“MODELLING & ANALYSIS OF GREEN HOME IN JAYPEE UNIVERSITY OF INFORMATION AND TECHNOLOGY”

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173 234

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"MODELLING & ANALYSIS OF GREEN HOME IN JAYPEE UNIVERSITY OF INFORMATION AND TECHNOLOGY"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Akshay Kumar** (131626)**, Lekzen Wangmo** (131670) and **Ishan Pal** (131650) during a period from August 2016 to May 2017 under the supervision of **Dr. Rajiv Ganguly,** Associate Professor and **Mr.Santu Kar,** Assistant Professor Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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ABSTRACT

The green building practices has recently taken a central role in the construction industry, alleviate the environmental impact of conventional buildings. Components like higher energy prices, higher cost of building materials and regulatory incentives are also contributing green building market to expand and grow. Countries like India with rising population, increasing living standards and rapid urbanization results give rise to building construction activities. Different regions demands different way of construction owing to its weather and geographical conditions. In this study the research was done in Waknaghat, Himachal Pradesh by modeling and analyzing a 3BHK green home which explores a various architectural and building technologies with suitable materials that are employed to achieve a low energy built environment with a detailed analysis using Revit software and cost calculation is also done to show extra cost required to construct green home. The objective is to achieve desired comfort by supplying minimum conventional energy. Architects and designers gets the task done through solar passive design, use of renewable energy technology systems and natural materials. Whilst designing such structure, new building stock can be built but also retrofitting can be done to existing building with energy efficient and eco-friendly technologies thereby substantially minimizing energy consumption which will give us a whole new structure, namely energy efficient housing.

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CHAPTER 1: INTRODUCTION

1.1 Green Building

Green building is an art of building structures using efficient techniques which are not only environmentally responsible but also resource efficient throughout the buildings life starting from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice not only grows but also supplements the normal building design regarding the utility, economy, durability and comfort. Green buildings have tremendous benefits, both tangible and intangible. The most tangible benefits are the reduction in energy and water consumption right from occupancy. Intangible benefits includes excellent day lighting, better indoor air quality, health and wellbeing of occupants and conservation of scarce natural resources.

1.2 Need for Study

A lot of building processes and users give out huge amount of wastes, which can either be recycled or reused. Thus one of the major pollutants are buildings which contributes to urban air quality and give rise to climate change (activities of building produces approximately 50% of the world's air pollution, 42% greenhouse gases, 50% of all water pollution, 48% of all solid wastes and 50% of all CFCs (chlorofluorocarbons) to the environment). Hence, need to design a green building and address all these issues in an integrated and scientific manner is very important. Clearly it is fact that it costs more to design and construct a green building than to conventional ones. On the contrary, it is a proved that it costs less to maintain green building and gives better place for the users to live and work in long run. Thus, green building's challenge is to attain all its benefits at affordable cost.

The green building aims to decrease the need nonrenewable resources, increase efficiencies of these resources when in use and increase the reuse, recycling, and utilization of renewable resources. Also increases the use of materials and construction by optimizing the use of onsite sources and uses less energy to power itself and efficient equipment for lighting, air conditioning, and other needs. It improves the energy of renewable sources, uses efficient waste and water management and gives hygienic and comfortable working conditions. It is developed through a design process which needs various input like the architect, landscape designer and the air conditioning, electrical, plumbing, and energy efficiency use. India, with rising population, increasing standards of living and rapid urbanization results in an increase in building construction activities. Thus designing and constructing a green building would be a stepping stone to the newer and better building technique which aims in achieving the needed comfort without much input of conventional energy.

1.3 Objective

- To study about the features of green building
- To model the Green home and Traditional home in Revit software.
- To do energy and cost analysis of both homes and compare them..
- Determine payback period

1.4 Scope of the Project

The scope of project is to d model the both green home and traditional home and show the differences between them in cold climatic condition. Energy analysis is done both manually as well as with the help of software to show efficiency of green home. Cost of construction is compared for both the homes and analysis is done manually to determine the payback period.

1.5 Significance

Most of the people are devoid of the knowledge that their residential buildings and offices could be harming environment. Without realization the buildings are emitting harmful pollutants. But by switching to sustainable practices of green buildings in India, not only environmental purpose, but for ourselves and for generations to come then we could not only reduce the pollutants but also reduce our total costs of ownership.

Industry of building construction contributes the second largest demolition waste and greenhouse gases (35%-40%) to environment but the green buildings generates lower pollution during construction and while in use and it is achieved mainly with careful practices such as proper storage of construction materials, during construction barricading the site to prevent air and noise pollution, clean storage and disposal of waste during construction and operation ensures less effect on the surrounding environment. Major energy usage in buildings is during the construction stage, in lighting and air-conditioning systems. Other features like lighting, water heating, air condition provides comfortability to occupants but consumes a massive amount of energy which increases the pollution. And also the occupants generates a massive amount of water and solid waste.

Green buildings built sustainably are environmentally responsible and resource efficient from the location selection to demolition after its lifecycle ends by using low energy, water and other natural resources and thrives to create less waste and minimize greenhouse gases leading to healthy surroundings for users as compared to conventional structure. TERI estimates, If all buildings were made to implement green building concepts, India could easily save more than 8,400 megawatts of power, which is just enough to light 550,000 homes a year.

Green buildings consume 40% - 60% lesser electricity as compared to normal buildings owing to passive design interventions while building and high efficiency materials and technologies in the engineering design of the building. It works towards onsite generation of energy via usage of renewable energy to fulfill its needs. Like, the normal electrical geyser in buildings can be replaced by solar thermal systems. Solar panels helps generate electricity which will minimize the buildings dependence on grid power. Compared to conventional building, green building absorbs 40 -80% lesser water. Also it generates lesser waste by adopting waste management strategies on site. Thus, it’s safe to say green buildings provides safety, health and sanitation for laborers and as well as the occupants. Green buildings avoids using high ozone depleting potential substances in their systems and during finishing. Green buildings offers greater marketability and image.

1.6 Five Principles of Sustainable Design

1. **Optimization of the utilization of the sun:** For the purpose of heating as well as cooling the homes mostly the people depend upon oil, natural gas, coal, as well as some other fossil fuels. All of these resources in spite of being pollutant and too much expensive, they also are being very quickly depleted. Therefore, a totally cost effective and a very simple option is plugging your home into the rays of the sun through either an active or maybe some passive techniques. The active strategies include using large solar panels that are capable of turning the heat of the sun into the energy whereas on the other hand the passive strategies mean that you are required to do some of the following things. That are design as well as orient the corresponding house to reduce or lessen the summer afternoon solar heat gain as well as maximize or increase the solar winter heating gain. Therefore, in the northern side of hemisphere which means directing the long sides of the home site to face southern and northern side as well as creating roof overhangs as well as landscaping which shade the west, east, and south sides of the home. Find the home to take the

advantage of ongoing breezes during the spring, fall, and summer. These kind of breezes that are not only precious for cross window ventilation in the home. In fact, they can also make screened in porches and rooms much more comfortable areas to live. Shrubs and shady trees around the user’s home. In the season of summers, well located foliage helps to maintain the house cool, whereas the bare branches in the season of winters let the sunlight pass via hence warming up the house.

2. **Improving the indoor air quality:** Up to as much as 90% of the average people spend most of their time in doors while quality of air maybe much more polluted than outdoors. Ranging from toxins which include formaldehyde and asbestos found in the building materials to allergens which include fungus, mild, dust mites as well as bacteria. The negative after-effects of these pollutants tend to cause the health problems on exposing initial or maybe even a lot of many years later. Therefore, there are a lot of measures that may be taken in order to improve indoor air quality index- Opt for the new ventilation systems that are able to remove dirt, dust, moisture, humidity, and pollutants. Seal garage from the home to pass away fumes from lawn mowers as well as cars. Selected materials including such as those without formaldehyde that restrict no toxic properties gassing, or minimal and don’t shed dust or fibre.

3. **Utilizing the land accountably:** By creating the good utilization of the land where your home resides as well as also by keeping this in mind that regarding the after effect of the home on the nearby environment and nature, users can also evolve a sustainable home. While finding to purchase a new house, one requires to keep in mind the advantages as follows- Purchase a more compact, smaller home on much which is placed near community services, public transportation, as well as work to save money and fuel. Choose a neighbourhood where homes are close clustered together, leaving much open space for the respective residents to help preserve and enjoy the natural landscape. Choose for intelligent gardening practices such as those like using organic pesticides composts, and native plants which don’t require irrigation systems that are very extensive. Inspite of paved surfaces, one may utilize landscaping that impedes infiltration of storm water,that generally results in the contamination of water sources that are mostly local.

4. **Build moisture resistant and high performance homes:** The roof, walls, doors and windows, of a home are creating an envelope that not only protects residents from the

intruders and weather which include dirt, noise and pests. It is also bound to control the entry of the sunlight and more importantly it even helps maintaining the indoor comfort. While trying to evolve a constant level of comfort that can be a wasteful and an expensive however, it can also be done much more efficiently as well as economically by the means as follows – first create a building envelope with an even more energy efficient materials as well also the durability which decreases control moisture, drafts, room temperatures, balance as well as also saves cooling and heating costs. Seal off all, any and every cracks or gaps where the moisture may get in as well as cooling or heat may leak out.

5. **Intelligently utilizing the earth's natural resources:** That is a fact that the earth gives us with a definite amount of natural resources only so it is our duty to make them last as well. We are also required to keep in our minds that the utilization of these resources are not fatal to environment as well as health. Meanwhile choosing the materials and products to utilize in house search for the ones having - high durability, renewability, and reusability as well as lower energy required or energy to transport, extract have lethal effects or environmental impact to indoor and outdoor environments.

1.7 Approach

Approach to completion of project will be followed in series of project which is explained in figure below. After modelling the homes in Revit, energy analysis will be done both manually as well as with the help of software to show efficiency of green home when compared with traditional home.

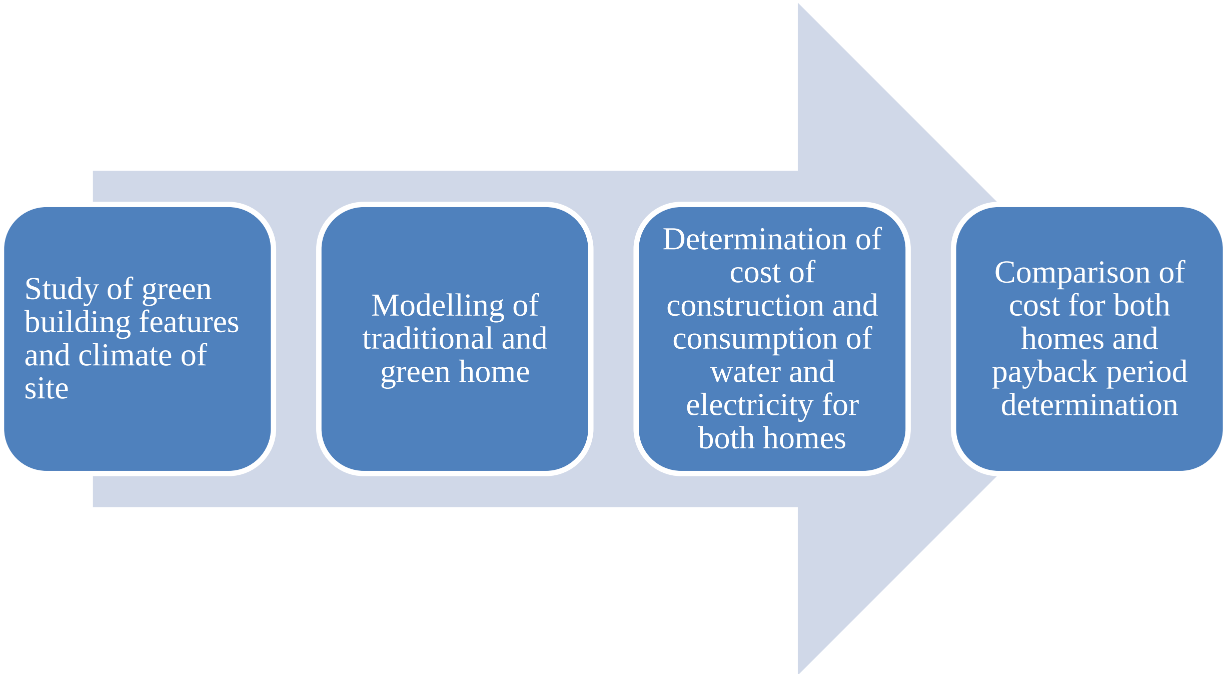


Fig 1.1 approach for project

CHAPTER 2: LITERATURE REVIEW

2.1 Climate of India

India is distinguished by a hot tropical climate. Between November to mid of March falls the winter and likewise from April to June is summer. Although northern parts remains dusty, unpleasant and dry during the summer. Monsoon is between mid of July to September and its nature being unpredictable where some parts experiences heavy rain, others experiences drought while others getting floods.

Climatic zones and their characteristics

The regions which have same characteristic of climate components are clubbed under one zone of climate. Bansal et al. did comprehensive research and found out that six climatic zones can be carried out for India namely hot and dry, warm and humid, moderate, cold and cloudy, cold and sunny, and lastly composite. Classification are shown in Table 2.1 showing climatic zones. Region is allotted to one of five climatic zones only when defined conditions exists there for more than six months. Bureau of Indian Standards (BIS) the country may be split in five major climatic zones. Table 2.1 presents it and Fig. 2.1 depicts the map of india in respective climatic classification. After comparing both the classification, there are only few differences, one which includes cold and sunny climate and other name of moderate climate is changed to temperate climate.

From Fig 2.1, we can see that cold weather is experienced in northern region of India and while central India experiences composite climate. In southern and eastern part of India, warm and humid climate is there and hot climate is found in north western region.

Table 2.1 classification of the climates

Criteria of Bansal et al. [1]			Criteria of SP 7: 2005 [9]		
Climate	**Mean monthly temperature (°C)**	**Relative humidity (%)**	**Climate**	**Mean monthly maximum temperature(°C)**	**Relative humidity (%)**
Hot and dry	>30	<55	Hot and dry	>30	<55
Warm and humid	>30	>55	Warm and humid	>30 >25	>55 >75
Moderate	25-30	<75	Temperate	25-30	<75
Cold and cloudy	<25	>55	Cold	<25	All values
Cold and sunny	<25	<55			
Composite	This applies, when six months or more do not fall within any of the above categories		Composite	This applies, when six months or more do not fall within any of the above categories	

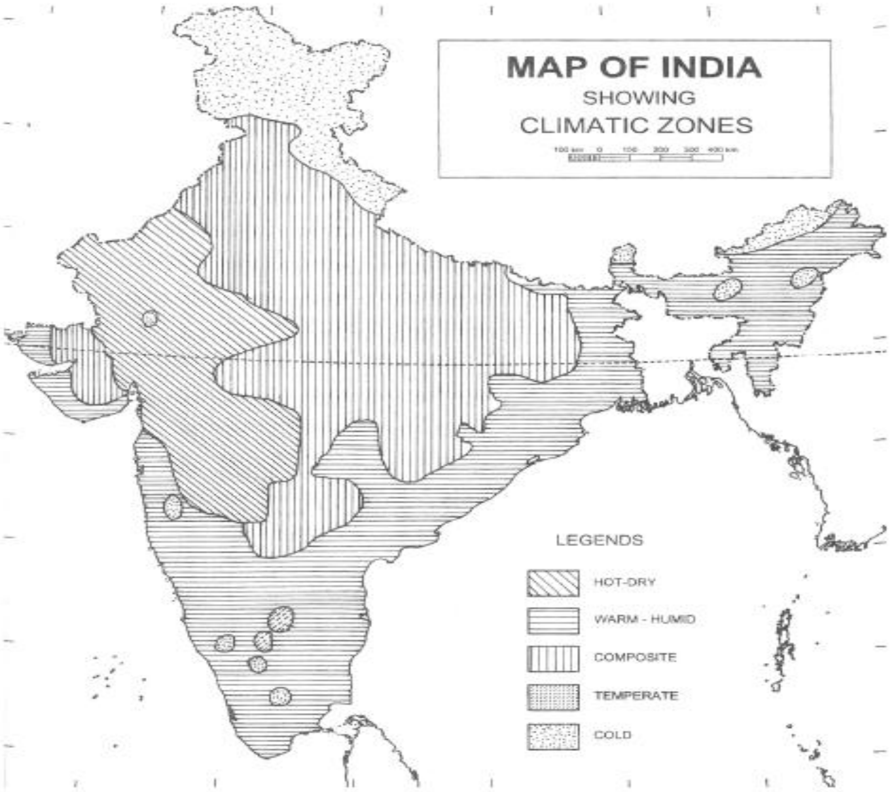


Fig. 2.1 climate zones of India

2.2 Sun Path In Northern Hemisphere (Nayak et al . , 2006)

During summer season, the days are longer and sun is high in sky. The fig 2.2 depicts path of sun in sky during longest day of year known as summer solstice (June 21). Also the day when sun is highest in southern sky. Day is so long that sun doesn't rise exactly in east rather rises to the north of east and sets to north of west allowing it to be in sky for a long time.

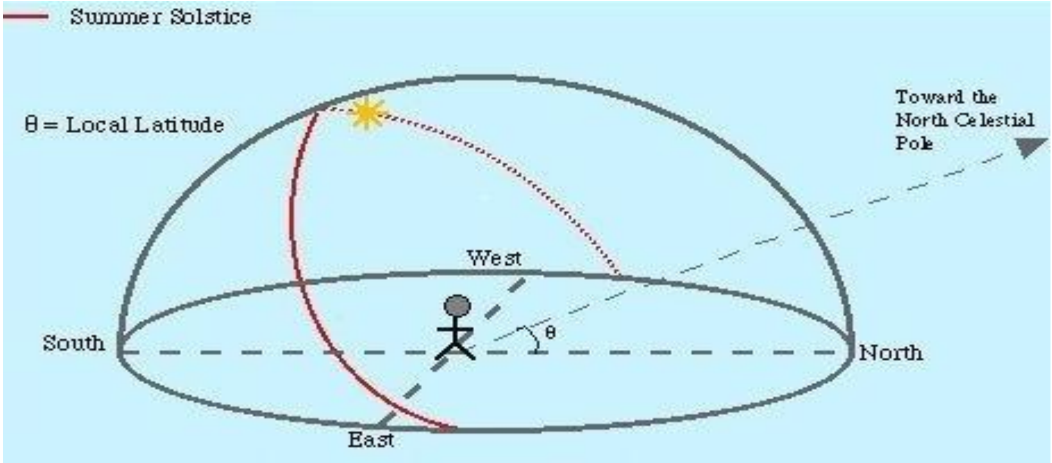


Fig. 2.2 path of sun in summer

After summer solstice the Sun follows lower path every day till it reaches to the stage where it is in sky for exactly twelve hours known as fall equinox (September 21st). Fig 2.3 shows it. Sun in spring equinox will rise at east and sets in west and everywhere in world will experience 12 hour a day. After fall equinox sun will continue to follow a lower path and days will get shorter till it reaches its lowest path and then back to winter solstice.

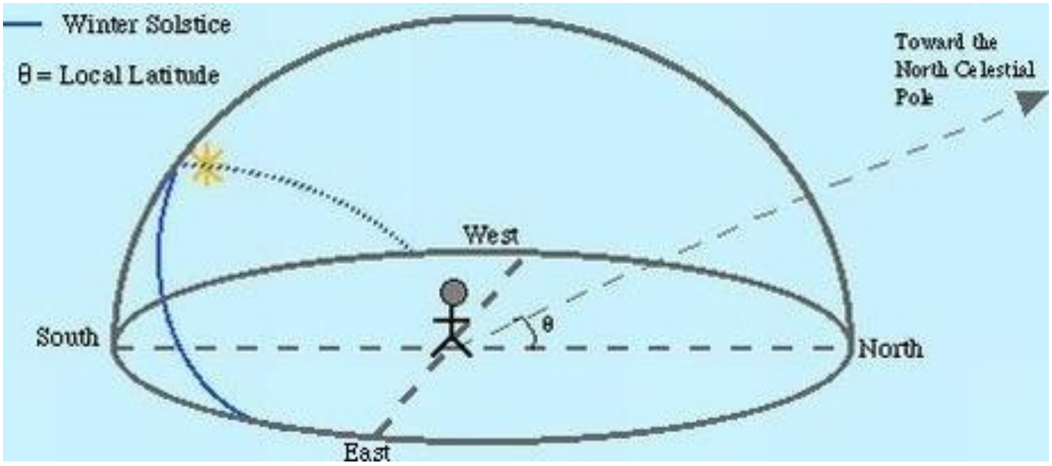


Fig. 2.3 path of sun winter

2. 3 Solar Passive Housing Technology For Hilly Regions

Large energy usage in building sector is of major issue today. In hilly areas, building design practices give a very little consideration to climatic conditions. It results in uncomfortable living situations during winters. Therefore it requires large quantity of fuel wood, fossil fuels and electricity for space heating. The State of Himachal Pradesh in the Western Himalayas, extends from snow covered Himalayan Mountains separating Tibet in the North to the plains of Punjab in the Southland West. The State with a geographical area of 55673 km^2 is located between latitude 30^{o} 22' 40" to 33^{o} 12' 40" North and longitude 75^{o} 45' 55" to 79^{o} 4' 20" East. The altitude ranging from 250m in the foothills and up to 6,975m above mean sea level in the high hills. Due to unique topography, it experiences severe winters. In Himachal Pradesh, the climate ranges from subtropical to alpine desert. Areas above 2000m receives moderate snowfall whereas alpine zone remains under snow for half time in a year. Thus, space heating of building is of major concern. The government buildings require central electricity or fossil fuel heating systems to create comfortable indoor living conditions. In residential areas, private sectors, shopping complexes, industrial units, hotels and houses consume large amount of energy like char coal, LPG, coal, wood, for space heating in winters or cooling in summers as these are not designed without any consideration to climatic conditions.

Solar passive housing is one of the best and proven technology which is suitable for climatic conditions of HP. It provides comfortable living conditions besides saving 50 - 60% of energy required for winter space heating. The cost effective discovery designs as per climatic requirements have not been followed by the rural communities in the absence of proper demonstration of these technologies. While designing the building according to solar passive technology, costs of the central oil, wood, electric, and fired heating in urban areas can be drastically reduced.

The advantage of this technology involves the reduction of greenhouse gas emissions which protect family members from indoor smoke pollution and providing them with healthy living environment.

With about 250 days of Sunshine per year, Himachal Pradesh has an ideal climate for solar passive heating.

2.4 Location's Weather Data

(Source : www. meteoblue.com, 6:00 pm, 24th November, 2016)

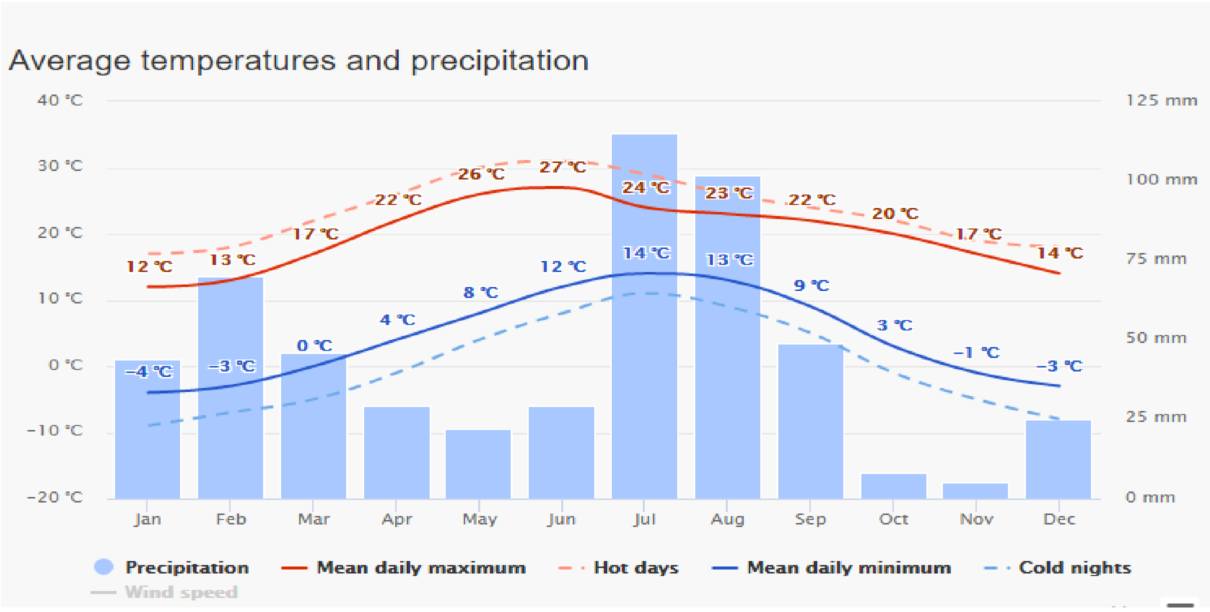


Fig 2.4 average temperature and precipitation

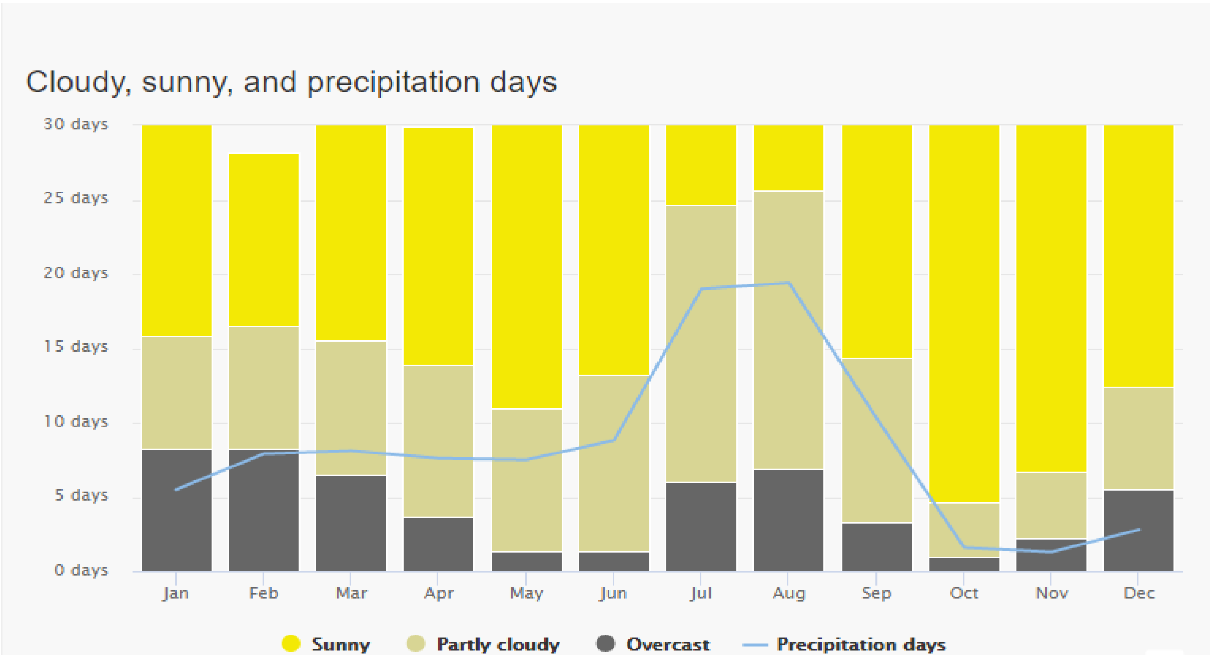


Fig 2.5 cloudy, sunny and precipitation days

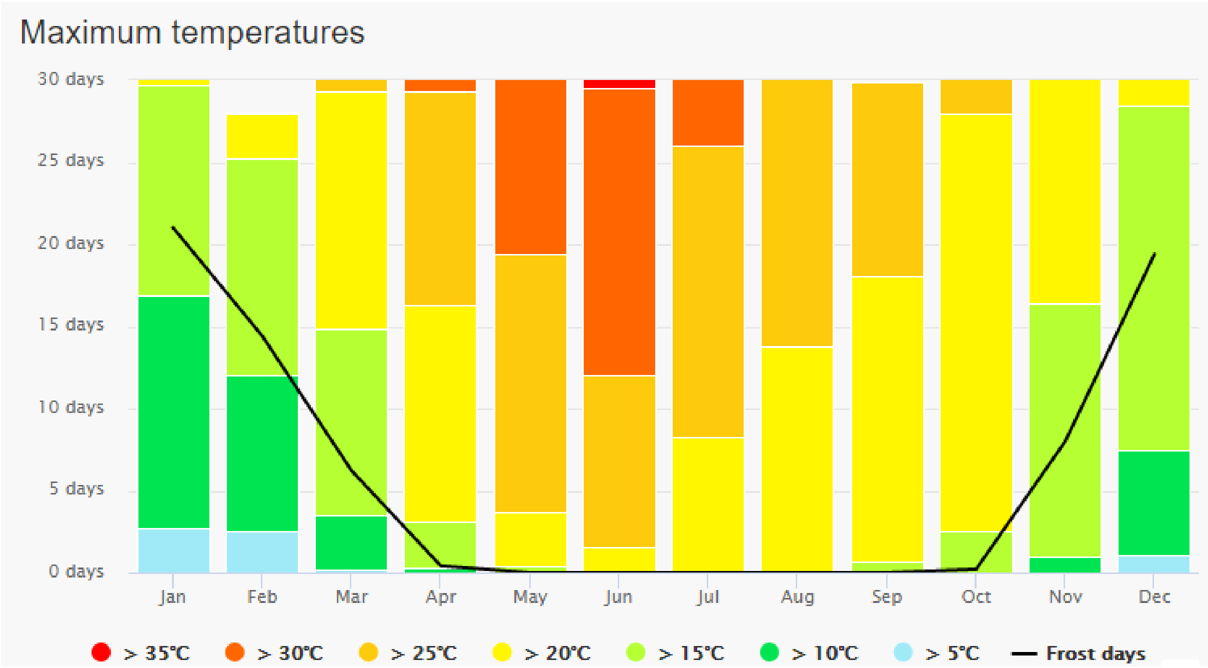


Fig 2.6 maximum temperature

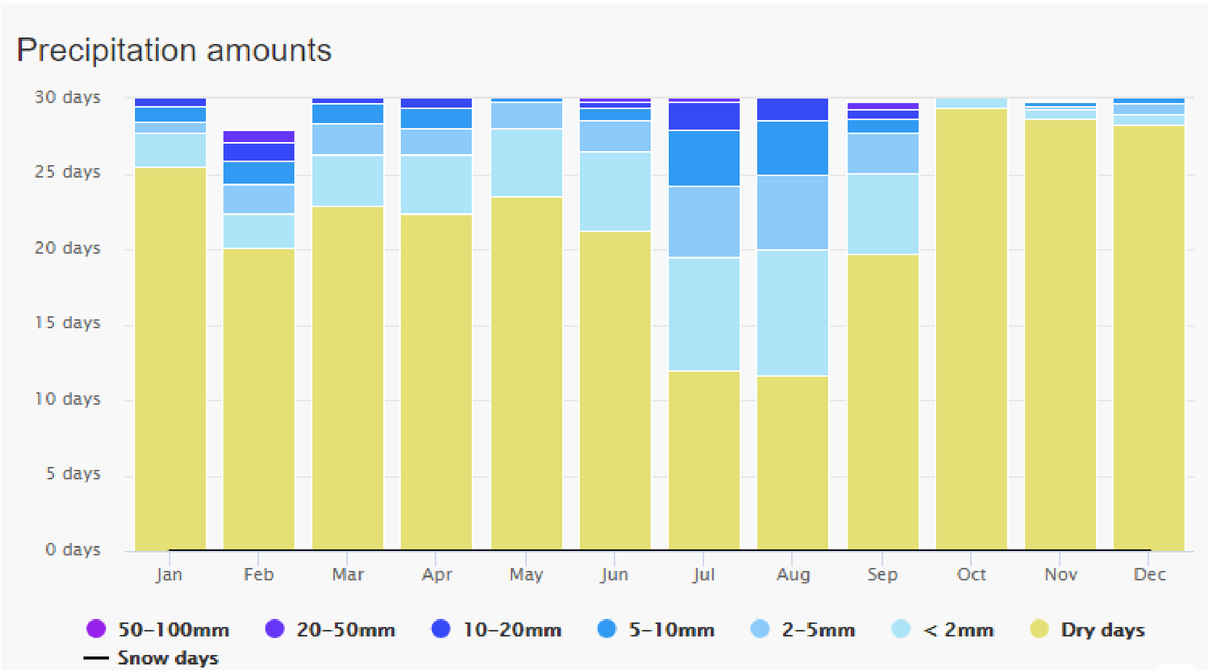


Fig 2.7 precipitation

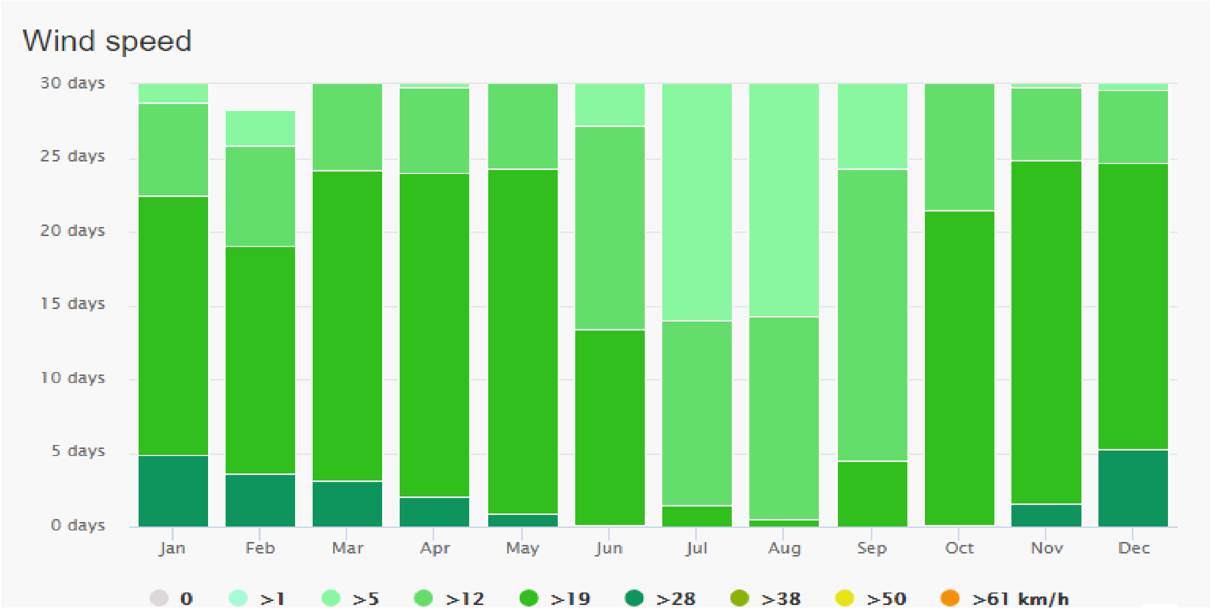


Fig 2.8 wind speed

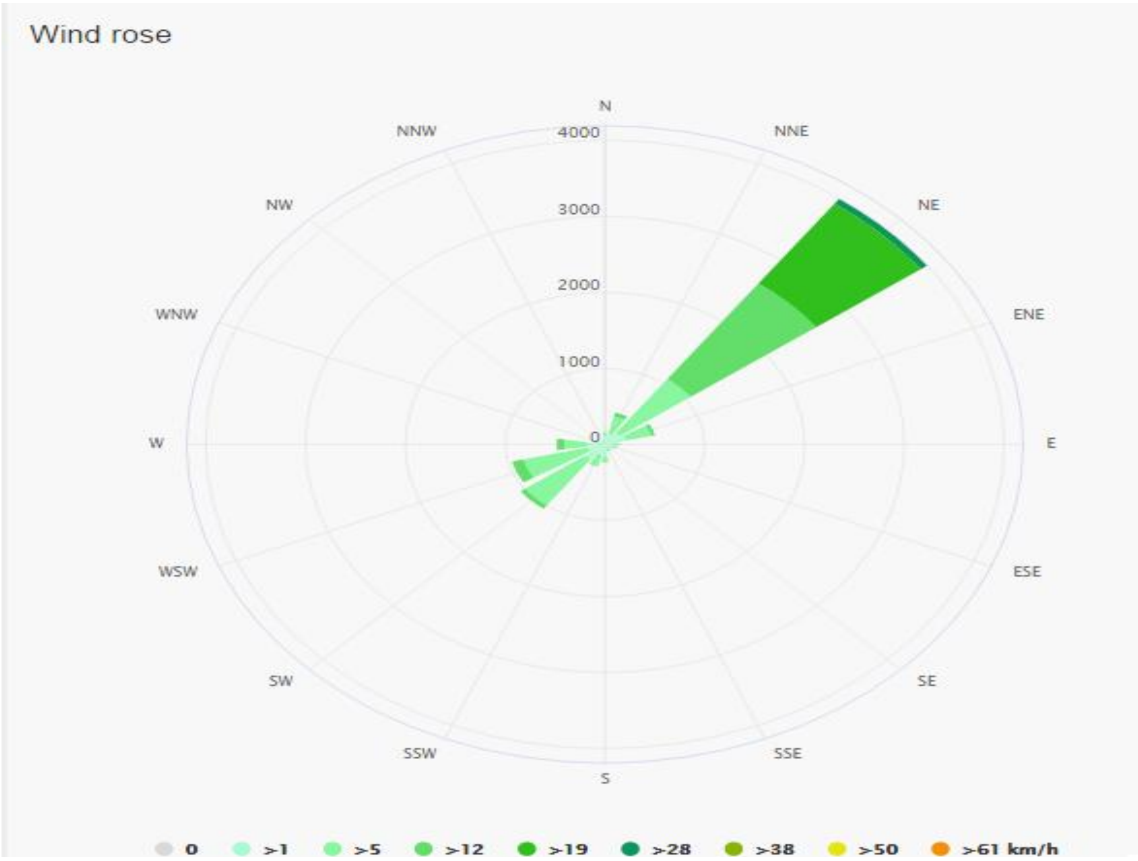


Fig. 2.9 wind rose diagram

2.5 Energy Efficiency

- **Passive solar design (Chaturvedi, 2008)**: Passive interventions and minimization of loads on conventional systems are integral parts of any architectural components and its similar to walls, windows and roofs in a normal structure. In any design, an architect can attain energy efficiency and simultaneously maximize comfort levels by studying the micro and macro climate of the site and applying bioclimatic architectural concepts in terms of building orientation with respect to the sun, shading of windows, colour, texture, landscaping etc. The solar passive design generally differs according to the climatic condition prevalent at the site.

- **Energy conservation (Chaturvedi, 2008)** : Energy conservation is possible by careful design of lighting and HVAC (heating, ventilation and air conditioning) systems, and then applying controls and operation strategies. Increasing insulation levels in conditioned buildings is considered as the most cost effective investment in energy efficiency. Thermal insulation of external walls, roofs and floors and double paned windows can reduce energy consumption for space heating by lowering heat losses through the envelope of the building. Energy consumption for cooling is also minimized because of lesser heat gains from outside through the envelope. Energy efficient windows with their high thermal insulating values and spectral selectivity can make air conditioning systems work more effectively leading to reduction in AC loads, lowering consumption of electrical energy and reduction in peak load demand. The use of energy efficient glazing helps in reducing unwanted solar gains in summer and heat losses in winter, while maximizing the amount of useful daylight in buildings. Lighting load comprises of about 10% – 15% of the total electrical load of a building and energy efficient lighting systems, such as compact fluorescent lamps and fluorescent tubes with electronic ballast, are generally recommended instead of normal lighting fixtures to reduce the lighting load. Although the initial cost of such installation is high but they last longer and the running cost is also less. As electricity is efficiently converted to light in energy efficient lamps so the amount of heat generated is also less.

- **Use of renewable energy technologies**: Renewable energy systems are installed to meet a partial load of the building, thus considerably reducing the overall electrical and thermal load. Solar energy could be made used for a variety of purposes and in a number of ways like generating electricity, providing hot water, heating, cooling, and lighting buildings. Solar photo voltaic (PV) cells can supply electricity for lighting. Solar thermal systems may be utilized for heating water or space heating and transpired solar collectors can preheat air for the building's ventilation system. Solar water heaters generate hot water at 60 - 85^{o}c and trombe wall being thermal storage wall with vents provided at the top and bottom. Trombe wall is made of concrete, masonry or composites of brick and sand and is generally located in the southern side (in the northern hemisphere) of a building to maximize the solar gains and is conveniently used for domestic use. The usefulness of a solar water heater can be discovered from the fact that a standard 100 litre capacity system can be installed as a substitute to electric geyser for residential use that can save up to 1500 units of electricity annually and could prevent emissions of 15 tons of carbon dioxide into the atmosphere every year.

2.6 Green construction principle (Yu et al . , 2014)

- **Decrease the interference of the site and respect the environment:**

Engineering construction interferes with the site environment, especially that is required for the latest project of underdeveloped region, dewatering, earthwork excavation, temporary and permanent facilities construction and site waste water treatment that will also affect the existing resources of animals, plants, and topography and groundwater level. Therefore, to protect the base environment as well as to decrease the site interference has a very big impact on the environmental protection. The design unit, owner, and the contractor are all accountable to identify the structural, natural, and cultural features amongst the construction site as well as to protect these features by the way of the construction, rational design as well as management. Sustainability of the site design plays a very important role in decreasing this interferences.

- **Creation integrated with the climate:**

The weather is also considered whenever the contractor chooses the machinery construction methods, as well as the management of the construction sequence, that may decrease the rising of the creation of resources, measures, energy as well as effectively reduces the construction cost. It may reduce the interference on the site of construction as well as the environment that is caused due to the extra construction measures. For considering the climate during construction, first of all initially the contractor must understand the features of meteorological data as well as the field area which includes the rainfall as well as the snowfall data, integrated with wind and temperature data.

- **Decrease environmental pollution and better the environmental quality:**

Construction noise, dust, harmful, poisonous gas as well as waste tend to cause serious effects on environmental quality and will also be harmful to the respective users, field staff, as well as public health. Hence, by improving and reducing the environmental quality is one of the basic principles of the green construction. Betterment of the outdoor and indoor air quality in the process of construction that is the main content of the corresponding principle. In the construction procedure, the generated dust from the construction system and the building materials, particles and volatile organic compounds generated from the construction equipment, products and materials may produce the indoor air quality problems. Large amounts of these particles or volatile organic compounds are a threat as well as potential damage to the health concerns which requires special safety protection. These damage and threat have a long term effect as even fatal effect. This effect needs to be paid much more attention especially for those people who are required to carry out the construction process in the building.

- **Implementation of construction quality and scientific management:**

The application of the process of the green construction in our country is restricted and has not even reached the level of the process of the green construction system yet. This green construction effect is not at all obvious since the poor economic effect of the green construction and the low management level of the enterprise are the main reasons. Therefore, the implementation of the process of the green construction needs to be carried out by the scientific management, maximize the management level of the enterprise as well as enable the enterprises to implement the process of the green construction standardization and institutionalization which shall play a critical role of the process of the green construction into maximize the economic effects of green construction and promoting sustainable development as well as the enthusiasm of the contractor ofcourse.

2.7 Work Done Till Date

Energy Efficiency And Sustainability In Buildings by Surabhi Chaturvedi (2008)

This paper emphasis on the importance of energy efficient buildings by adopting a different techniques like solar passive design, means to conserve energy judiciously and strictly make use of the renewable energy resources. The author also described about the key features of construction like orientation, internal room layout, window placement, sizing and shading, direction of window with different types of glazing and lastly the insulations. There is also a brief explanations about the low energy materials and methods for constructions. The author also studied about some of the energy efficient housing in the world. It is concluded that passive design could prove to be a cost effective solution and should not cost more than 15 to 20 percent of the total building cost.

Application of green construction technology in construction projects by Zhiwei YU, Chen LU and Bingbing (2014)

This paper focuses on the fundamental importance of the green building constructions explains the significance and the meaning of the green constructions and examines the green construction principles. Then the useful green construction technical measures is put forward in order to give reference for engineers and researchers. In the application of the green construction, it is supposed to minimize the site disturbance, enhance the usage efficiency of the resources and the materials, maximize material recycling and make sure the construction project quality. At last the main project is introduced as an example to depict the implementations and management measures to reduce the pollution, minimize the natural resource usage, and make environmentally friendly energy saving green buildings.

An Energy Methodology of Operation Resources Analysis For Green Construction by Yuna Wang, Yuelong Yu and Xianwei Meng (2015)

This paper centers on the onsite construction stage from the starting to the finishing. Viewing from the ecological economics based on energy theory and its methodology, a critical analysis on the flows of the input-output capital, material and energy is carried out to the construction operational resources namely manpower, material, and equipment framework of energy analysis is setup which connects ecological and economical system of construction process. This research has theoretical and practical source for the innovation of reconsidering the building operational resources keeping in mind about the idea of green construction.

Green and Non-Green School Buildings; An Emperical Comparision of Construction Cost and Schedule by <u>Pramen P. Shrestha and Nitisha Pushpala(2012)</u>

The study has been carried out to do comparative analysis of energy consumption of green and non-green school buildings. Also there are various techniques to reduce energy consumption of buildings given.

Impact Of Green Building Design And Construction by <u>Sathyanarayanan Rajendran, John A. Gambatese, and Michael G. Behm(2009)</u>

The paper covers about impact of green building design and construction on the health and productivity of the final occupants of that particular facility. Also discussed about impact of green building design and construction on worker's health and safety. The study findings provide valuable information and knowledge to the construction industry for the purpose of project safety planning and the assessment of safety and health on project.

Cost comparative analysis of a new green building code for residential project development by <u>Jin-Lee Kim, Martin Greene and Sunkuk Kim(2014)</u>

In this paper they have done a detailed cost comparative analysis for the impact of the new Green Building Code on residential project development from project management point of view. The analysis results shows that the use of such green systems causes the construction costs to increase by 10.77% more than the conventional building, however, the amount of working days increases by two days only. Thus, these can be used as a guidelines for project owners to make smart decisions concerning their monetary initial investments while getting a full benefit from energy cost savings over the life cycle of the building**.**

Builders Role: Innovative Green Technologies' Integration Process To Construction Projects By <u>Suat Gunhan(2012)</u>

This study focuses about expected qualifications (regarding innovative green technologies integration process to buildings) from construction firms during preconstruction, during construction and post-construction stages. The latest qualifications like developing skills in life cycle cost analysis, involvement in BIM applications, managing knowledge driven commissioning process and absorbing knowledge in post occupancy check defines the new defined roles for construction firms in a innovative green technology integration process in building construction.

Comparative Study Of Energy Efficiency Of Glazing Systems For Residential And Commercial Building By Tim Ariosto and Ali M. Memari(2013)

The paper contains the comparative study analysis of energy efficiency of glazing systems for residential and commercial buildings involving the investigation of different types of glazing solutions and concludes with highly insulated systems performing best in the cold weather climates, while carefully selecting systems that focuses on minimizing solar heat gain and which performs the best in warm weather.

Building Information Modeling (BIM) and Sustainability Using Design Technology in Energy Efficient Modeling Eng. By Parisa Esmaeili Moakher and Prof. Dr. S. S. Pimplikar

The paper mainly highlights how today some of the latest design technology can be used to accurately analyze daylight in our buildings namely Autodesk's Revit Architecture, Autodesk Ecotect Analysis and Green Building Studio. Revit Architecture solves very complex processes of sustainable design like solar access and daylighting. It also aids in light calculations, specification management and energy analysis. This has the ability to save money from design changes, energy costs, material changes and lastly retrofitting. Save to say it improve the aesthetic look of building, improve visual comfort and reduce the overall energy usage. Thus, it is beneficial for both the designer and for the owner.

Energy Efficient Buildings By Shristi Khosla And S.K. Singh

This study deals with the various energy saving concepts which can be considered at the time of planning, designing, constructing and executing stage mainly to gain energy efficiency in buildings however keeping in mind the idea of cost. These buildings are then analyzed in Autodesk Green Building Studio to evaluate its energy efficiency, mainly to optimize it.

CHAPTER 3: METHODOLOGY

Green buildings (also known as sustainable building) refers to both the structure and using of processes that are environmentally beneficial and resource-efficient throughout a building's life cycle ranging from siting to design, construction, operation, maintenance, renovation, and demolition. In other words we can say that green building design involves finding the balance between home-building and the sustainable environment. This requires close co-operation among the design team, architects, engineers and client at all project stages. The Green Building practice is expanding and complements the classical building design concerns of economy, utility, durability, and comfort.

3.1 Methods

In order to make Green Home we have to consider various condition on site. According to conditions prevailing on site, we will choose the suitable design and select proper construction materials. We will also do analysis of green home so as to know whether we are able to achieve desired conditions. Feasibility of green home can be shown by following steps:-

Step 1: Obtain weather data from site.

Step 2: Identify Climatic zone of site to get idea of strategies to achieve comfort.

Step 3: Study about the micro climate of site and adopt appropriate strategies.

Step 4: Model the plan of home and make 3d model of home using all passive techniques and sustainable construction material in Autodesk Revit.

Step 5: Do energy analysis of green home in Revit and analyze thermal loads in building.

Step 6: Make changes according to energy analysis report and get the optimum design.

Step 7: Calculate the construction cost of making green home and compare the cost with construction cost of traditional home.

Step 8: Calculate electricity consumption cost of traditional home and green home. Find out how much electricity is saved

Step 9: Similarly calculate water consumption of both homes

Step 10: Determine the payback period of extra cost incurred during construction of green home to know about the feasibility of project.

3.2 Main design features

- **Orientation (Nayak et al . , 2006) :** Longer axis of house is from west to east so as to receive large amount of sunlight. The design of building according to proper orientation building can provide better living condition inside the building. It helps to decrease the effects of harsh weather to a large extent. For example, in cold climatic condition, a building should have proper orientation to receive maximum solar heat gain inside the home on one hand, while preventing the prevailing chill winds on the other. While, in hot areas, solar heat gain and hot winds should be prevented in summer, while cool winds must be provided for ventilation.

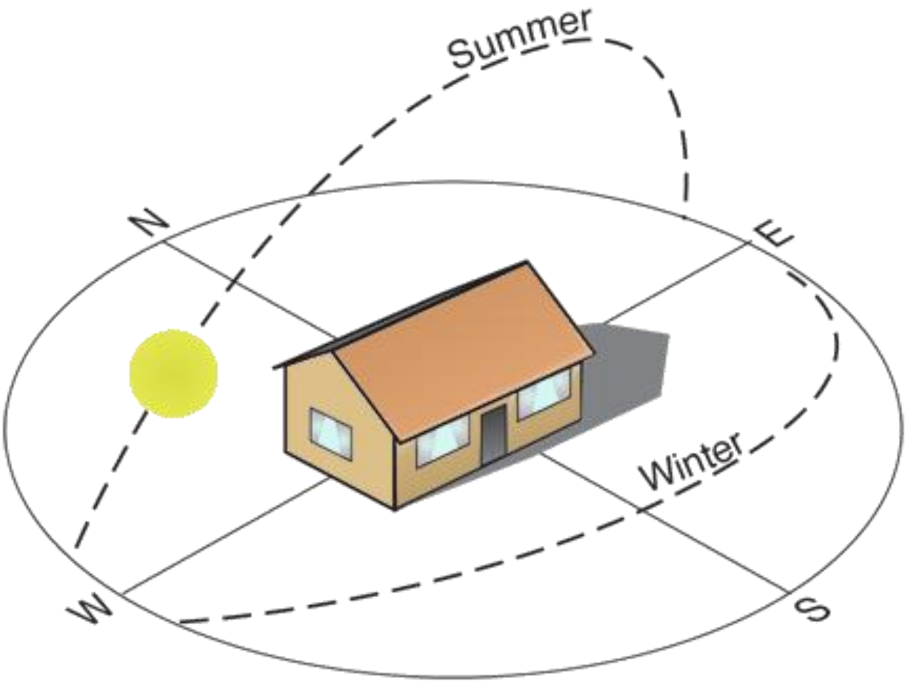
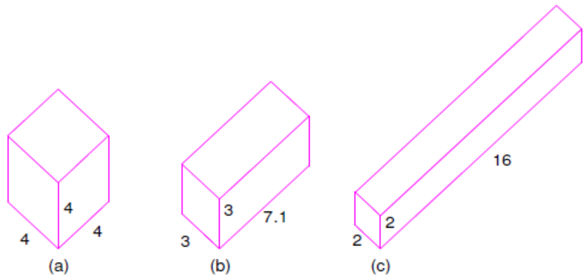


Fig. 3.1 orientation of home

- **Building configuration (Nayak et al . , 2006) :** A compact building format of minimum surface-to-volume ratio is best for reducing the heat loss. The ratio of the surface area to the volume of the building (S/V ratio) depicts the amount of the heat conduction inside and outside of the building envelope. The larger the S/V ratio, the greater the heat conduction for a given volume of space. Conversely, a smaller S/V ratio will result in the reduction of heat conduction. For example, in cold climates, house forms must be compact with minimum S/V ratio.



SOLID SHAPE	SURFACE AREA 'S'	VOLUME 'V'	SURFACE AREA/ VOLUME RATIO 'S/V'
a	96	64	1.5
b	103.2	64	1.61
c	136	64	2.13

Fig. 3.2 surface area to volume ratio (S/V)

- **Direct heat gain (Nayak et al . , 2006)** : Direct gain (South facing facades) is a passive heating method that is generally beneficial in cold climates. In this technique, sunlight is allowed to enter directly into the living spaces through openings or glazed windows. The sunlight heats up the walls and floors, which then store and transmit the heat to the indoor living rooms. The main requirements of a direct gain system are large glazed windows to receive the maximum part of solar radiation and thermal storage mass. During the day time, thermal storage mass is provided in the form of bare massive walls or floors to absorb and thus store heat. This also prevents overheating of the room. The stored heat is released at night time when it is needed most for space heating. Carpets and curtains shouldn't be used to cover floors and walls used as storage mass because they hinder the heat flow rate. Suitable overhangs for shading and openable windows for ventilation should be provided to avoid overheating in the summer.

- **Indirect heat gain (Nayak et al . , 2006)** : Trombe wall must be placed on south. trombe wall is a thermal storage wall made of materials possessing high heat storage capacity such as concrete, bricks or composites of bricks, block and sand. A typical trombe wall is illustrated in Fig 3.14. The external surface of the wall is painted dark (black) so as to increase its absorptivity and is directly placed behind the glazing's with an air space in between. Solar radiation is absorbed by the blackened surface of the wall and is thus stored as sensible heat.

In an unvented wall, the stored heat slowly gets migrated to the interior spaces, where it heats up the adjacent living rooms. If properly designed, the wall can provide adequate heat to the living space throughout the night time. Some of the heat generated in the air space between the glazing and the storage wall is lost back to the outside environment through the glass. The hotter the air will be in the airspace, the greater will be the heat loss. This heat loss can be countered by venting the storage wall at the top and bottom of the trombe wall. Such units are known as 'vented Trombe walls'. The air, in the volume between the glazing and the wall gets warmed up and enters the living room through the upper vents. Cool room air takes the place through the lower vents, thus establishing a natural circulation pattern (thermo circulation) that needs no mechanical means for moving the air. In a vented system, due to circulation of hot air, the amount of heat available for storage by the Trombe wall is reduced.

An unvented system does not lose heat in this way and thus has the advantage over vented system of storing a greater percentage of the solar energy available to it than does a vented wall. This stored heat is, however, is not readily available for immediate use, instead, it is transferred slowly into the living area. Hence, an un-vented Trombe walls must be provided for residences, which require heating mainly during the night time. Furthermore, in cold climates where day-time as well as night-time heating requirements are high, it is advisable to provide a certain amount of heat directly into the living space. In such situations, a vented wall may be used. In moderate climatic areas where daytime heating is not as important as night-time heating, an unvented system may be preferable.

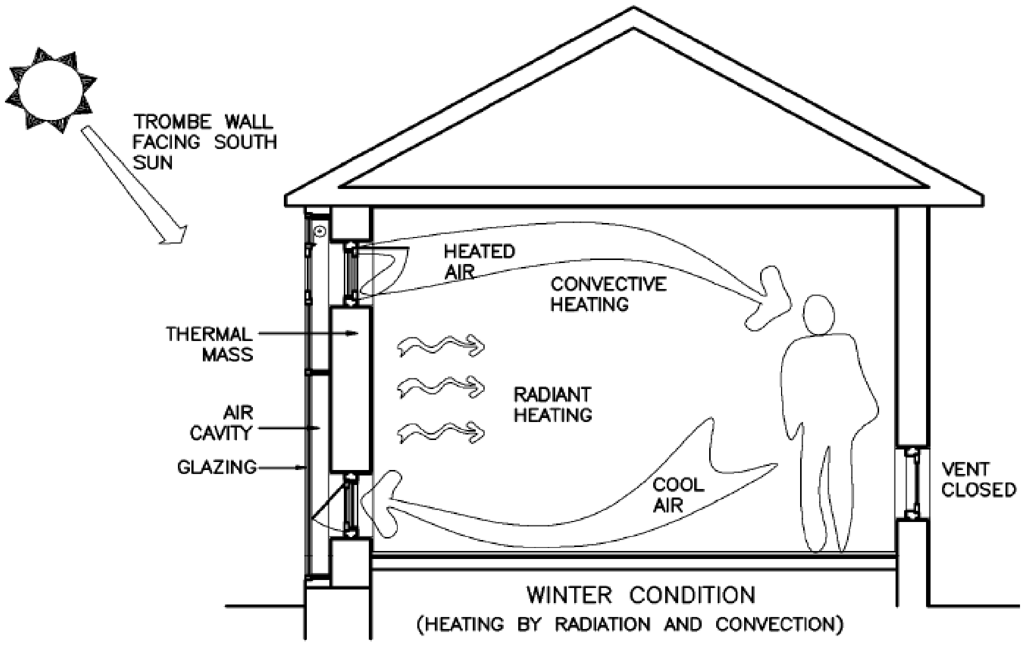


Fig. 3.3(a) working of trombe wall in winter

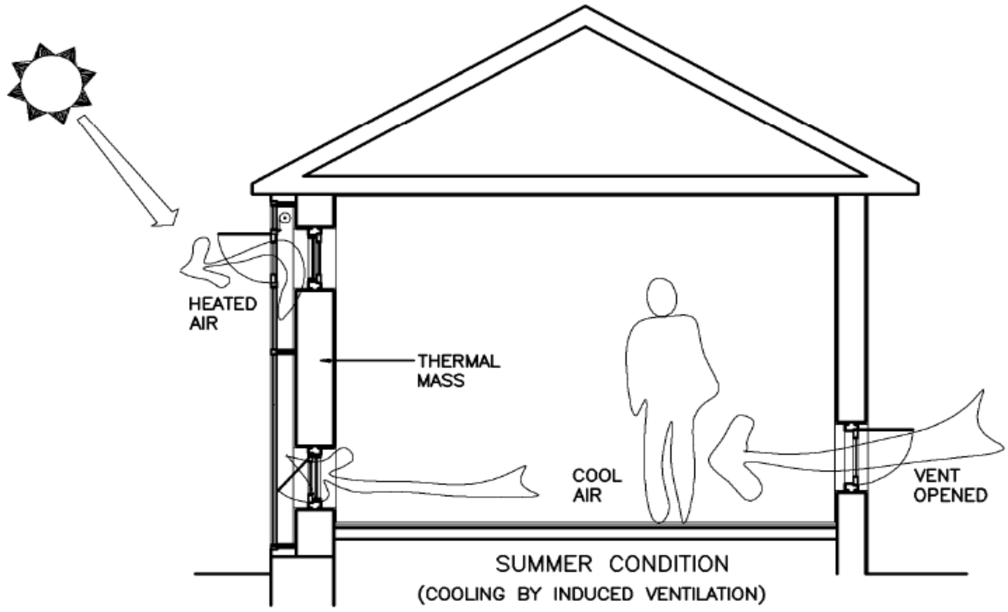


Fig. 3.3 (b) working of trombe wall in summer

- **Insulation:** Insulated floors, roofs and walls are used in a green building. Insulating materials can be applied externally or internally to the roofs.. For internal application, the insulating material can be fixed by adhesive or by other means on the underside of the roofs. In case of external application, the insulating material has to be to be protected by waterproofing methods. Walls should be insulated from north and east so as to avoid heat loss during winter and are uninsulated from south and west so as to allow heat gain. Floors are insulated so as to avoid heat loss during winter.

- **Day lighting:** Windows on south and west side of home. South facing windows introduce sunlight into the home, particularly in winters when the sun is at lower height in the sky and direct sunlight warms the green home. Light coloured interior surfaces reflect more light and reduces the amount of artificial lighting required by green home

Fig.3.4 day lighting in house

- **Vegetation:** Deciduous tress on west and south. Planting the deciduous trees to shade east and west walls will be beneficial in hot and dry climatic zones. In summer, they provide shade from intense morning and evening sun radiations, reduces glare, as well as helps to cut off hot breezes. In winters, deciduous trees shed their leaves and allow solar radiation to heat up the building. The cooling effect of vegetation in hot and dry climates comes mainly from evaporation, while in hot humid climates the shading effect is more predominant. Trees can be used as windbreaks to protect both buildings and outer areas such as lawns and patios.

- **Solar panels**: Solar panels are used on south face sloping roof. Photovoltaic (PV) technology has been used to lighten homes for many past years, and with good output.
  PV is moving beyond its former product status to become a source of price- competitive and zero greenhouse gas emission energy to homes and businesses across the country. The average cost of producing electricity from solar modules is broadly equivalent to purchasing electricity from the power-grid. Rooftop systems can be made either partially or fully integrated. In full integration some points should be kept in mind like must also fulfillment of the general functions such as strength, water tightness and drainage. The installation must be carefully planned and the appropriate products and services must be confirmed.

Fig. 3.5 solar panels on roof

- **Sustainable construction material:** Sustainable construction material is used which have low embodied energy in them. Recyclable material is used wherever it is possible without compromising the safety standards. Locally available materials can used which help in reduction in transportation and contribute to low energy consumption. Non toxic material is used during construction which have non voc compounds. Sustainable wood products are also used.

- **Rain water harvesting**: Rain water harvesting technique is widely used and rain water is collected from curved roof and inclined roof into water storage tank. Rainwater harvesting can lessen water bills, provide an alternative supply during emergency conditions and help maintain a green, clean and also a healthy garden. Depending on tank size and climatic conditions, mains water usage can be reduced by up to 100%. This in turn can help to reduce the need for new dams or desalination plants, protect remaining environmental flows in rivers and reduce infrastructure operating costs.

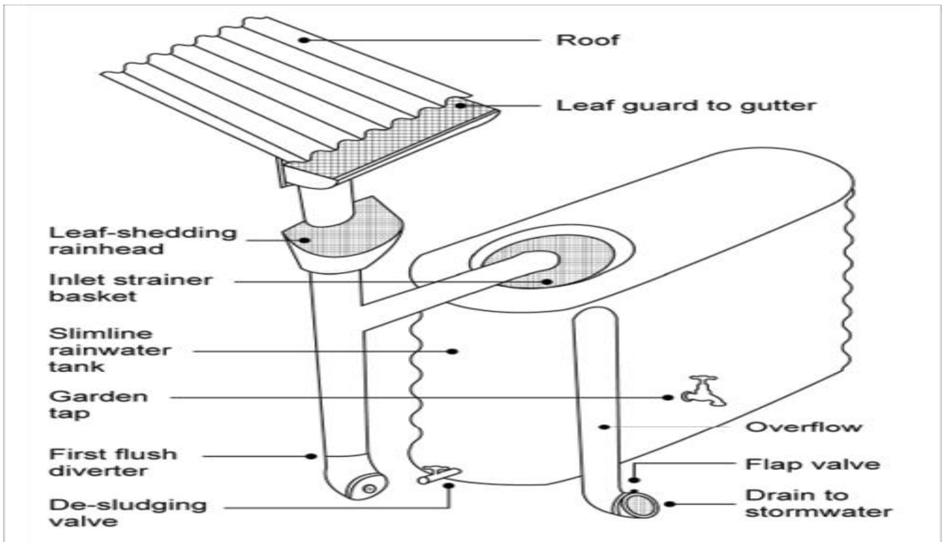


Fig.3.6 water harvesting system

- **Reduce water use**: Reduced indoor water use by choosing water-efficient showers, toilets, taps and appliances. Minimize outdoor water usage by choosing plants that are appropriate for less water use and by including low water use areas in the garden design through the use of indigenous plants.

- **Energy efficient appliances**: Using energy efficient and water efficient appliances with high star rating to minimize energy use.

Household energy use	%
Heating and cooling	40
Water heating	21
Appliances and equipment including refrigeration and cooking	**33**
Lighting	6
Appliances and equipment energy use data	**% (of the 33% above)**
Fridge freezer	18
Cooking	15
TV	19
Home entertainment	5
Home office	9
Pool and spa	5
Stand-by	10
Microwave	2
Dishwasher	2
Clothes dryer	2
Clothes washer	2
Miscellaneous	11

Source: DEWHA 2008

Fig. 3.7 energy load of appliances

3.3 Difference Between Materials in Green Home And Traditional Home

Construction	Traditional Home	Green Home
Roof	Concrete Roof (100 mm)	Insulated Roof
Wall	Brick (200 mm)	AAC Block with Extruded Polystyrene Insulation
Glass	1/8 Inch Single Glazed Glass	Low Emissivity Glass
Solar Panels	Not used	1200 Watt Capacity PV
Floor	Ceramic Tiles	Terrazzo Tiles
Window Frame	Aluminium	UPVC
Door	Aluminium	UPVC
Trombe Wall	Not Used	Used
Water Efficient	Standard Water Flow Fixtures	Low Water Flow Fixtures Rain Water Harvesting Xeriscaping

Table 3.1 difference between materials in green home and traditional home

3.4 Software Used

All the above techniques are added and to be added into house and are drawn in 3d model with the help of Autodesk Revit Architecture which is a designing software.

Autodesk Revit

Autodesk Revit is a powerful architectural design and documentation software application created by Autodesk. The tools and features are specifically in accordance with building information modeling (BIM) workflows. By utilizing BIM in comparison with computer-aided drafting (CAD), Revit Architecture has advantage as it is able to include dynamic information in intelligent models — allowing building models with complexity to be designed with precision and documented in very less time. Each designing model made with Revit Architecture depicts an entire project and is stored in a single database file. This allows modification made in one part of the model to be automatically distributed to other parts of the model, thus improving the workflow for Revit Architecture users.

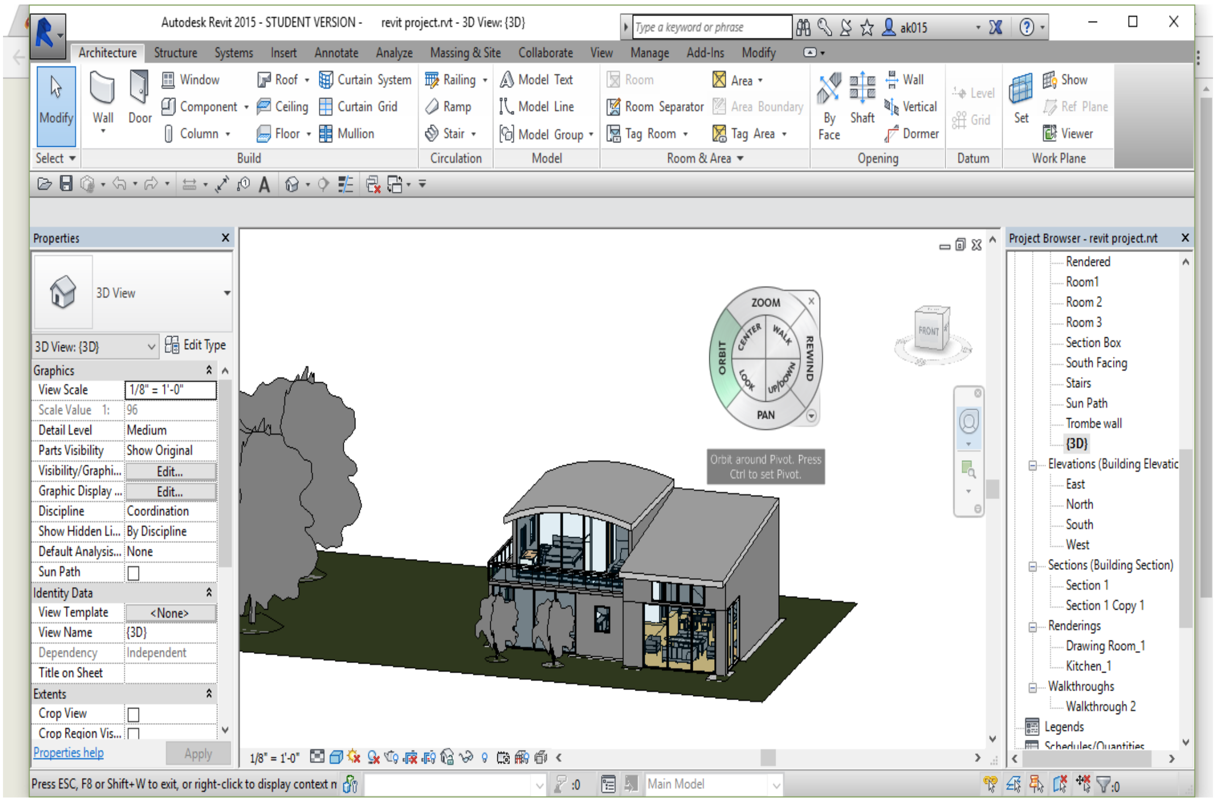


Fig. 3.8 autodesk revit

3.5 Designing

With the help of key desing features and revit plan of green building was drawn taking care of every aspect of sustainable design principle and plan was converted into 3D model of green home with revit as shown in fig. 3.8. All features were included so as to reduce energy consumption of building and make the building which has less carbon footprint. The plan of green building at JUIT is shown in fig. 3.9

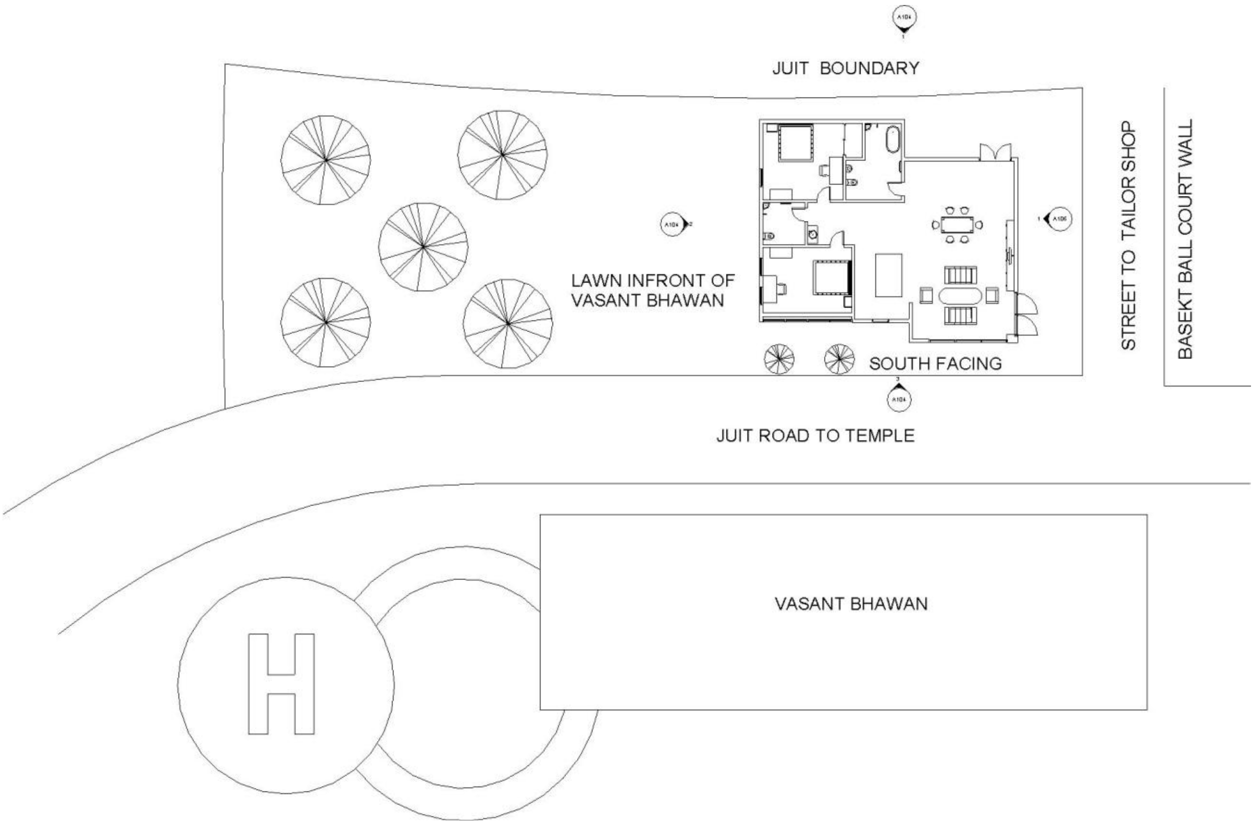


Fig. 3.9 juit plan drawn with help of revit

CHAPTER 4: MODELLING OF TRADITIONAL HOME AND GREEN HOME

4.1 Traditional Home

a) Outside view

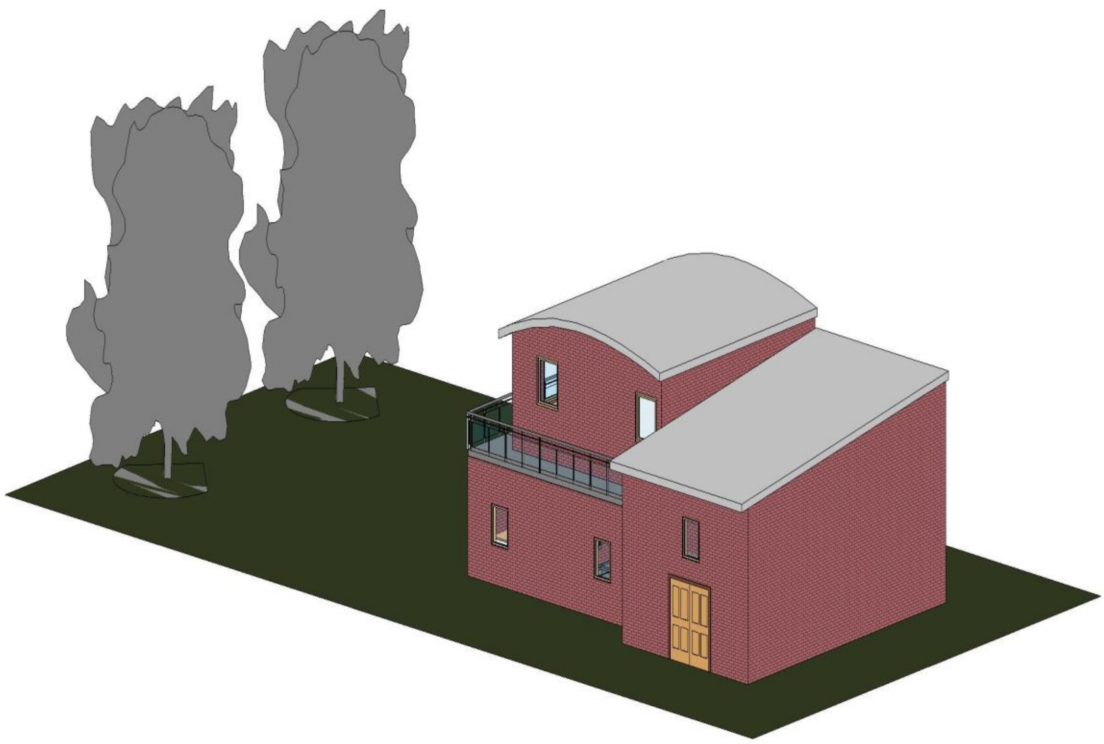


Fig 4.1 outside view of traditional home

b) Roof

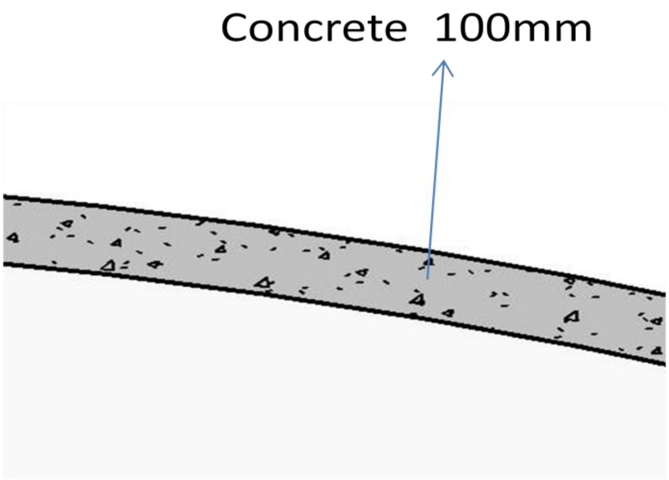


Fig 4.2 roof material of traditional home

c) Outside wall

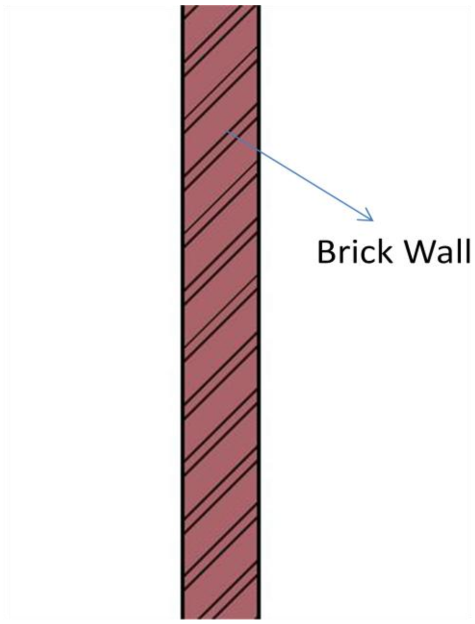


Fig 4.3 outside wall material of traditional home

4.2) Green Home

a) Outside view

Fig 4.4 outside view of green home

b) Roof

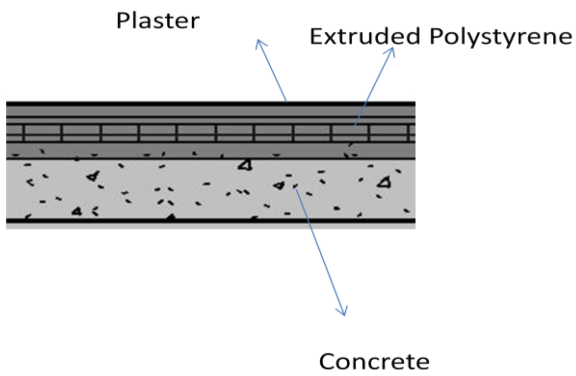


Fig 4.5 roof materail of green home

Extruded Polystyrene has low u value which decreases the conductivity of material. It is also good moisture resistance, low weight and high structural strength. Generally, Extruded Polystyrene has thickness of 60 mm

c) Outside wall

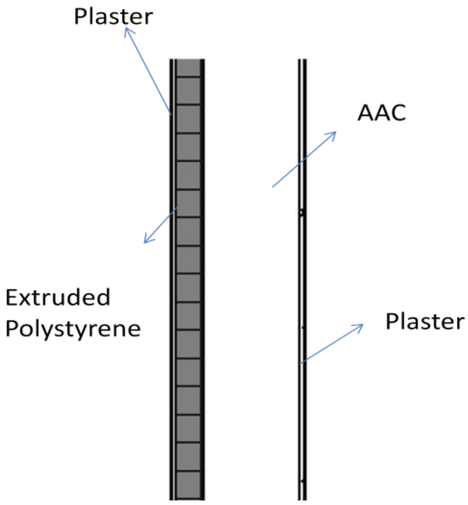


Fig 4.6 outside wall materail of green home

AAC is fire resistant, Pest resistant, Sound proof, light weight material and has thermal insualtion value. Thermal conductivity helps in achieving comfort level inside home when there is extreme conditions outside. It leads to decrease in heating as well as cooling loads. It is also moisture resistant

d) Drawing room

Fig. 4.7 drawing room of green home

e) View from stairs

Fig. 4.8 view from stairs

f) View of kitchen

Windows at south for day lighting and heat gain

Fig. 4.9 view of kitchen

g) Ground floor outside room view

Fig. 4.10 ground floor view from outside

Compacted building plan to decrease surface to volume ratio & stairs located on north side of building

h) Stairs

Fig. 4.11 view of stairs

f) Room 1

Trombe wall with vented walls & windows on west side to

Fig. 4.12 trombe wall

Trombe wall provides indirect heat gain in winter during night time. As trombe wall is made up of thicker material, it provides thermal lag (heat is stored during day and released during night). It provides heat at night when temperature is very low outside.

g) View of room 2

Windows on west side of wall to provide glazing

Fig. 4.13 view of room 2

h) Trombe wall

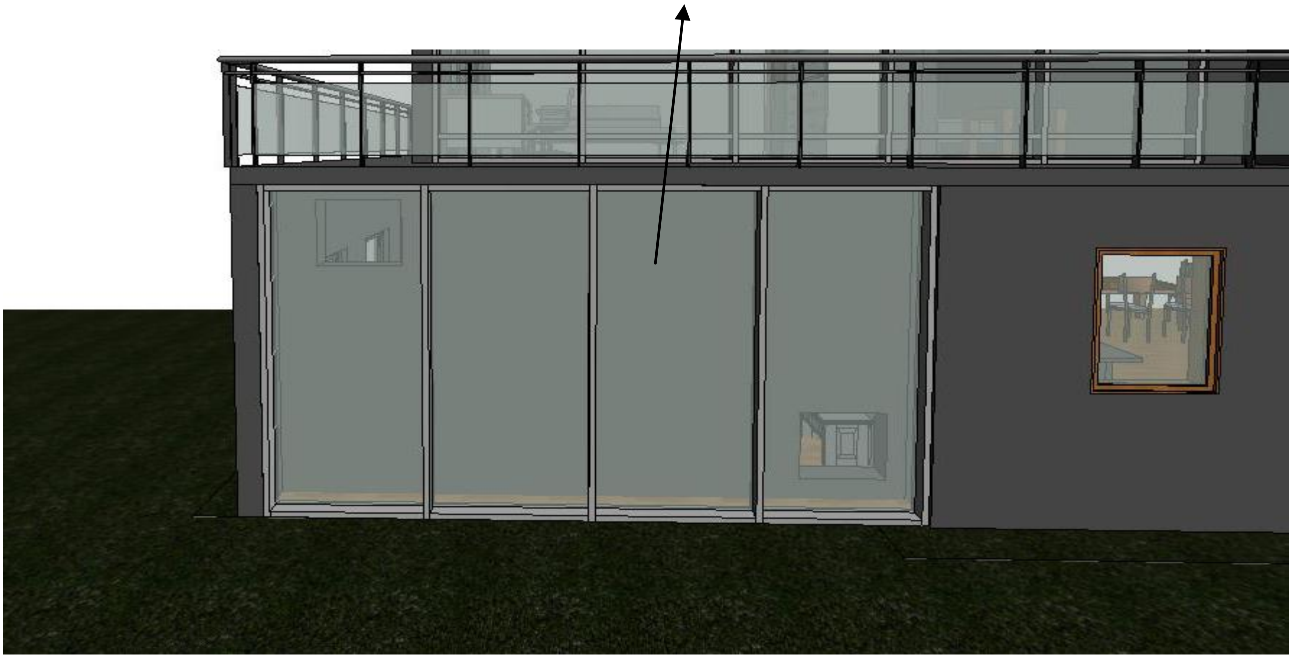


Fig. 4.14 view of trombe wall in southern side

f) South facing wall

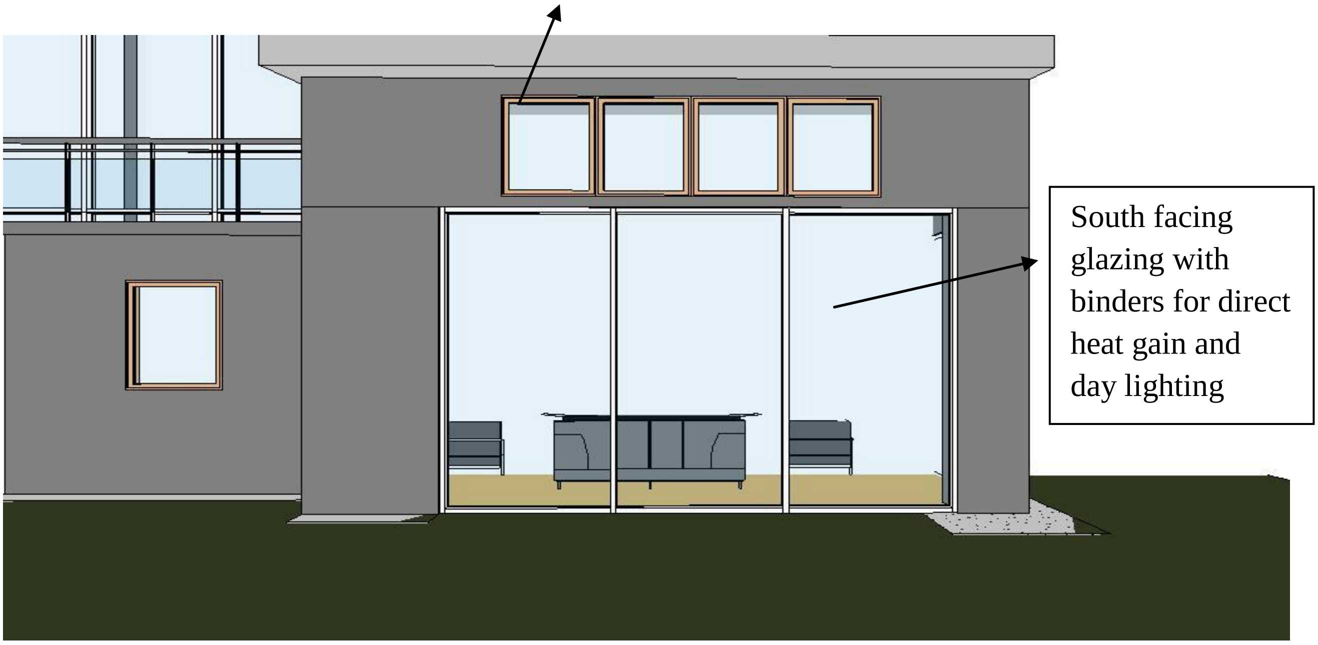


Fig. 4.15 view of South facing wall

South facing glazing is there as to receive maximum sunlight for winter. It will also provide daylighting. Electricity consumption will decrease due to it. Overhangs are also provided for shading in summer when sun is at high altitude

g) First floor view

South facing glazing

Fig. 4.16 first floor view

h) Room 3

South facing glazing with binders on it to prevent heat during summer

Fig. 4.17 view of room 3

i) Washroom

All plumbing fixtures are water efficient so as to reduce water

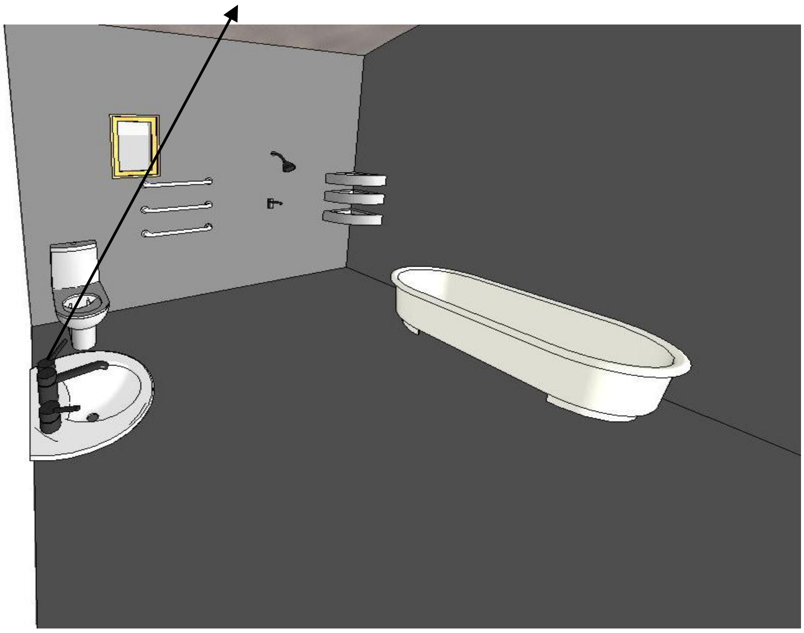


Fig. 4.18 view of washroom

j) Section 1 of green home

Fig. 4.19 section 1 of green home

k) Section 2 of green home

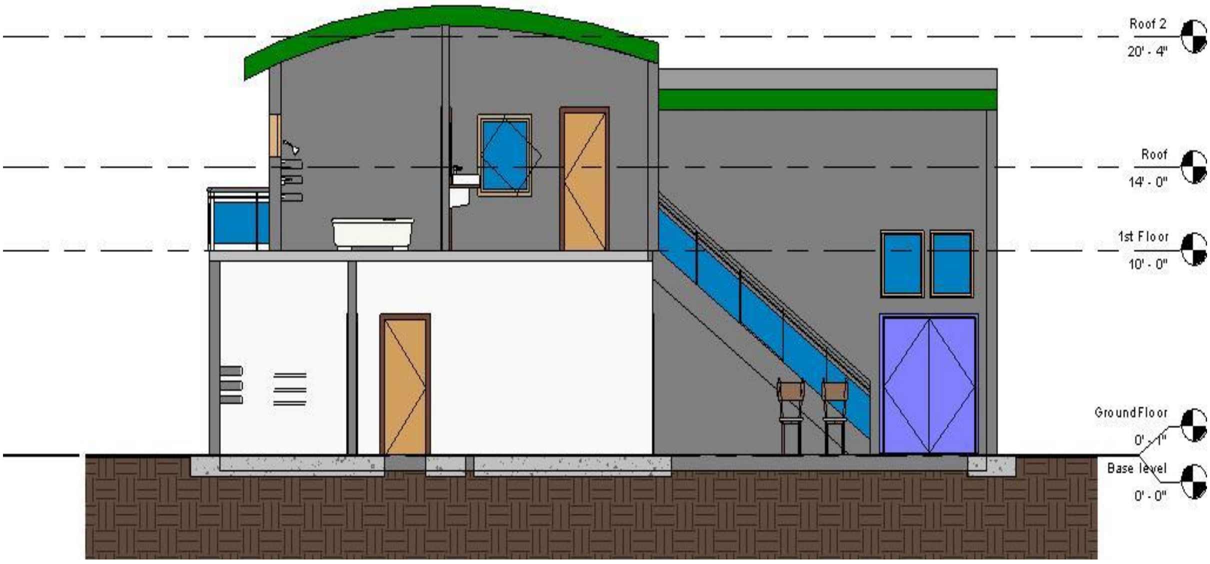


Fig. 4.20 section 2 of green home

l) Rendered drawing room

Fig. 4.21 rendered view of drawing room

m) Rendered kitchen

Fig. 4.22 rendered view of kitchen

CHAPTER 5: RESULT AND DISCUSSION

Energy analysis and values of area and volume of construction are calculated with the help of Autodesk Revit software. Energy Analysis is done both manually and with the help of software. By using software, we will come to know the actual difference between green home and traditional home as Revit also take care of thermal properties of material as well as site climate data. Revit has automatically included electricity consumption of appliances. It also includes the embodied energy of materials and rest of calculation is done manually to show the similarity of analysis of green home and traditional home. Revit has also taken care of climatic condition prevailing over the site and analysis in done in accordance with climate data.

5.1 Energy Analysis (Software)

a) Life cycle electricity, fuel and energy use

Table 5.1 Life Cycle Electricity, fuel and energy use

	Traditional Home	Green Home
Number of People	5	5
Exterior wall area	0.03	0.10
Life cycle electricity use (kwh)	706,148	527,040
Life cycle energy cost (Rs)	1696920	1318380

*30 Year Life and 6.1 Discount Rate for Costs

b) Comparison of monthly cooling load (mBtu)

Monthly cooling load means amount of load is required by cooling appliances to maintain the temperature at comfortable level. This charts shows how building components are contributing to cooling loads of building. Positive value indicates addition of heat by these components while negative value indicates removal of heat by these components.

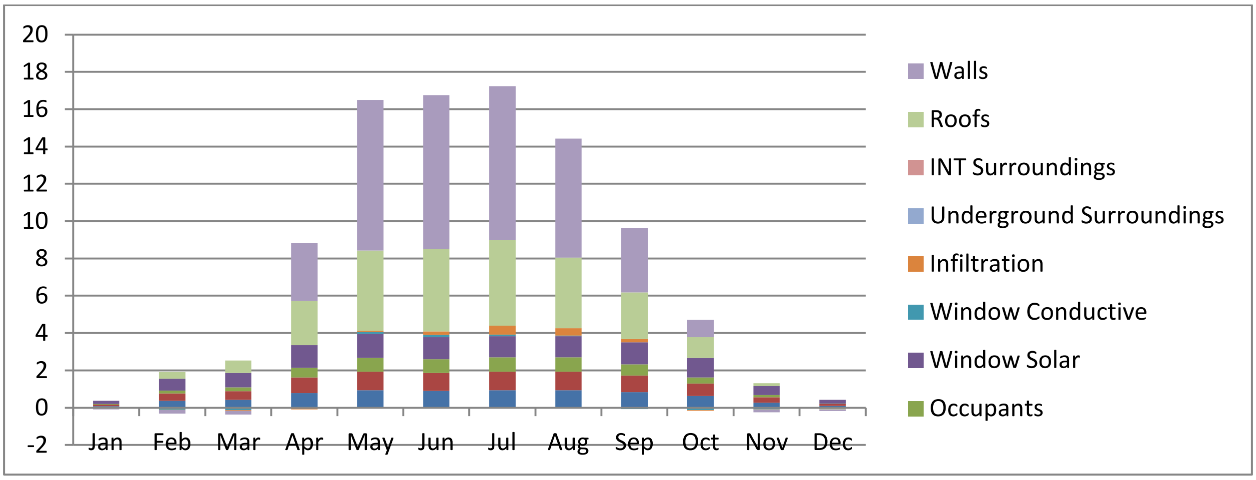


Fig 5.1 showing monthly cooling load (mBtu) in traditional home

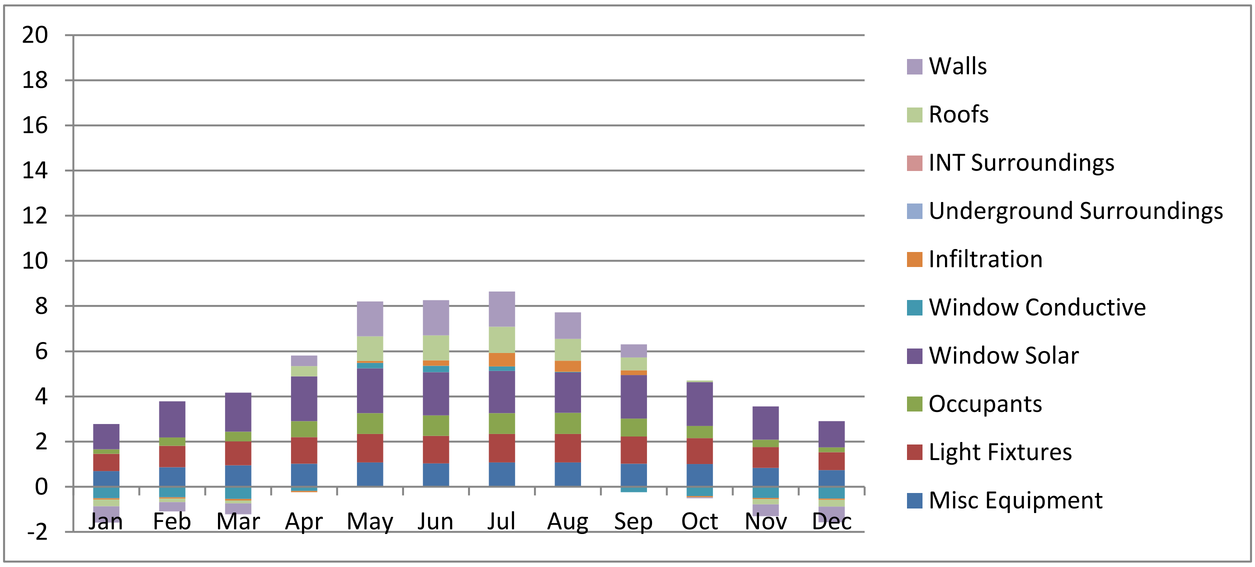


Fig 5.2 showing monthly cooling load (mBtu) in Green Home

c) Comparison of monthly heating load (mBtu)

Monthly heating load means amount of load is required by heating appliances to maintain the temperature at comfortable level. This charts shows how building components are contributing to heating loads of building. Positive value indicates addition of heat by these components while negative value indicates removal of heat by these components.

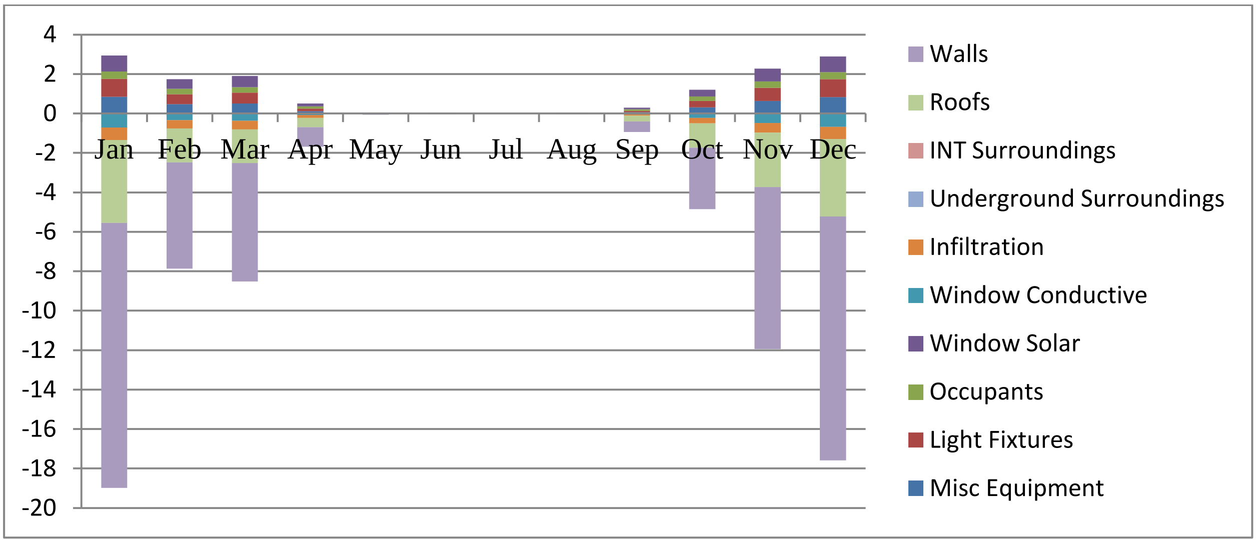


Fig 5.3 Showing monthly heating load (mBtu) in traditional home

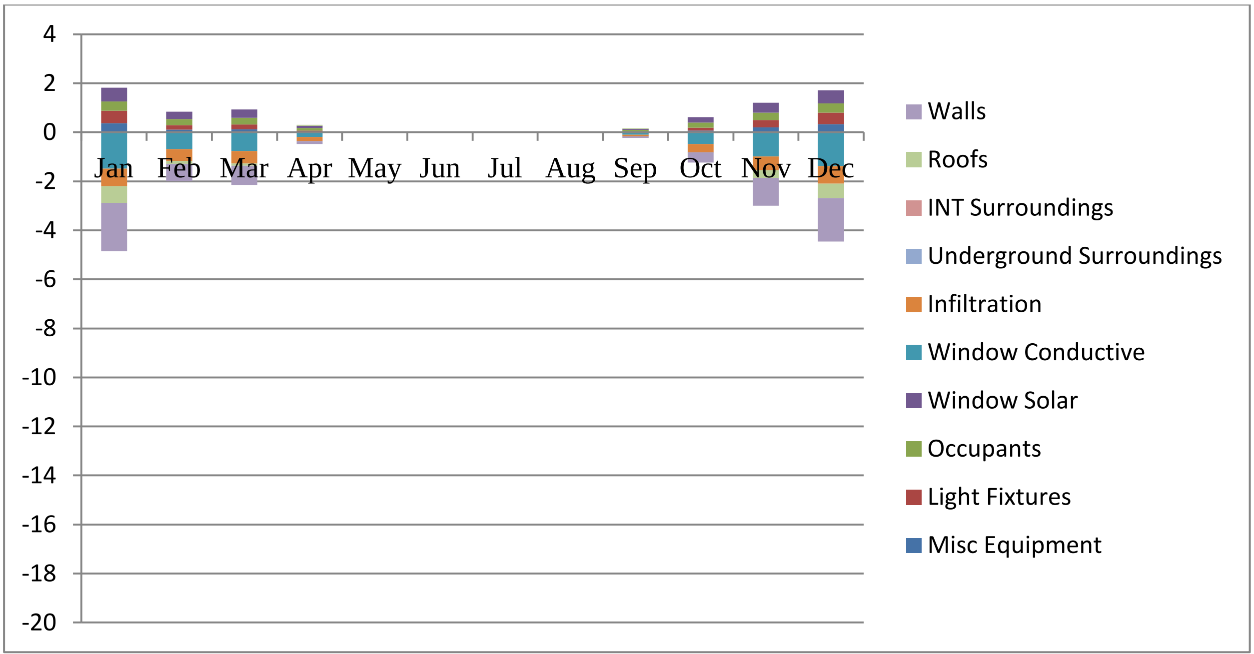


Fig 5.4 showing monthly heating load (mBtu) in Green Home

d) Comparison of electricity consumption in Kwh using software

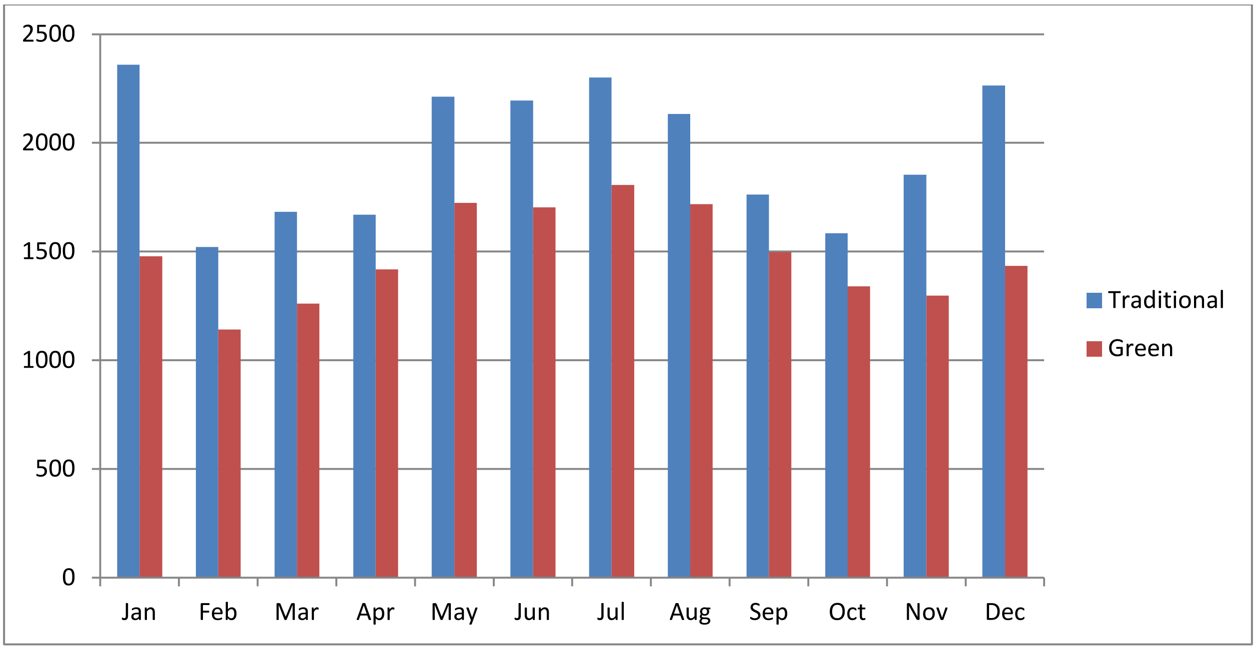


Fig 5.5 comparison of electricity consumption in Kwh using software

e) Monthly peak demand

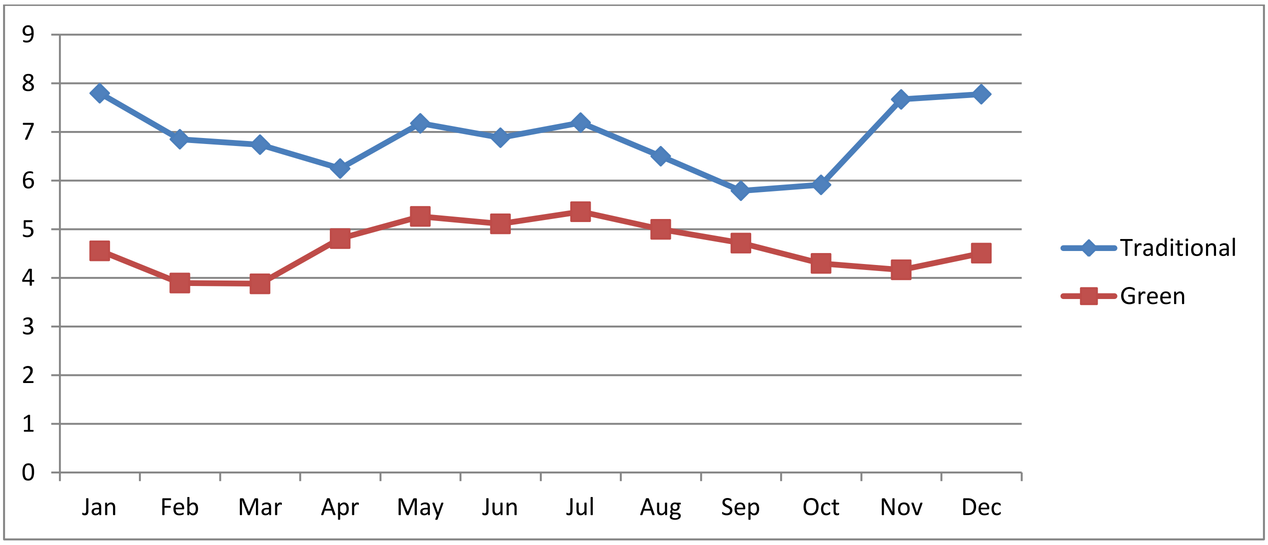


Fig 5.6 monthly peak demand

5.2 Cost of Construction

a) Green home

b) Table 5.2 cost of construction of green home

Construction	Cost
Walls (Exterior + Interior)	₹ 4,53,394.58
Roof	₹ 3,25,677.96
Window's Glass Cost	₹ 89,448
Flooring (Both Floors)	₹ 1,51,595.11
Total	₹ 10,20,115.95

For Calculations refer to **ANEXURE 10 & ANNEXURE 11**

c) Traditional home

Table 5.3 cost of construction of traditional home

Construction	Cost
Walls (Exterior + Interior)	₹ 2,87,990.88
Roof	₹ 2,44,461.96
Window's Glass Cost	₹ 25,650.00
Flooring (Both Floors)	₹ 75,077.11
Total	₹ 6,33,179.95

For Calculations refer to **ANEXURE 10 & ANNEXURE 12**

c) Solar system cost

Table 5.4 solar system cost of traditional home

Solar Appliances	Cost
Solar Panel Capacity(1200 Watts)	₹ 84,000
Two Battery For Solar Panel (1200 Watt each)	₹ 22,000
Solar Inverter	₹ 10,000
Solar Water Heater (400 L)	₹ 55,000
Total	₹ 1,71,000

For efficiency of Solar Panels refer to **ANNEXURE 13**

5.3 Comparison of Electricity Consumption manually for both homes in Kwh

Table 5.5 comparison of electricity consumption manually for both homes in kwh

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total	Total Cost(Rs)
Traditional Home	1703	1541	1335	1095	920	820	848	884	828	878	1378	1703	13934	41,801
Green Home	856	647	748	389	298	288	298	577	288	294	558	786	6025	18,075

Electricity rate per Kwh = **Rs. 3** for Shimla (www.bijlibachao.com, 9:00 pm, 28th March, 2017)

For Calculations refer to **ANNEXURE 14 & ANNEXURE 15**

5.4 Comparison of Water Consumption manually for both homes in Litres

Table 5.6 comparison of water consumption for both homes in litres

Description	Baseline (Litres)	Proposed (Litres)
Annual Volume From Fixtures	474500	372300
Annual Volume of Water Used For Landscaping	98550	59130
Total Volume	573050	431430
Annual Volume of Stored Water Used For Flushing		18000
Annual Volume of Stored Water Used For Landscaping		50000
Annual Volume after usage of Stored Water		363430
Percentage Saving		36.58%
Water Cost/Year	₹ 2,865	₹ 1,817
Net Savings	₹ 1,048	

Water rate = **Rs 4/ KL** for Shimla (www.hpiph.org, 9:10 pm, 28th March, 2017)

For Calculations refer to **ANNEXURE 16**

5.5 Net Cost Comparison of Traditional Home and Green Home

a) Extra cost of construction of green home

Table 5.7 extra cost incurred in both traditional home

Total Cost	Traditonal Home (Rs.)	Green Home (Rs.)
Wall	2,87,991	4,53,395
Roof	2,44,462	3,25,678
Windows	25,650	89,448
Flooring	75,077	1,51,595
Solar Panel	NA	1,16,000
Solar Water Geyser	NA	55,000
Total Cost	6,33,180	11,91,116
Difference In Construction	5,57,936	

b) Net savings in green home

Table 5.8 net savings in green home

Electricity Consumption/ Year	41,801	18,075
Water Consumption/Year	2,865	1,817
Total Cost (Rs.)	44,666	19,892
Net Savings		

5.6 Payback Period

Payback period includes inflation rate & discount rate from which modified discount rate is calculated.

Payback Period = 50 Years

For calculation refer to **ANNEXURE 17**

5.7 Discussion

After analysing energy analysis, we found that there is reduction in life cycle electricity consumption of green home when compared to traditional home. Reduction in electricity is due to decrease heating load as well as cooling load as there is use of passive techniques as well as sustainable construction material in green home. Cost of construction for green home is more as compared with traditional home due to application of insulation, high performance glasses etc in green home. Cost analysis of major component such as roof, walls, windows and flooring is done as major difference will be in these components and cost of rest of components will remain approximately same. Solar panels as well as solar water heater is also used in green home which adds up the cost of construction but decreases electricity consumption of green home. Water consumption of green home has also reduced by use of low water fixtures, rain water harvesting and xeriscaping of garden. Payback calculations are done by both using inflation and discount rate and without it. This is done to make payback period calculation more realistic. For calculating payback period all savings are calculated on net present value using discount rate and value of saving will also keep on increasing due to inflation as electricity and water prices will increase in future.

CHAPTER 6: CONCLUSION & FUTURE SCOPE

6.1 Conclusion

- Cost of construction for green home is almost double in our case which also includes cost of solar panels and solar water heater.
- Electricity savings of 25.3 % while calculated with the help of software in green home as compared to traditional home due to decrease in cooling load and heating load.
- Electricity savings of 56% in green homes while calculated manually due to usage of solar panels and solar water heater which does not have any operating consumption.
- Decrease in water consumption of 36% which is good result. As water scarcity is of major concern now a days.
- Payback period of 50 years which is high but it does not include other benefits like lesser health problem which decreases medicine bills due to comfortable living condition inside the home. It also decreases negativity atmosphere in green home, which leads to increase in productivity, as there is day lighting and is connected with outside with nature with the help of windows.
- Save the environment which is under threat due to increase in pollution and population by conserving natural resources and decrease in emission of pollutants and green house gases because there is use of eco-friendly material

.

6.2 Future Scope

Energy analysis can be done with the help of other energy analysis softwares like E-quest, Energy Plus which are quite complex and needs a deeper understanding of it. These software gives more reliable result but takes time. Other features can also be included like house hold separation of waste and organic waste composting which also has numerous benefits. Various other materials can be used for constructing green homes. Building management system can also be added to system which includes HVAC and lighting controls, emergency lighting and water management and control which increases efficiency of green home.

REFERENCE

- Ariosto, T. and Memari, A. M. (2013). "Comparative Study Of Energy Efficiency Of Glazing Systems For Residential And Commercial Buildings." , 3-6.

- Chaturvedi, S. (2008). "Energy Efficiency And Sustainability In Buildings." Building Integration Solutions, 1-8.

- Central Public Works Department (CPWD) – Delhi Schedule of Rates 2014 , 2-442
.
- Central Public Works Department (CPWD) – Himachal Pradesh Town and Country Planning tools 2014 (Amended upto 2016), 10.

- Gunhan, S. (2012). "Builders' Role: Innovative Green Technologies Integration Process To Construction Projects."2-4.

- I.S Code 7272.1.1974 –" Indian Standard, Recommendation for Labour Output Constants for Building Work", UDC 69.008:331.024 (545)

- Kim, J.L. Greene, M. and Kim, S. (2014). "Cost Comparative Analysis of a New Green Building Code for Residential Project Development." , 1-6.

- Majumdar, M. (2001) " Energy Efficient Buildings In India. " Teri, New Delhi., 2-100

- McGee, C. (2013) "Passive Design" < http://www.yourhome.gov.au/passive-design> (Nov. 3, 2016).

- Nayak, J.K. and Prajapati, J.A. (2006) " Handbook On Energy Conscious Buildings. " R & D project no. 3/4(03)/99-SEC between Indian Institute of Technology, Bombay and Solar Energy Centre, Ministry of Non-conventional Energy Sources, Government of India, 2-20(2), 5-40(3).

- Rajendran, S.Gambatese, J.A and Behm, M.G. (2009). "Impact of Green Building Design and Construction on Worker Safety and Health." , 1-3.

- Riedy, C. (2013) "Appliances." <http://www.yourhome.gov.au/energy/appli-ances > (Nov. 3, 2016).

- Shrestha, P.P and Pushpala, N. (2012). "Comparative Analysis Of Energy Consumption Of Green And Non-Green School Buildings. ", 1-5.

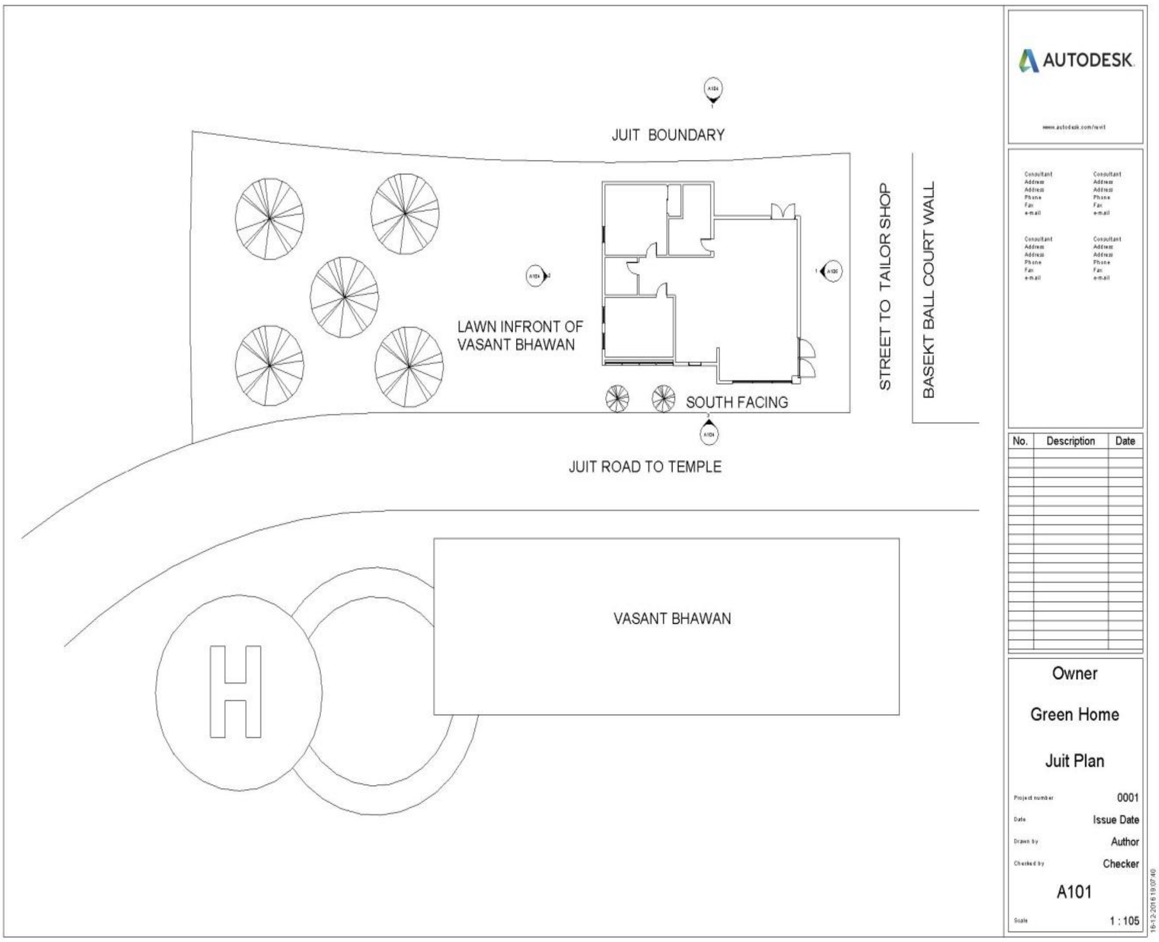
- S. Fereidoon , “Ministry of New and Renewable Energy”, Green stream

- Yu, Z. Lu, C. and San, B. (2014). "Application of Green Construction Technology in Construction Projects." Smart Construction and Management in the Context of New Technology, 2-8.

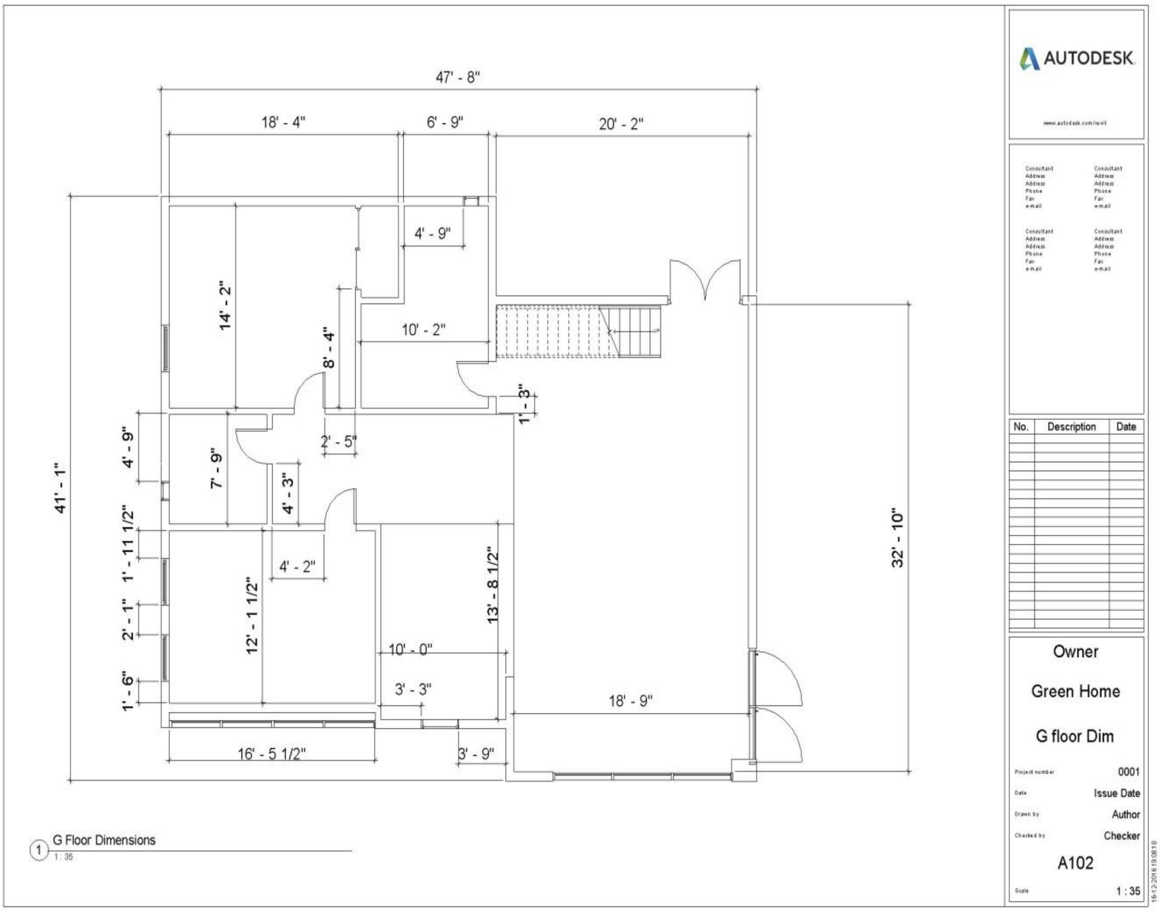
- Wang, Y. Yu, Y. and Meng, X. (2015). "An Energy Methodology of Operational Resources Analysis for Green Construction. " , 2-5.

APPENDIX

ANNEXURE 1

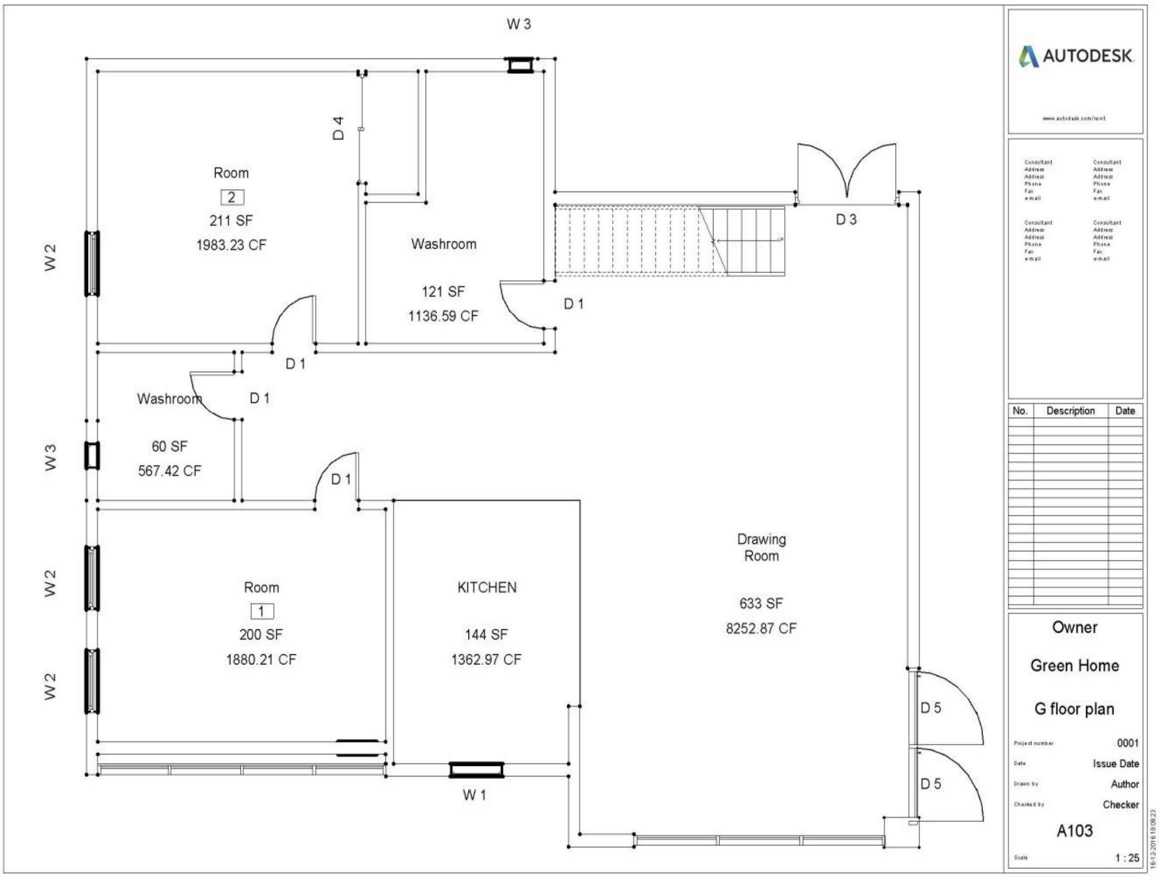

AUTODESK
JUIT BOUNDARY
LAWN INFRONT OF
VASANT BHAWAN
STREET TO TAILOR SHOP
BASEKT BALL COURT WALL
SOUTH FACING
JUIT ROAD TO TEMPLE
VASANT BHAWAN
No.
Description
Date
Owner
Green Home
Juit Plan
0001
Issue Date
Author
Checker
A101
1 : 105

ANNEXURE 2

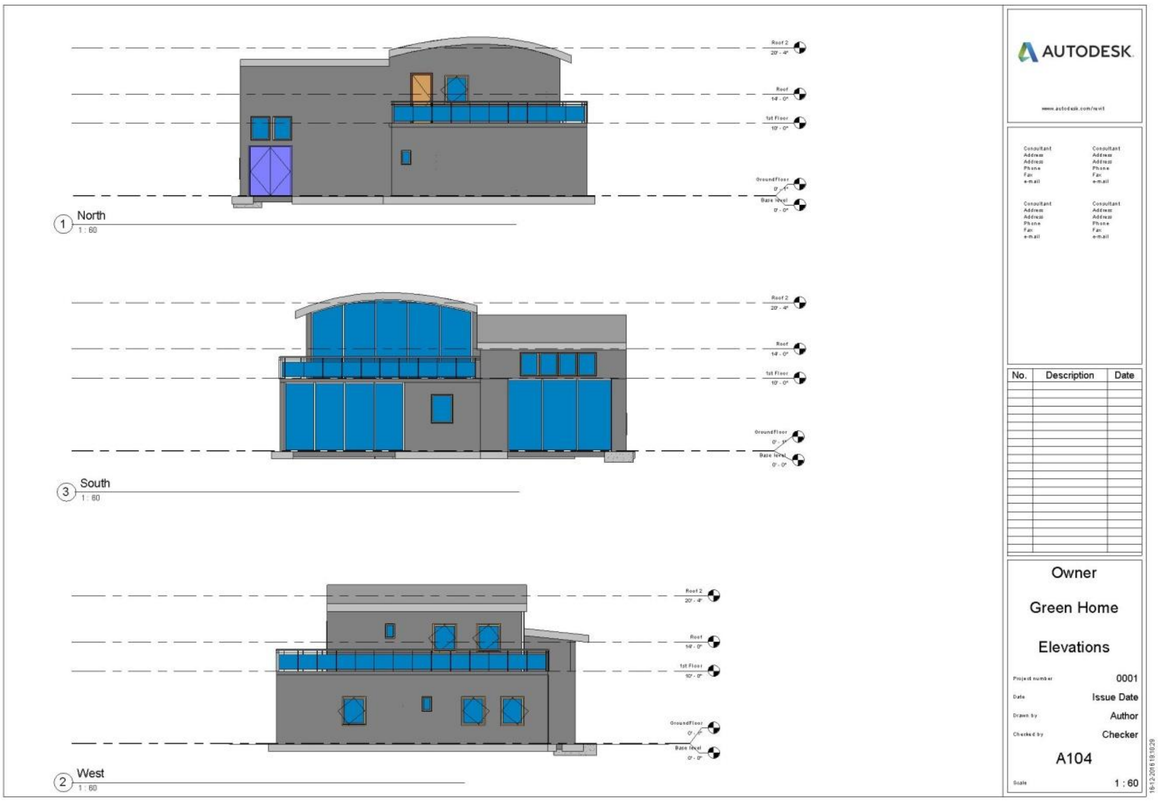


47' - 8"
18' - 4"
6' - 9"
20' - 2"
4' - 9"
14' - 2"
10' - 2"
8' - 4"
1' - 3"
41' - 1"
4' - 9"
7' - 9"
2' - 5"
4' - 3"
1' - 11 1/2"
4' - 2"
12' - 1 1/2"
13' - 8 1/2"
2' - 1"
10' - 0"
1' - 6"
3' - 3"
18' - 9"
32' - 10"
16' - 5 1/2"
3' - 9"
G Floor Dimensions
1 : 35
AUTODESK
No.
Description
Date
Owner
Green Home
G floor Dim
0001
Issue Date
Author
Checker
A102
1 : 35

ANNEXURE 3


W 3
AUTODESK
D 4
Room
2
211 SF
1983.23 CF
W 2
Washroom
121 SF
1136.59 CF
D 1
D 3
D 1
Washroom
D 1
60 SF
567.42 CF
W 3
D 1
Drawing
Room
633 SF
8252.87 CF
Room
1
200 SF
1880.21 CF
W 2
W 2
KITCHEN
144 SF
1362.97 CF
D 5
D 5
W 1
No.
Description
Date
Owner
Green Home
G floor plan
0001
Issue Date
Author
Checker
A103
1 : 25

ANNEXURE 4


North
1 : 60
South
1 : 60
West
1 : 60
AUTODESK
No.
Description
Date
Owner
Green Home
Elevations
0001
Issue Date
Author
Checker
A104
1 : 60

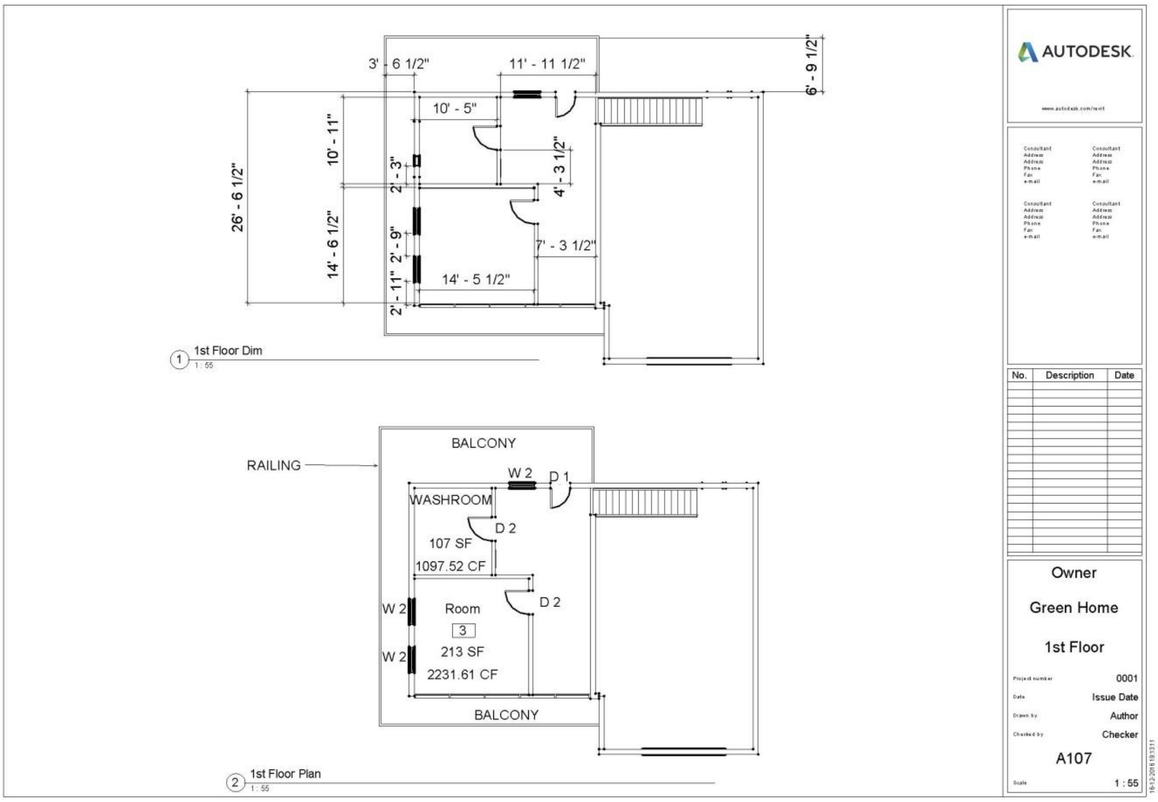
ANNEXURE 5


AUTODESK
No.
Description
Date
Owner
Green Home
Rendered 3d
0001
Issue Date
Author
Checker
A105
1
Rendered

ANNEXURE 6

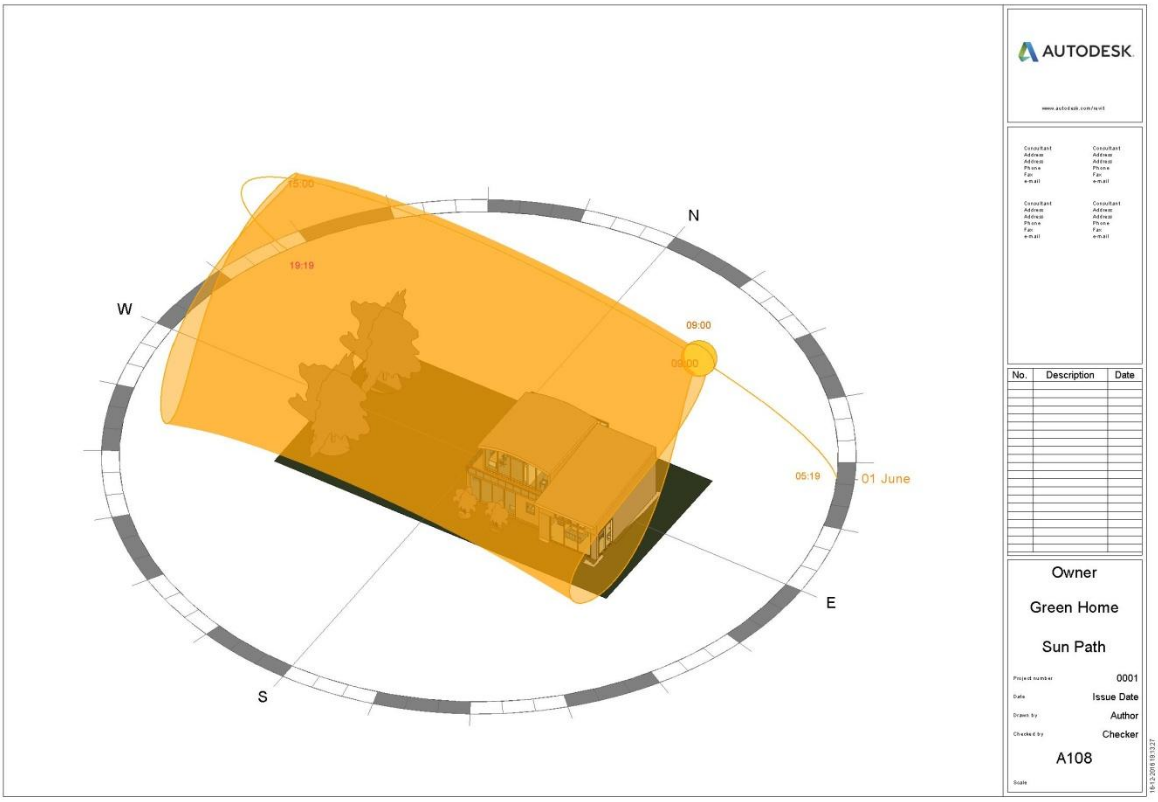
AUTODESK
East
1 : 60
Section Box
No.
Description
Date
Owner
Green Home
Elev & Sec
0001
Issue Date
Author
Checker
A106
1 : 60

ANNEXURE 7

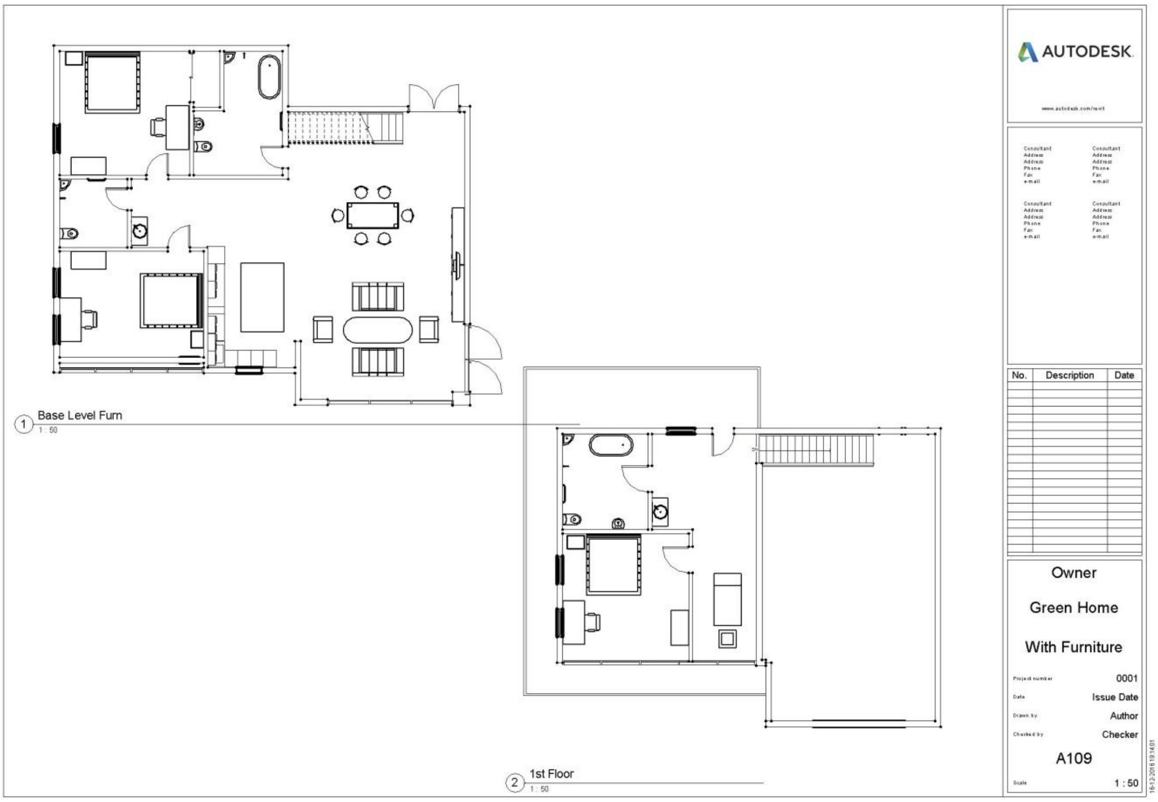


AUTODESK
3' - 6 1/2"
11' - 11 1/2"
6' - 9 1/2"
10' - 5"
10' - 11"
26' - 6 1/2"
2' - 3"
4' - 3 1/2"
14' - 6 1/2"
2' - 9"
7' - 3 1/2"
14' - 5 1/2"
2' - 11"
1st Floor Dim
BALCONY
RAILING
W 2
D 1
WASHROOM
D 2
107 SF
1097.52 CF
Room
3
213 SF
2231.61 CF
BALCONY
1st Floor Plan
No.
Description
Date
Owner
Green Home
1st Floor
0001
Issue Date
Author
Checker
A107
1 : 55

ANNEXURE 8


AUTODESK
N
W
E
S
19:19
09:00
05:19
01 June
No.
Description
Date
Owner
Green Home
Sun Path
Project number
0001
Date
Issue Date
Drawn by
Author
Checked by
Checker
A108

ANNEXURE 9



AUTODESK
Base Level Furn
1 : 50
1st Floor
1 : 50
No.
Description
Date
Owner
Green Home
With Furniture
0001
Issue Date
Author
Checker
A109
1 : 50

ANNEXURE 10

Rates of Common Materials

a) Concrete (1: 1.5 : 3)

Table 10(a) calculation of rate of concrete per unit m^3

1Cum=1440KG=1.44 TONS	Unit	Quantity
1Cum		
Concrete Mix=1:1.5:3	Cum	28.626
Volume = 1Cum		
Dry Volume = 1.25*Volume	Cum	1.25
Volume including wastage = 1.1*D V	Cum	1.375
Aggregates	Cum	0.75
Sand	Cum	0.375
Cement	Cum	0.25
Cement	Tonnes	0.36

S.No	Description	Unit	Quantity	Rate	Amount (Rs)	Remark
1	Material					
1.1	Reinforced cement concrete					
	Cement	Cum	0.25	9072	2268	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = Rs.9072
	Sand	Cum	0.375	700	262.5	For 1 Cum
	Aggregates	Cum	0.75	1050	787.5	For 1 Cum Size vary from25 to 50 mm
	Carriage of Cement	Cum	0.25	228	57.02	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km

	Carriage of Sand	Cum	0.375	106	39.93	Distance 3 to 4 km
	Carriage of Aggregates	Cum	0.75	106	79.86	Distance 3 to 4 km
1.2	REINFORCEMENT					
	Steel Bars	kg	1	64.9	64.95	
	Carriage of Steel	kg	1	0.94	0.94	Distance 3 to 4 km
1.3	Shuttering					
	For Slab	Sqm	1	401	401.65	
2	Labour					
2.1	REINFORCEMENT					
	Bar bender	Mandays	0.01	329	3.29	For 1 kg
	Mazdoor	Mandays	0.01	363	3.63	For 1 kg
2.2	RCC					
	Mason	Mandays	0.23	435	100.05	For 1 Cum
	Mazdoor	Mandays	3.5	363	1,270.50	For 1 Cum
	Bhisti	Mandays	0.9	363	326.70	For 1 Cum
	Mixer Operator	Mandays	0.1	363	36.30	For 1 Cum
3	Plant and Machinery					
	Mixer	Days	1	800	800	
	Vibrator	Days	1	350	350	
	Total Cost of RCC				5228.37	For 1 Cum
	Plant and machinery for 1 day				1150	
	Plant and machinery for 15 day				17250	
	Water Charges		1.5% of total cost		78.42	
	Tools		3% of total cost		156.83	
	Profit		10% of total cost		522.83	
	Total Cost of RCC for 1 Cum				Rs. 5986.49	

b) Bricks

Table 10(b) calculation of rate of bricks per unit m^3

Volume	1 CUM		Quantity	Unit	Remark
Nominal size of bricks used	200*100*100	2000000			
Brick size(without mortar)	190*90*90	1539000			
		461000			
Total number of bricks		500			
Mortar volume		230500000	0.2305	(cum)	(Wet volume)
Dry volume of bricks			0.2875	(cum)	D.V = 1.25* W.V
Volume inc .wastage			0.31625	(cum)	Wastage = 1.1 * D.V
cement volume			0.052708333	(cum)	
sand volume			0.263541667	(cum)	Cement : Sand for brick work=1:6
cement weight	1CUM=1.44 TONS		0.0759	(ton)	First Class Brick

S. No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remark
1	Labour					
	Mason	Mandays	0.25	435	109	For 1 Cum
	Mazdoor	Mandays	0.4	363	145	For 1 Cum
	Bhisti	Mandays	0.1	363	36	For 1 Cum
2	Material					
.2	Bricks	Per brick	500	3.3	1,650	Rate 1000 bricks = 3300
2.2	Cement	Cum	0.053	9072	478	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
2.3	Sand	Cum	0.26	700	184	
2.4	Carriage of Bricks	per brick	500	0.2839	142	Rates 1000 bricks = 283.96 for distance 3 to 4 km

2.5	Carriage of Cement	Cum	0.05	136.29	7	Rate 1 Cum=1.44*94.65=136.29 Rs for Distance = 3 to 4 km
2.6	Carriage of Sand	Cum	0.26	106.49	28	Distance = 3 to 4 km
	Total				2,780	For 1 Cum
4	Profit		10% of total cost		278	
5	Tools		3% of total cost		83	
6	Water Charges		1.5% of total cost		42	
	Total Brick work Cost for 1 Cum				3,183	

c) Plaster (1 :4)

Table 10(c) calculation of rate of plaster per unit m^3

Taking Volume = 1 Cum	
Dry Volume = 1.25*Volume	1.25 Cum
Volume including wastage = 1.1*D V	1.375
Cement : Sand = 1:4	
Cement (Cum)	0.275
Sand (Cum)	1.1

S.No	Description	Unit	Quantity	Rate	Amount	Remark
1	Labour					
1.1	Mason	Mandays	0.08	435	35	For 1 Sqm
1.2	Mazdoor	Mandays	0.1	363	36	For 1 Sqm
2	Material					
2.1	Cement	Cum	0.275	9072	2,495	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
2.2	Sand	Cum	1.1	700	770	For 1 Cum
2.3	Carriage Of Cement	Cum	0.275	228.1065	63	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
2.4	Carriage Of Sand	Cum	1.1	106.49	117	Distance = 3 to 4 km
	Total Cost				3,445	For 1 Cum
	Tools		3% of total cost		103	
	Profit		10% of total cost		344	
	Water Charges		1.5% of total cost		52	
	Total Cost of Material for 1 Cum				Rs 3,944	
	Total Cost of Labour				71	For 1 Sqm
	Tools		3% of total cost		2	
	Profit		10% of total cost		7	
	Water Charges		1.5% of total cost		1	
	Total Cost of Labour for 1 Sqm				Rs. 81	

ANNEXURE 11

Calculation for Construction Cost of Green Home

a) Roof

1. Steel in Roof

Table 11 (a.1) calculation of steel in roof of green home

Steel in Roof	Length (mm)	Breadth (mm)	Spacing between bars (mm)	Number of bars along length	Number of bars along breadth	Bar Diameter in mm	Steel (kg/m)	Total Steel (kg)	Steel Cost /kg	Steel Cost (Rs)
Inclined Roof	10973	6260	200	55	32	10	0.617283951	497.8939	83.37	41,509.42
Curved Roof	8979	7993	200	45	40	10	0.617283951	451.2632	83.37	37,621.81
Total										79,131.23

2. Concreting

Table 11 (a.2) calculation of concreting in roof of green home

Concreting(1:1.5:3)	Volume in m^3	Rate /m^3	Total Cost (Rs)
Inclined Roof	7.93	5,986.00	47,468.98
Curved Roof	7.72	5,986.00	46,211.92
Total			93,680.90

3. Shuttering

Table 11 (a.3) calculation of shuttering of roof of green home

Shuttering	Area in m^2	Rate/m^2	Shuttering Cost (Rs)
Inclined Roof	66.78	401.00	26,778.78
Curved Roof	68.58	401.00	27,500.58
Total			54,279.36

4. Plastering

Table 11 (a.4) calculation of plastering of roof of green home

Plaster (1 :4)	Area in m^2	Plaster Rate /m^3	Labour Rate/m^2	Thickness(mm)	Plaster Cost	Labour Cost	Total Cost (Rs)
Inclined Roof	66.78	3,944.00	81.00	12	3,160.56	5,409.18	8,569.74
Curved Roof	68.58	3,944.00	81.00	12	3,245.75	5,554.98	8,800.73
Total							17,370.48

5. Insulation

Table 11 (a.5) calculation of insulation of roof of green home

Extruded Polystyrene	Area in m^2	Rate/m^2	Total Cost (Rs)
Inclined Roof	66.78	600.00	40,068.00
Curved Roof	68.58	600.00	41,148.00
Total			81,216.00

Total cost of roof = Rs. 3,25,677,96

b) Walls

1. Brick

Table 11(b.1) calculation of rate of bricks in wall of green home

Bricks in Interior Walls	Volume in m^3	Rate including mortar(1:6) $/m^3$	Total Cost (Rs)
	15.99	3,183.60	50,905.76

2. Plaster

Table 11(b.2) calculation of rate of plasters in wall of green home

Plaster (1 :4)	Area in m^2	Rate $/m^3$	Rate/m^2	Thickness(mm)	Total Cost (Rs)
Cost for Labour	362.25	NA	81.00	12	29,342
Cost for plaster	362.25	3,944.00	NA	12	17,145
Total					46,487

3. Insulation

Table 11(b.3) calculation of rate of insulation in wall of green home

Insulation	Area in m^2	Rate/m^2	Total Cost (Rs)
Extruded Polystyrene	247.95	600	1,48,770.00

4. Material for outside wall

Table 11(b.4) calculation of rate of material for outer wall of green home

Autoclaved Aerated Concrete	Volume in m^3	Rate including mortar(1:6) $/m^3$	Total Cost (Rs)
AAC Blocks	64.76	3200	Rs 2,07,232.00

Total cost of Wall = Rs 4,53,394.58

c) Window's Glass

Table 11(c) calculation of rate of window’s glass in green home

Windows Cost	Area in m^2	Rate/m^2	Glass Cost (Rs)
High Performance Glass	21.87	Rs 4,090.00	89,448

d) Flooring

Table 11(d) calculation of rate of flooring in green home

Terrazo Flooring	Area in m^2	Thickness of mortar (1:4) in mm	Rate including mortar(1:4) /m^3	Rate of Tiles /m^2	Mortar Cost (Rs)	Tiles Cost (Rs)	Total Cost (Rs)
Ground Floor	91.71	20	Rs 3,444	575	6,317	52,733	59,050
Area Floor	143.73	20	Rs 3,444	575	9,900	82,645	92,545
Total Cost (Rs)							1,51,595

Total Cost of Construction for Green Home = Rs 10,20,115

ANNEXURE 12

Calculation for Construction Cost of Traditional Home

a) Roof

1. Steel in Roof

Table 12(a.1) calculation of rate of steel in roof of traditional home

Steel in Roof	Length (mm)	Breadth (mm)	Spacing between bars (mm)	Number of bars along length	Number of bars along breadth	Bar Diameter in mm	Steel (kg/m)	Total Steel (kg)	Steel Cost /kg	Steel Cost (Rs)
Inclined Roof	10973	6260	200	55	32	10	0.62	497.89	83.37	41,509
Curved Roof	8979	7993	200	45	40	10	0.62	451.26	83.37	37,622
Total (Rs)										79,131

2. Concreting

Table 12(a.2) calculation of rate of concreting in roof of traditional home

Concreting(1:1.5:3)	Volume in m^3	Rate /m^3	Total Cost (Rs)
Inclined Roof	7.93	5,986.00	47,468.98
Curved Roof	7.72	5,986.00	46,211.92
Total Cost (Rs)			93,680.90

3. Shuttering

Table 12(a.3) calculation of rate of shuttering of roof in traditional home

Shuttering	Area in m^2	Rate/m^2	Shuttering Cost (Rs)
Inclined Roof	66.78	401.00	26,778.78
Curved Roof	68.58	401.00	27,500.58
Total Cost (Rs)			54,279.36

4. Plaster

Table 12(a.4) calculation of rate of plasters in roof of traditional home

Plaster (1:4)	Area in m^2	Plaster Rate /m^3	Labour Rate/m^2	Thickness(mm)	Plaster Cost	Labour Cost	Cost (Rs)
Inclined Roof	66.78	3,944.00	81.00	12	3,160.56	5,409.18	8,569.74
Curved Roof	68.58	3,944.00	81.00	12	3,245.75	5,554.98	8,800.73
Total Cost (Rs)							17,370.48

Total Cost of Roof = Rs 2,44,461.96

b) Walls

1. Bricks

Table 12(b.1) calculation of rate of bricks in walls of traditional home

Bricks	Volume in m^3	Rate including mortar(1:6) $/m^3$	Total Cost (Rs)
	74.19	3,183.60	2,36,191.28

2. Plaster

Table 12(b.2) calculation of rate of plasters in walls of traditional home

Plaster (1:4)	Area in m^2	Rate $/m^3$	Rate$/m^2$	Thickness(mm)	Cost (Rs)
Cost for Labour	403.65	NA	81	12	32,695.65
Cost for plaster	403.65	3944	NA	12	19,103.95
Total (Rs)					51,799.60

Total cost of wall = Rs. 2,87,990.88

c) Window's Glass

Table 12(c) calculation of rate of window's glass of traditional home

Windows Cost	Area in m^2	Rate$/m^2$	Glass Cost (Rs)
Glass	13.5	1,900.00	25,650.00

d) Flooring

Table 12(d) calculation of rate of flooring in traditional home

Ceramic Flooring	Area in m^2	Thickness of mortar (1:4) in mm	Rate including mortar(1:4) $/m^3$	Rate of Tiles $/m^2$	Mortar Cost (Rs)	Tiles Cost (Rs)	Total Cost (Rs)
Ground Floor	91.71	20	3,444	250	6,317	22,928	29,244
Area Floor	143.73	20	3,444	250	9,900	35,933	45,833
Total (Rs)							75,077

Total Cost of Construction of Traditional Home = Rs. 6,33,179.9

ANNEXURE 13

Efficiency of Solar Panels

Table 13 calculation of Solar Panel Efficiency

Month	Appliances	Wattage (Watts)	No. of APPLIANCES	Working hours Per Day	KWH Per day
May	Tube Light (Electric Choke)	36	4	10	1.44
	LED (Bed Room)	10	3	8	0.24
	LED(Wash Rooms)	10	3	1.5	0.045
	Drawing Room Lights	36	2	4	0.288
	Exhaust Fan (Kitchen)	100	1	5	0.5
	Exhaust Fan	100	3	1	0.3
	Efficient Ceiling Fan (Bed Room)	45	3	20	2.7
	Efficient Ceiling Fan (Drawing Room)	45	2	6	0.54
	Television	100	4	5	2
	Washing Machine	500	1	1.5	0.75
					8.80

Solar Panel Capacity (Watts)	1200
Number Of Sunlight Hrs In Day	9
Total Unit Produced In a Day (KWH)	10.8

ANNEXURE 14

Electricity Consumption of Traditional Home

Table 14 monthly electricity consumption of traditional home

Month	Appliances	Watts	No. of Appliance	Working Days	Working hours Per Day	Kwh Per Month
January	Tube Light (Ordinary Choke)	52	4	31	13	83.824
	CFL (Bed Room)	15	3	31	8	11.16
	CFL(Wash Rooms)	15	3	31	1.5	2.0925
	Drawing Room Lights	52	2	31	2	6.448
	Refrigerator	400	1	31	24	297.6
	Heater	1500	3	31	6	837
	Electric Geyser	2000	3	31	2	372
	Exhaust Fan (Kitchen)	100	1	31	5	15.5
	Exhaust Fan	100	3	31	1	9.3
	Television	100	4	31	5	62
	Washing Machine	500	1	8	1.5	6
	Total					**1702.925**
February	Tube Light (Ordinary Choke)	52	4	28	13	75.712
	CFL (Bed Room)	15	3	28	8	10.08
	CFL(Wash Rooms)	15	3	28	1.5	1.89
	Drawing Room Lights	52	2	28	2	5.824
	Refrigerator	400	1	28	24	268.8
	Heater	1500	3	28	6	756
	Exhaust Fan (Kitchen)	100	1	31	5	15.5
	Exhaust Fan	100	3	31	1	9.3
	Electric Geyser	2000	3	28	2	336
	Television	100	4	28	5	56
	Washing Machine	500	1	8	1.5	6
	Total					**1541.106**
March	Tube Light (Ordinary Choke)	52	4	31	13	83.824
	CFL (Bed Room)	15	3	31	8	11.16
	CFL(Wash Rooms)	15	3	31	1.5	2.0925
	Drawing Room Lights	52	2	31	2	6.448
	Refrigerator	400	1	31	24	297.6
	Heater	1500	3	25	5	562.5
	Exhaust Fan (Kitchen)	100	1	31	5	15.5
	Exhaust Fan	100	3	31	1	9.3

March	Electric Geyser	2000	3	31	1.5	279
	Television	100	4	31	5	62
	Washing Machine	500	1	8	1.5	6
	Total					**1335.425**
April	Tube Light (Ordinary Choke)	52	4	30	13	81.12
	CFL (Bed Room)	15	3	30	8	10.8
	CFL(Wash Rooms)	15	3	30	1.5	2.025
	Drawing Room Lights	52	2	30	2	6.24
	Refrigerator	400	1	30	24	288
	Heater	1500	3	15	3	202.5
	Ceiling Fan (Bed Room)	75	3	30	10	67.5
	Ceiling Fan (Drawing Room)	75	2	30	4	18
	Exhaust Fan (Kitchen)	100	1	30	5	15
	Exhaust Fan	100	3	30	1	9
	Electric Geyser	2000	3	30	1.5	270
	Television	100	4	30	5	60
	Washing Machine	500	1	8	1.5	6
	Total					**1036.185**
May	Tube Light (Ordinary Choke)	52	4	31	13	83.824
	CFL (Bed Room)	15	3	31	8	11.16
	CFL(Wash Rooms)	15	3	31	1.5	2.0925
	Drawing Room Lights	52	2	31	2	6.448
	Exhaust Fan (Kitchen)	100	1	31	5	15.5
	Exhaust Fan	100	3	31	1	9.3
	Ceiling Fan (Bed Room)	75	3	31	18	125.55
	Ceiling Fan (Drawing Room)	75	2	31	6	27.9
	Refrigerator	400	1	31	24	297.6
	Electric Geyser	2000	3	31	1.5	279
	Television	100	4	28	5	56
	Washing Machine	500	1	8	1.5	6
	Total					**920.3745**
June	Tube Light (Ordinary Choke)	52	4	30	13	81.12
	CFL (Bed Room)	15	3	30	8	10.8
	CFL(Wash Rooms)	15	3	30	1.5	2.025
	Ceiling Fan (Bed Room)	75	3	30	20	135
	Ceiling Fan (Drawing Room)	75	2	30	6	27
	Refrigerator	400	1	30	24	288
	Electric Geyser	2000	3	30	1	180
	Drawing Room Lights	52	2	30	2	6.24
	Exhaust Fan (Kitchen)	100	1	30	5	15

June	Exhaust Fan	100	3	30	1	9
	Television	100	4	30	5	60
	Washing Machine	500	1	8	1.5	6
	Total					**820.185**
July	Tube Light (Ordinary Choke)	52	4	31	13	83.824
	CFL (Bed Room)	15	3	31	8	11.16
	CFL(Wash Rooms)	15	3	31	1.5	2.0925
	Ceiling Fan (Bed Room)	75	3	25	20	112.5
	Ceiling Fan (Drawing Room)	75	2	25	5	18.75
	Refrigerator	400	1	31	24	297.6
	Electric Geyser	2000	3	31	1.2	223.2
	Drawing Room Lights	52	2	31	2	6.448
	Exhaust Fan (Kitchen)	100	1	31	5	15.5
	Exhaust Fan	100	3	31	1	9.3
	Television	100	4	31	5	62
	Washing Machine	500	1	8	1.5	6
	Total					**848.3745**
August	Tube Light (Ordinary Choke)	52	4	31	13	83.824
	CFL (Bed Room)	15	3	31	8	11.16
	CFL(Wash Rooms)	15	3	31	1.5	2.0925
	Ceiling Fan (Bed Room)	75	3	25	17	95.625
	Ceiling Fan (Drawing Room)	75	2	25	4	15
	Refrigerator	400	1	31	24	297.6
	Electric Geyser	2000	3	31	1.5	279
	Drawing Room Lights	52	2	31	2	6.448
	Exhaust Fan (Kitchen)	100	1	31	5	15.5
	Exhaust Fan	100	3	31	1	9.3
	Television	100	4	31	5	62
	Washing Machine	500	1	8	1.5	6
	Total					**883.5495**
September	Tube Light (Ordinary Choke)	52	4	30	13	81.12
	CFL (Bed Room)	15	3	30	8	10.8
	CFL(Wash Rooms)	15	3	30	1.5	2.025
	Ceiling Fan (Bed Room)	75	3	20	15	67.5
	Ceiling Fan (Drawing Room)	75	2	20	4	12
	Refrigerator	400	1	30	24	288
	Electric Geyser	2000	3	30	1.5	270
	Drawing Room Lights	52	2	30	2	6.24
	Exhaust Fan (Kitchen)	100	1	30	5	15

September	Exhaust Fan	100	3	30	1	9
	Television	100	4	30	5	60
	Washing Machine	500	1	8	1.5	6
	Total					**827.685**
October	Tube Light (Ordinary Choke)	52	4	30	13	81.12
	CFL (Bed Room)	15	3	30	8	10.8
	CFL(Wash Rooms)	15	3	30	1.5	2.025
	Ceiling Fan (Bed Room)	75	3	10	15	33.75
	Ceiling Fan (Drawing Room)	75	2	10	4	6
	Refrigerator	400	1	30	24	288
	Electric Geyser	2000	3	30	2	360
	Drawing Room Lights	52	2	30	2	6.24
	Exhaust Fan (Kitchen)	100	1	30	5	15
	Exhaust Fan	100	3	30	1	9
	Television	100	4	30	5	60
	Washing Machine	500	1	8	1.5	6
	Total					**877.935**
November	Tube Light (Ordinary Choke)	52	4	30	13	81.12
	CFL (Bed Room)	15	3	30	8	10.8
	CFL(Wash Rooms)	15	3	30	1.5	2.025
	Refrigerator	400	1	30	24	288
	Heater	1500	3	30	4	540
	Electric Geyser	2000	3	30	2	360
	Drawing Room Lights	52	2	30	2	6.24
	Exhaust Fan (Kitchen)	100	1	30	5	15
	Exhaust Fan	100	3	30	1	9
	Television	100	4	30	5	60
	Washing Machine	500	1	8	1.5	6
	Total					**1378.185**
December	Tube Light (Ordinary Choke)	52	4	31	13	83.824
	CFL (Bed Room)	15	3	31	8	11.16
	CFL(Wash Rooms)	15	3	31	1.5	2.0925
	Refrigerator	400	1	31	24	297.6
	Heater	1500	3	31	6	837
	Electric Geyser	2000	3	31	2	372
	Drawing Room Lights	52	2	31	2	6.448
	Exhaust Fan (Kitchen)	100	1	31	5	15.5
	Exhaust Fan	100	3	31	1	9.3
	Television	100	4	31	5	62
	Washing Machine	500	1	8	1.5	6
	Total					**1702.925**

ANNEXURE 15

Electricity Consumption of Green Home

Table 15 calculation of electricity consumption of green home

Month	Appliances	Watts	No. of Appiance	Working Days	Working hours Per Day	Kwh Per Month	Solar Applicablilty
Jan	Tube Light (Electric Choke)	36	4	31	8	0	Solar Panels
	LED (Bed Room)	10	3	31	8	0	Solar Panels
	LED(Wash Rooms)	10	3	31	1.5	0	Solar Panels
	Drawing Room Lights	36	2	31	2	0	Solar Panels
	Refrigerator	400	1	31	24	298	NA
	Heater	1500	3	31	4	558	NA
	Electric Geyser	2000	3	31	2	0	Solar Water Heater
	Exhaust Fan (Kitchen)	100	1	31	5	0	Solar Panels
	Exhaust Fan	100	3	31	1	0	Solar Panels
	Television	100	4	31	5	0	Solar Panels
	Washing Machine	500	1	8	1.5	0	Solar Panels
	Total					**856**	
Feb	Tube Light (Electric Choke)	36	4	28	8	0	Solar Panels
	LED (Bed Room)	10	3	28	8	0	Solar Panels
	LED(Wash Rooms)	10	3	28	1.5	0	Solar Panels
	Drawing Room Lights	52	2	28	2	0	Solar Panels
	Refrigerator	400	1	28	24	269	NA
	Heater	1500	3	28	3	378	NA
	Exhaust Fan (Kitchen)	100	1	31	5	0	Solar Panels
	Exhaust Fan	100	3	31	1	0	Solar Panels
	Electric Geyser	2000	3	28	2	0	Solar Water Heater
	Television	100	4	28	5	0	Solar Panels
	Washing Machine	500	1	8	1.5	0	Solar Panels
	Total					**647**	
Mar	Tube Light (Electric Choke)	36	4	31	8	0	Solar Panels
	LED (Bed Room)	10	3	31	8	0	Solar Panels
	LED(Wash Rooms)	10	3	31	1.5	0	Solar Panels
	Drawing Room Lights	52	2	31	2	0	Solar Panels
	Refrigerator	400	1	31	24	297.6	NA
	Heater	1500	3	25	4	450	NA
	Exhaust Fan (Kitchen)	100	1	31	5	0	Solar Panels

Mar	Exhaust Fan	100	3	31	1	0	Solar Panels
	Electric Geyser	2000	3	31	1.5	0	Solar Water Heater
	Television	100	4	31	5	0	Solar Panels
	Washing Machine	500	1	8	1.5	0	Solar Panels
	Total					**747.6**	
Apr	Tube Light (Electric Choke)	36	4	30	8	0	Solar Panels
	LED (Bed Room)	10	3	30	8	0	Solar Panels
	LED(Wash Rooms)	10	3	30	1.5	0	Solar Panels
	Drawing Room Lights	52	2	30	2	0	Solar Panels
	Refrigerator	400	1	30	24	288	NA
	Heater	1500	3	15	1.5	101.25	NA
	Efficient Ceiling Fan (Bed Room)	45	3	30	10	0	Solar Panels
	Efficient Ceiling Fan (Drawing Room)	45	2	30	4	0	Solar Panels
	Exhaust Fan (Kitchen)	100	1	30	5	0	Solar Panels
	Exhaust Fan	100	3	30	1	0	Solar Panels
	Electric Geyser	2000	3	30	1.5	0	Solar Water Heater
	Television	100	4	30	5	0	Solar Panels
	Washing Machine	500	1	8	1.5	0	Solar Panels
	Total					**389.25**	
May	Tube Light (Electric Choke)	36	4	31	8	0	Solar Panels
	LED (Bed Room)	10	3	31	8	0	Solar Panels
	LED(Wash Rooms)	10	3	31	1.5	0	Solar Panels
	Drawing Room Lights	52	2	31	2	0	Solar Panels
	Exhaust Fan (Kitchen)	100	1	31	5	0	Solar Panels
	Exhaust Fan	100	3	31	1	0	Solar Panels
	Efficient Ceiling Fan (Bed Room)	45	3	31	18	0	Solar Panels
	Efficient Ceiling Fan (Drawing Room)	45	2	31	6	0	Solar Panels
	Refrigerator	400	1	31	24	297.6	NA
	Electric Geyser	2000	3	31	1.5	0	Solar Water Heater
	Television	100	4	28	5	0	Solar Panels
	Washing Machine	500	1	8	1.5	0	Solar Panels
	Total					**297.6**	
Jun	Tube Light (Electric Choke)	36	4	30	8	0	Solar Panels
	LED (Bed Room)	10	3	30	8	0	Solar Panels
	LED(Wash Rooms)	10	3	30	1.5	0	Solar Panels
	Efficient Ceiling Fan (Bed Room)	45	3	30	20	0	Solar Panels
	Efficient Ceiling Fan (Drawing Room)	45	2	30	6	0	Solar Panels

Jun	Refrigerator	400	1	30	24	288	NA
	Electric Geyser	2000	3	30	1	0	Solar Water Heater
	Drawing Room Lights	52	2	30	2	0	Solar Panels
	Exhaust Fan (Kitchen)	100	1	30	5	0	Solar Panels
	Exhaust Fan	100	3	30	1	0	Solar Panels
	Television	100	4	30	5	0	Solar Panels
	Washing Machine	500	1	8	1.5	0	Solar Panels
	Total					**288**	
Jul	Tube Light (Electric Choke)	36	4	31	8	0	Solar Panels
	LED (Bed Room)	10	3	31	8	0	Solar Panels
	LED(Wash Rooms)	10	3	31	1.5	0	Solar Panels
	Efficient Ceiling Fan (Bed Room)	45	3	25	17	0	Solar Panels
	Efficient Ceiling Fan (Drawing Room)	45	2	25	5	0	Solar Panels
	Refrigerator	400	1	31	24	297.6	NA
	Electric Geyser	2000	3	31	1.2	0	Solar Water Heater
	Drawing Room Lights	52	2	31	2	0	Solar Panels
	Exhaust Fan (Kitchen)	100	1	31	5	0	Solar Panels
	Exhaust Fan	100	3	31	1	0	Solar Panels
	Television	100	4	31	5	0	Solar Panels
	Washing Machine	500	1	8	1.5	0	Solar Panels
	Total					**297.6**	
Aug	Tube Light (Electric Choke)	36	4	31	8	0	Solar Panels
	LED (Bed Room)	10	3	31	8	0	Solar Panels
	LED(Wash Rooms)	10	3	31	1.5	0	Solar Panels
	Efficient Ceiling Fan (Bed Room)	45	3	25	15	0	Solar Panels
	Efficient Ceiling Fan (Drawing Room)	45	2	25	4	0	Solar Panels
	Refrigerator	400	1	31	24	297.6	NA
	Electric Geyser	2000	3	31	1.5	279	Solar Water Heater
	Drawing Room Lights	52	2	31	2	0	Solar Panels
	Exhaust Fan (Kitchen)	100	1	31	5	0	Solar Panels
	Exhaust Fan	100	3	31	1	0	Solar Panels
	Television	100	4	31	5	0	Solar Panels
	Washing Machine	500	1	8	1.5	0	Solar Panels
	Total					**576.6**	
Sept	Tube Light (Electric Choke)	36	4	30	8	0	Solar Panels
	LED (Bed Room)	10	3	30	8	0	Solar Panels
	LED(Wash Rooms)	10	3	30	1.5	0	Solar Panels
	Efficient Ceiling Fan	45	3	20	15	0	Solar Panels

Sept	Efficient Ceiling Fan (Drawing Room)	45	2	20	4	0	Solar Panels
	Refrigerator	400	1	30	24	288	NA
	Electric Geyser	2000	3	30	1.5	0	Solar Water Heater
	Drawing Room Lights	52	2	30	2	0	Solar Panels
	Exhaust Fan (Kitchen)	100	1	30	5	0	Solar Panels
	Exhaust Fan	100	3	30	1	0	Solar Panels
	Television	100	4	30	5	0	Solar Panels
	Washing Machine	500	1	8	1.5	0	Solar Panels
	Total					**288**	
Oct	Tube Light (Electric Choke)	36	4	30	8	0	Solar Panels
	LED (Bed Room)	10	3	30	8	0	Solar Panels
	LED(Wash Rooms)	10	3	30	1.5	0	Solar Panels
	Efficient Ceiling Fan (Bed Room)	45	3	10	15	0	Solar Panels
	Efficient Ceiling Fan (Drawing Room)	45	2	10	4	0	Solar Panels
	Refrigerator	400	1	30	24	288	NA
	Electric Geyser	2000	3	30	2	0	Solar Water Heater
	Drawing Room Lights	52	2	30	2	0	Solar Panels
	Exhaust Fan (Kitchen)	100	1	30	5	0	Solar Panels
	Exhaust Fan	100	3	30	1	0	Solar Panels
	Television	100	4	30	5	0	Solar Panels
	Washing Machine	500	1	8	1.5	6	Solar Panels
	Total					**294**	
Nov	Tube Light (Electric Choke)	36	4	30	8	0	Solar Panels
	LED (Bed Room)	10	3	30	8	0	Solar Panels
	LED(Wash Rooms)	10	3	30	1.5	0	Solar Panels
	Refrigerator	400	1	30	24	288	NA
	Heater	1500	3	30	2	270	NA
	Electric Geyser	2000	3	30	2	0	Solar Water Heater
	Drawing Room Lights	52	2	30	2	0	Solar Panels
	Exhaust Fan (Kitchen)	100	1	30	5	0	Solar Panels
	Exhaust Fan	100	3	30	1	0	Solar Panels
	Television	100	4	30	5	0	Solar Panels
	Washing Machine	500	1	8	1.5	0	Solar Panels
	Total					**558**	
Dec	Tube Light (Electric Choke)	36	4	31	8	0	Solar Panels
	LED (Bed Room)	10	3	31	8	0	Solar Panels
	LED(Wash Rooms)	10	3	31	1.5	0	Solar Panels
	Refrigerator	400	1	31	24	297.6	NA
	Heater	1500	3	31	3.5	488.25	NA

Dec	Electric Geyser	2000	3	31	2	0	Solar Water Heater
	Drawing Room Lights	52	2	31	2	0	Solar Panels
	Exhaust Fan (Kitchen)	100	1	31	5	0	Solar Panels
	Exhaust Fan	100	3	31	1	0	Solar Panels
	Television	100	4	31	5	0	Solar Panels
	Washing Machine	500	1	8	1.5	0	Solar Panels
	Total					**785.85**	

ANNEXURE 16

Water Consumption of both homes

Table 16 calculation of water consumption for both homes

Fixtures	Duration uses (in min)	Daily Uses / person /day	Number of person	Baseline		Proposed	
				Flow Rate/ Capacity (in LPF/LPM)	Total Water Use per day (Litres)	Flow Rate/ Capacity (in LPF/LPM)	Total Water Use Per day (Litres)
Water Closets (High Flush) in LPF	1	1	5	6	30	4	20
Water Closets (Low Flush) in LPF	1	4	5	3	60	2	40
Faucet in LPM	0.25	5	5	8	50	8	50
Kitchen Sink in LPM	3	3	5	8	360	6	270
Showerhead in LPM	8	2	5	10	800	8	640
Daily Flow from Fixtures (Litres)					1300		1020
Number of Operational Days					365		

Annual Rain Water Harvesting Capacity	Annual Rainfall (metres)	Catchment Area (m^2)	Run off Coefficient For Concrete	Volume(Litres)
	1.319276	117.36	0.9	139347.2082

	Water Requirement per m^2 in Litres	Landscape area	Operational Days	Total Volume of Water Required (Litres)
Water Requirement For Landscaping	5	54	365	98550
Xeriscaping for Green Homes	3	54	365	59130

ANNEXURE 17

Payback Period

Modified Discount Rate $= \left(\left(\frac{1+\text{interest } rate}{1+\text{inflation rate}}\right) - 1\right) * 100$

Net present Value = $\frac{\text{Savings per year}}{(1+\text{modified discount rate})^{\text{nth year}}}$

Table 17 calculation of payback period

Determination of Payback Period				
Extra Investment = ₹ 5,57,936.00				
Inflation Rate = 8.00%	Modified Discount Rate = 3.70%			
Interest Rate = 12.00%				
Year	Expected Savings per year	Present Value	Cumulative cash flow	Remaining Cash Need to recover Investment in present value
0	0	0	0	5,57,936
1	24,775	23,891	23,891	5,34,045
2	24,775	23,039	46,930	5,11,007
3	24,775	22,216	69,146	4,88,790
4	24,775	21,424	90,570	4,67,366
5	24,775	20,659	1,11,229	4,46,707
6	24,775	19,922	1,31,152	4,26,785
7	24,775	19,211	1,50,363	4,07,573
8	24,775	18,526	1,68,889	3,89,047
9	24,775	17,865	1,86,754	3,71,182
10	24,775	17,228	2,03,982	3,53,955
11	24,775	16,613	2,20,594	3,37,342
12	24,775	16,020	2,36,615	3,21,322
13	24,775	15,449	2,52,063	3,05,873
14	24,775	14,897	2,66,961	2,90,976
15	24,775	14,366	2,81,326	2,76,610
16	24,775	13,853	2,95,180	2,62,756
17	24,775	13,359	3,08,539	2,49,397
18	24,775	12,882	3,21,421	2,36,515
19	24,775	12,423	3,33,844	2,24,092

20	24,775	11,980	3,45,824	2,12,113
21	24,775	11,552	3,57,376	2,00,561
22	24,775	11,140	3,68,516	1,89,421
23	24,775	10,742	3,79,258	1,78,678
24	24,775	10,359	3,89,617	1,68,319
25	24,775	9,990	3,99,607	1,58,329
26	24,775	9,633	4,09,240	1,48,696
27	24,775	9,289	4,18,530	1,39,407
28	24,775	8,958	4,27,488	1,30,449
29	24,775	8,638	4,36,126	1,21,810
30	24,775	8,330	4,44,456	1,13,480
31	24,775	8,033	4,52,489	1,05,447
32	24,775	7,746	4,60,236	97,701
33	24,775	7,470	4,67,706	90,231
34	24,775	7,203	4,74,909	83,027
35	24,775	6,946	4,81,856	76,081
36	24,775	6,699	4,88,554	69,382
37	24,775	6,460	4,95,014	62,922
38	24,775	6,229	5,01,243	56,693
39	24,775	6,007	5,07,250	50,686
40	24,775	5,793	5,13,043	44,894
41	24,775	5,586	5,18,628	39,308
42	24,775	5,387	5,24,015	33,921
43	24,775	5,194	5,29,209	28,727
44	24,775	5,009	5,34,218	23,718
45	24,775	4,830	5,39,049	18,887
46	24,775	4,658	5,43,707	14,229
47	24,775	4,492	5,48,199	9,738
48	24,775	4,332	5,52,530	5,406
49	24,775	4,177	5,56,707	1,229
50	24,775	4,028	5,60,735	- 2,799
51	24,775	3,884	5,64,619	- 6,683
52	24,775	3,746	5,68,365	- 10,429
53	24,775	3,612	5,71,977	- 14,041
54	24,775	3,483	5,75,460	- 17,524