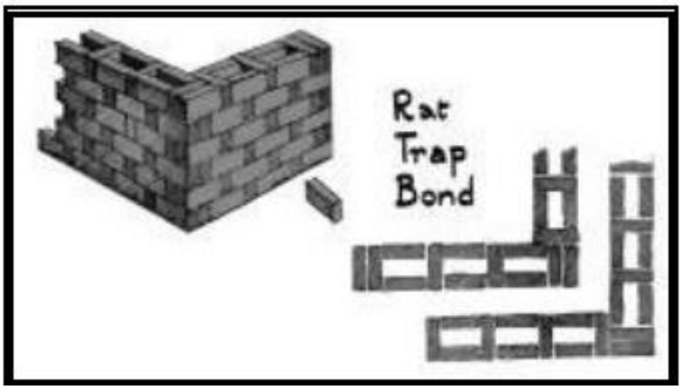

Figure 4- Rat Trap bond wall.(source: www.civilindia.in)

This technique had been developed by the architect Laurie Baker and has been tested and proven during the past 40 years in India. The rat-trap bond is laid by placing the bricks on their sides have a cavity of (80-100) mm, with alternate course of stretchers and headers. The headers and stretchers are staggered in subsequent layers to give more strength to the walls the main advantage of this bond is the economy in use of bricks, giving a wall of one brick thickness with fewer bricks than a solid bond.

3.4.4. *Doors and Windows*

Figure 5- Door frame.(source: http://www.iaeme.com/)

It is suggested to use wooden doors and windows in place of concrete or steel section frames as was done for this project thus achieving good thermal insulation, cause wooden doors and windows have less effect of temperature variations or sun light as compared to the concrete and steel doors and windows and the location of these doors and windows were mostly in northern or southern direction so as not to face the sunlight directly, in the mean time providing sufficient ventilation and air circulation for giving cooling effect.

3.4.5. *Tiles on The Outer Face of The Wall*

In the insulated cavity wall construction, the cavity was filled by wooden powder so there were chances of fire due to the use of wooden materials by short-circuits or any other accidental conditions and also in case of heavy rainfall, chances of water penetration also prevailed into the cavity, Therefore to protect walls from those detrimental conditions, tiles were provided on the outer and inner faces of the walls. Tiles also provided protection to the walls from coming in direct contact of atmospheric heat ensuring the reduction of the temperature as well as increasing the cooling effects as well.

3.5 Research methodology and findings

The research is descriptive in nature. A quantitative research method was employed, described by Borrego, Douglas & Amelink (2009: 54) as good for deductive approaches, in which a theory or hypothesis justifies the variables, the purpose statement, and the direction of the narrowly defined research questions. The hypothesis being tested and the phrasing of the research questions all govern how the data will be collected, as well as the method of statistical analysis used to examine the data. The review of the literature resulted in the formulation of the following three main research questions, namely built environment stakeholders'

1.perception on whether green buildings are more expensive than conventional buildings;

2.their familiarity with green concepts, and

3.preference of green versus traditional building projects.

4.The survey instrument used to obtain the primary data for addressing the research questions consisted of a structured questionnaire circulated to a randomly selected sample of fifty quantity surveyors, engineers, construction managers, architects and contractors in Mauritius. A response rate of 62% was achieved and this formed the basis for data analysis and the subsequent conclusions. Moyo & Crafford (2010: 68) state that contemporary built-environment survey response rates range from as little as 7% to as much as 40% in general. As such, the above response rate of 62% can be regarded as very high. The response group included quantity surveyors (23%), engineers (16%), construction managers (16%), architects (29%) and contractors (16%). Questionnaires were completed anonymously to ensure a true reflection of the respondents' views and to meet the ethical criterion of confidentiality. It was assumed that the respondents were sincere in their responses as they were assured of their anonymity. Responses were evaluated on a perceived level of agreement with statements based on a 5-point Likert scale where 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree. Once the questionnaires were returned, the responses were electronically captured using a Microsoft Office Excel spreadsheet to calculate percentages and mean scores (MS); as indicated in the tables. Acta Structilia 2011: 18(1) 92 4.

3.6 Results and findings

Built environment stakeholders' perception on whether green buildings are more expensive than conventional buildings

The questionnaire survey explored the perceptions of Mauritian built environment stakeholders in terms of the cost of green buildings compared to that of traditional buildings. The responses are summarised in Table 1

Statement	*Response (%)*						*MS*
	Unsure	*1 =Fully disagree, 3=Neutral, 5=Fully agree*					
		1	*2*	*3*	*4*	*5*	
Green building design decreases operational and maintenance costs	3.2	6.5	35.5	25.8	29.0	0.0	2.83
Green building materials are more durable than conventional materials, resulting in cost savings	0.0	3.2	9.7	29.0	38.7	19.4	3.65
Green buildings use less energy, resulting in cost savings	3.2	0	9.7	25.8	41.9	19.4	3.77
Green buildings have less waste disposal, resulting in cost savings	6.5	3.2	12.9	35.5	32.3	9.6	3.38
Green buildings use less water, resulting in cost savings	6.5	0.0	9.7	29.0	38.7	16.1	3.69
Green buildings use technology that is cheaper than conventional buildings	0.0	6.5	38.7	22.6	29.0	3.2	2.87
Green buildings cost less than conventional buildings	0.0	12.9	32.3	29.0	22.6	3.2	2.74
						Average	3.28

Figure 6: Table 1

Although the majority of the respondents (35.5%) ‘disagreed’ on whether green-building design decreases operational and maintenance costs, the majority (38.7%) ‘agreed’ that greenbuilding materials are more durable than conventional materials which should result in lower maintenance costs. Regarding the use Buys & Hurbissoon • Green buildings 93 of energy, water and waste disposal, the majority of the respondents also ‘agreed’ that green buildings use less energy (41.9%) and water (38.7%) while the majority were ‘neutral’ (35.5%) on whether there is less waste disposal, resulting in cost savings. The Table also shows that respondents are not convinced that green buildings use cheaper technology than conventional buildings (MS=2.87). The literature review indicated that the cost of green buildings can be slightly higher than that of conventional buildings. This was confirmed by the majority of the survey respondents (32.3%) as they ‘disagreed’ that green buildings cost less than conventional buildings. Although the overall MS of all aspects indicates a higher ‘neutral’ MS of 3.28, leaning slightly more towards the ‘agree’ range, the outcome that green buildings cost less than conventional buildings can possibly be attributed to savings occurring during the project’s life cycle. Property developers are often more concerned with initial construction costs when deciding whether to continue with a construction project whereas the life-cycle cost of the development should be a more important factor in decision-making. When green buildings are constructed, the life-cycle cost of the building will result in bigger savings than when conventional materials are used.

3.6.1 ***Awareness of green-building concepts***

The questionnaire survey also explored the awareness of builtenvironment stakeholders with respect to various aspects of green buildings. The responses are summarised in Table 2

Statement	Unsure	Response (%) 1=Fully disagree, 3=Neutral, 5=Fully agree					MS
		1	2	3	4	5	
I am familiar with the Environment Conservation Act	0.0	0.0	9.7	38.7	48.4	3.2	3.48
I am familiar with the National Environment Management Act	0.0	0.0	12.9	38.7	38.7	9.7	3.48
I am aware that natural materials are scarce	0.0	0.0	0.0	9.7	74.2	16.1	4.10
I am aware that the environment is degenerating	0.0	0.0	0.0	0.0	70.9	29.1	4.32

Statement	Unsure	Response (%) 1=Fully disagree, 3=Neutral, 5=Fully agree					MS
		1	2	3	4	5	
I am aware of the benefits that green buildings have on the environment	0.0	0.0	0.0	9.7	83.9	6.4	4.00
The above benefits are substantial	0.0	0.0	0.0	6.5	54.8	38.7	4.35
I am aware of my firm's impact on the environment	0.0	0.0	9.7	38.7	48.4	3.2	3.48

Figure 7:Table 2

The majority of the respondents (48.4%) 'agreed' that they are familiar with the Environment Conservation Act while the majority of the respondents were either 'neutral' or 'agreed' (38.7%) that they are familiar with the National Environmental Management Act. The majority of the respondents also 'agreed' that they are aware: • that natural materials are scarce (74.2%); • that the environment is degenerating (70.9%); • of the benefits of green buildings on the environment (83.9%); • that the advantages are substantial (54.8%), and • of their firm's impact on the environment (48.4%). The above results are a clear indication that Mauritian builtenvironment stakeholders are fairly familiar with most green-building concepts and related Acts. It is thus important to determine why so few green buildings are being built, especially because the majority of the respondents indicated that they were aware of the benefits of green buildings (MS 4.0) and that these are 'substantial' (MS 4.35). The next section shows the results of respondents' views on their preference in using conventional versus green buildings. Respondents were requested to state their views on the use of green versus conventional buildings by indicating to what extent they agreed with the following statements

(Table 3):

Preference: Green versus conventional buildings

Statement	Response (%)						MS
	Unsure	1=Fully disagree, 3=Neutral, 5=Fully agree					
		1	2	3	4	5	
Professional firms prefer using conventional materials over green materials or products	0.0	3.2	19.4	25.8	45.2	6.4	3.35
Contractors prefer the use of conventional materials over green materials or products	0.0	6.4	12.9	25.8	48.4	6.5	3.39
Contractors are more familiar with conventional materials	0.0	3.2	12.9	19.4	54.8	9.7	3.58
Building professionals are experienced in green-building concepts	0.0	3.2	41.9	32.3	22.6	0.0	2.78
Contractors understand the nature of green materials or products	3.2	6.4	32.3	32.3	25.8	0.0	2.79
Green materials and methods are still new concepts in the construction industry	0.0	3.2	45.2	25.8	22.6	3.2	2.81

Figure 8 :Table 3

The results indicate that the majority of both professional teams (45.2%) and contractors (48.4%) 'agree' with the statement that they still prefer to use conventional materials over green materials or products. This may be because the majority of the respondents (54.8%) indicated that contractors are more familiar with conventional materials and therefore refrain from using green materials. However, the majority of the respondents (41.9%) indicated that they 'disagree' with the statement that professionals are experienced in green-building concepts. This may be one of the reasons why there is not really a growth in green buildings being built. If professionals do not have sufficient experience in green-building materials/ concepts, they may be hesitant to specify them. The majority of the respondents also indicated that they 'disagree' (32.3%) with the statement that contractors understand the nature of green materials or products, whereas 32.3% of the respondents were 'neutral' regarding this statement. From the results it is also clear that the majority of the respondents (45.2) do not believe that green

materials and concepts are still new to the construction industry. Acta Structilia 2011: 18(1) 96
The above results indicate that there is still a tendency not to use green materials or products. This could be because professionals and contractors are not fully familiar with such materials and therefore are hesitant to specify or use them. Clients, however, are becoming more aware of green buildings and materials and may insist that professionals and contractors specify and use such materials. This is also obvious in the following results.

3.7 Observations And Analysis

In the project discussed above a house which was constructed with conventional methods and another experimental house having green roof and eco-friendly technologies constructed the temperature observations were taken on both the houses and following were the observation found At the time of experiment the following observation were taken on the traditional and green building:-

Normal Temperature Outside = 32.00C
Room Temperature of Traditional Building = 31.40C
Room Temperature of Green Building = 29.30C
Reduction in Temperature for Traditional Building = 0.60C
For Green Building = 2.70C
Difference between Reductions in Temperature of
Traditional and Green Building = 2.10C
After the increase in temperature by the lighting effect Temperature outside around Traditional and Green Building= 37.00C
Room Temperature of Traditional Building = 34.90C
Room Temperature of Green Building = 30.10C
Reduction in temperature For Traditional Building = 2.10C
For Green Building = 6.90C
Difference between Reductions in temperature of Traditional and Green Building = 4.80C

Therefore the result shown above indicate that a Green building will have reduced room temperature and provide more cooling effect as compared to the traditional building.

3.7.1 *Studies with Objective Health Outcome Measures*

Objective health metrics are even more important than objective measurements of IEQ because the relationship between building design and IEQ is currently better understood than the relationship between building design and health Because of their unique focus on hospitals, they had the most objective health assessment of the studies reviewed; hospital records on both the patients and employees were compared at the two hospitals . The authors conclude that the results, Blead to a reasonable observation that the facility did in fact contribute to the overall improvements.^ Without measurements of IEQ in this study, it is not possible to identify the specific green building attributes that were responsible for the improvements.

3.7.2 *Health Performance Indicators*

Many of the studies in our review asked occupants to self-report on their health and perceptions of the indoor environment. Several measured indicators of indoor environmental quality performance as an indicator of health (e.g., ventilation, VOCs, particles), and a few used true, objective measures of occupant health (e.g., standardized healthcare performance metrics). Here, we propose a framework for conceptualizing these and other metrics for studying health in buildings, borrowing a business term: key performance indicator (KPI).

We believe that a common set of HPIs apply to nearly all buildings. For example, building design and performance (e.g., green building, ventilation), measures of environmental health (e.g., chemicals, biologicals, radiological hazards), and measures of occupant health (e.g., self-reported health, objective physiological measures, asthma). Our research, and the research of countless other health scientists, has informed the inclusion of many other example HPIs into this figure, from the obvious (e.g., ventilation), to the more obscure (e.g., lawsuits). For schools, the same baseline factors are important, but school-specific metrics would also likely include teacher health, student absenteeism, standardized test scores, and other school-specific factors.

The proliferation of mobile health sensors, sometimes termed Health (mobile health) or referred to as the Quantified Self movement, is enhancing our ability to obtain objective, leading and direct measures of health of occupants of buildings. Last, we hope this framework stimulates health researchers to evaluate their metrics in order to avoid the availability and overconfidence issue.

CHAPTER 4: RATING SYSTEMS IN INDIA

4.1 Most Popular Rating Systems In India

4.1.1 *GRIHA*:

GRIHA or Green Rating for Integrated Habitat Assessment, is the national rating system of India for any completed construction. It has been developed by TERI (The Energy and Resources Institute) and is endorsed by the MNRE (Ministry of New and Renewable Energy).It is an assessment tool to measure and rate a building‘s environmental performance. Griha is a point based rating system that consists of 34 criteria categorized under various sections such as site selection and site planning, conservation and efficient utilization of resources, building operation and maintenance, innovation etc. It helps with the improvement in the environment by reducing GHG (greenhouse gas) emissions, reducing energy consumption and the stress on natural resources, reducing pollution loads and waste generation [33]. Some GRIHA rated buildings are CESE (Centre of Environmental Sciences and Engineering) building of IIT Kanpur, Suzlon One Earth in Pune, Fortis Hospital in New Delhi, Common Wealth Games Village in New Delhi [16].

4.1.2 *IGBC* :

Following the formation of the Indian Green Building Council (IGBC) in 2001, the membership quickly realised the need for measuring ―green buildings‖. IGBC is the non profit research institute having its offices in CIISohrabji Godrej Green Business Centre, which is itself a LEED certified building [16]. Since it achieved the prestigious LEED rating for its own centre at Hyderabad in 2003, the Green building movement has gained tremendous momentum in India. Thus, IGBC adopted the LEED for India as an Indian partner of USGBC. It acts as a channel for registration of Indian projects under LEED programme. IGBC building rating system is quite similar to that of USGBC, but slightly modified to suit Indian conditions [21]. The committee included architects, engineers, building owners, developers, manufacturers and industry representatives. This people and professionsadded a richness to the process and to the ultimate output. The green design field is growing and changing day by day. New technologies and products are coming into the market and innovative designs are showing their effectiveness.

4.1.3 BEE: *Bureau of Energy Efficiency (BEE)*

(BEE) developed its own rating scale based on 1 to 5 star scale. More stars mean more energy efficiency. BEE has developed the Energy Performance Index (EPI). The unit of Kilo watt hours per square meter per year is considered for rating the building. The Government of India set up BEE on March,2002 under the provisions of Energy Conservation Act,2001 [15]. To coordinate energy efficiency, they establish systems and procedures to measure, monitor and verify energy efficiency results in individual sectors as well as at macro level. The Indian Bureau of Energy Efficiency (BEE) had launched the Energy Conservation Building Code (ECBC) on February 2007. The code is set for energy efficiency standards for design and construction with any building of minimum conditioned area of 1000 Sq. mts and a connected demand of power of 500 KW or 600 KVA. The energy performance index of the code is set from 90 kW·h/sqm/year to 200 kW·h/sqm/year. Any buildings that fall under the index can be termed as "ECBC Compliant Building" [28]. Reserve Bank of India‘s buildings in Delhi and Bhubaneswar, CII Sohrabji Godrej Green Business Centre and many other have received BEE 5 star rating16]. Among all the buildings, Suzlon One Earth is the only building in India with the highest ratings from LEED (Platinum rating with 57 points which it obtained in 2010) and GRIHA (Five Star rating with 96 points).

CHAPTER-5: PROBLEMS AND ADVANTAGES RELATED TO GREEN BUILDING

5.1 Problem and countermeasure of building material

The utilization of GBM in construction projects is extremely beneficial from a social and personal point of view as well as from a corporate perspective. Green building materials will certainly be promising in the future. Compared with foreign countries, China's green building materials have developed relatively slowly. From the real situation, there are some problems still left to be solved in the future.

Higher perceived First Cost: The most significant barrier to residential green building most cited by industry professionals and the public is higher perceived first cost. The added cost of incorporating green building features into residential projects depends largely on local factors such as climate, local building customs, and labor skill levels. The upfront costs may discourage investment, particularly where the benefits are long-term or are externalised beyond the individual organisation making the investment (Saunders and Schneider, 2000). Homebuyers in India, are still quite averse to pay an extra premium (Times of India, 2015).

*ii. Lack of Knowledge**:*** Another barrier to residential green building is a lack of knowledge, including biases in perception, apathy, and lack of understanding about benefits of green residential building. This lack of knowledge appears pervasive at all levels of the industry, including lenders, realtors, builders, general contractors, home inspectors, buyers, suppliers, and regulatory officials (United Nation Environment program, 2010).

*iii. Lack of Widely used Standards**:*** The third major challenge to green residential design and construction is the lack of widely used standards to consistently define criteria for a "green" product, service, or building. While some standards have emerged for specific product categories (such as the Carpet and Rug Institute's Green Label Plus criteria for chemical content or the Green Seal limits for volatile organic compounds in paints), builders and consumers cite concerns over "green washing" as an obstacle to evaluating products or residences marketed as green. 47 With over 80 different regional green home rating systems operating in the United States, some builders imply that confusion over which standard to follow, or the difficulty in adhering to different local programs in multiple markets, is a deterrent from undertaking green building.

iv. Scarcity of Products and Expertise:. A fourth barrier to more widespread green housing design and construction is the scarcity of products and expertise. While environmentally preferable products and high performance residential equipment and systems are increasingly available at the national level, many markets are still underserved by manufacturers of green products and by industry professionals knowledgeable in green means and methods. Even where products or personnel are available, the lead times can be extraordinary, as demand for green outstrips the supply capacity.

v. Lack of Implementation of Energy Conservation Building Code (ECBC): Implementation of Energy Conservation Building Code (ECBC) is the first and the foremost requirement. Till now, ECBC is currently voluntary, but in the future, either the central or state governments should decide to adopt it as a mandatory standard. No states have adopted it yet. Bureau of Energy Efficiency (BEE) is working closely with national and state-level government agencies to promote ECBC. Once ECBC becomes mandatory at either the central or state level, one can assume that the implementation and enforcement approach will be similar to that employed for other mandatory building codes.

vi. Lack of Seriousness and Leadership: All these initiatives towards conservation measures taken by the government remained as an appendix to the long term energy policy. All the measures which taken were reactive to certain events, not proactive by nature. Moreover, even after three years of its formation, BEE remained almost non operational. Until September 2005, it did not even have a full time head. A more mobility is needed from administration side so that long term goal of India as an energy efficient, developed economic giant can be traced on realistic grounds even if in short term we have to pay for it.

vii.Awareness for Global Marketing Needs: Signs of improvement in the energy intensity figures were only observed with the opening up of the economy during the last one and half decades. Increased competition both at home and abroad, has compelled the business leaders to look into alternative options to save energy cost. In this new century, when most of the industries were gearing up to boost exports, they realized that the cost of energy was robbing off their competitive edge in the international market. In India, the cost of power has escalated three fold in the last ten years. This probably can explain better why the green buildings which are estimated to reduce energy cost by 40% are likely to be the fighting front in the global markets.

viii.Addressing with Economics Perspective: It was recently observed that, to minimize environmental impacts by significant orders of magnitude requires the blending of good engineering with good economics as well as changing consumer preferences. Recent experiences, provides a valuable lesson on how to avoid the common pitfall of “green buildings myopia”. While noble, the benefits of the concept appealed to only the deepest green niche of consumers. In practice, green appeals are not likely to attract mainstream consumers unless they also offer a desirable benefit, such as cost-savings or improved product performance.

ix. Risk and Uncertainty: Although investments and interest in green building are growing rapidly, a number of complex and varied reasons, financial case for green building has not yet firmly taken hold in real estate and development community. There are many risks that exist in real estate community regarding green building. They are as follows:

• Uncertainty over reliability of green building technologies

• Uncertainty over costs of developing green real estate

• Uncertainty about the economic benefits of green real estate

• Uncertainty about green building performance over time

x. Lack of Experienced Workforce: Another main problem which is faced by India in implementing and making the customers accept the concept of green building is lack of experienced workforce. India is lacking in having many experienced consultants in the area of green building who is well explored in the literature and research in the rapid growing industry. Expansion in this industry is threatened by lack of experience workforce. It increases more risk of inexperienced and untrained service providers entering the green building market in search of a premium on their services.

xi. Multi Dwelling Homes: These kinds of homes where collective decision making the necessary pose a particular challenge to green building refurbishment (Golove and Eto, 1996).

xii. Lack of Effective Enforcement of Policies: It was reported in United Nations Environment program(2010) that there was lack of effective enforcement of policies by the government was found as one of the great barrier.

xiii. Lack of Financial Incentives: Due to lack of financial incentives was faced as barrier as reported by United nations Environment program (2010).

xiv. Resistance to change: This is a natural human tendency and not unique to the green building movement. People are reluctant to change old habits and ways of thinking. Just because green buildings seems “new” at the moment, it doesn’t mean everyone is going to jump on the bandwagon in the near future (Prouty and Glover, 2010).

5.2 Advantages of green building material

According to some authoritative studies on a variety of GBM now commonly used in Compared with traditional building materials, they usually have the following advantages:

5.2.1 *Global Environmental Benefits:*

Since buildings use such vast amounts of resources in their operation and since they are made of materials that need to be extricated, processed, and manufactured, it is no wonder that approaching their design in a sustainable way could have global impacts on the environment. Sustainable design offers significant advantages in the areas of energy and water use reduction, air quality improvement, and increased material efficiency.

(i) Reduce energy consumption: Use waste slag and domestic waste as raw materials for production, or use renewable environmental protection materials to achieve the purpose of reducing the consumption of water resources and land resources, and use more advanced production technologies to increase energy efficiency, so the energy saving and emission reduction in the production process is able to realized ,as well as the green environmental protection.

(ii) Sustainability: Qualified materials can be used again after being produced and recycled for many times to avoid energy consumption and pollution emissions caused by repeated production or reproduction of materials.

(iii) Health and harmless: Unlike traditional building materials, because of the material itself or the introduction of certain chemical substances, green building materials is not harmful for the human’s health while meeting functional needs.

(iv) Good material properties: Most of the GBM have the characteristics of high strength, high water resistance, and light weight, which can reduce the cost of material handling and improve the quality of buildings. In summary, the application of green building materials can not only improve the efficiency of the progress of production and construction quality, avoid health hazards, but also meet the requirements of sustainable development. Therefore, the state should promote the use of it and inject green vitality into the construction industry.

(v) Reduced Air Pollution: Fossil fuel is a slowly depleting resource, world over (IGBC, 2012). There are a number of indirect (relative to buildings) sources of pollution such as vehicle pollution from the transport of building products and the manufacturing of building products. There are also directpollutant sources such as HVAC refrigerants and the toxic emissions from our finishes. All of these have impacts on global warming, ozone depletion, and air pollution. Green Building construction and design helps to overcome the problem to some extent.

5.2.2 *Economic Benefits:*

There are some clear economic advantages to sustainable building. Reducing the consumption of energy and water would lessen the financial burden of building operations. In the case of passive heating and cooling systems, this also means a reduction in maintenance costs. And by improving the comfort for buildings' occupants, employee turnover can be reduced. The economic benefits of sustainable design can be realized in the short term, long term, and in the added value projects.

•*Short Term Benefits:* Sustainable buildings can offer immediate savings in the area of utility costs. Whether from reduced electrical energy and water usage, or from reduced cost of storm water mitigation infrastructure, green buildings have the opportunity to lessen the cost of running utility bills. In addition, buildings with efficient layouts can reduce the cost of building materials and construction waste. Also, if a building utilizes smaller HVAC equipment and relies more on passive strategies for heating and cooling, then the first cost of equipment could be less. There could also be financial incentives from local utility companies for buildings utilizing sustainable design strategies.

• *Long Term Benefits:* Utility cost savings over the long term could pay for possible upfront cost increases. While the payback duration on items like photovoltaic panels is debatable, some other measures may realize quick pay-offs. Passive systems may need little to no ongoing maintenance; therefore a building owner could save on the building operations budget. This translates into the landscape designs as well. Natural landscapes generally require less maintenance than conventional ones. Another benefit is the churate.Buildings designed for flexible layouts can reduce the costs of reconfiguration

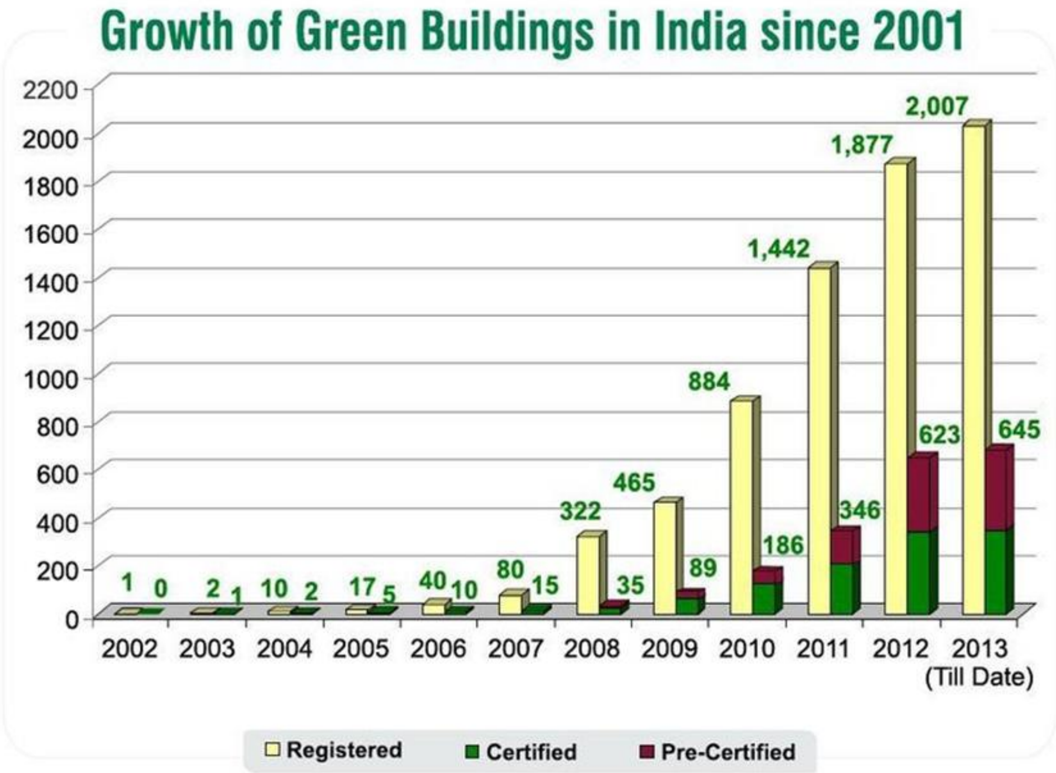

Figure 9: Growth of green buildings since 2001(source: www.igbc.in)

CHAPTER 6: CASE STUDIES IN GREEN BUILDING

6.1 ITC Green Centre, Gurgaon.

Spread over a rambling 1, 80,000 sq. ft, the ITC Green Centre has set a benchmark for green structures in India. Situated in Sector-32, Gurgaon, the structure has been granted the Platinum Green Building rating by USGBC-LEED (Green Building Council-Leadership in Energy and Environmental Design), making it the first corporate house in the country The structure is planned remembering the most elevated ecological guidelines. It is comprised of blocks and cement containing fly-ash and is outfitted with high-productivity gear that diminishes 53 percent energy utilization over an ordinary structure and 40 percent consumable water prerequisites. Zero water release, sunlight-based heating innovation, rainwater system, intelligent high-albedo rooftop paint, minimum outside lighting and separate smoking rooms with exhaust framework are a portion of different highlights of the structure.[15] Albedo is the measurement of reflected light from the surface.

Figure 10- ITC Green Centre, Gurgaon(source: http://www.iaeme.com/)

6.2 Patni (I-GATE) Knowledge Center, Noida.

Situated in rural Noida and spread over more than 4, 60,000 sq ft, the structure's intelligence is planned so that it provides 75% of daylight to its interior. Around 50 percent of the zone is saved for open green space. What's more, the grounds follows the productive water management like water gathering, sunlight based water heating and drip water system. 100 percent sewage is dealt with and the reused water is utilized to cool the tower makeup, cultivating and flushing.

6.3 Olympia Tech Park, Chennai

Situated in the core of Chennai (Gundy), the Olympia Tech Park has gotten one of the greatest and generally looked for after IT parks in Chennai. The tech park houses MNCs that works day and night which is the reason energy saving highlights and the eco-friendly condition turn into a need. Evaluated as one of the biggest gold LEED rating structures on the planet, the structure utilizes energy and water saving strategies (water gathering) and reusing and to accomplish zero percent release. The double pipes line of the structure which helps in treating greywater is utilized for flushing or in gardening.

Figure 11- Olympia Tech Park, Chennai (source: www.awdesign.in)

6.4. Bank Of India, Goa:

A world of eco-friendly lights and airconditioning, intelligent glazing, modern capsule lifts, and indoor fountains – this is what sums of this popular bank in Goa. The building uses Nano

Misty Blue, softening colour glass manufactured by Saint Gobin Glass, India for producing the cool effect and saving energy. The glass has solar control and thermal insulation properties. The building is a complete package of modern look of today‘s bank.

6.5. Rajiv Gandhi International Airport (RGIA), Hyderabad:

The structure of the airport is planned in a way so as to consume less water, electricity and conserves natural resources. Within the campus of the airport, there is a green belt of about 273 hectares having numerous plants. RGIA has been successful in saving energy for nearly 3.97 million kWh and have reduced the carbon footprint by 3331 tons.

6.6 Suzlon One Earth ,Pune:

Suzlon one earth is 100% powered by onsite and offsite renewable sources. The campus has 18 hybrid wind turbines that fulfil 7% of the total energy consumption, the rest of energy demand is met from offsite wind turbines. The structure is designed in such a way that it can get a maximum daylight exposure which helps in reducing artificial lighting consumption. The infrastructure within the campus is designed to enable water percolation and thereby control storm water runoff thus, contributing towards an increased water table level.

CHAPTER 7: ENERGY-EFFICIENCY CERTIFICATION IN GREEN BUILDING

A Whole-house energy efficiency certification is essential to creating home energy systems consistent with the model. Buildings use more than one-third of all energy in the United States, and two-thirds of all electricity consumption. Homes and apartments use more than half of the energy used in all buildings in the United States (Doxley 2006). Furthermore, buildings consume or are responsible for 40 percent of the world’s total energy use (ECP 2007, 3). In the United States from 1990 to 2001, average energy costs increased $1,600. Improvements that make a home 20 percent more efficient, a conservative estimate for many green homes, could significantly reduce a homeowner’s annual utility expenses (NAHB 2006, 2). One of the best-known whole house energy-efficiency certification programs is Energy Star. Energy Star homes receive independent verification of energy efficiency. Energy Star 15 Though not the focus of this research, energy efficiency can reduce dependence on foreign fossil fuels through conservation. 29 homes are evaluated based on heating, cooling, and hot water energy use. The homes typically include building envelope upgrades, high performance windows, controlled air infiltration, upgraded heating and air conditioning systems, tight duct systems and upgraded water-heating equipment. These features improve home quality and comfort, and lower energy demand and reduce air pollution (ECP 2007, 23). James Rather (2006, 61) observes that Energy Star has come to represent a de facto energy code for Community Development Corporations. Creating an Energy Star qualified house is not prohibitively expensive. Table 3.1 illustrates the additional costs and credits to building an Energy Star home.

7.1 Energy Efficient Lighting, Fixtures, and Appliances

Seemingly minor portions of a new construction or rehabilitation project represent opportunities to inexpensively improve energy efficiency and should be considered in an affordable Green building model. Appliances account for two-thirds of the electricity used in American homes (USDOE 1999). Energy Star qualified lighting uses two-thirds less energy and lasts six to ten times longer than traditional lighting, resulting in reduced energy use, lower utility costs, and lower greenhouse gas emissions (ECP 2007, 25; NAHB 2006, 110). Compact fluorescent light bulbs (CFLs) use two-thirds less energy than a standard incandescent bulb and must meet additional operating and reliability guidelines (Doxley 2006). Energy Star refrigerators are 15 percent more efficient than the minimum federal efficiency standard (Doxley 2006). Community Development Corporations frequently use Energy Star appliances, windows and lighting, evidence of the lower cost a perceived value (Rather 2006, 31-55). The Green premium for energy efficient lighting can reach $500, while the premium for appliances is approximately $175 (Magnelli & Sloss 2006). While implementing energy efficiency in appliances is effective, heating, ventilation and air conditioning provides a significant opportunity to reap energy efficiency rewards.

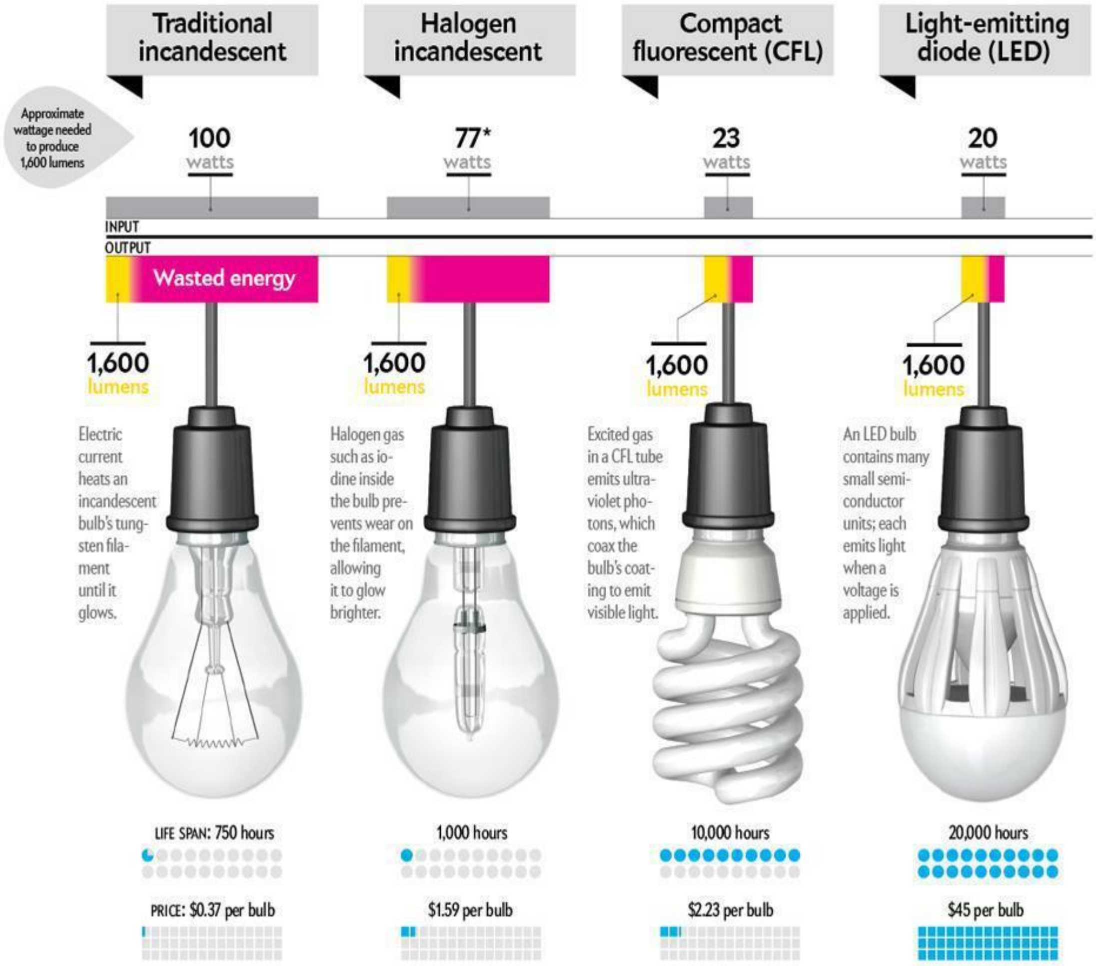

Figure 12-Comparison between Traditional bulb, Halogen bulb, CFL and LED

(source: www.energyoutlet.com)

7.2 Air, Energy Efficient Heating, Ventilation and Conditioning

Heating, ventilation and air conditioning (HVAC) systems account for a substantial amount of electricity sales to US households and are expected to play a significant role in energy use increases over the next 20 years. HVAC systems accounted for 31 percent of electricity sales to US households in 2001 and the increased use of electricity is projected to account for 68 percent of the projected increase in residential energy use between 2003 and 2025 (Phillips

2006, 4). Load reducing technology and the systems that supply a building's energy needs contribute to a building's energy efficiency (Stromberg 2005, 17). Several methods are available 31 to improve energy efficiency, many of which are related closely to indoor air quality discussed later in this chapter. Builders may choose to run vents in conditioned space, such as a sealed attic; running them outside can lose 15 to 30 percent of conditioned air (Global Green 2006, 69). Community Development Corporations frequently use high-efficiency HVAC, such as Energy Star, in their projects (Rather 2006, 31-55). The Green premium is not severe considering the potential benefit to occupants, approximately $600 (Magnelli & Sloss 2006). Many methods designed to improve air quality also result in gains to energy efficiency, and reduced heating, ventilation and air conditioning costs. Efficient HVAC often relies on tight construction to achieve maximum performance.

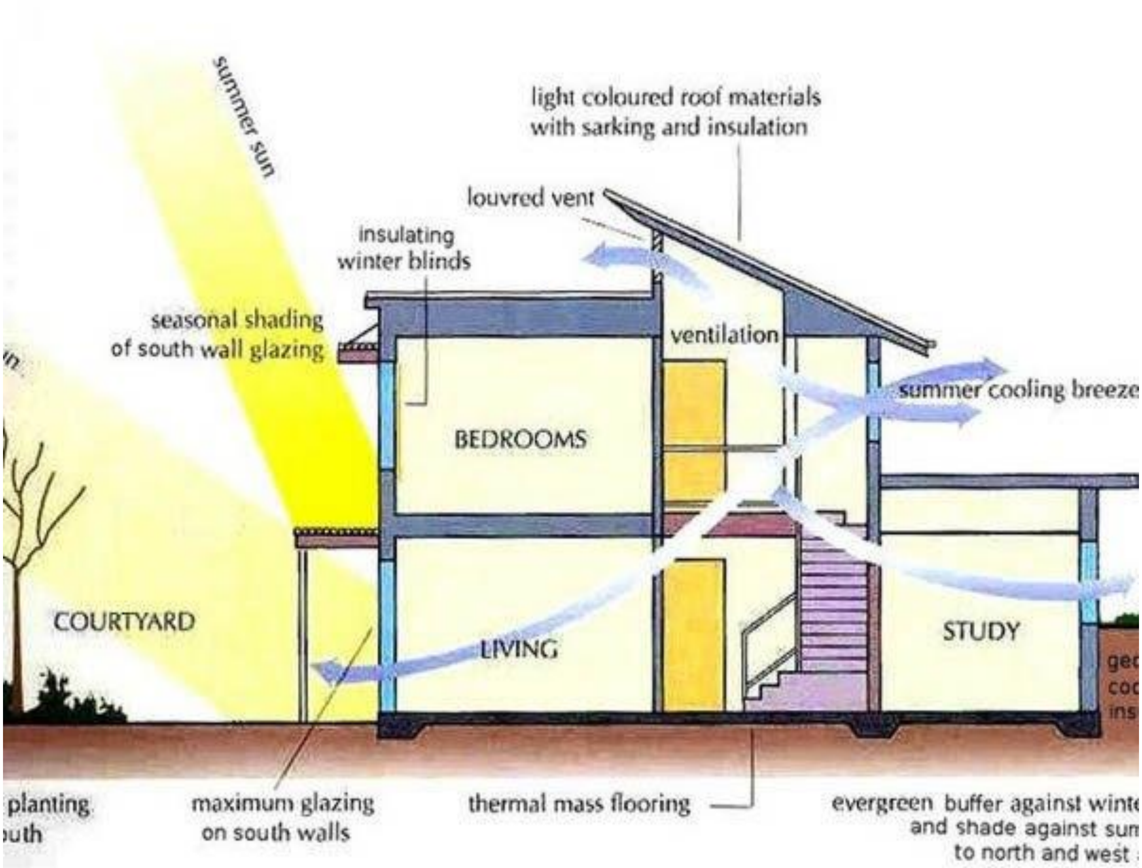

Figure 13-Elevation of a building with HVAC system.(source: www.greenbuilding.com)

7.3 Tight Construction

Tight construction has a significant bearing on the effectiveness of a home's energy systems. In commercial and residential buildings, "over 50% of energy loss is associated with heat transfer and air leakage through building envelope components" (Oak Ridge 2007; NAHB 2006, 98). The building envelope should protect structural members from moisture build up, reduce heat leakage, bring in light, and prevent pest problems (Global Green 2006, 59). Good building envelopes can reduce the need for furnaces, air conditioners, and lights, cutting construction and operating costs (Global Green 2006, 59). Community Development Corporations frequently use tight building envelopes in their projects (Rather 2006, 31-55). Penetration sealing typically comes at a $230 premium (Magnelli & Sloss 2006). While tight construction is important, taking advantage of the sun is an often overlooked aspect of efficient energy systems.

7.4 Solar Design

To create energy systems in compliance with Green building model, solar design provides a low-cost, yet effective means of improving energy efficiency. Lighting significantly affects energy efficiency and thermal comfort. The sun is an ideal source of lighting that is free and widely available (Stromberg 2005, 19). Daylighting brings outdoor light into buildings, reducing the need for artificial light sources (Global Green 2006, 61). Solar energy is practical, renewable heat energy. The most practical renewable energy use is to heat with solar energy. Community Development Corporations found passive solar design a cost-effective means to improve efficiency and environmental stewardship (Rather 2006, 31-55). Building orientation is essential for systems to work efficiently. For centuries, people have used roof overhangs, awnings and other techniques to block the sun (Stromberg 2005, 19). Building designers can take several steps to account for solar design (ECP 2007, 14; Stromberg 2005, 20; LaRue 2006; Global Green 2006, 62): ˆ Elongate building on east-west axis; ˆ Place interior spaces requiring the most light and heating/cooling along the south face of the building; ˆ Design a narrow floor plate with single-loaded corridors and an open floor plan to optimize daylight penetration and passive ventilation; ˆ Design shading through overhangs and canopies on the south and trees on the west prevent the summer sun from entering the interior. In addition, builders should consider future opportunities for owners to reduce energy use. They should site, design and wire the development to accommodate installation of photovoltaic systems (solar panels) in the future. The initial cost of photovoltaic systems is 33 prohibitive under most programs, but grants and subsidies are available in many states and cities for individual homeowners. Providing connectivity reserves the opportunity to install a system later when the resources become available (ECP 2007, 25). Like energy efficiency, water conservation makes many strong economic arguments for inclusion in the affordable Green building model, such as utility cost reductions.

7.5 Water Conservation

Water conservation provides many financial and environmental benefits and warrants inclusion in the Green building model. Water efficiency reduces utility bills while conserving fresh water resources. Between 20 percent and 40 percent of the contiguous United States has experienced moderate to extreme drought in the late 20th and 21st Centuries (ECP 2007, 5). Running a water debt sometimes causes communities to draw on substandard, saline, or polluted sources (Ogorzalek 2003, 27). While most water consumed in the United States goes to agricultural irrigation, domestic consumption is second on the list. Sixty percent of urban water use is residential, and 24 percent is devoted to toilet flushing alone (Ogorzalek 2003, 25; USGBC 2007, 4). Buildings consume or are responsible for 16 percent to 25 percent of fresh water withdrawal (ECP 2007, 3; Wells 2006). In 2005, mean per capita indoor daily water use was slightly over 64 gallons. Implementing water conservation measures can reduce average usage to fewer than 45 gallons (NAHB 2006, 3). In addition, water prices have risen steadily (Ogorzalek 2003, 28). For less than a five percent increase in capital costs, affordable housing can use 10 percent to 20 percent less water, saving on utility bills while reducing demand for water (Connelly 2006). Through 34 installation of water efficient fixtures and improved exterior water efficiency, many water conservation benefits can be realized.

7.5.1 *Water Efficient Fixtures*

Significant water savings can be realized by specifying and installing water-efficient appliances and plumbing fixtures. Studies conducted through Enterprise Community Partners (2007, 21) show “showers and faucets account for approximately 25 percent of indoor water use and toilets account for approximately 20 percent.” Saving water reduces energy required for water heating and total consumption, resulting in significant utility savings. The use of low flow toilets, sinks and washers17 can reduce the consumption of water by 245 gallons per household per day (Edwards & Turrent 2000). Compared with fixtures manufactured before 1992, low-flow fixtures can reduce the amount of water used in showers 75 percent and sinks 50 percent (ECP 2007, 21). Low-flow fixtures are approximately a $100 premium (Magnelli & Sloss 2006). A low-flush toilet uses 40 percent less water, has an initial investment of $150, a payback period of 5 years, and a savings period of 10 years, for a 13 percent return on investment (Wells 2006). Community Development Corporations frequently use low-flow fixtures (Rather 2006, 31-55). The Oakland Housing Authority (OHA) installed 1,500 ultra-low-flow toilets, 2,100 aerators, and 1,100 low-flow showerheads. In 2002, OHA saved $189,000 in water costs and nearly 36 million gallons of water. An average 3-person household can save $60 annually and 54,000 gallons of water each year with these three items (Ogorzelek 2003, 26). Water efficiency should expand outside of the residence’s walls as well.

Figure 14- Water efficient fixtures (source: www.awdesign.in)

7.5.2 *Exterior Water Efficiency*

Homes can save significantly on water consumption by using low-water landscape methods, rainwater catchment or graywater sources (ECP 2007, 5). Community Development Corporations frequently implement rainwater recycling in their projects (Rather 2006, 31-55). Cisterns and other rainwater collection systems are a cost-effective method to save water for irrigation (Global Green 2006, 51; NAHB 2006, 131). Green building is more than protecting the environment and saving money; it includes, as in the case of indoor air quality, improving human health.

7.6 Indoor Air Quality

Given the amount of time individuals spend indoors, indoor air quality is essential to any Green building model due to risks to residents' health. Platts-Mills (1995) estimates individuals born after 1995 will spend over 95 percent of their lives inside. As a result, the National Association of Home Builders (NAHB) (2006, 3) reports many Green building consultants cite indoor air quality as the most important feature of Green homes after energy efficiency. The USCDC has classified indoor pollution as a high environmental risk factor (USCDC 1994). Samet and Spengler (2003, 1489) found "risks for diverse diseases are increased by indoor air pollutants, surface contamination with toxins and microbes, and contact among people at home, at work, in transportation, and in many other public and private places." The publication of The American Journal of Public Health special issue on the built environment signals growing recognition of the affects indoor environments have on human health. The emphasis on the built environment indicates a shift toward a more holistic approach to indoor 36 environments and the public's health (Samet & Spengler 2003, 1489). Additionally, it recognizes the many environmental factors that play a role in human health (Samet & Spengler 2003, 1489). Two milestones facilitated recognition of the of the built environment's importance to health. The initial milestone came when measurements of specific pollutant levels were assessed in indoor air for the first time (Samet & Spengler 2003, 1490). The second occurred as other researchers analyzed those measures, revealing indoor air pollutants played a larger role than outdoor in affecting human health (Samet & Spengler 2003, 1490). Dramatic problems, such as mobile homes that could not be occupied because of extremely high levels of formaldehyde from building materials, indicated construction methods might be to blame (Samet & Spengler 2003, 1490). The health consequences of dampness and mold are a current example. In addition, there are emerging issues such as phthalates, organophosphates, and pyrethroid pesticides (Samet & Spengler 2003, 1489). Substandard housing conditions, indoor environmental exposures, and environmental smoke exposure contribute and are more prevalent in low-income areas (Gold & Wright 2005). Neighborhoods influence incidence of asthma, with a disproportionate burden in communities of color and impoverished neighborhoods (Spielman et al 2006, 102). According to the United States Center for Disease Control, low-income people endure the highest rates of asthma, with many known and suspected triggers linked to conditions in the home (ECP 2007, 3). The increase in asthma has coincided with major changes to the home environment, in part driven by alterations to building design hastened by high fuel costs during the 1970s energy crisis. Modern homes better insulated than was previously the case, often without regard for the affects tighter construction can have on indoor air quality (Jones 1998, 755). 37 Greening affordable housing mitigates the risk of liability. Many government researchers believe indoor air quality is the next lead paint-type issue in low and moderate income housing (Connelly 2006). Moreover, the United States Department of Housing and Urban Development has over 9,000 court cases involving moisture problems, double the next closest (Doxley 2006). Affordable housing should provide safe, suitable living environment for low-income residents. Safety includes avoiding building methods and materials that harm residents' health, especially those particularly weak such as children, seniors, and individuals with existing respiratory problems and compromised immune systems. A healthy living environment minimizes residents' and workers' toxic material exposure, and uses safe, biodegradable materials as alternatives to hazardous materials (ECP 2007, 6). Interventions to improve housing are essential to advancing children's health (Chaudhuri 2004, 220). Preventative measures are a simple and effective solution to the problems caused by indoor air, and should be the prime focus in any asthma or allergy management program (Chaudhuri 2004, 220). To facilitate prevention, governments need to set and enforce home building standards regarding indoor air quality (Jones 1998, 761). Reducing exposure to negative health triggers is essential to reducing economic disparities in hospitalizations, emergency room visits, and missed school days due to asthma (Spielman et al 2006, 102). General improvements in living conditions and life opportunities are the only ways to ensure long-term health improvements (Gold & Wright 2005). Samet and Spengler (2003, 1492) postulate if achieving a healthy indoor environment were a specific requirement for buildings, many of the recurring problems of mold, pest allergens, radon, organic compounds, nitrogen dioxide and carbon monoxide could be controlled. 38 For less than a five percent increase in construction costs, affordable housing developers can make buildings that are healthier to live in, have better indoor air quality, have less toxics and pesticides, increase comfort, and reduce noise pollution (Connelly 2006). "Community based interventions that target elements of the built environment, such as poor housing conditions, have great potential to address the negative health effects caused by the building environment" (Spielman et al 2006, 107). As discussed earlier, Energy Star18 results in increased comfort, even temperatures throughout the house, eliminates drafts, and improves indoor air quality. In addition, Energy Star increases durability, and eliminates water and mold problems by controlling moisture (Doxley 2006). Energy Star bathroom fans exhausted to outside with a humidistat sensor or timer reduce moisture condensation, decreasing the likelihood for indoor mold growth, which studies have found yield odors and pose health hazards. In addition, these fans remove carbon monoxide and carbon dioxide. Energy Star fans use 65 percent less energy on average than standard models and move more air per unit of energy used with less noise19. Beyond Energy Star equipment, material selection can have a significant affect on indoor air quality. Affordable housing should use non-vinyl, non-carpet floor coverings in all rooms, such as natural linoleum, laminate, ceramic tile, bamboo, cork, wood or rubber (ECP 2007, 45). (LaRue 2006) (Stromberg 2005, 21). In addition, using paints with little or no volatile organic Compounds improves indoor air quality (LaRue 2006; Magnelli & Sloss 2006; Stromberg 2005, 21). The Green premiums for such actions are little or even zero cost in some cases. Formaldehyde free carpet and cabinets, and low VOC paint do not carry additional costs. 18 See Note 6. 19 See ECP 2007, 37; LaRue 2006; Magnelli & Sloss 2006; Global Green 2006, 71; NAHB 2006, 107. 39 Microwave and stove vents carry an $80 premium, Energy Star bath fans cost approximately $90, and HVAC zone heating and cooling approximately $600 (Magnelli & Sloss 2006). Allergens and Volatile Organic Compounds are two significant areas of indoor air quality that must be addressed in an effective Green building program.

Figure 15- Potential hazards due to indoor pollution (source: www.awdesign.in)

7.7 Allergens

Over the past several decades, researchers have identified numerous indoor allergens that exacerbate and cause allergic diseases (Samet & Spengler 2003, 1491). Various indoor initiants, such ashouse dust mites, molds, fungal spores, and nitrogen dioxide from poorly vented gascooking, are associated with asthma (Hasselblad et al 1992). Currently, insurance companies are attempting to write policies excluding mold liability or simply refusing to provide coverage in states where mold claims are widespread (Samet & Spengler 2003, 1492). Their reluctance to provide service stems from high costs associated with health expenses from mold exposure, particularly the toxic varieties. Molds thrive in warm and humid areas with low sunlight exposure. Like mold, dust mites thrive in soft furnishings, particularly in warm and humid rooms (Jones 1998, 755). The relationship between molds and dust mites means that, as well as being a risk factor for allergic sensitization, molds are a risk for increased house dust-mite concentrations (Luczynska 1994). Platts-Mills (1997) estimates exposure to mite allergen may trigger attacks in up to 85 percent of asthmatics. Resident exposure to mite allergen, especially infants, may induce the onset of asthma itself (Call et al 1992, 865). Similar to dust mites, cockroaches have been associated with the manifestation of symptoms in individuals with allergic asthma and up to 60 percent of asthmatics test positive to 40 cockroach allergen (Kuster 1996). Rosenstreich (1997) measured concentrations of the allergen in dust taken from 476 homes situated in various inner-city locations in the USA. He concluded the problems of cockroach sensitization might be particularly severe amongst the residents of poor quality inner-city housing, as these homes provide an ideal environment in which cockroaches and other allergens thrive. Sensitization to indoor allergens is strongly associated with the development of asthma. Given the evidence that exposure to allergens in infancy may cause asthma, indoor allergen avoidance is the most effective strategy for prevention (Jones 1998, 759). Recent clinical trials have shown that simple avoidance measures are effective in reducing asthma morbidity (Jones 1998, 761). Similarly, recent evidence indicates altering the home environment may decrease exposure to indoor allergens, reducing symptoms of atopic asthma in urban children (Morgan et al 2004). Carpet attracts allergens, so removal of carpet and replacement with sealed flooring, such as ceramic tile, wood and laminate, is an effective means to reduce allergic symptoms (ECP 2007, 35; Jones 1998, 759). The most effective treatment for mite populations, however, is a decrease in overall levels of air humidity (Jones 1998, 760; Global Green 2006, 60). Sizing heating, ventilation and air conditioning systems in accordance with Air Conditioning Contractors of America Manuals D, J and S20 prevents short cycling and ensures adequate dehumidification. This ensures proper sizing of the cooling system, accounting for orientation, window design and insulation rating, and can result in reduced costs for mechanical equipment21. While considered a type of allergen in some cases,volatile organic compounds have many other attributes that warrant further exploration.

Figure 16- Tips to make a home allergy proof. (source: www.inhabitat.com)

7.8 Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are chemicals containing carbon molecules volatile enough to evaporate from material surfaces into indoor air at normal temperatures. VOCs may pose health hazards to residents and workers, reacting with sunlight and nitrogen to form groundlevel Ozone, which damages ecosystems and lung tissue, reducing lung function and sensitizes the lungs to other irritants (ECP 2007, 34; NAHB 2006, 3). Indoor pollution sources are generally a far more significant contributor to total personal exposures to toxic VOCs than are releases by some industrial sources into outdoor air (Wallace 1987). The elderly, those with weak immune systems, and young children are most prone to the effects of VOCs (Global Green 2006, 71). Common sources of VOCs include solvents, floor adhesives, particle-board, wood stain, paint, cleaning products, polishes, and room fresheners. Levels of most VOCs can be five to ten times higher indoors than outdoors (Samet 1990; Global Green 2006, 71; USGBC 2007, 4). High concentrations of VOCs and formaldehyde have been associated with asthma, as well as asthmatic breathlessness (Wieslander et al 1997). Particle- and fiber-board often emit formaldehyde, a VOC that can cause watery eyes, nausea, coughing, chest tightness, wheezing, skin rashes, allergic reactions and burning sensations in the eyes, nose and throat. The World Health Organization International Agency for Research on Cancer lists formaldehyde as a known carcinogen because evidence indicates it causes nasopharyngeal cancer in humans (ECP 2007, 35; Wells 2006). Dioxin is increased through manufacturing of many building materials, leading to increased rates of cancer (Wells 2006). A better indoor environment may be achieved by selecting building construction, building materials, and indoor fittings on the principle that the emission of pollutants such as VOCs and formaldehyde should be as low as reasonably achievable. The use of insulation materials that emit formaldehyde should be avoided (Jones 1998, 761; Global Green 2006, 71). In addition to providing a haven for allergens, carpet often emits a variety of VOCs (ECP 2007, 35; Wells 2006). As discussed earlier, the premium to install low- or no-VOC materials and paint is often zero. There are several third-party verifiers available to assist with selecting low- or noVOC materials, including the Carpet and Rug Institute’s Green Label program, and the Green Seal program for paint. Community Development Corporations often use low- and no-VOC construction materials, paint, adhesives, caulk and cabinets, and no carpet (Rather 2006, 31-55). Though construction methods have a significant role in Green building, many Green building goals can be achieved through site selection, design and landscaping.

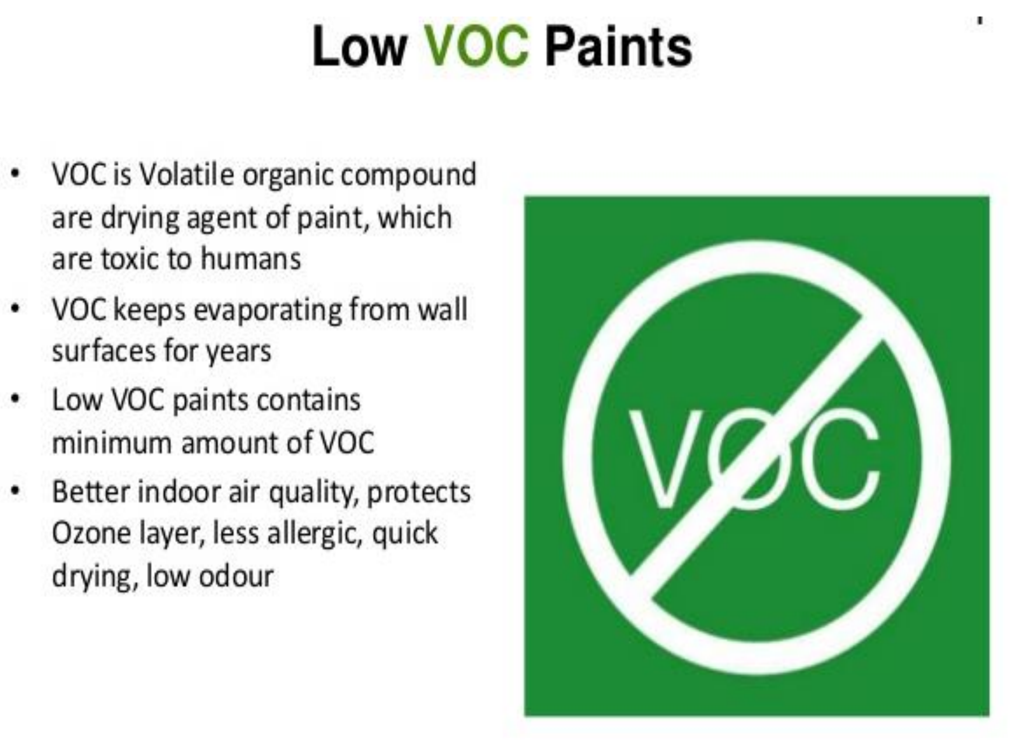

Figure 17- Volatile organic compound. (source : www.iaeme.com)

7.9 Site Selection, Site Design, and Landscape Ecology

Research suggests site selection, site design, and landscape ecology are necessary components of Green building and thus warrant inclusion in the model. Sustainable design and site planning minimize environmental site impacts, enhance human health, reduce construction costs, maximize energy, augment water and natural resource conservation, improve operational efficiencies, and promote alternative transportation (ECP 2007, 5). Placing homes near community amenities, such as public transportation, to create walkable neighborhoods, results in stronger communities and more opportunities fore residents while reducing sprawl-related 43 transportation impacts (ECP 2007, 4). For less than a 5 percent increase in initial costs, affordable housing providers can make buildings that have easier to maintain landscapes with more amenities, while infiltrating storm-water, often reducing costs. (Connelly 2006). Each of the following sections discusses a particular aspect of site selection, site design and landscape ecology for inclusion in the model.

CHAPTER 8: TECHNOLOGY USED- THE USE OF GREEN BUILDING INFORMATION MODELLING FOR SUSTAINABLE AND GREEN BUILDINGS.

8.1 Building information modeling (BIM)

It is a process supported by various tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of places. It is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure. **Building Information Modelling** is a process for creating and managing **i**nformation on a construction project across the project lifecycle. One of the key outputs of this process is the **Building Information Model**, the digital description of every aspect of the built asset.

8.2 Green BIM Technology

Green BIM technology is defined as a method of using BIM based sustainability tools, to achieve green objectives and improve sustainable outcomes of a green building development. Green BIM is a model-based development of generating and managing coordinated and consistent building data over the lifecycle, which helps to accomplish the desired sustainability goals. Green BIM has been incorporated with sustainable design methods which are used to examine the impacts of green buildings, with all necessary aspects including lighting, energy efficiency, sustainability of materials and other building performance parameters.

8.3 Green BIM Techniques

BIM software/tools are typically involved in designing the basic BIM model of the building. The developed model is then exported into BIM simulation tools to perform the Green BIM techniques . The Green BIM techniques includes energy/thermal analysis, heating, ventilation and air conditioning analysis (HVAC), lighting/shading analysis, acoustic and value/cost analysis . The techniques available in Green BIM technology are presented in **Table 01**, as identified from the prevailing the literature. Features were not separately identified for some techniques in below table including value and cost analysis, acoustic analysis, water harvesting, space simulation and system simulation.

Green BIM Techniques/ Simulations	Features	Outcomes
• **Energy and Thermal Analyses**	• Energy Usage • Carbon Emissions • Resource Management • Thermal Analysis • Heating/Cooling Loads • Ventilation and Air Flow • Heat loss calculations • Simulation of indirect environmental effects such as atmospheric pollutants associated with building energy use	• Energy use intensity • Renewable energy potential • Annual carbon emissions • Annual energy cost and consumption • Building heating and cooling loads • Breakdowns of energy use for major electric and gas components such as HVAC and lighting • Energy end use charts
• **Lighting and Shading Analysis**	• Solar Analysis • Day lighting Assessment • Shading Design Analysis • Lighting Design Analysis • LEED Daylight credit 8.1 • Radiance analysis	• Calculations of solar energy absorption • Glare and discomfort spaces • Spaces where solar directly enters • Cooling and heating energy consumption • Solar orientations for the building
• **Value and Cost Analyses**		• Life Cycle Assessment • Life Cycle Cost
• **Acoustic Analysis**		• Noise dispersion and its effect inside the building
• **Water Harvesting**		• Monthly non- potable water usage • Monthly potable water usage • Monthly water savings • Total water reuse potential • Building water demand • Rain water capture from the roof
• **Space Simulation**		• Comparisons of alternative indoor air quality levels • Comparisons of alternative windows and shades • Dimensioning of air conditioning equipment • Analysis of temperature problems of the building
• **System Simulation**		• Comparisons of alternative HVAC systems • Optimization of zones for AHUs • Dimensioning of cooling equipment based on actual cooling loads

Geometry Data	Simulation Data
Floor Plan details	Number of occupants
Doors and Windows details	Number of days of occupancy per month
Specification Details (Azhar et al. 2010)	Number of hours of a working day
Elevation Details	HVAC system types, efficiencies and operating schedules
Roof Plan details	Hot water system types, efficiencies and operating schedules
Sectional Drawings	Lighting types, efficiencies and operating schedules
Foundation Details	Utility rates, Sound sources
Beams and Columns Details	Types of fixtures, Types of equipment
	Fixture count, Number of equipment
	Indoor temperatures, Number of occupants
	Types of materials
	Volume of materials
	Cost of capital of the building
	Costs of operation & maintenance & NPV indicators

FIGURE 18: Green BIM techniques and features

8.4 Research Method

A comprehensive literature review was conducted first to identify the data required for the Green BIM. Subsequently, a questionnaire was developed including the data gathered from the literature. The questions formed in the questionnaire was to mention the available data and non-available data from the given data list which is identified from literature. Questionnaire survey was conducted focusing the existing green buildings which have been accredited LEED rating system. The sample for the questionnaire survey was selected using convenience sampling method. The survey should be conducted on existing green buildings certified under the categories of LEED certification including new construction and renovation, building core and shell development, design of commercial interiors and operation and maintenance of existing buildings. The findings of the questionnaire survey revealed the available and non-available data in each green building. Accordingly, the level of data availability was established with percentages for each case separately. Finally, a single case study was conducted which involved the practical implementation of Green BIM technology for a selected green building. Accordingly, case study is carried out for the case with the highest data availability, among the surveyed green buildings. The highest data availability was selected as it presents the maximum number of available data and facilitates the implementation of Green BIM. The reason to analyse the data availability was, as the use of Green BIM is mainly depended on the availability of required Green BIM data. In the case study, two main steps were included as model creation and simulation. The model creation was carried out using the Autodesk Revit 2017 BIM designing software and simulation was done using web based Autodesk Green Building Studio. Only the energy simulation was performed for the selected case using the software.

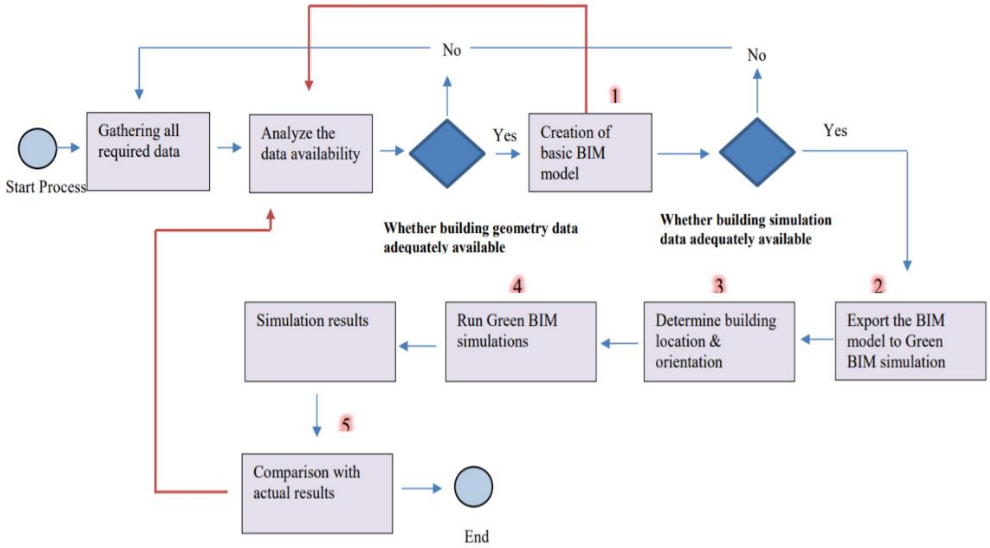

Figure 19- Framework of Green BIM implementation (source: www.griha.com)

According to the framework, the required data are gathered first and secondly, the data availability is analyzed through the creation of building model in BIM and running Green BIM techniques using the model. The availability of building geometry data is analyzed by the process of creating the basic BIM model of the building. The availability of building simulation data is also analyzed while conducting the simulations by exporting the BIM model to a Green BIM simulation software and comparing the analysis results with actual results of the building. The comparison was limited to few of available actual results, since all the analysis results coming from the software, were not actually available. Such comparison was focused to analyze the availability of simulation data up to a certain level, for further clarification of data availability. Within these two processes, any deviations of available data would be recognized. These two steps are reconnected to the start as shown by red highlighted arrows. For simulations, the location and orientation of the building should be specified using the map given in the simulation software, after exporting the BIM model and before running the simulations. It is important to ensure that the directions of solar path over the building is corrected and weather data are properly specified, which directly affect to the simulation results such as energy analysis and day lighting analysis.

8.5 Application of Green BIM Techniques in the Case Study

Step 01 – Creation of the Building Model in BIM

Using Autodesk Revit BIM software, the BIM model of the selected case was created first as shown in the figure 02. In the process of creating the model, it was identified that there was a difference between CAD drawing and the paper drawing of the building

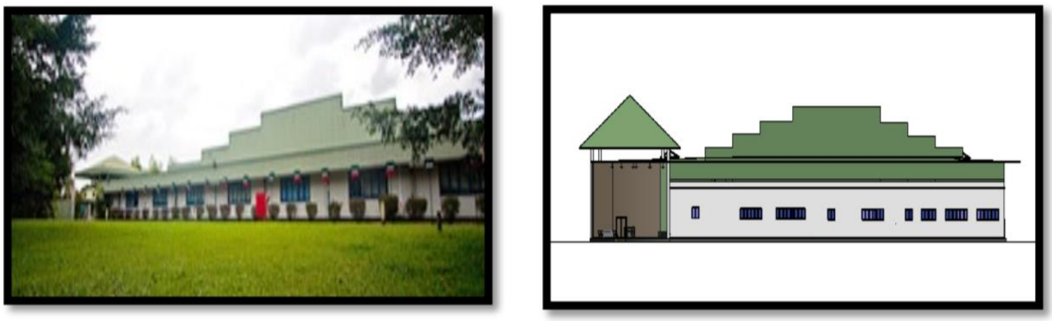

Figure 20- Actual building and created BIM model(source: www.sangathipl.com)

Step 02 – Exporting Model to the Simulation Software

After creating the model, it was exported to the Autodesk Green Building Studio from Revit, which is a BIM based simulation software. The model was exported through the gbxml data transferring format as the interoperability standard between Revit and GBS. After exporting the model to the simulation software, basic parameters were specified including building type, location, project phase, building envelope, ground plane and export category which are important for simulation.

Step 03 – Determination of the Geographical Location

As the third step, location data were included to the software for the energy simulations. In this step, different types of contextual information were included to simulate the energy analysis, such as geographic location, site location and related information including weather data for a typical year. Once the location data included, information of the building location including latitude and longitude, altitude, city and state and time zone were obtained. The importance of location selection is to set the related climatic conditions and other related weather data, which affect to the building energy performance. After building location is selected, simulation data were entered to the GBS software which were identified previously. Simulation data included HVAC system types and efficiencies, building occupancy, lighting types and efficiencies and indoor temperatures.

Step 04 – Running Energy Simulations

Once the required simulation data were entered, the gbxml file of the building model, which transfer the building data to GBS was uploaded to the GBS software to run the energy simulations. The resulted energy simulation information are discussed in this section.

CHAPTER 9: CONCLUSION

If trees are cut off to clear up the plot for building construction, the same number of trees are to be planted elsewhere. Only this mentality of mankind can save the Earth from destruction. The condition of our planet at present is alarming. The anthropogenic activities mainly lead to such a condition. Scientists are keep on working for invention of technologies which have less or no negative impact on Earth. The researchers state that building construction is one of the main causes of environmental degradation. They are responsible for a huge amount of harmful emissions, accounting for about 30 percent of greenhouse gases, due to their operation, and an additional 18 percent induced indirectly by material, exploitation and transportation [5]. Globally, buildings are responsible for nearly 40 percent of energy use (including 60 percent of electricity use), 40 percent of waste generated (by volume), and 40 percent of material resource use. In cities, buildings occupy 50 percent or more of land area [25].Buildings are responsible for not just a large percentage of the world‘s water use, but a large percentage of wasted water as well. In order to mitigate the effect of buildings along their life cycle, Green Building (GB) has become a new building philosophy, which uses more environmentally friendly materials, implements strategies to save resources and energy, lowers waste generation, improves indoor environmental quality, reduces harmful gas emissions etc. This might lead to environmental, financial, economic, and social benefits [5]. For instance, savings in operation and maintenance costs in GBs can be realized through the installation of high-efficiency illumination and insulation systems or through a suitable material. The characteristics of green buildings are energy-efficient, resource efficient and environmentally responsible. The primary concern is to protect our planet with the aim of creating a better and healthier environment for people. The results of this research indicated that various authors pointed out that green buildings may be more costly at the outset, but they contribute to long-term savings. This was confirmed by the majority of the survey respondents who stated that green building materials are more durable than conventional materials, resulting in cost savings.

It is therefore recommended that:

1. Contractors familiarise themselves better with green materials;
2. Professionals gain more experience in green-building concepts;

3.Tertiary institutions or other service providers provide green building training opportunities for all built-environment stakeholders, and that

4. Built-environment stakeholders familiarise themselves with the Building Sustainability Index (BASIX) introduced by the government of New South Wales, Australia, to regulate the energy efficiency of new buildings. It offers an online assessment tool for rating the expected performance of residential developments in terms of water efficiency, thermal comfort and energy usage. Furthermore, professionals and contractors should consider implementing the Sustainable

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