MODELLING AND ANALYSIS OF CONVENTIONAL AND GREEN BUILDING IN REVIT SOFTWARE FOR COLD AND CLOUDY CLIMATE

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

HIMACHAL PRADESH, INDIA

MAY, 2017

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Modelling and Analysis of Conventional and Green Building in REVIT Software for Cold and Cloudy Climate"** 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 **Gagan Sindwani (131637), Rajat Sharma (131665), Rajat Chander Katoch (131701)** during a period from July 2016 to May 2017 under the supervision of **Mr. Santu Kar** Assistant Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

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ABSTRACT

Green Building also known as green construction or sustainable building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle. Green building deals with the various energy saving concepts which can be incorporated at the time of planning, designing, construction and execution stage to have energy efficiency keeping in mind the cost perspective. This report aims at studying the different features of a Green Building and preparing a 3D model in REVIT Software of Conventional Building and Green Building.

The Green Building has incorporated with various parameters for energy savings and modelled in the software Autodesk REVIT. In this project, Conventional building and Green buildings are designed for a Cold and Cloudy Climate for the region Shimla where maximum temperature is 30^{o}C and minimum temperature is -2^{o}C. Cost of construction is estimated for Conventional Building and Green Building. A comparison between the Conventional Building and Green Building is done on the basis of Cost of Construction and Energy Cost and a payback period is determined.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

India being emerging as a fastest growing economy and progressive outlook towards infrastructure development have boosted confidence among industry owners that a high-performance green building can either capture lease premiums or present a more competitive asset in a tough segment of market driven economy.

Green building are referred to as sustainable building which necessitate the use of energy efficient materials, integrated design, for reducing the environmental hazards and enhancing the indoor air quality.

Green buildings are designed, constructed and operated to boost environmental protection, ensure economic equality, inculcate waste reduction, fortify sustainable site planning as well as enhancing health and productivity performance in comparison to conventional buildings.

Study of key green building & green construction technologies is always based on "Conservation and Environmental Protection", and it aims to realize resource economization & recycling and sound insulation and noise reduction etc., so as to achieve sustainable development. (Ye H.2014)

1.2 NEED FOR STUDY

The growth and development of any country is a backbone to its economic enrichment. With rising economic pace the threats to environment needs to be identified and handled with cooperation through various treaties among the world in order to remain within the ambit of sustainable development.

In India real estate devour around 40% energy and thus acting to be a prime factor for contributing to Green House gas emissions. On perceiving the above scenario it's imperative to incorporate construction of Green buildings in our diverse society so as to preserve our environment and uphold the legal ratifications signed by our country at global level.

Green Building carries out a vast muster of practices, techniques and skills to reduce and ultimately eliminate the impact of buildings on the environment and human health. It involves use of renewable sources instead of finite fossil fuels i.e. incorporating solar devices and photovoltaic cells, disaster fortitude designs and using plants, trees through green roofs, and reduction of rainwater runoff.

1.3 OBJECTIVES

1. To Study different features of Green Building and their Benefits.
2. To prepare 3D model in REVIT Software of Conventional Building and Green Building.
3. To estimate Cost of Construction and Energy Cost of Green Building and Conventional Building and to compare them.
4. Determining the payback period of extra cost incurred during Construction of Green Building.

1.4 SCOPE OF THE PROJECT

The Scope of this project is to prepare a 3D model of Green Building highlighting all the features incorporated according to Cold and Cloudy Climate using AUTOCAD AND REVIT Software. Energy analysis will be done manually as well as through software. A comparison will be done between Conventional Building and Green Building.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

A green building takes in consideration about environment effects at different construction stages. The various stages include the design stage, the construction stage, the operation stage and maintenance stage. Construction firms which are involved with sustainable building projects will most likely deal with innovative green technologies' integration to buildings. In order to run a successful integration process, construction firms need to possess new skills. (Gunhan, S. 2012).

The following information focuses on the various strategies and technologies, key principles associated with green building.

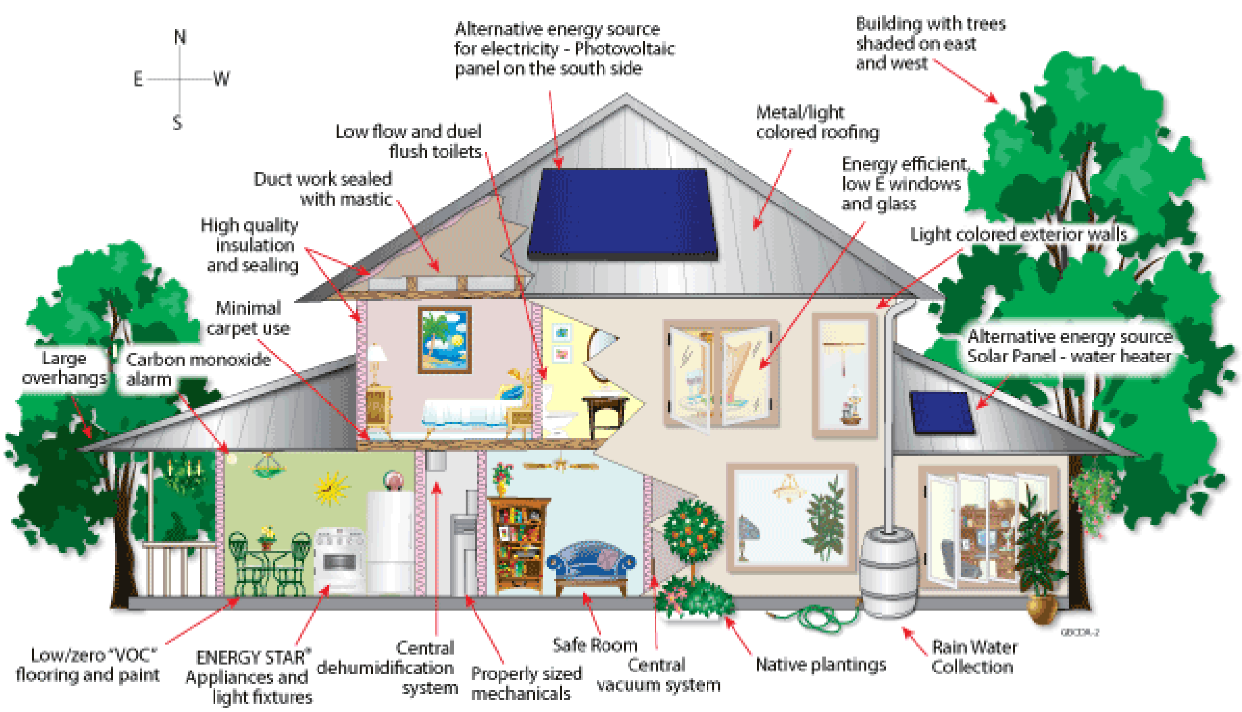


Fig – 2.1 Features of Green Building

2.2 CLIMATE AND BUILDING (S. Fereidoon, 2007)

The atmospheric condition of a given place is determined according to the weather conditions of that particular place. Due to the variations in climate we experience many different situations. These conditions can be comfortable and uncomfortable. In some months of the year we experience hot climate whereas on the other side we experiences cold climate. So there is a need to design our building according to the uncomfortable condition. For such cases Green buildings are designed so that the discomfort can be eliminated. For E.g. - If we take region of Rajasthan we can see that it is located in hot region. So the cooling systems must be installed in the houses. On the other side if we take region of Shimla which is located in Cold region we must ensure that proper heating systems must be provided inside the rooms. So accordingly the buildings are designed depending upon the weather conditions of that particular area in which building is situated.

2.2.1 FACTORS AFFECTING CLIMATE

Climate and weather are affected by various factors. They are as follows:

(A) Solar radiation
(B) Ambient temperature
(C) Air humidity
(D) Sky condition

(A) Solar radiation

The radiant energy received from sun is termed as solar radiations. It is expressed as watts per sqm. i.e the sun rays falling on the surface per unit time per unit area. The geographical location of the area decides the incidence of sun rays. In the mid noon the sun is overhead so the sun rays strikes vertically on the surface. The buildings that are built on the cold climatic region experience more sun rays in the southern direction. The inclined surface experiences more sun rays as compared to flat horizontal surfaces. This can be seen from the Fig 2.2(a)

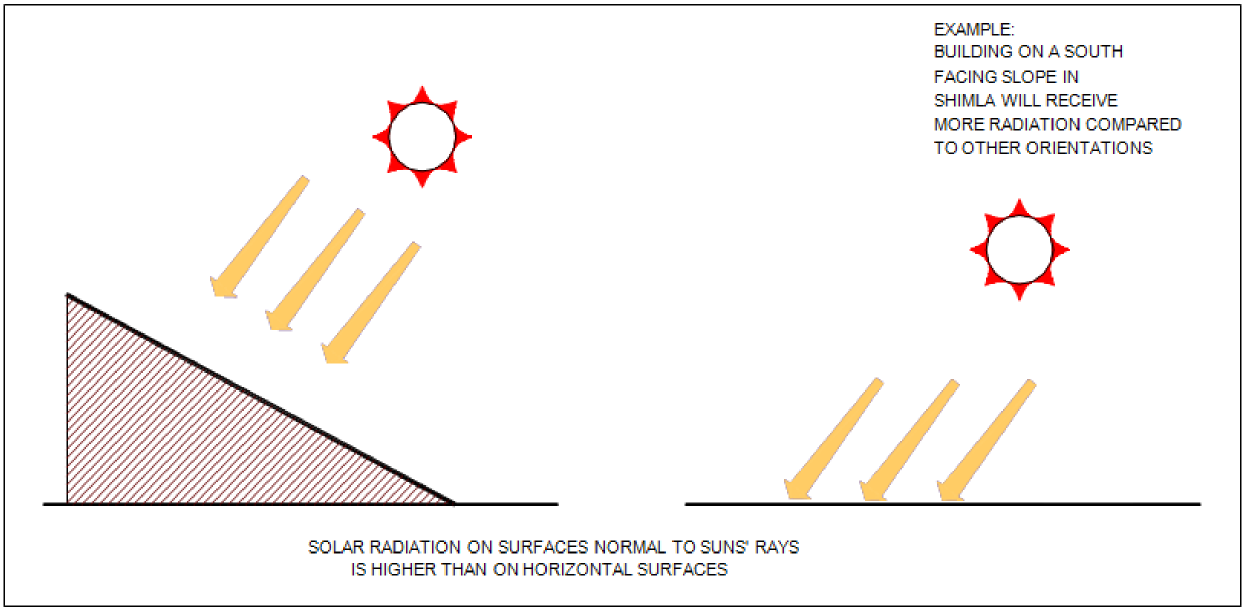


Fig – 2.2(a) Effect of Orientation

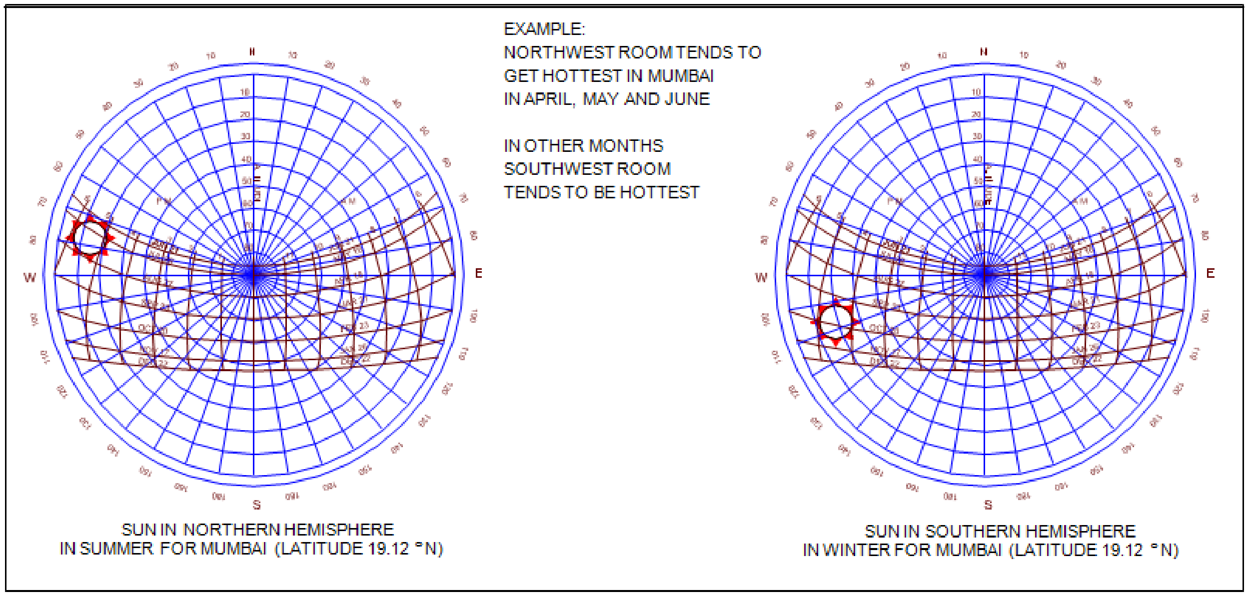


Fig – 2.2(b) Effect of Season

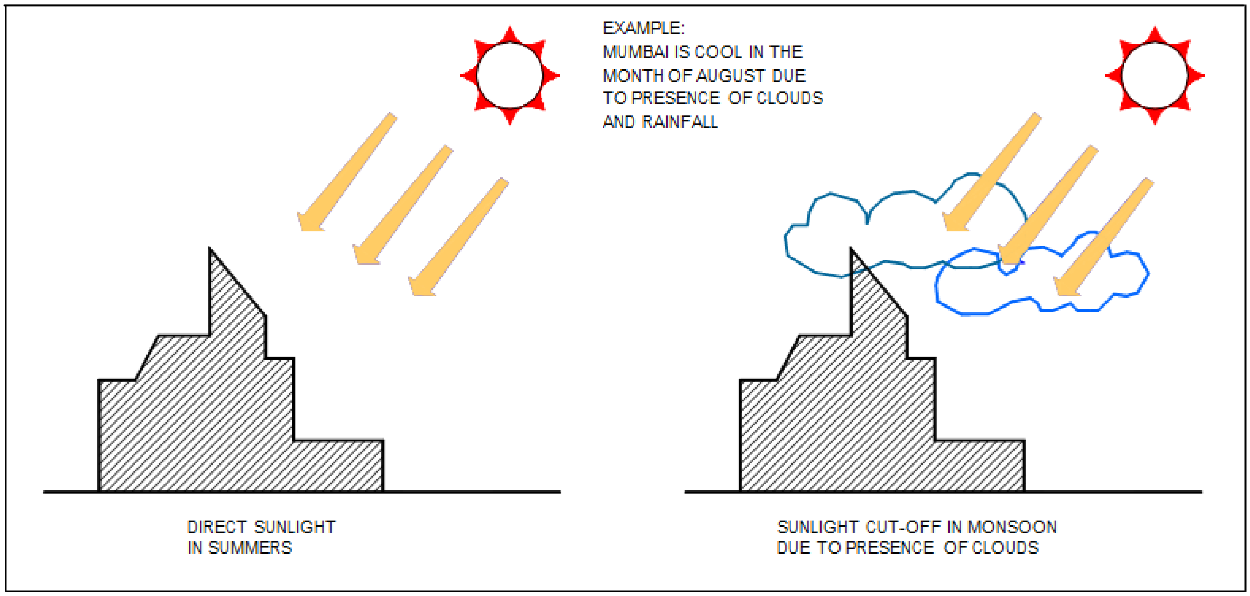


Fig – 2.2(c) Effect of Sky Cover

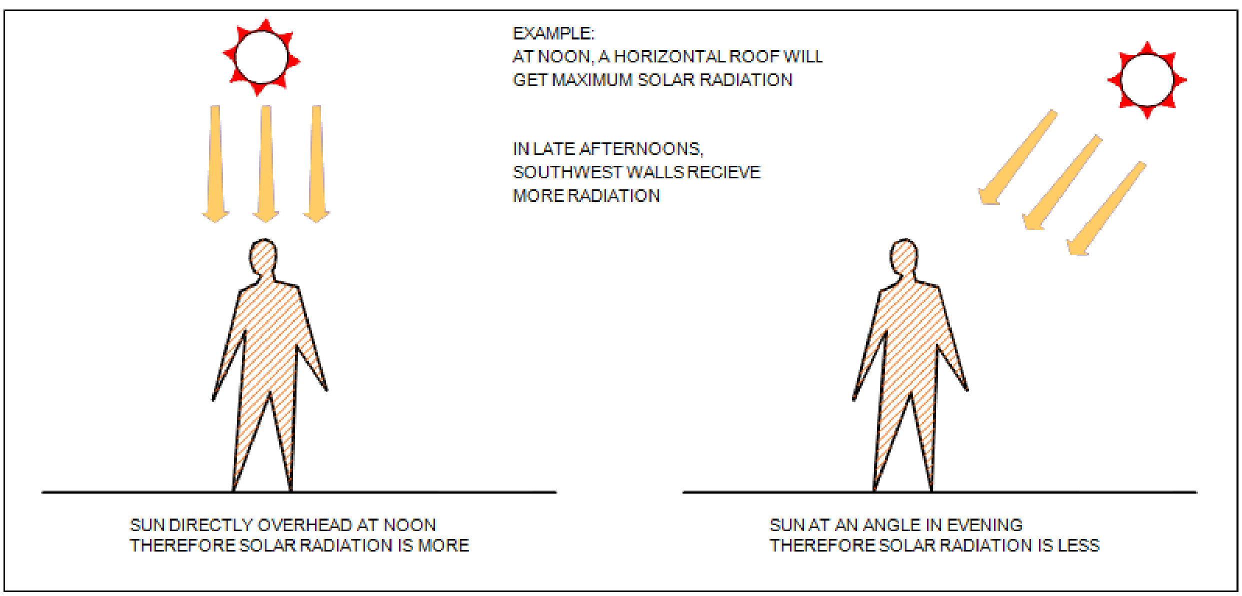


Fig – 2.2(d) Effect of Time

(B)Ambient temperature

The temperature of air that is in closed ventilated enclosure is known as ambient temperature. Its units are degree Celsius (ºC). The temperature of a particular area can vary by various factors such as winds, presence of water bodies etc. In order to maintain optimal temperature inside the rooms we provide deciduous trees. Deciduous trees serves advantage that they provides shades to the wall facing the sun during peak summers whereas they shed their leaves during winters so maximum sun rays fall on the external walls of the building.

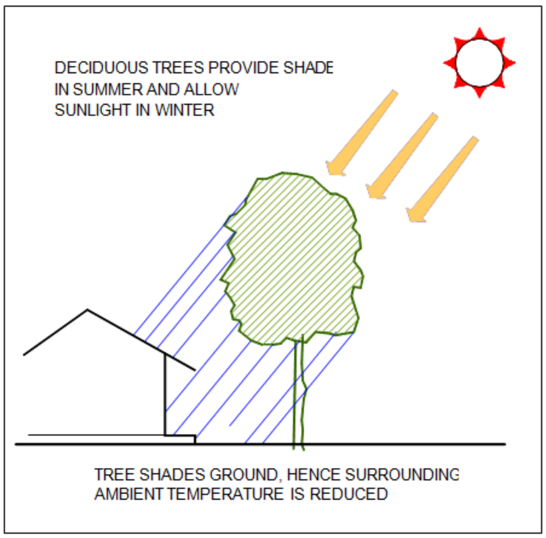


Fig – 2.3(a) Effect of Shading

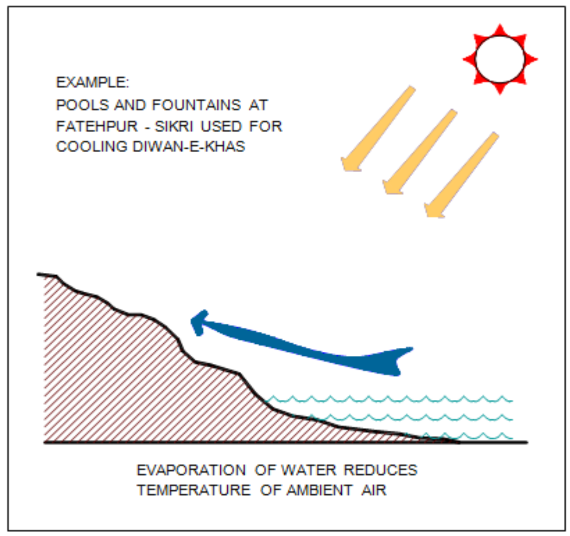


Fig – 2.3(b) Effect of Water Body

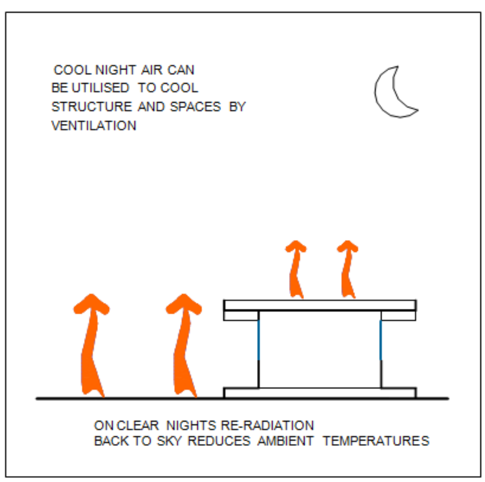


Fig – 2.3(c) Effect of Sky Condition

(C)Air humidity

The moisture level in the air is termed as air humidity. Relative humidity is the ratio of mass of water vapour in a certain volume of moist air at a certain temperature. It is expressed in percentage. When the temperature of air falls then humid aid will be more and if the temperature of air rises then there will be less humidity in air. Humidity will be lowest during the summer months especially in the noon.Whereas it will be highest during peak winters. A lot of discomfort will be there when both the air humidity and ambient temperature will be high.

(D) Sky condition

The amount of sunlight that falls on the building is decided by the extent of sky cover. During monsoon the sky is not clear so there will be less sunlight that falls on the building whereas in summers the sky is clear so maximum sun rays strike the surface of building. Sky cover is measured in okatas. This effect of sky cover can be well understood by the Fig 2.4

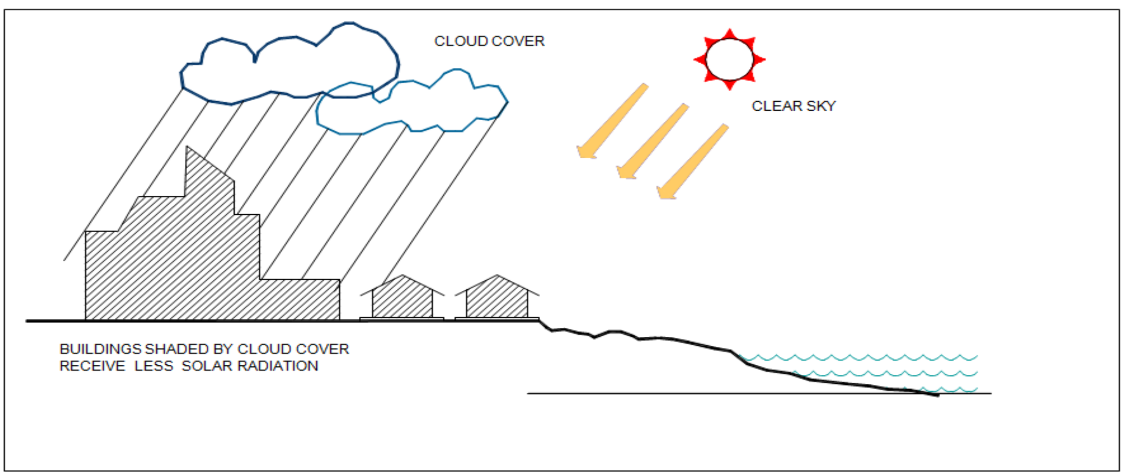


Fig – 2.4 Effect of Sky Condition

In addition to these factors other factors also affect the sky conditions which includes hills, valleys, ponds etc.

2.3 INDIA CLIMATE

India remains subjected to tropical climate which makes difficulty in predicting the climate variations and phenomena as it varies from region to region. The summers in India normally occurs between periods i.e. April-June whereas winters accounts between periods i.e. November-March. The monsoon prevalent over periods i.e. between July-September is highly turbulent due to heavy rains in some interiors of our country and severe drought like conditions in other parts of our country. The geographic phenomena i.e. El Nino and La Nina also have adverse effects on our country by causing delay in monsoon which directly hampers the economic pace of our country.

2.3.1 CLIMATIC ZONES AND THEIR CHARACTERISTICS

The division of India into 6 climatic zones was done by Bansal et al. The determinacy of various climates i.e. hot and dry, warm and humid, moderate, cold and cloudy, cold and sunny, and composite accounts for climate unpredictability and changes in various geographic phenomena. The occurrence of **hot and dry climate** mainly resides in the areas of north western part-(Rajasthan, Maharashtra etc.) characterized by intense heat of scorching sun. The **warm and humid** climate resides in coastal regions of our country. The prevalence of **cold and cloudy** climate is mainly in the Northern part i.e. (Himachal Pradesh, Uttarakhand, J&K) with intense cold like conditions. The absence of any of these categories over 6 months or longer would result into a composite climatic zone.

Table - 2.1 Climatic zones and their characteristics(S. Fereidoon, 2007)

Criteria of Bansal et al.			Critera of SP 7		
Climate	Mean monthly temperature ^{o}C	Relative humidity (%)	Climate	Mean monthly maximum temperature ^{o}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	Temperature	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	

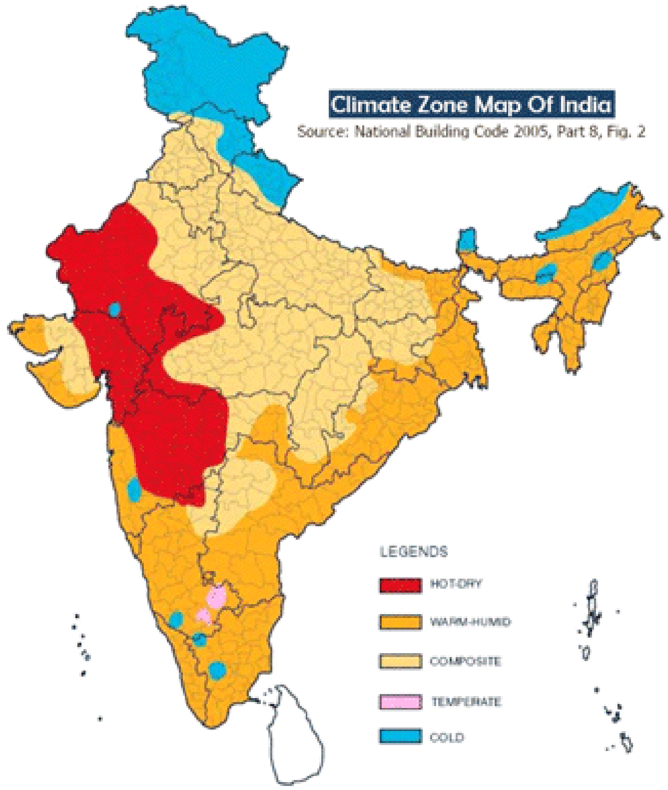


Fig – 2.5 Regions of different climatic zones

2.4 PATH OF SUN IN SUMMER AND WINTER IN THE NORTHERN HEMISPHERE

The 2 types of season play a vital role in determining the weather phenomena. The summer season usually accounts for longer days as compared to winter season.

Chief characteristics of summer season:

1. Days are usually of longer duration with occurrence of sun in high altitude of sky.
2. 21 June is regarded as the Summer Solstice (Longer day of year) when the sun in considered to be highest in the southern sky.
3. The prevalence of long duration of day will show change in the rising and setting phenomena of sun i.e. sun will deviate from its original path from east that will allow it to rise in the
   north of east and set to the north of west.
4. After the accomplishment of Summer Solstice the sun follows a lower path each day until it reaches a point where it equals the sky for exactly 12 hours which is regarded as Fall Equinox (September 21).

Chief characteristics of winter season:

1. Days are usually of shorter duration with occurrence of sun in lower altitude of sky.
2. December 21 is regarded as the Winter Solstice (Shorter day of year) when the sun in considered to be highest in the southern sky.
3. The prevalence of shorter duration of day will show change in the rising and setting phenomena of sun i.e. sun will approach nearer to its original path i.e. east that will allow it to rise in the
   South of east and set exactly in the south of west.

   The Summer and Winter Solstice is depicted in the figures below:

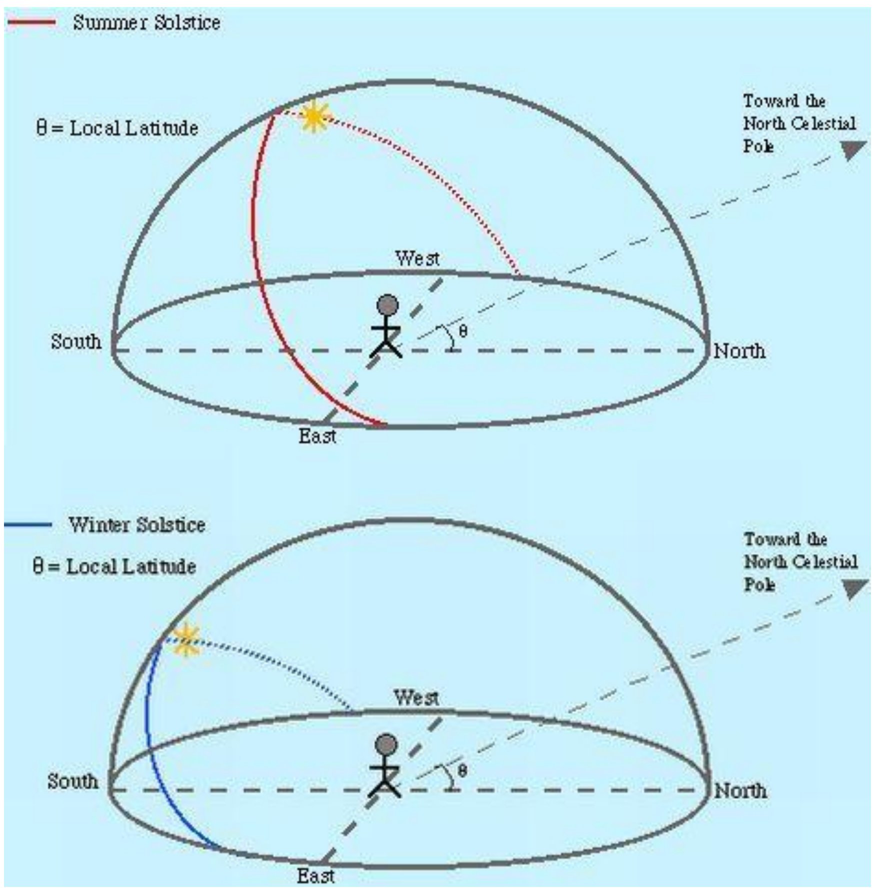


Fig – 2.6 Path of Sun

2.5 FIVE PRINCIPLES OF SUSTAINABLE DESIGN

1. **Optimizing Use of the Sun:**

   The concept of sustainable development is very important in today's scenario so as to boost our economic pace. The increased dependence on coal, natural gas, fossil fuels for our domestic purposes will pannier our environment as they are polluting, expensive and depleting at faster pace. To overcome from this situation alternative sources of energy need to be taken into account. Incorporation of solar panels will capture sun's heat and convert into energy which could be utilized for various purposes and thus playing a vital role in embedding the concept of sustainable development.

2. **Improving Indoor Air Quality**

   Considering the life span of an individual most of its time resides indoor which promptly acts as a contributing factor towards air pollution than outdoors. These pollutant contains toxic substances such as asbestos which can pose various health problems. In order to evacuate from these problems there is a need to install effective ventilation system that helps in removing dirt, dust, moisture. In order to improve our indoor air quality materials which don't contains harmful pollutants as well as not being able to shed dust should be taken into account. (Yu, Zhiwei, Chen Lu, and Bingbing San. 2014)

3. **Using the Land Responsibly**

   The sustainable design of house incorporates wise use of land as well as ensuring its impact on the external environment. The construction of a new house should possess following advantages:

   1. The use of sustainable practices such as organic pesticides, compost as well as native plants which don't require use of extra water.
   2. Surfaces which are paved often result into storm water infiltration can lessen its effect by using landscaping.

4. **Creating High-Performance and Moisture-Resistant Houses**

   The high-performance and moisture-resistant houses installs effective roof, walls, windows and doors which acts as a barrier for protecting populace from severe weather conditions, effects of pests, noise, dirt as well as controlling the amount of intense penetration of sunlight as to maintain indoor comfort. In order to succeed in creating high-performance houses one should facilitate energy efficient materials that plays a vital role in curbing the detrimental effect of temperature, moisture, heating and cooling.

5. **Wisely Using the Earth's Natural Resources**

   There are various factors which sustain the life of an individual but one of them being the most important is the existence of abundant natural resources. The judicious use of natural resources is key factor in upholding the concept of sustainable development. In this process one should incorporate energy efficient materials, regular amendment and ratification of various environmental policies.

2.6 ENERGY EFFICIENT LANDSCAPING

The features incorporated in energy efficient landscaping includes:

- The shed of planted trees near the building can play vital role in reducing the cost of cooling.
- Incorporation of energy efficient systems like solar panels, led bulbs so as to generate high efficiency.
- Usage of vines in the building for breaking the wind.
- Natural landforms are provided for positioning of building.
- Green roofs to cover the process of evapotranspiration. Through better understanding, design, and planning, green roof comprehensive benefits can be realized, including: runoff reduction, peak flow attenuation, reduction of urban heatisland effects, energy savings, improved air quality, and minimized nutrient loading. (Gibler, M. 2015)

2.7 BUILDING ORIENTATION

Building orientation plays a key role in determining the shape and orientation of a building located on a site and determining the alignment of its windows, rooflines, and other features. A green building desined using effeicient materials such as solar panels takes advantage of both passive and active solar strategies. Passive solar strategy involve direct intake of heat from sun whereas active solar system incorporates use of solar collectors to effectively distribute sun's energy.

The passive solar strategy does not involve the use of mechanical and electrical devices, such as pumps, fans, or electrical controls. Passive solar heating incorporates effective use of building components to collect, store, distribute, and control solar heat gains to reduce the demand for fossil fuel powered space heating.

The key advantage associated with passive solar heating strategies is their ability to provide opportunities for day lighting and views to the outdoors through well ventilated provisions. Their key function is to in-trap large amount of heat and minimize conductance. They also play imperative role in eliminating heat from the building and thus keeping the temperature inside the building cool.

The unwanted solar heat which keeps the interior part of the building intense hot can be effectively reduced by involving the use of shading devices which helps in blocking the sun rays during summer periods while natural ventilation, which relies on natural airflow and breezes, can reduce the need for mechanical cooling when the building is occupied.

How to Optimize Building Orientation

The building orientation can effectively be optimized by using passive solar design systems.

They usually consist of:

- Rectangular floor plans to optimize building.
- Adopting from light shelves from the summer sun; the direction of south elevation overhanging should be horizontal while the direction of east and west elevations requires construction of both horizontal and vertical overhang.

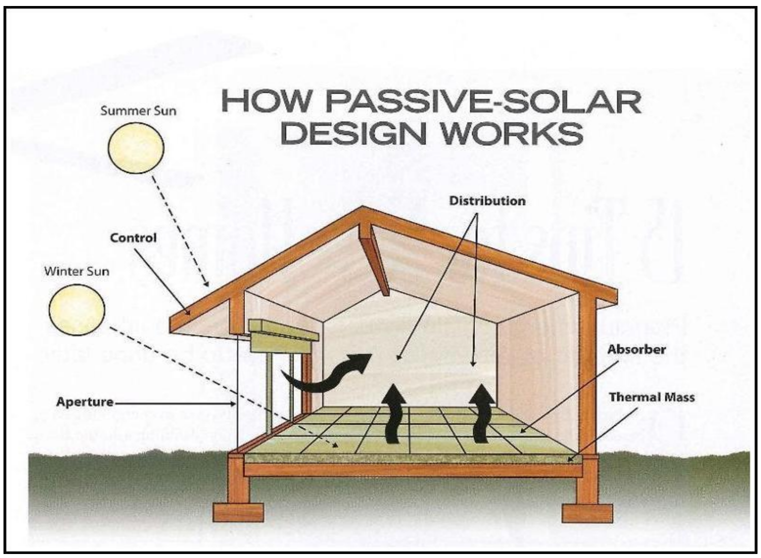


Fig – 2.7 Passive Solar Design

Besides incorporating all passive solar designs system and energy-conservation technologies, active solar systems can also play a proactive role if integrated properly into a building's design and systems. Buildings designed according to design parameters of active solar collectors should not be shaded or covered by trees and buildings should have solar arrays or roof area facing south.

2.8 FUNDAMENTAL PRINCIPLES OF GREEN BUILDING

A. Structure Design Efficiency.
B. Energy Efficiency.
C. Water Efficiency.
D. Materials Efficiency.

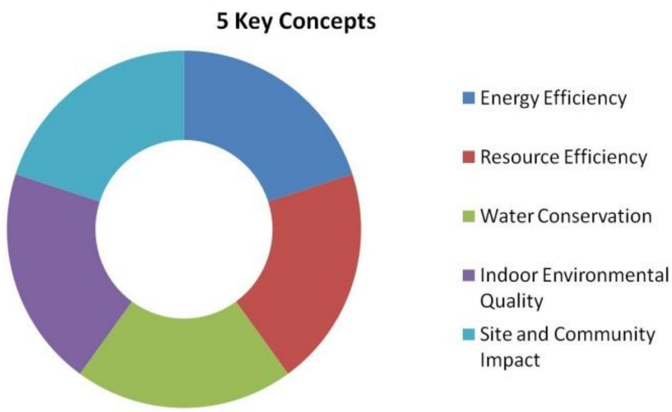


Fig - 2.8 Fundamental Principles of Green Building

(A) STRUCTURE EFFICIENCY:

1. Sustainable building adopts the use of energy efficient materials which shows progressive impact both on cost as well as on overall performance.
2. Environmental impact associated with all life-cycles is reduced.

(B) ENERGY EFFICIENCY:

1. The main purpose of energy efficiency is to conserve energy so that it can be used during adverse conditions.
2. Eco-friendly techniques can be opted by shading the roof.
3. The cost of heating is significantly reduced by using solar panels which helps in heating of water.
4. Solar power, wind power, biomass can reduce the environmental impact of the building.

(C) WATER EFFICIENCY:

1. The key objectives involved in sustainable building is reducing the amount of water consumption as well as protecting the quality of water.
2. Water consumption can be minimized by using the water which has been collected from roof tops, used and also involving rain water harvesting techniques.
3. The incorporation of water conserving fixtures such as ultra-low flush toilets and low-flow shower heads help in reducing the wastewater.

(D) MATERIAL EFFECIENCY:

1. There is a need to utilize materials that can be recycled and reused again as well as hold potential of generating surplus amount of energy.
2. The selection of material/product for green building is done according to 2 criteria :
   1. Resource efficiency.
   2. Indoor air quality.

1. RESOURCE EFFICIENCY:

1. **Resource efficient manufacturing process** – The manufacturing of products should adopt the use of resource-efficient processes which plays imperative role in reducing energy consumption, minimizing waste (recycled, recyclable and or source reduced product packaging), and playing vital role in reducing the emissions of greenhouse gases to the atmosphere.

2. **Locally available** - The materials, components, systems involved in the construction of building, should be either locally or regionally available as it helps in saving energy and resources in transportation to the project site.

2. INDOOR AIR QUALITY:

The main purpose of Indoor air quality is to reduce the generation of Volatile organic compounds and other air impurities such as growth of microbial contaminants. The proper provision of ventilation system in the building either naturally or mechanically-powered provides provision of adequate ventilation of clean air from outdoors.

1**. Low or non-toxic** - The material to be incorporated should be free from carcinogens, reproductive toxicants, or irritants and should inculcate appropriate testing by the manufacturer.

2. **Moisture resistant** – The products, components and systems that plays proactive in resisting the moisture content and inhibit the growth of biological contaminants inside the buildings should be installed.

2.9 BENEFITS OF GREEN BUILDING:

The Green building possesses various financial, economic and environmental benefits as listed below:

1. **No increase in first cost**- The construction of green building lessens its cost value as compared to construction of conventional building. The adoption of resource efficient strategies and integrated design incorporated play indispensible role in overall cost reduction.
2. **Increased resale value of energy-efficient facilities-** The financial risk of an owner can be significantly reduced by making investments in energy-efficient green building that earn a higher rate of return than the stock market or bonds.
3. **Increased value for developers and owners-** India being emerging as a faster growing economy and progressive outlook towards infrastructure development have boosted confidence among industry owners that a high-performance green building can either capture lease premiums or present a more competitive property in a tough segment of market driven economy.
4. **Improved health and productivity-** The worker productivity and quality of product can be enhanced greatly by assimilating cost effective strategies that plays imperative role in enhancing energy-efficiency as well as indoor air quality.
5. **Stretch local infrastructure capacity-** Decreased energy and material requirements coupled with appropriate siting help stretch the capacity of overburdened public systems for grid supplied power, water, wastewater and transportation.
6. **Enhanced security-** National interests prevails according to situation prevailing in our country current scenario. The concerns related to energy are prior concern for any country national interest. The excessive use of fossil fuel is slowly and gradually depleting its pace thus making our country more dependent on foreign economies for their aid. The use of renewable energy sources and energy efficient appliances can pave imperative role in safeguarding our national interests.

2.10 MODELLING OF BUILDING USING REVIT

REVIT was intended to allow architects and other building professional to design and document a building by creating a parametric three-dimensional model that included both the geometry and non-geometric design and construction information, which later become known as Building Information Modelling or BIM. The REVIT work environment allows users to manipulate whole buildings of assemblies (in the project environment) or individual 3D shapes (in the family editor environment).

The REVIT work environment allows users to employ entire buildings as well as assemblies in the project environment and individual 3D shapes objects present in the family editor environment.

Autodesk REVIT Architecture is a building design and documentation platform in which a digital building model is created using parametric elements such as walls, doors, windows, and so on. Using the 3D elements of REVIT, we can visualize the architectural or interior with respect to its scale, volume and proportions.

2.11 GREEN BUILDING RATING SYSTEM

There are many green rating systems. The Leadership in Energy and Environmental Design **(LEED)** developed by the U.S. Green Building Council **(USGBC)** has become the standard by which all sustainable buildings are designed and rated. It has five goals (Castro-Lacouture, D., Sefair, J., Flórez, L., and Medaglia, A. 2009)

1. Sustainable Sites
2. Water Efficiency
3. Energy and Atmosphere
4. Materials and Resources
5. Indoor Environmental Quality .

Innovation and design process is included as an additional category. It addresses the energy issue in the third goal. Under energy and atmosphere (EA), buildings aspiring to achieve LEED certification are required to meet three perquisites and six energy credits. EA prerequisite dealing with fundamental commissioning of the building energy systems, requires the following systems to be commissioned: (Ali, M. 2008)

1. Heating, ventilation, air conditioning, and refrigeration (HVAC&R) systems and associated controls.
2. Lighting and daylighting controls.
3. Domestic hot water systems.
4. Renewable energy systems.

CHAPTER 3

CASE STUDY OF DIFFERENT GREEN BUILDINGS

3.1 H.P.STATE CO-OPERATIVE BANK BUILDING, SHIMLA

(Majumdar Mili, 2001)

Location: Shimla, Himachal Pradesh
Climate: Cold and Cloudy (-2^{o}C -30^{o}C)

Features incorporated in the building:

This building is located in Shimla which is a three storied structure. The longer axis is the east-west direction. The winter winds are being experienced by the wall on the north side which are emerged from north-eastern direction. Ventilation is also provided in this building and day lighting system is also installed in this building.

Energy conscious features:

1. For maintenance of heating inside the building Tromie walls are installed.
2. Solar collectors are provided in the roofs so that heat can get circulated by mode of ducts.
3. Cavity walls are constructed facing the northern side.
4. Double glazed systems and proper insulation systems are installed facing the west direction.
5. For air proper exchange air locking systems are provided along with proper ventilation system.

Efficiency and performance of the building:

1. The total energy savings of this Green building:
2. Western wall double glazed insulation= 43250kWh
3. Roof insulation = 23896 kWh
4. Solar collector= 10288 kWh
5. Trombe wall=7498 kWh
6. Total= 84932 kWh

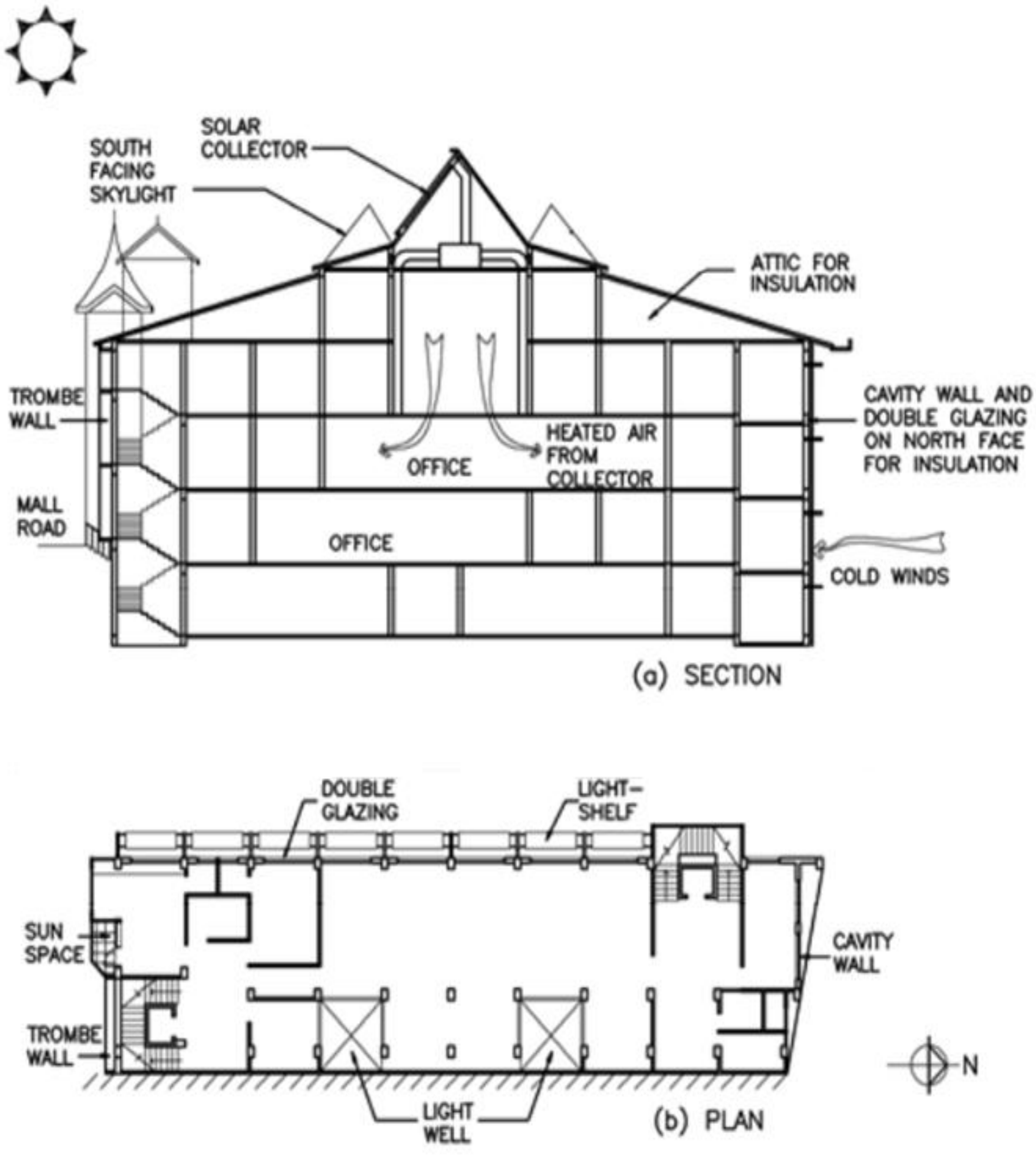


Fig – 3.1 Section and Plan of H. P. state co-operative bank, Shimla

3.2 SATLUJ JAL VIDYUT NIGAM LIMITED (SJVNL), SHIMLA

Location: Shimla, Himachal Pradesh
Climate: Cold and Cloudy (-2^{o}C -30^{o}C)

Brief description of building:

This building is recently constructed in Shimla. It is a four-storied structure with its longer axis facing in the east-west direction.Building relies on a properly designed HVAC (heating ventilation and air conditioning system) to provide adequate ventilation provision.. There is also a provision of natural lighting systems in this building to ensure maximum heat can be used by sun so that it can be used for the lighting systems inside and outside the building. Solar water heating, collector drain pipes, fountain systems are also installed in this building.

Energy conscious features:

1. Solar window: Photovoltaic windows not only provide a clear view and illuminate rooms, but also plays vital role in trapping the heat of sunlight for generating electricity.
2. Roof window: A sloped window used for day lighting as shown in fig 3.3.
3. Insulation in Walls, ceilings, and floors: Insulation reduces unwanted heat loss or gain and can decrease the energy demands of heating and cooling systems.
4. Solar Panels are installed upon roof for using Sun light for heating water and making solar energy.
5. Designing for dual plumbing hot recycles water in toilet flushing.
6. Use of ultra-low flush toilets.
7. Use of low-flow shower heads.
8. Reuse of grey water for Watering gardens.
9. Rainwater Harvesting.
10. Internal Lightning of the office area, in which light automatically shut off, if no person is found or all computers are off.

Performance of the building:

1. Energy efficient measures to conserve 15-20% of energy.
2. Water efficient fixtures to save water to the tune of 40-45%.
3. Reuse of 100% treated waste water for landscaping and flushing requirements.
4. Over 90% of the construction waste recycled and reused on the site.
5. 40% of building material is extracted and manufactured locally/ regionally.

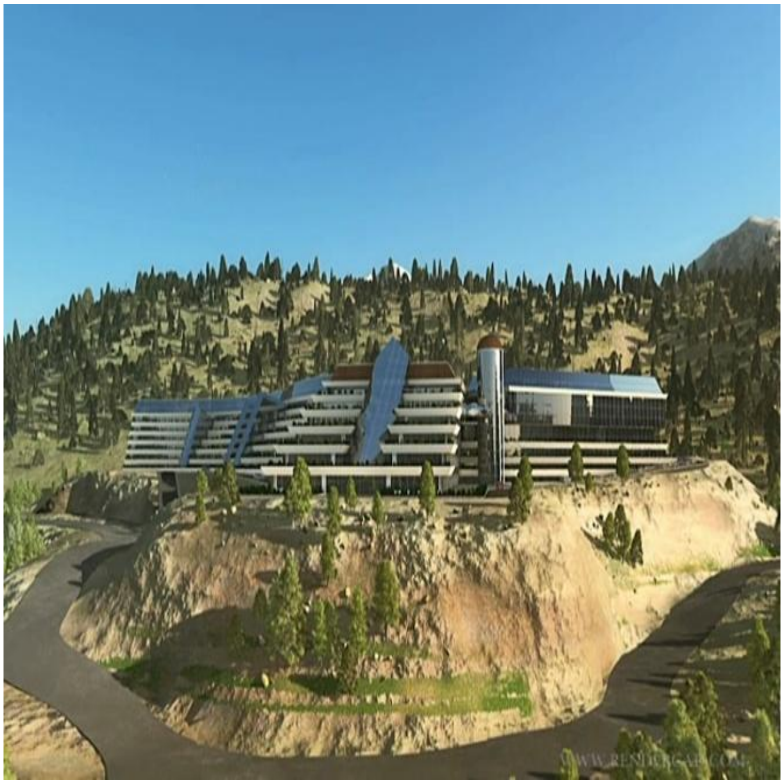


Fig – 3.2 Photograph of SJVNL , Shimla

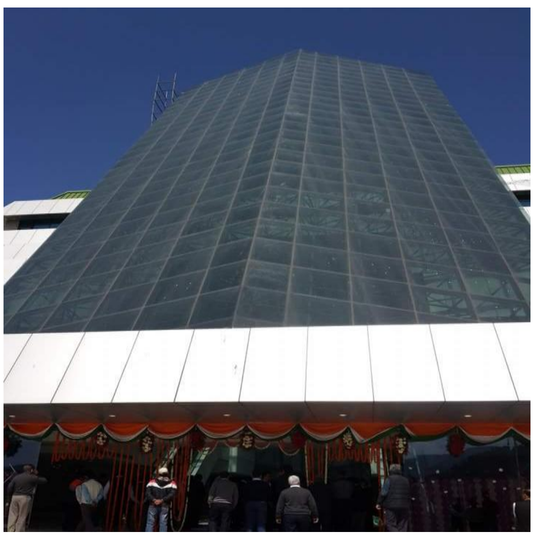


Fig – 3.3 Solar Window and Roof window used in SJVNL for Energy Efficiency

Fig – 3.4 Solar Water Heating in SJVNL

Fig – 3.5 Collector Drain Pipes in SJVNL

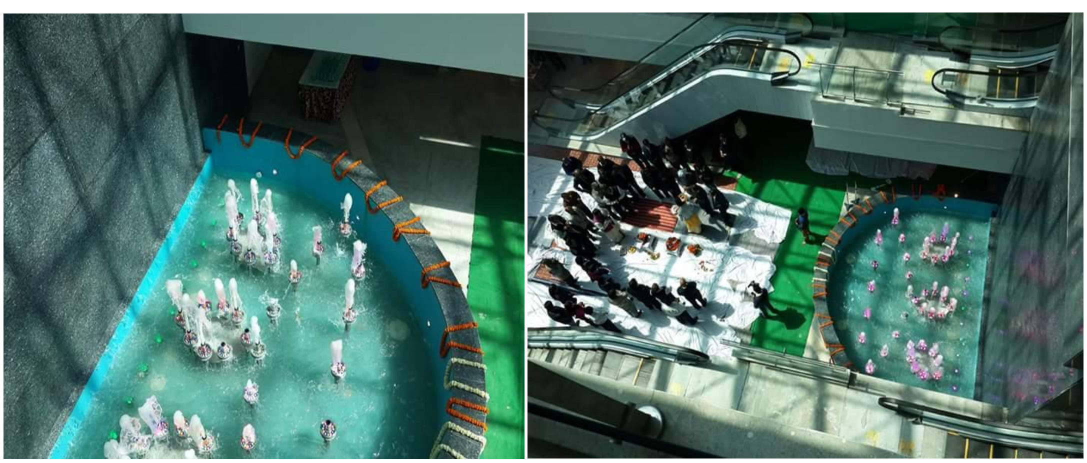


Fig – 3.6 Rain Water used for foundationin SJVNL

CHAPTER 4

CLIMATE AND FEATURES IN GREEN BUILDING FOR COLD AND CLOUDY CLIMATE

4.1 BUILDING IN COLD CLIMATE

At higher altitudes we experiences cold climate during cold winters. The temperature ranges from -2 ºC to -6 ºC during winters and 25 ºC to 35 ºC during summers. So heat must be trapped during winters and in the same manner the building must also be properly insulated so that it experiences minimum heat loss. We should also take in consideration about cold winds that are produced during winter season.

4.2 RELEVANCE OF SOLAR PASSIVE HOUSING TECHNOLOGY FORHILLY REGIONS

In hilly areas, the modern building design practices give little consideration to climatic conditions, resulting in uncomfortable living during winters requiring large quantity of fuel wood, fossil fuels & 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 plains of Punjab in the Southland West. The State with a geographical area of 55673 sq km 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. Due to peculiar topography, it experiences severe winters. In Himachal Pradesh, the climate ranges from sub-tropical to alpine desert. In private sector, hotels, industrial units, shopping/residential complexes and houses consume large amounts of electricity & other fuels like wood, char coal, coal, LPG for space heating in winters or cooling in summers as these are not designed without any consideration to climatic conditions.

4.3 WEATHER DATA PERTAINING ACCORDING TO SHIMLA LOCATION:

Since the location for which the Green building is made is Shimla. So the weather data for this location is as follows (Meteroblue Climate)

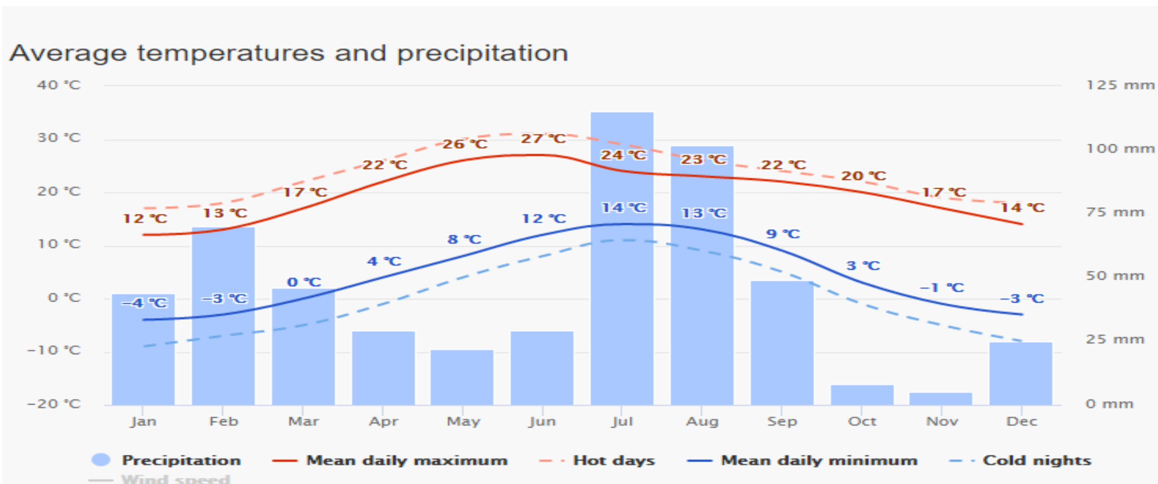


Fig – 4.1 Average Temperature and Precipitation Data

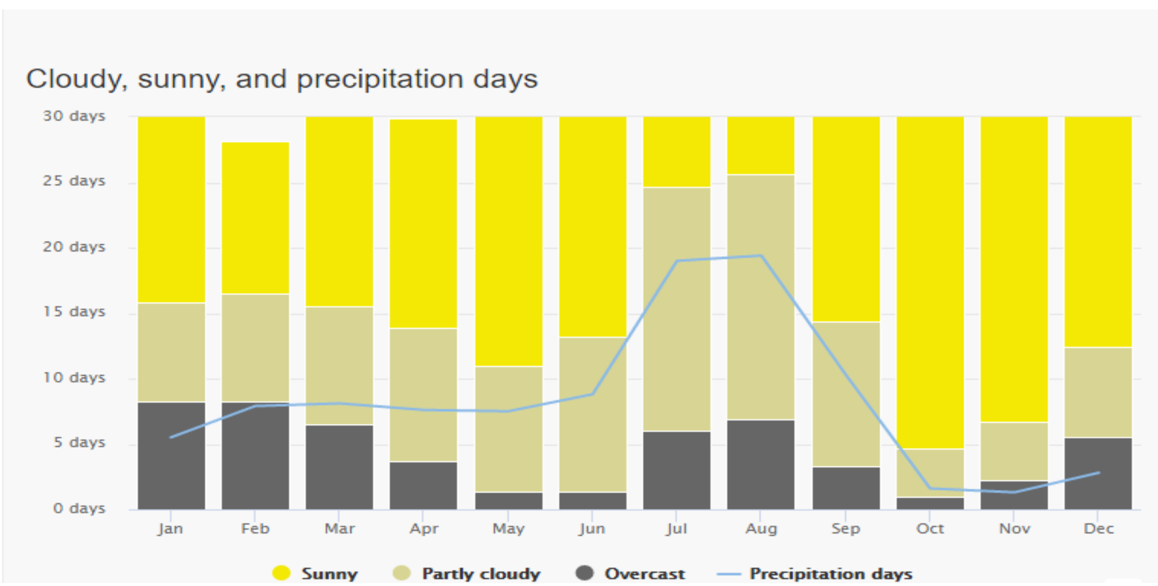


Fig – 4.2 Cloudy, Sunny and Precipitation days Data

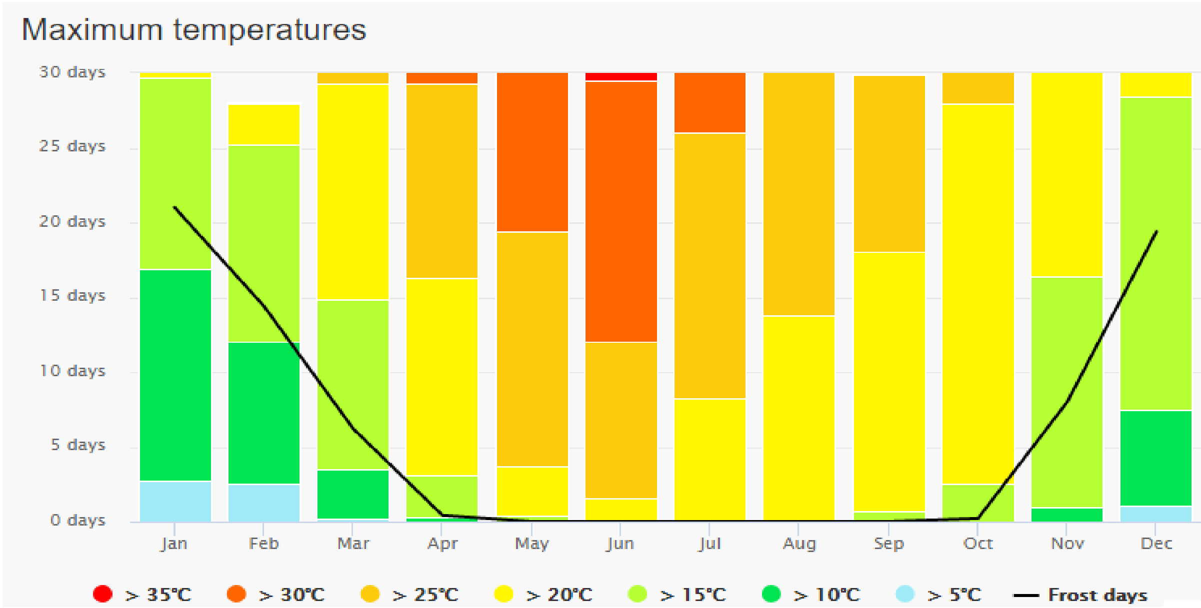


Fig – 4.3 Temperatue Variation Data

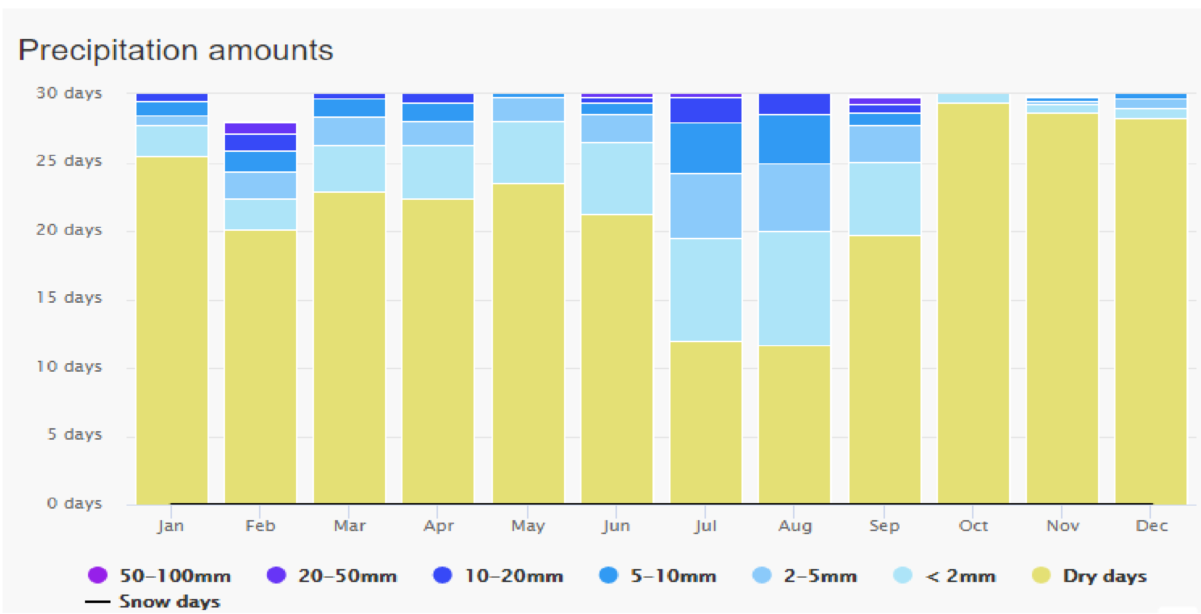


Fig – 4.4 Precipitation Variation Data

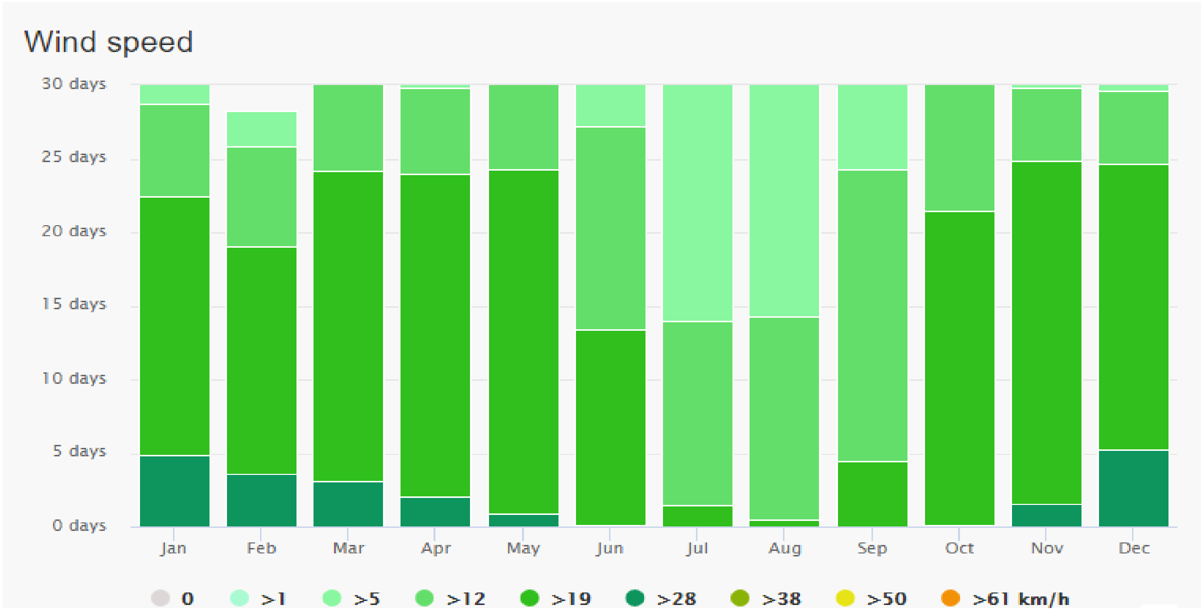


Fig – 4.5 Wind Speed Variation Data

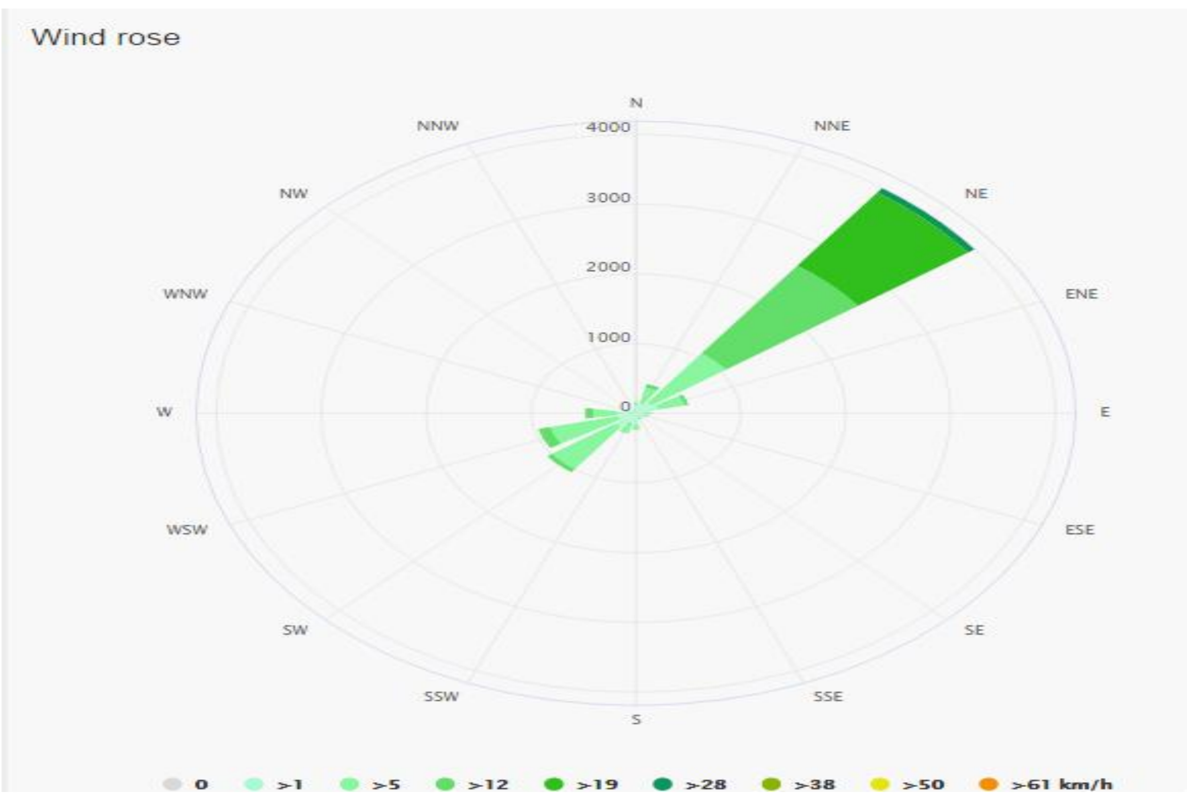


Fig – 4.6 Wind Rose Diagram

4.4 ABOUT THE BUILDING

A single storey 4 BHK, 100 feet x 60 feet rectangular building plan is being made for Cold and Cloudy Climate like Shimla. The front elevation phasing south guides entry into the house that leads to the Hall and the dining area of the house. Moreover there is also an entry from east facing that leads to the Drawing Room of the House. Using Autodesk REVIT Architecture, the plan is modeled both in a traditional conventional technique and in an innovative energy efficient green building.

4.5 MATERIAL USED FOR BUILDING DESIGN

Table - 4.1 Materials used for building design

S. No	Item	Conventional Material	Green Material
1	Wall	Brick Wall (225 mm)	Trombe Wall and Cavity Wall
2	Roof	Concrete Roof (100 mm)	Warm Roof with Puffed Insulation
3.	Glass	Single Glazing	Double glazing with different SHGC
4	Flooring	Concrete Flooring	PVC Flooring
5	Windows and Door Frame	Aluminium	Soft Wood
6.	Lighting Fixtures	Tube Lights and CFLs	Low watt LED Lights and Bulb
7.	Solar Panels	Not Used	Used(1500Watt, 8 in no.)
8.	Water Efficient	Standard Water Flow Fixtures	Low Water Flow Fixtures Native Vegetation, Rain Water Harvesting

Table - 4.2 Types of Glass used for Building Design

S. No	Item	Conventional Material	Green Material
1	Northern	3 Windows with single glazed glass	Cavity Wall ,5 Windows with Double Glazed glass SHGC = 0.7
2	Southern	6Windows with Single glazed glass	Trombe wall, 6 Windows Double Glazed glass (SHGC =0.2)
3.	Eastern	2 Windows with single glazed glass	Cavity Wall, 2 Windows with Double Glazed glass SHGC = 0.7
4	Western	2 Windows with Single glazed glass	Trombe Wall, 2 Windows with Double Glazed glass SHGC = 0.2

4.6 MAIN OBJECTIVES OF GREEN BUILDING DESIGN

Table - 4.3 Objectives of green building design

OBJECTIVES	PHYSICAL MANIFESTATION
1 Resist heat loss	
• **Decrease exposed surface area**	Orientation and shape of building. Use of trees as wind barriers.
• **Increase thermal resistance**	Roof insulation, wall insulation and double glazing.
• **Increase thermal capacity**	Thicker walls
• **Increase buffer spaces**	Air locks/lobbies
• **Decrease air exchange rate**	Weather stripping
• **Increase Surface absorptivity**	Darker colours
2 Promote heat gain	
• **Reduce shading**	Walls and glass surfaces
• **Utilise heat from appliances**	
• **Trapping heat**	Sun spaces/Trombe walls

4.7 KEY DESIGN FEATURES

1. Orientation

In cold climates, a building must be oriented to receive maximum solar radiation into the living areas for warmth on one hand, while keeping out the prevailing cold winds on the other. Longer axis of Building is from **east to west** so as to get large amount of sunlight. The Building is south facing which entrap maximum sunlight. Appropriate orientation of buildings can provide physically and psychologically comfortable conditions in the building.

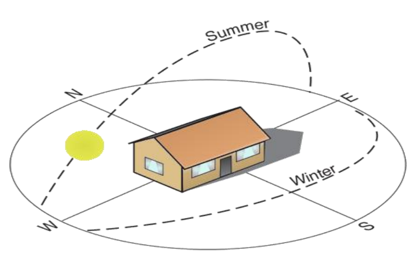


Fig – 4.7 Orientation of Sun

2. Insulation

Insulation is useful to keep the building saved from unwanted heat losses. So insulated floors, roofs and walls are used. Puffed insulation are used in Roofs , as it is easily available in Shimla. It has low thermal conductivity value of maximum 0.021 w/mk at 10°C. It is not easily ignitable and has negligible water permeability. Unlike most thermoplastics, PUF / PIR has low smoke emission and will not melt or drip in a fire, Being rigid Polyisocyanurate foam, it also has a higher hot surface performance of 150°C compared with only 110°C of normal Polyurethane Foam. This makes it ideal for use directly over steam or electrical tracing. Insulating materials may be applied externally or internally to the roofs. Walls are insulated from north and east so as to avoid heat loss during winter and are un-insulated from south and west to allow heat gain. Floors are insulated with PVC tiles flooring.

3. Trombe Wall

A Trombe wall is a passive solar building design. These walls entrap the heat from outside source which can we saved in the inner spaces between the glass and walls. Vents are also provided so that this heat can be used during winters. The inner sides of the walls are painted with dark colour because black colour absorbs maximum sun rays. The trombe walls are very useful for places like H.P. especially in Shimla region which experiences severe winters. They are usually provided in west and south facing walls.

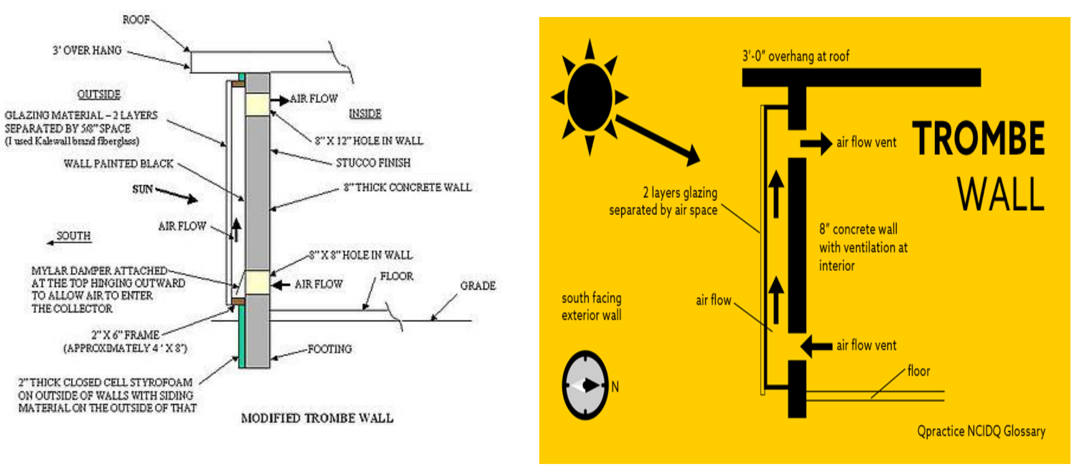


Fig – 4.8 Trombe Wall

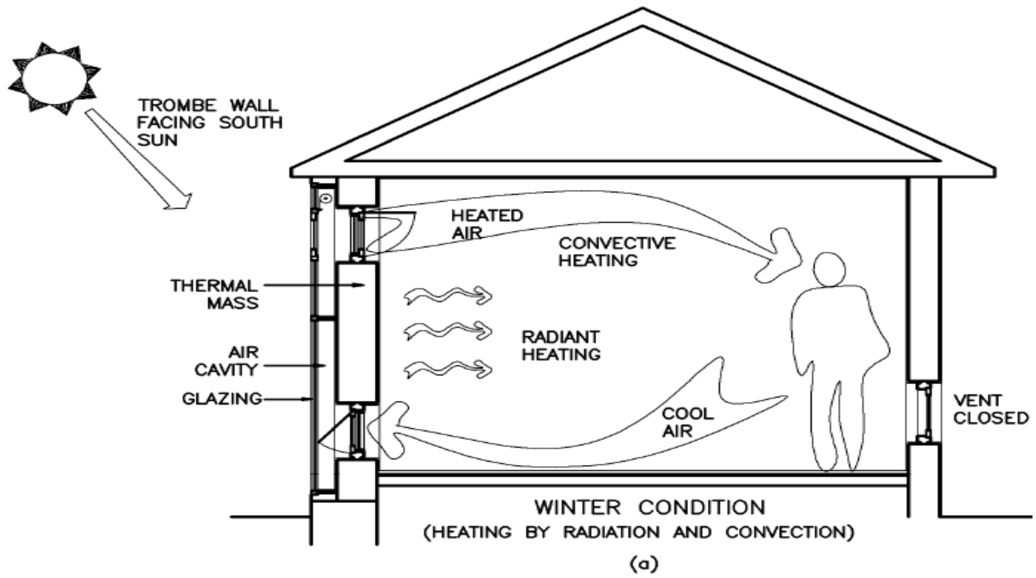


Fig – 4.8(a) Trombe Wall Winter Condition

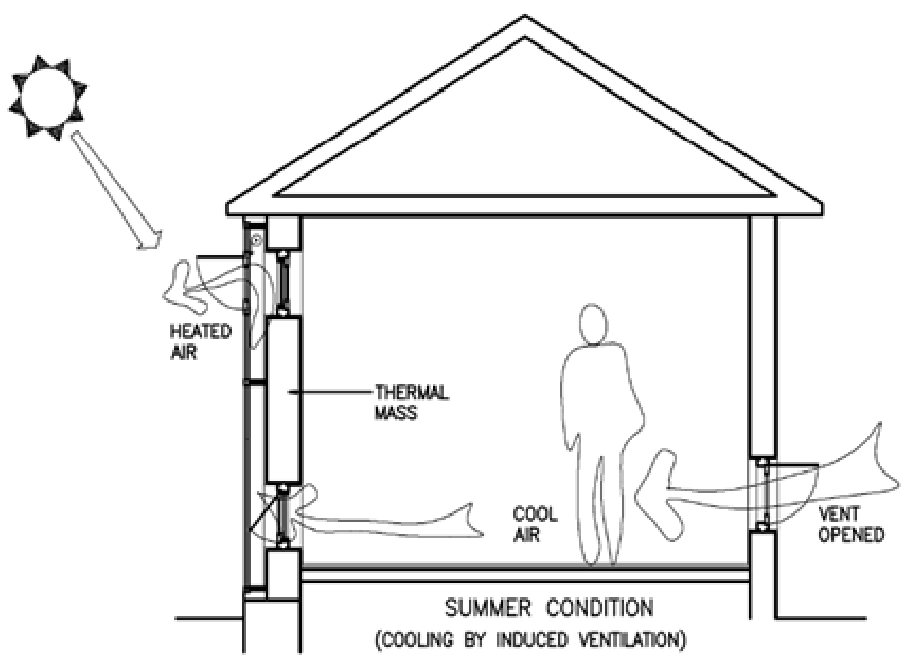


Fig – 4.8(b) Trombe Wall Summer Condition

4. Cavity Wall

Cavity walls formed by two layers of walls which are very helpful if the moisture content is high. The advantage of using such walls is that the inner wall gets protected because the effect of moisture is experienced in the external walls only. These walls are generally provided in the north sides because the north side experiences the prevailing winter winds. These walls are highly suitable to be constructed in the cold regions such as Shimla where cold season is experienced in the maximum months of the year. The layers used are Brick work layer and AAC Block Layer.

Autoclaved Aerated Concrete (AAC) blocks :-It is produced using materials including silica,sand, lime, cement, gypsum, water, and fly-ash and aluminum powder. The special combination of these substances yields a material with excellent construction properties such as thermal insulation, structural strength, density and fire resistance. It has uniformity over clay bricks. Due to its big size, light weight and easy to cut in any size and shape, it increases the speed of the construction. After using AAC blocks, there is a reduction of approx. 30% on air conditioned load. The U value of AAC Blocks are 0.67 **(W/m K)**

Advantages of using AAC Block

1) Eco-friendly & Sustainable -Makes productive use of recycled industrial waste (fly ash).
2) Lightweight -3-4 times lighter than traditional bricks -Usage reduces overall dead load of a building, thereby allowing construction of taller buildings.
3) Thermally Insulated & Energy Efficient
4) Fire Resistant -Can withstand up to 6 hours of direct exposure.
5) Acoustic Performance -Superior sound absorption qualities due to porous structure of blocks.
6) Easy Workability and Design Flexibility -Blocks can be easily cut, drilled, nailed, milled and grooved to fit individual requirements. -Available in custom sizes.
7) Seismic Resistant
8) Precision -Available in exact sizes. -Reduces cement and steel usage.
9) Savings in Cost -Reduces construction cost by 7% and lower maintenance.
10) Faster Construction -Reduces construction time by 20%

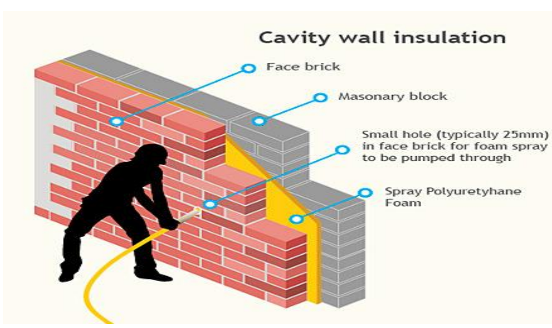


Fig – 4.9 Cavity Wall

5. Day-lighting

In the south face maximum heat comes inside the building so the day lighting systems is installed in the top roof. Sloped glazing roof and South facing windows introduce sunlight and daylight into the home, particularly in winter when the sun is lower in the sky and direct sunlight contributes to heating the house. If the interior is light coloured then it reflects maximum of the heat falling inside the room.

Fig – 4.10 Sloped Glazed Roof

6. Rainwater Harvesting

Rainwater Harvesting (RWH) systems are used to collect the rain water and use that water for various purposes. The water can be used for House cleaning, flushing, gardening; car washing. RWH systems can conserve the utilization of water to a greater extent. This water cannot be used for drinking purposes.

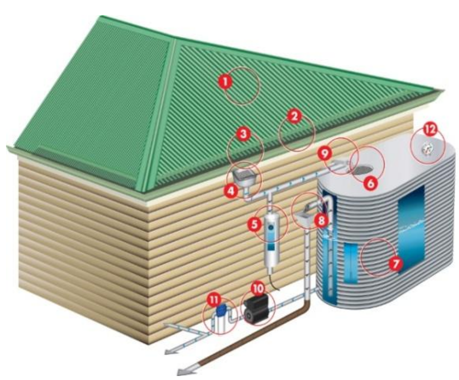


Fig – 4.11 Rain Water Harvesting.

7. Solar Panels

Solar panels are used to absorb the sun rays and these are then converted to electricity. It can be helpful to reduce the electricity cost of the building by about **30%**. The panels have an electrode which gets charged when sun rays strikes its surface. Solar panels are useful in the regions like Shimla where we can save electricity. The electricity generated from these solar panels can be used for functioning of Air Conditions, fans etc. It is a very vital component of Green house.

Fig – 4.12 Solar Panels

8. Glazed Windows Glass

The Glass used in windows of green building are Doubled glazed glass with different SHGC (Solar Heat Gain Coefficient) depending on the side of the wall a window is placed. Moreover The Glass used has lower U- value and Higher R- value

1. U-Value: This is a measure of the heat transmitted from the exterior of a building to its interiors because of temperature difference. (Thermal transmittance) is the heat transmission in unit time through unit area of a material or construction and the boundary air films, induced by unit temperature difference between the environments 2 on each side. The lower the U-value, the better the energy conservation. . U-value is expressed in W/m K. (Ariosto, T. and Memari, A. 2013)

2. R-Value : Insulation is rated in terms of thermal resistance, called R-value, which indicates the resistance to heat flow. The higher the R-value, the greater the insulating effectiveness. The Rvalue of thermal insulation depends on the type of material, its thickness and its density. R-value is the reciprocal of the time rate of heat flow through a unit area induced by a unit temperature difference between two defined surfaces of material or construction under steady state conditions.R-value is expressed in m^2 K/W.

Fig – 4.13 Double Glazed Windows

9. Deciduous Trees

Deciduous trees help to protect the building during summers from the sun rays. The sun rays do not get directly strike on the walls but passes through these trees. This serves the advantage that during peak summer the rooms will not get hot to a greater extent. During winters these trees shed their leaves which allow maximum sun rays to strike on the walls so that the room can get sufficient warmth.

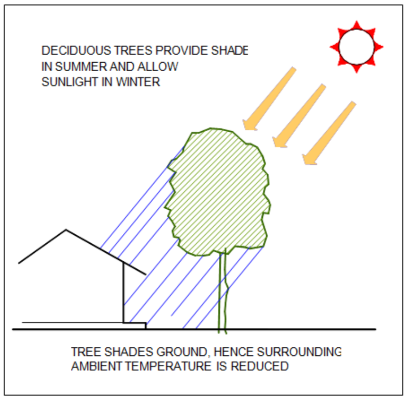


Fig – 4.14 Deciduous trees

10. Sustainable construction material:

Sustainable construction materials are used which are locally available because it will reduce the transportation cost. The materials which are available locally can be useful for construction purposes. This ensures better affordability and cheap transportation.

11. Reduce water use :

Reduced indoor water use by choosing water efficient showers, toilets, taps and appliances. Minimise outdoor water use by choosing plants that are appropriate for local growing conditions and by including low water use areas in the garden design through the use of indigenous plants or low water use species.

12. Energy efficient appliances :

Using energy efficient appliances with high star rating to minimize energy use.

CHAPTER 5

MODELLING OF CONVENTIONAL AND GREEN BUILDING IN REVIT SOFTWARE

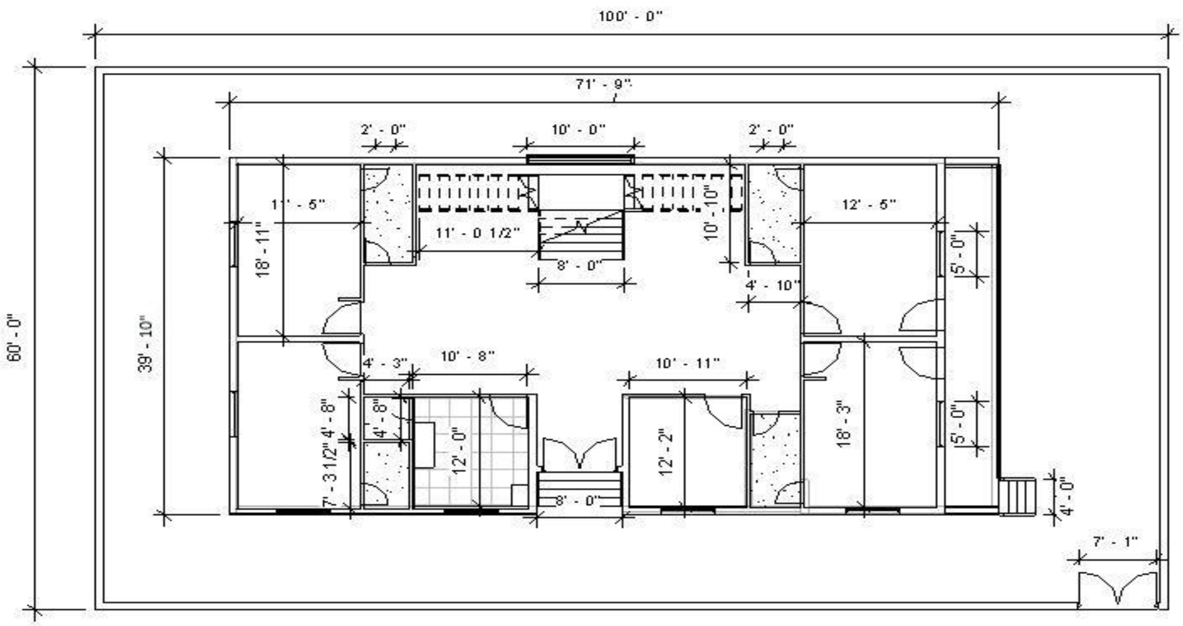


Fig – 5.1 Plan with dimensions of Conventional Building

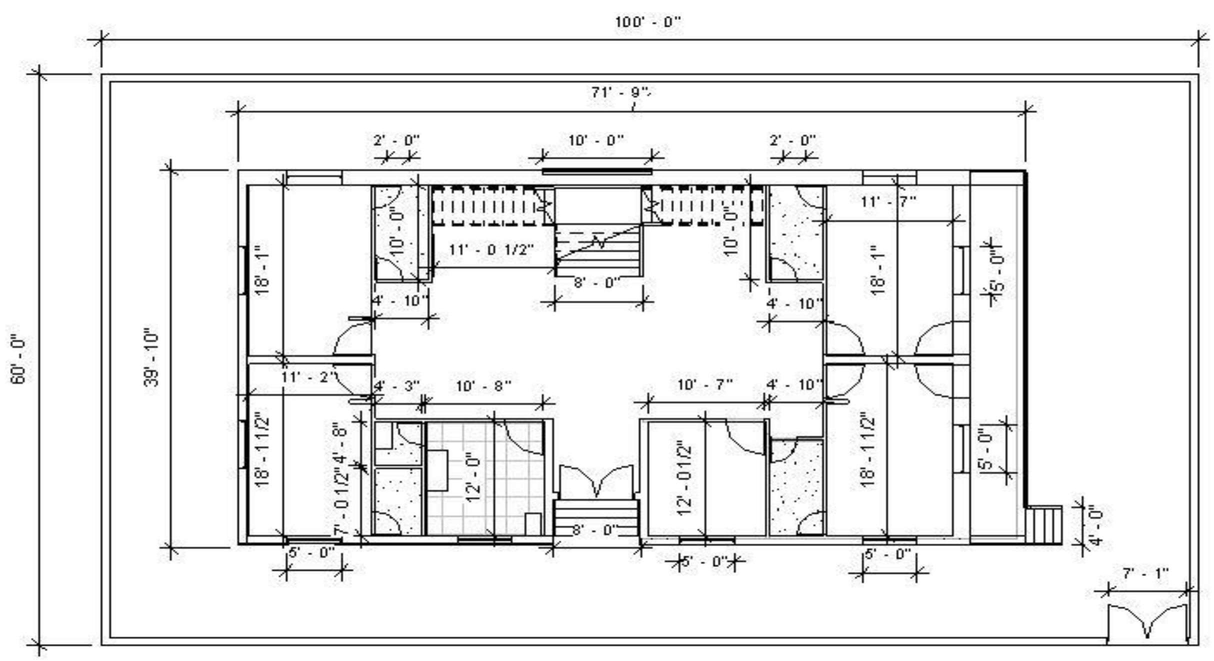


Fig – 5.2 Plan with dimensions of Green Building

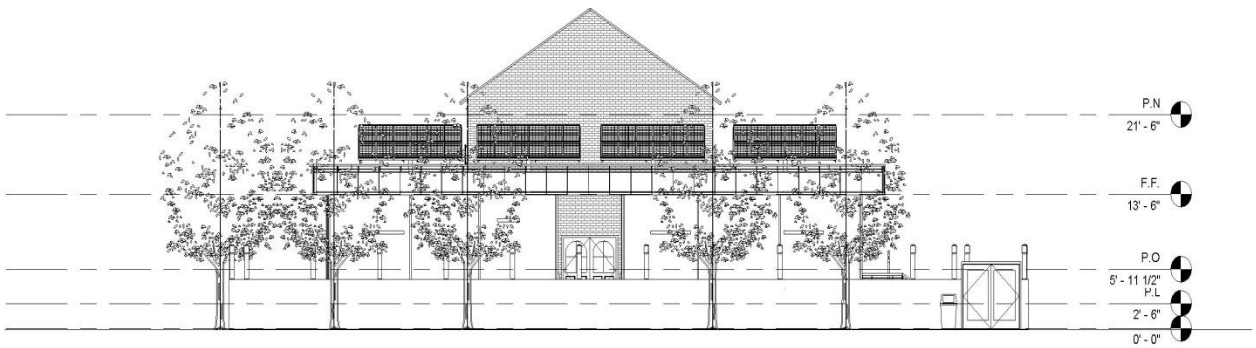


Fig – 5.3 Front Elevation South face of Building

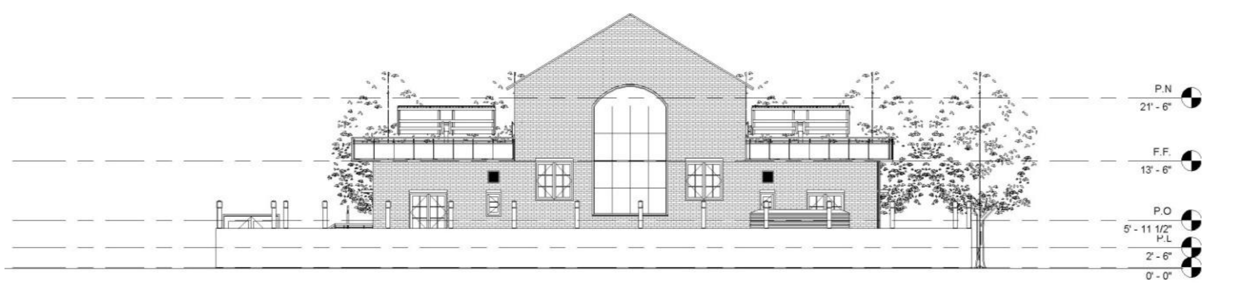


Fig – 5.4 Back Elevation North face of Building

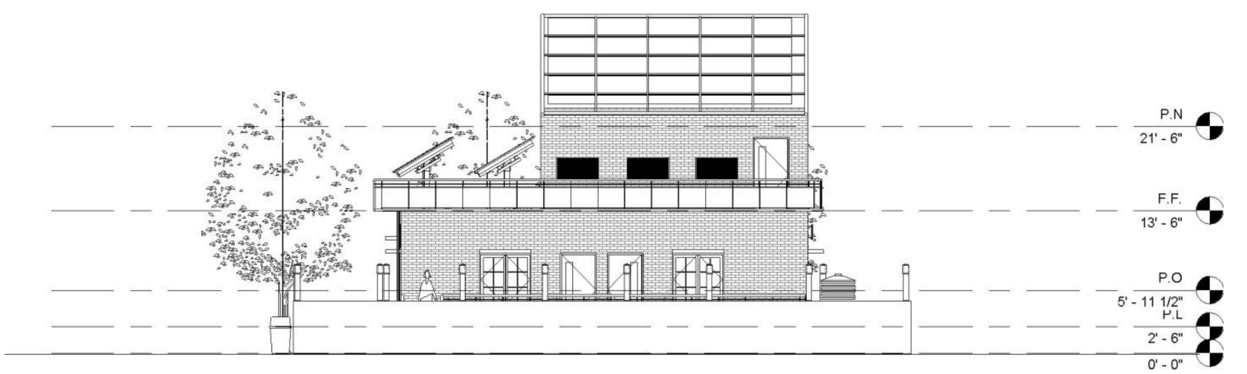


Fig – 5.5 Side Elevation East face of Building

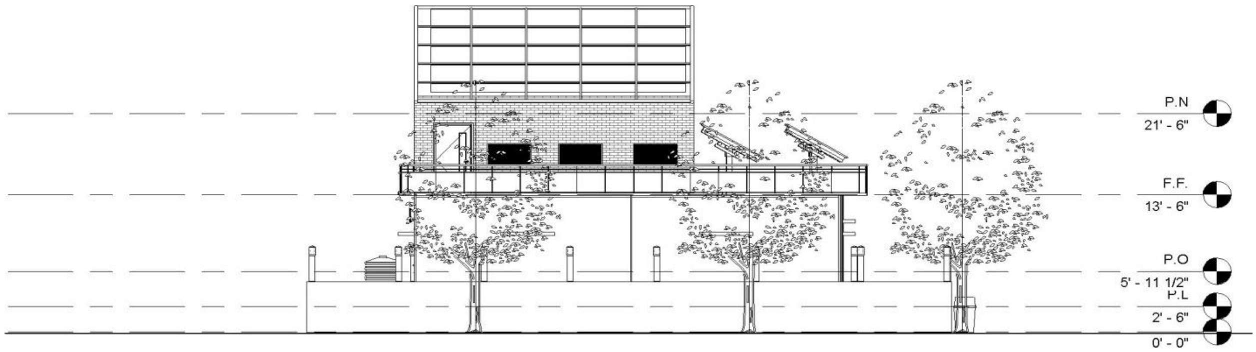


Fig – 5.6 Side Elevation West face of Building

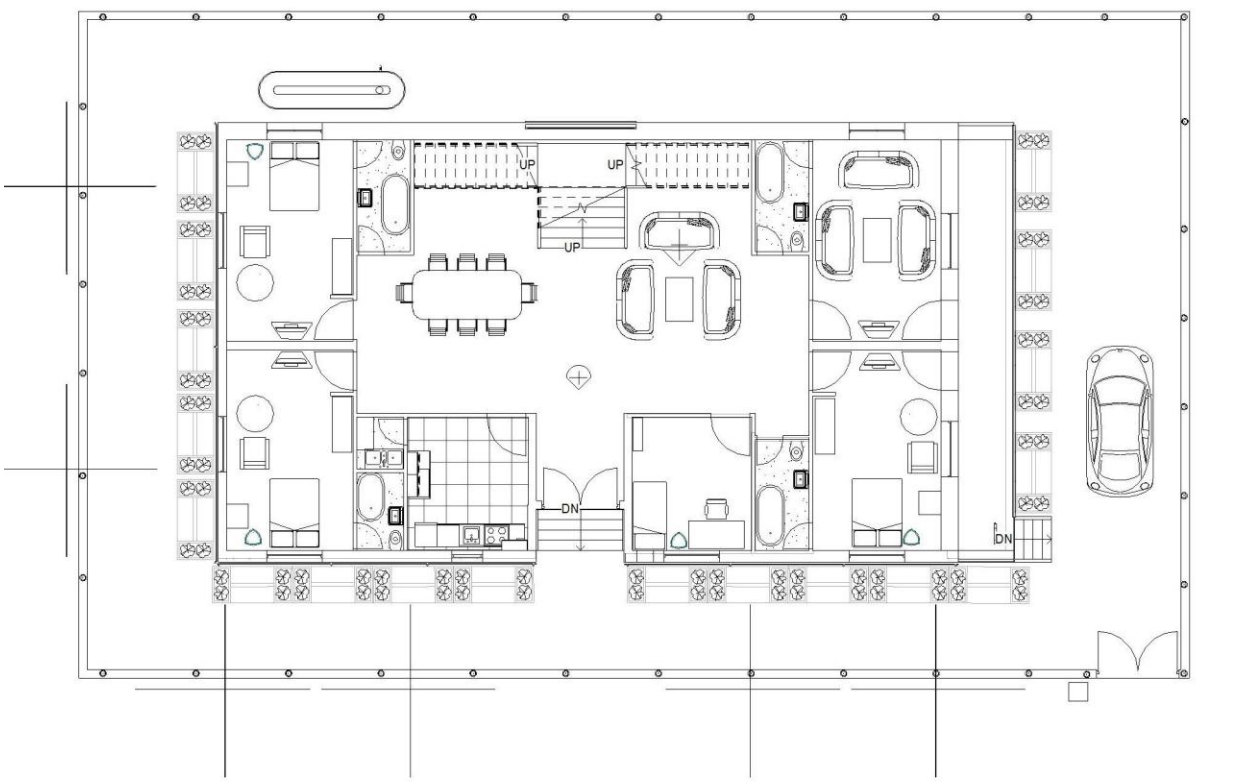


Fig – 5.7 Plan with Internal Components placed inside the Building

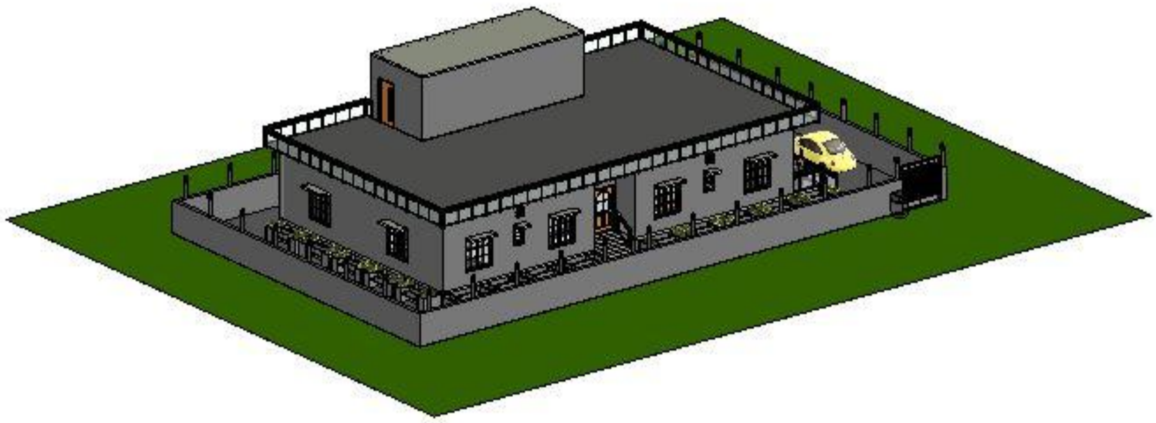


Fig – 5.8 3D View of Conventional Building

Fig – 5.9 3D View of Green Building

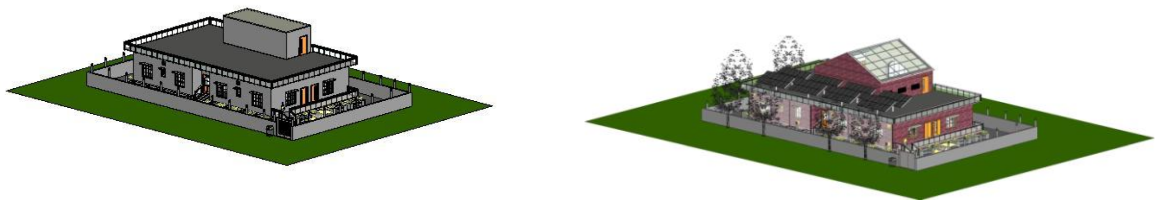


Fig – 5.10 3D Model of Buildings (South-East)

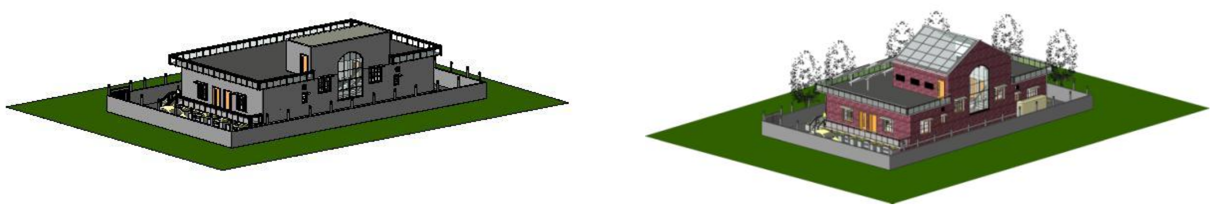


Fig – 5.11 3D Model of Buildings (North-East)

Fig – 5.12 3D Model of Buildings (North-West)

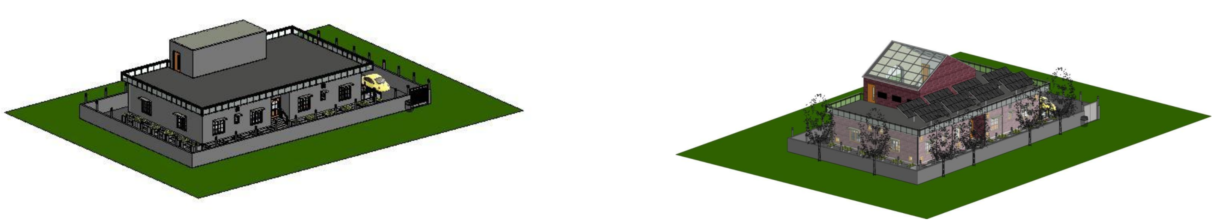
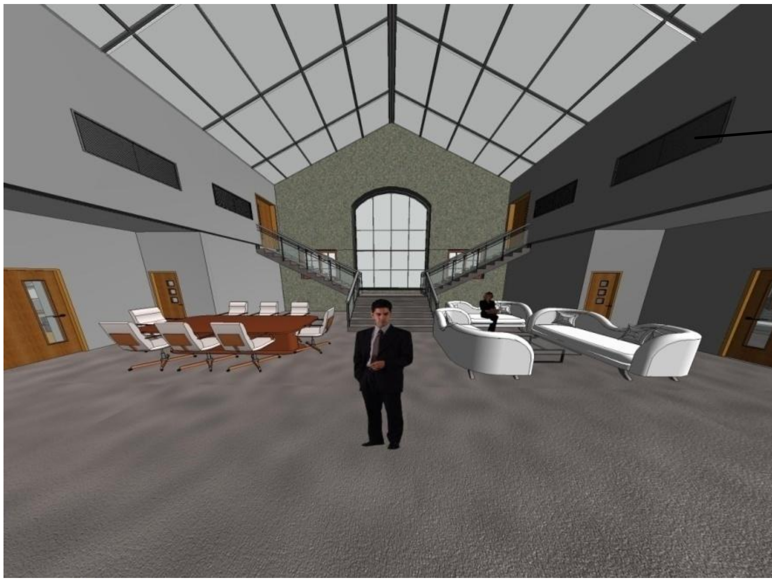


Fig – 5.13 3D Model of Buildings (South-West)



Ventilation System for the Central Hall of the Building

Fig – 5.14 Central Hall of Green Building

A Sloped Glazing Roof is provided for Day Lighting

Fig – 5.15 Interior Hall of Green Building

Fig – 5.16 Drawing room of Green Building

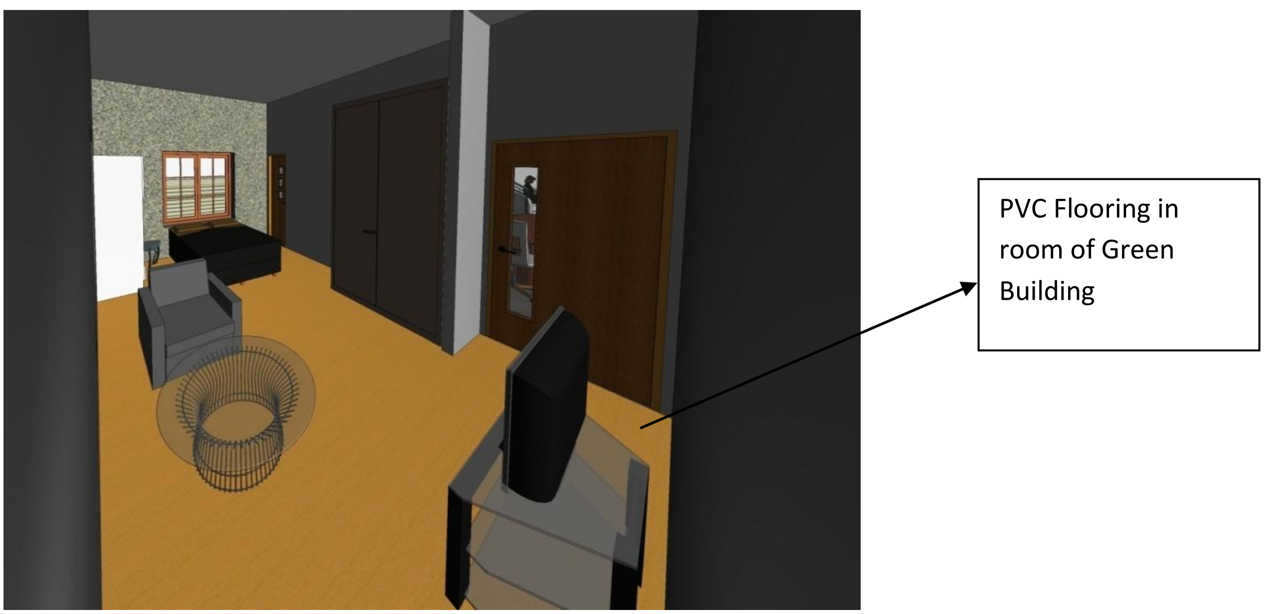


Fig – 5.17 Bed Room of Green Building

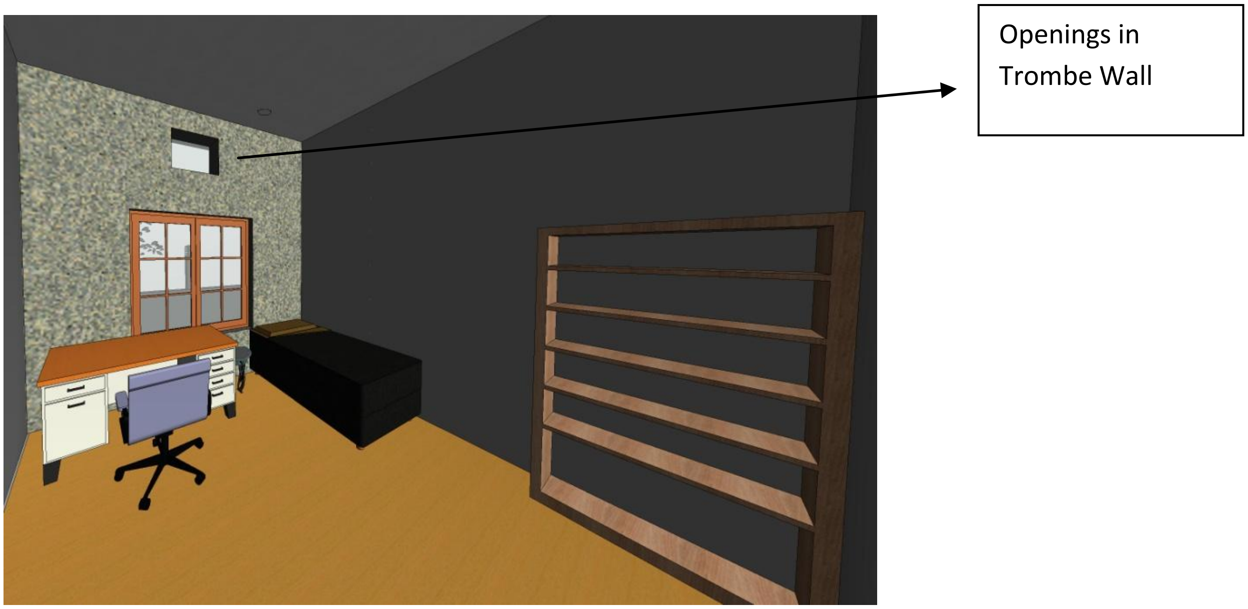


Fig – 5.18 Study Room of Green Building

Fig – 5.19 Kitchen of Green Building

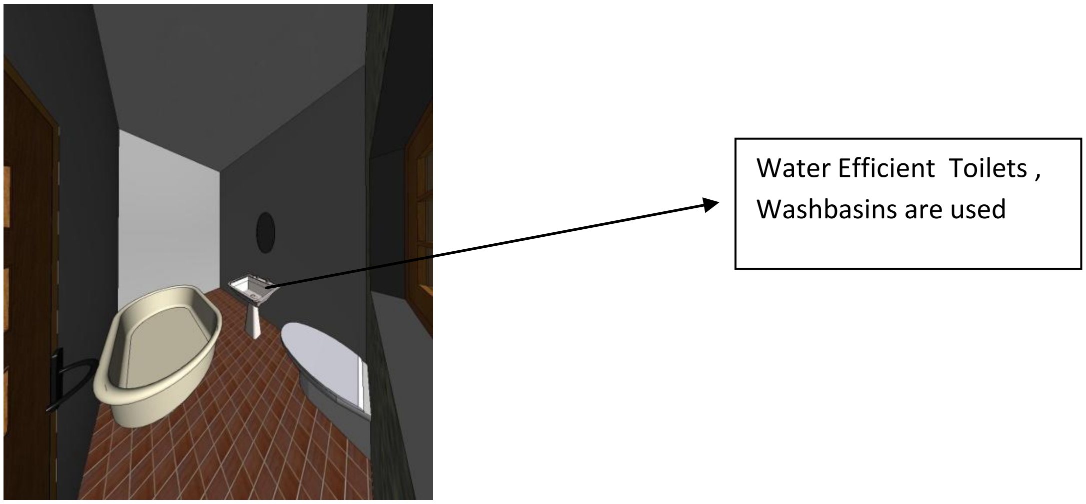


Fig – 5.20 Washroom of Green Building

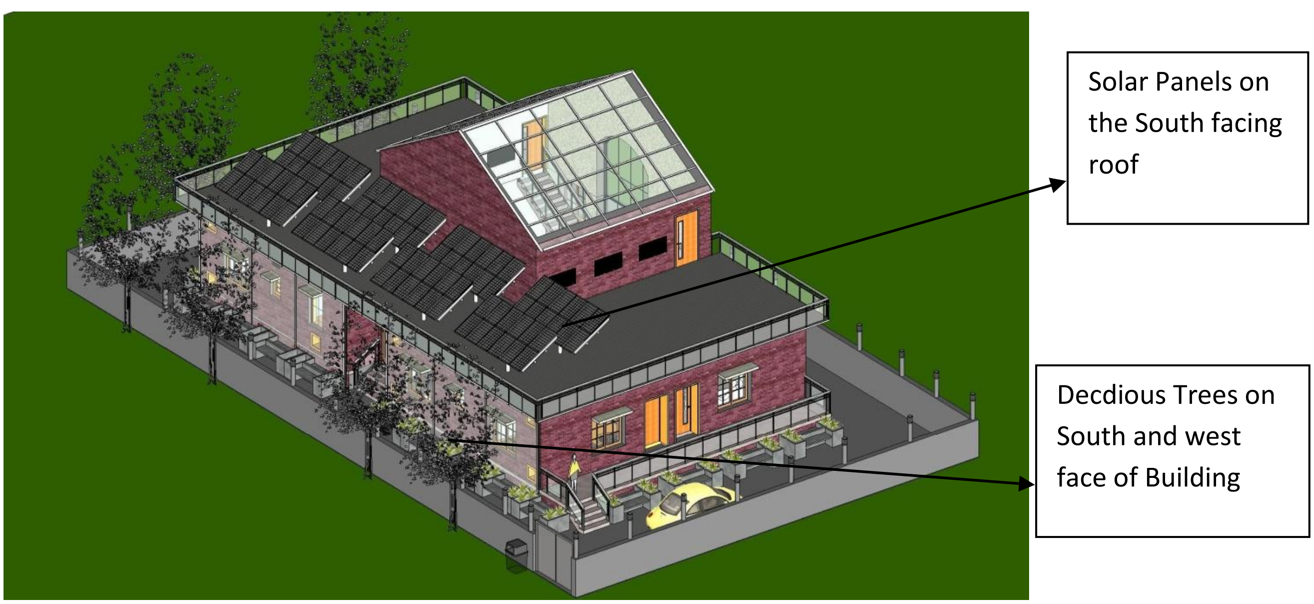


Fig – 5.21 3D View South East

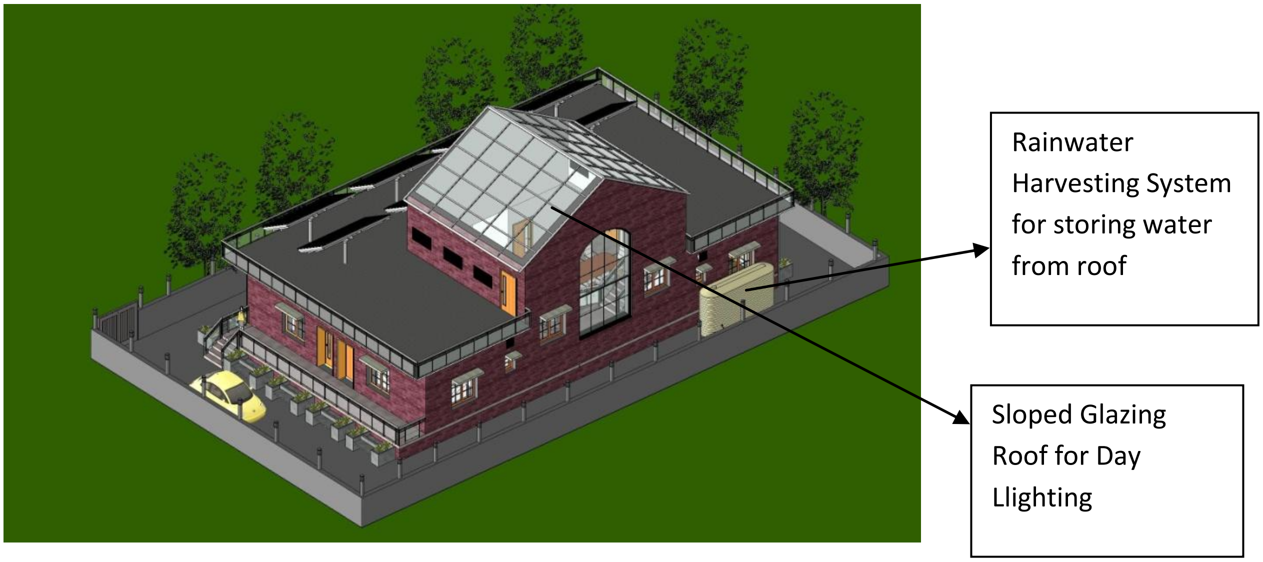


Fig – 5.22 3D View North East

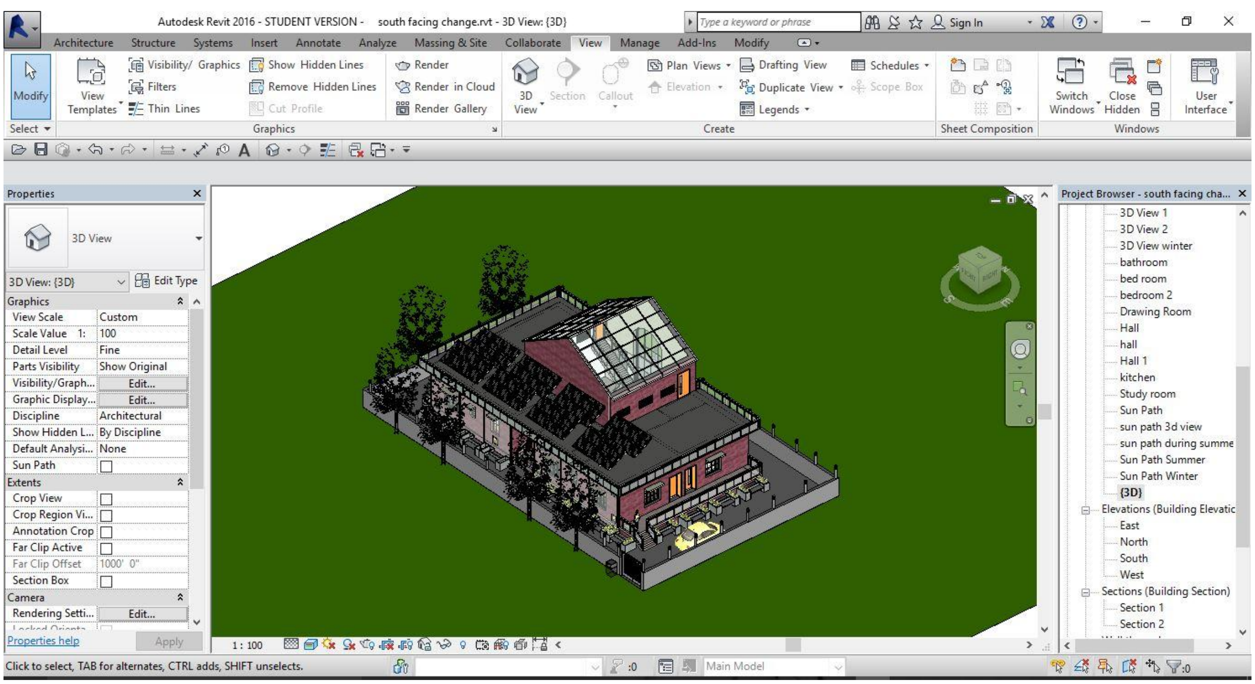


Fig – 5.23 3D View of Green Building in Revit Software

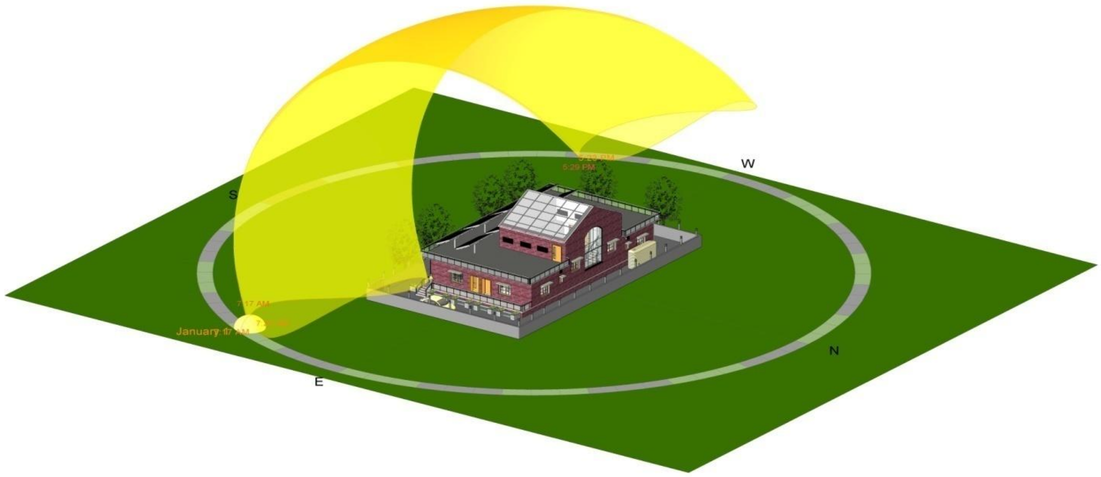


Fig – 5.24 Sun Path One Year Solar Study

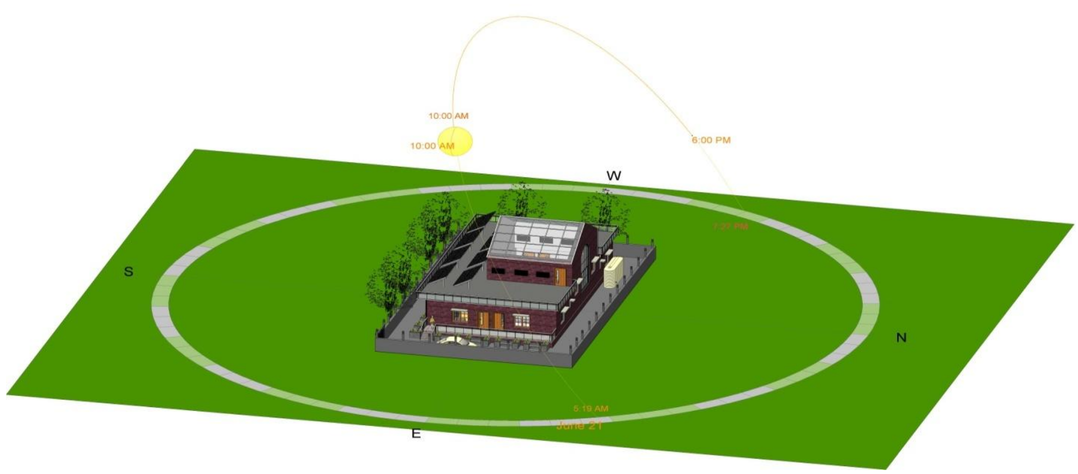


Fig –5.25 Sun Path Summer Solstice (June 21)

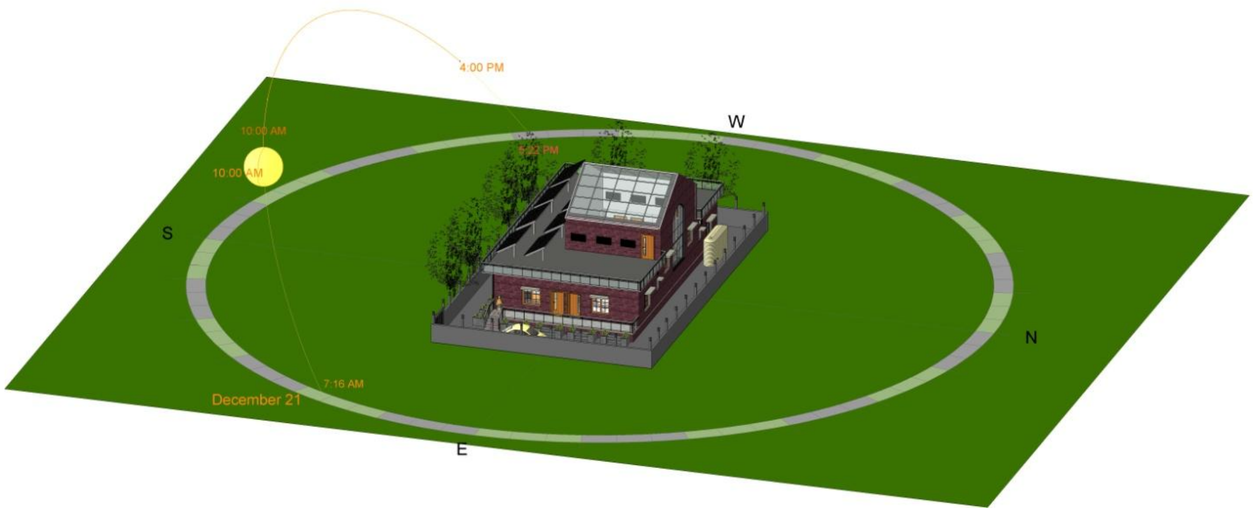


Fig –5.26 Sun Path Winter Solstice (December 21)

CHAPTER 6

COMPARISON OF CONVENTIONAL BUILDING WITH GREEN BUILDING

6.1 COSTING AND ESTIMATION

The purpose of cost estimating is to forecast the cost of a project prior to its actual construction. Cost estimating is a method of approximating the probable cost of a project before its construction. The exact cost of a project is known after completion of the project. Cost estimate is prepared at various stages during the life of a project on the basis of the information available during the time of preparation of the estimate. Generally for any construction project, three parties are involved namely owner, design professionals and construction professionals. In some cases the design professional and construction professional are from the same company or they form a team through a joint venture for providing service to the owner in the project. It is the responsibility of each party involved in the project to estimate the costs during various stages of the project. An early estimate helps the owner to decide whether the project is affordable within the available budget, while satisfying the project's objectives.

6.2 AIM OF COST ESTIMATION

1. To determine the most economical process.
2. To make decisions.
3. To evaluate the alternate designs.
4. To prepare production budget.
5. To initiate the cost reduction in existing facilities.

Table - 6.1 Cost of Construction of Conventional Building

Total Construction Cost Of Conventional Building					
S.No	Activity	Quantity	Unit	Rate	Cost (Rs)
1	Excavation	92.58	Cum	278.93	25822
2	Lime Concreting	27.82	Cum	3706.23	103103
3	Brick Work in Foundation	73.96	Cum	3183.25	235445
4	Earthwork in filling plinth	179.8	Cum	110.75	19913
5	DPC	23.715	Sqm	390.7	9266
6	Column Casting				
6.1	Reinforcement	465.96	Kg	83.37	38849
6.2	Formwork	10.55	Sqm	453.35	4784
6.3	Concreting	2.315	Cum	5960.21	19548
7	Beam Casting				
7.1	Reinforcement	954.57	Kg	83.375	79587
7.2	Formwork	22.124	Sqm	453.35	10030
7.3	Concreting	4.74	Cum	5960.21	34001
8	Brick Work in Superstructure	61.69	Cum	3183.25	196374
9	Slab Casting				
9.1	Reinforcement	2030	Kg	83.375	169251
9.2	Shuttering	288.85	Sqm	401.65	116016
9.3	Concreting	28.626	Cum	5986.5	188619
10	Wood Work	1.885	Cum	47446.1	89436
11	Glass Work	24.8	Sqm	2241.276	55584
12	Lintel	1	Cum	4918	4918
13	Floor Finishing				
	Material	4.7632	Cum	3944.14	18787
	Tiles and Labour	238.16	Sqm	417.53	99440
14	Cement Plaster				
	Material	13.917	Cum	3944.15	54891
	Labour	1160	Sqm	81.4	94435
15	Painting	1262.2	Sqm	114.57	144618
	Total Cost				**1812717**

For Calculation Refer to **ANNEXURE 1**

Table - 6.2 Cost of Construction of Green Building

Total Construction Cost Of Green Building					
S.No	Activity	Quantity	Units	Rate	Cost (Rs)
1	Excavation	109.95	Cum	278.929	30668
2	Lime Concreting	30.25	Cum	3706.23	112114
3	Brick Work in Foundation	90.27	Cum	3183.25	287352
4	Earthwork in filling plinth	172.38	Cum	110.75	19091
5	DPC	35.67	Sqm	390.7	13937
6	Column Casting				
6.1	Reinforcement	621.278	Kg	83.375	51799
6.2	Formwork	12.06	Sqm	453.35	5467
6.3	Concreting	3.087	Cum	5960.21	24149
7	Beam Casting				
7.1	Reinforcement	954.57	Kg	83.375	79587
7.2	Formwork	22.124	Sqm	453.35	10030
7.3	Concreting	4.74	Cum	5960.21	34001
8	Walls				
8.1	Brick Work in Superstructure	77.83	Cum	3183.25	247752
8.2	AAC Blocks	19.76	Cum	4604.63	90988
8.3	Glass in Trombe wall	80.98	Sqm	345	27938
9	Slab Casting				
9.1	Reinforcement	1706	Kg	83.375	142238
9.2	Shuttering	212.71	Sqm	401.65	85435
9.3	Concreting	21.055	Cum	5986.49	143296
9.4	Skylight Roof	82.98	Sqm	345	27938
9.5	Puffed Insulations	212.71	Sqm	600	127626
10	Wood Work	1.885	Cum	47446.1	89436
11	Glass Work	24.8	Sqm	4717	116983
12	Lintel	1	Cum	4918	4918
13	Floor Finishing				
	Material	4.49	Cum	3944.14	17709
	Tiles and Labour	224.54	Sqm	669.4	150315
14	Cement Plaster				
	Material	12.847	Cum	3944.15	50670
	Labour	1070.6	Sqm	81.4	87157
15	Painting	1173.05	Sqm	114.57	134402
	Total Cost				**2212996**

For Calculation Refer to **ANNEXURE 2**

6.3 ENERGY ANALYSIS

AutoDesk Green Building Studio is a flexible cloud- based service that allows to run building performance simulations to optimize energy efficiency and to work towards carbon neutrality in the design process. The Autodesk Green Building Studio web service provides Annual Energy Cost, Life cycle cost (30 years), life cycle Energy Consumption, Cooling load and Heating Load. Analysis Results are presented in a highly visual, graphical format for easy interpretation.

Below is the comparison in the energy analysis of conventional building and green building.
The building performance factors of both the buildings are :

Table – 6.3 Building performance factor

Location	Shimla, India
Outdoor Temperature	Max 30^{o}C/ Min -2^{o}C
Average Lighting Power	0.6 W/feet^{2}
People	6 people
Electrical Cost	Rs 3/kWh

Table - 6.4 Life Cycle Energy usage and Cost of Both the Building

Parameters	**Conventional Building**	**Green Building**
Life Cycle Electricity Use(kWh)	**372242**	**180180**
Life Cycle Energy Cost (Rs.)	**1116726**	**540540**
30 Years Life and 3.7 % Discount rate including 12% Interest rate and 8% Inflation Rate		

6.4 MONTHLY COOLING LOAD

The Cooling Load is the amount of heat energy that would need to be removed from a space (cooling) to maintain the temperature in an acceptable range.

It is the rate of heat energy that is being removed by cooling systems. For ex. If we take a building then the mode of transfer of heat in that building can be through walls, roofs, floors, doors, people, light etc. So this heat must be removed through conduction systems such as refrigeration and ventilation etc. This is called monthly cooling load

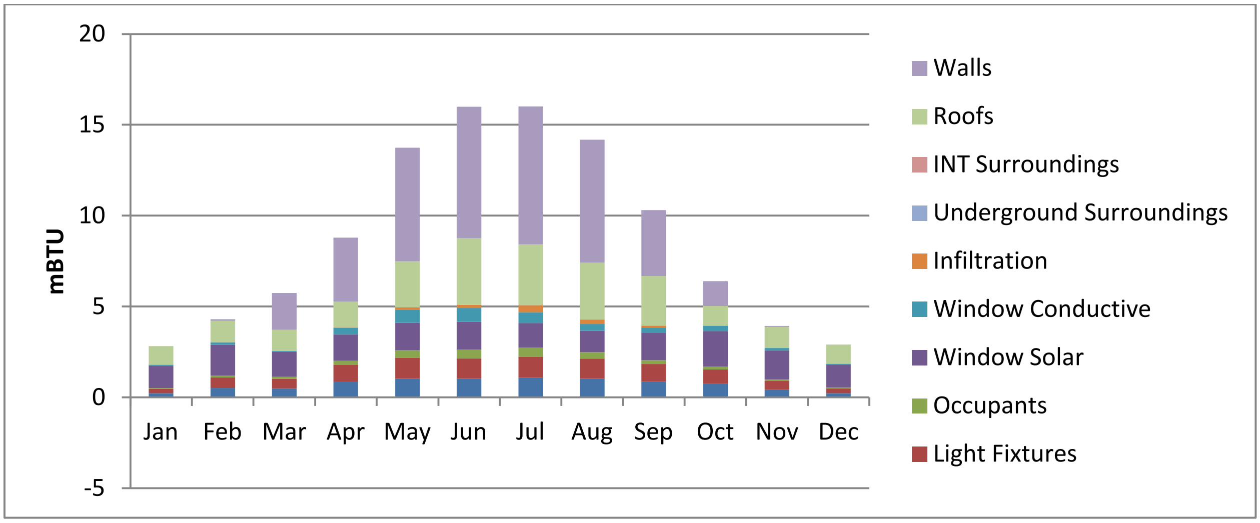


Fig – 6.1 Monthly Cooling Load of Conventional Building

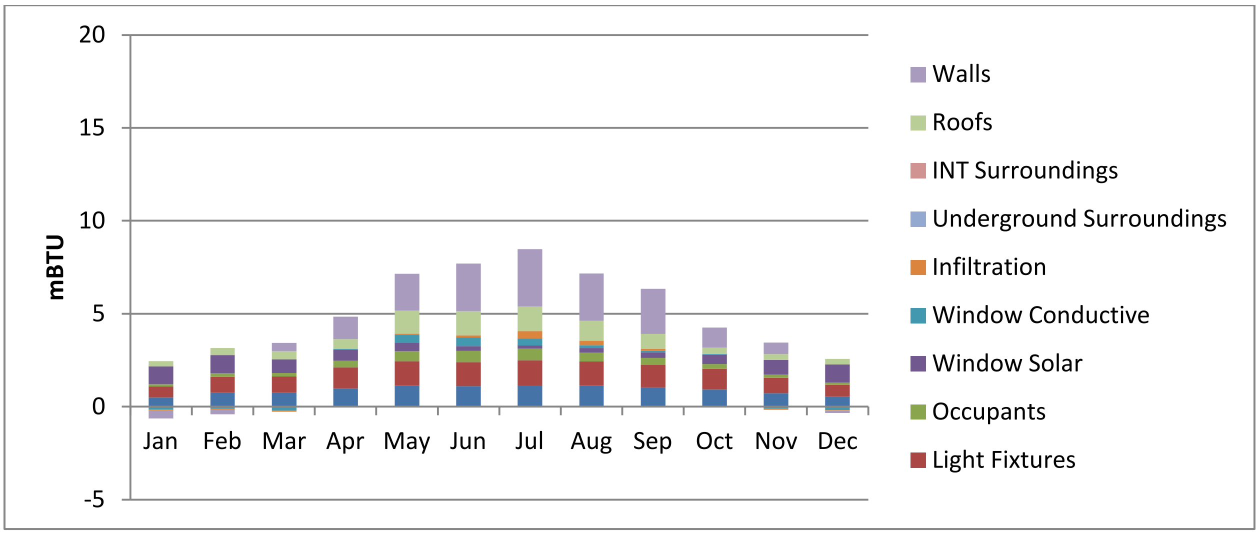


Fig – 6.2 Monthly Cooling Load of Green Building

6.5 MONTHLY HEATING LOAD

The heating load is the amount of heat energy that would need to be added to a space to maintain the temperature in an acceptable range.

It is the rate at which heat is being gained. For ex during the peak summer months such as may, june, we experience maximum heat. So we have to decide the time interval for this heating load. We usually take time between 3pm to 4 pm because it takes 2 to 3 hours for the sun rays to heat up the Building. This is termed as monthly heating load

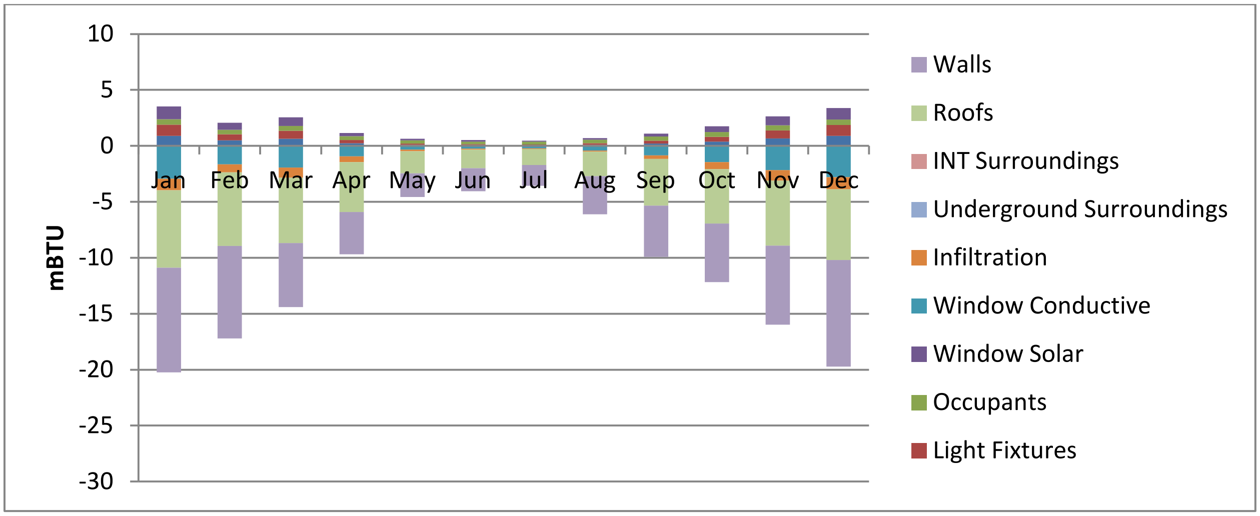


Fig – 6.3 Monthly Heating load of Conventional Building

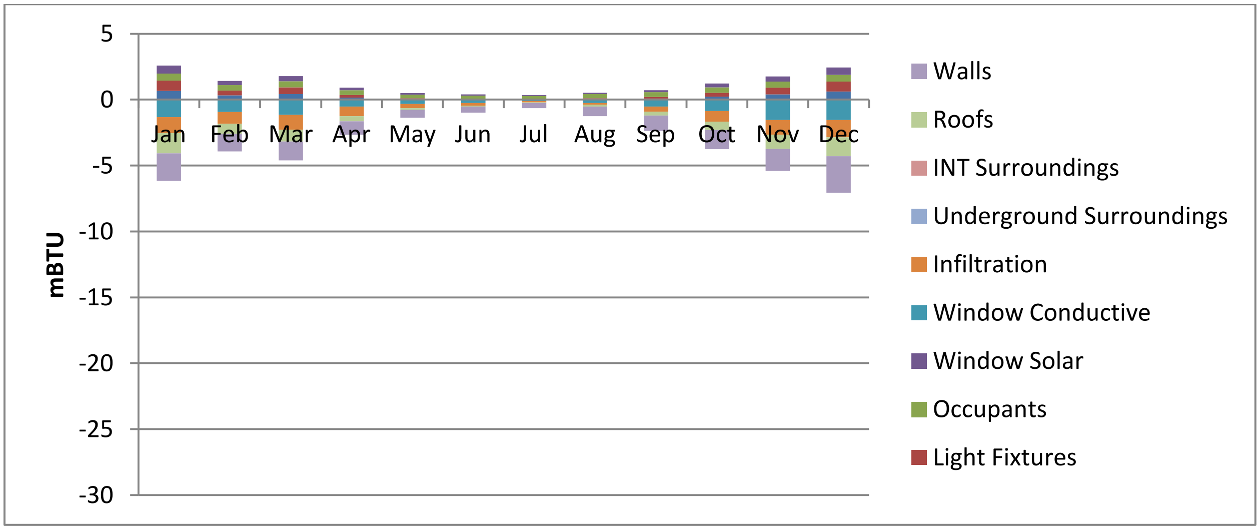


Fig – 6.4 Monthly Heating Load of Green Building

6.6 MANUAL ENERGY ANALYSIS

Building thermal performance calculations are made for 2 primary reasons. They are made to size and select mechanical equipment or to predict the annual energy consumption of a structure.

Step 1 : Determine the no. of thermal appliances:

The no. of thermal appliances will vary depending on many factors including the building use, size and shape.

Step 2 : Calculate load for each appliances

A load is to be required hourly rate of heat removal in summers (or heat supply in winter) necessary to keep a building comfortable. In step 2 The annual , peak hourly heating and cooling must be calculated.

Step 3: Select HVAC Systems

Based on the peak loads calculated in step 2 size and select building mechanical equipment.

Step 4: Calculate hourly energy consumption

Calculate the loads placed on the selected equipment for each hour of a typical meteorological year and determine the amount of energy required by the equipment.

Step 5: Input Electric Utility

For the specific building construction site, input energy rate information including electric peak demand charges.

Step 6 : Calculate Energy Costs

Calculate the energy consumed for each hour of the year and then calculate the annual hourly consumption of the year.

Table – 6.5 Monthly Electricity Consumption of Conventional Building

MONTH	**APPLIANCES**	**NO. OF APPLIANCES**	**NO. OF DAYS**	**NO. OF HOURS**	**kWh**	**kWh PER MONTH**
JAN	HEATER	3	31	6	1.5	837
	REFRIGERATOR	1	31	24	0.18	133.92
	WASHING MACHINE	1	10	2	0.5	10
	LIGHT IN BEDROOM	6	31	7	0.025	32.55
	LIGHT IN HALL	3	31	12	0.025	27.9
	ELECTRIC GEYSER	3	31	3	4	1116
					TOTAL	**2157.37**
FEB	HEATER	3	28	6	1.5	756
	REFRIGERATOR	1	28	24	0.18	120.96
	WASHING MACHINE	1	8	2	0.5	8
	LIGHT IN BEDROOM	6	28	7	0.025	29.4
	LIGHT IN HALL	3	28	12	0.025	25.2
	ELECTRIC GEYSER	3	28	2	4	672
					TOTAL	**1611.56**
MAR	HEATER	3	15	3	1.5	202.5
	REFRIGERATOR	1	31	24	0.18	133.92
	WASHING MACHINE	1	10	2	0.5	10
	LIGHT IN BEDROOM	6	31	6	0.025	27.9
	LIGHT IN HALL	3	31	12	0.025	27.9
	ELECTRIC GEYSER	3	31	2	4	744
					TOTAL	**1146.22**
APR	REFRIGERATOR	1	30	24	0.18	129.6
	WASHING MACHINE	1	10	2	0.5	10

	LIGHT IN BEDROOM	6	30	6	0.025	27
	LIGHT IN HALL	3	30	12	0.025	27
	ELECTRIC GEYSER	3	30	1	4	360
					TOTAL	**553.6**
	FAN	4	31	4	0.08	39.68
	REFRIGERATOR	1	31	24	0.18	133.92
	WASHING MACHINE	1	10	2	0.5	10
MAY	LIGHT IN BEDROOM	6	31	5	0.025	23.25
	LIGHT IN HALL	3	31	12	0.025	27.9
	ELECTRIC GEYSER	3	31	1	4	372
					TOTAL	**606.75**
	FAN	4	30	5	0.08	48
	REFRIGERATOR	1	30	24	0.18	129.6
	WASHING MACHINE	1	10	2	0.5	10
JUNE	LIGHT IN BEDROOM	6	30	5	0.025	22.5
	LIGHT IN HALL	3	30	12	0.025	27
	ELECTRIC GEYSER	3	30	1	4	360
					TOTAL	**597.1**
	FAN	4	31	5	0.08	49.6
	REFRIGERATOR	1	31	24	0.18	133.92
	WASHING MACHINE	1	10	2	0.5	10
JULY	LIGHT IN BEDROOM	6	31	5	0.025	23.25
	LIGHT IN HALL	3	31	12	0.025	27.9
	ELECTRIC GEYSER	3	31	1	4	372
					TOTAL	**616.67**
AUG	REFRIGERATOR	1	31	24	0.18	133.92

	WASHING MACHINE	1	10	2	0.5	10
	LIGHT IN BEDROOM	6	31	6	0.025	27.9
	LIGHT IN HALL	3	31	12	0.025	27.9
	ELECTRIC GEYSER	3	31	2	4	744
					TOTAL	**943.72**
SEPT	REFRIGERATOR	1	30	24	0.18	129.6
	WASHING MACHINE	1	10	2	0.5	10
	LIGHT IN BEDROOM	6	30	6	0.025	27
	LIGHT IN HALL	3	30	12	0.025	27
	ELECTRIC GEYSER	3	30	2	4	720
					TOTAL	**913.6**
OCT	HEATER	3	15	3	1.5	202.5
	REFRIGERATOR	1	31	24	0.18	133.92
	WASHING MACHINE	1	10	2	0.5	10
	LIGHT IN BEDROOM	6	31	6	0.025	27.9
	LIGHT IN HALL	3	31	12	0.025	27.9
	ELECTRIC GEYSER	3	31	2	4	744
					TOTAL	**1146.22**
NOV	HEATER	3	30	3	1.5	405
	REFRIGERATOR	1	30	24	0.18	129.6
	WASHING MACHINE	1	10	2	0.5	10
	LIGHT IN BEDROOM	6	30	7	0.025	31.5
	LIGHT IN HALL	3	30	12	0.025	27
	ELECTRIC GEYSER	3	30	2	4	720
					TOTAL	**1323.1**

DEC	HEATER	3	31	6	1.5	837
	REFRIGERATOR	1	31	24	0.18	133.92
	WASHING MACHINE	1	10	2	0.5	10
	LIGHT IN BEDROOM	6	31	7	0.025	32.55
	LIGHT IN HALL	3	31	12	0.025	27.9
	ELECTRIC GEYSER	3	31	3	4	1116
					TOTAL	**2157.37**

Table - 6.6 Monthly Electricity consumption of Green Building

MONTH	APPLIANCES	NO. OF APPLIANCES	NO. OF DAYS	NO. OF HOURS	kWh	kWh PER MONTH	ENERGY SAVED USING SOLAR PANELS	TOTAL ENERGY REQUIRED (kWh)
JAN	HEATER	3	31	4	1.5	558	167	390.6
	REFRIGERATOR	1	31	24	0.2	133.9	40.2	93.744
	WASHING MACHINE	1	10	2	0.5	10	3	7
	LIGHT IN BEDROOM	6	31	7	0	15.62	0	15.624
	LIGHT IN HALL	3	31	7	0	7.812	0	7.812
	ELECTRIC GEYSER	3	31	2	4	744	223	520.8
							TOTAL	**1035.58**
FEB	HEATER	3	28	4	1.5	504	151	352.8
	REFRIGERATOR	1	28	24	0.2	121	36.3	84.672
	WASHING MACHINE	1	8	2	0.5	8	2.4	5.6
	LIGHT IN BEDROOM	6	28	7	0	14.11	0	14.112

	LIGHT IN HALL	3	28	7	0	7.056	0	7.056
	ELECTRIC GEYSER	3	28	2	4	672	202	470.4
							TOTAL	**934.64**
MAR	REFRIGERATOR	1	31	24	0.2	133.9	40.2	93.744
	WASHING MACHINE	1	10	2	0.5	10	3	7
	LIGHT IN BEDROOM	6	31	6	0	13.39	0	13.392
	LIGHT IN HALL	3	31	6	0	6.696	0	6.696
	ELECTRIC GEYSER	3	31	2	4	744	223	520.8
							TOTAL	**641.632**
APR	REFRIGERATOR	1	30	24	0.2	129.6	38.9	90.72
	WASHING MACHINE	1	10	2	0.5	10	3	7
	LIGHT IN BEDROOM	6	30	6	0	12.96	0	12.96
	LIGHT IN HALL	3	30	6	0	6.48	0	6.48
	ELECTRIC GEYSER	3	30	1	4	360	108	252
							TOTAL	**369.16**
MAY	FAN	4	31	4	0.1	39.68	11.9	27.776
	REFRIGERATOR	1	31	24	0.2	133.9	40.2	93.744
	WASHING MACHINE	1	10	2	0.5	10	3	7
	LIGHT IN BEDROOM	6	31	5	0	11.16	0	11.16
	LIGHT IN HALL	3	31	5	0	5.58	0	5.58

	ELECTRIC GEYSER	3	31	0	4	0	0	0
							TOTAL	**145.26**
JUNE	FAN	4	30	5	0.1	48	14.4	33.6
	REFRIGERAT OR	1	30	24	0.2	129.6	38.9	90.72
	WASHING MACHINE	1	10	2	0.5	10	3	7
	LIGHT IN BEDROOM	6	30	5	0	10.8	0	10.8
	LIGHT IN HALL	3	30	5	0	5.4	0	5.4
	ELECTRIC GEYSER	3	30	0	4	0	0	0
							TOTAL	**147.52**
JULY	FAN	4	31	5	0.1	49.6	14.9	34.72
	REFRIGERAT OR	1	31	24	0.2	133.9	40.2	93.744
	WASHING MACHINE	1	10	2	0.5	10	3	7
	LIGHT IN BEDROOM	6	31	5	0	11.16	0	11.16
	LIGHT IN HALL	3	31	5	0	5.58	0	5.58
	ELECTRIC GEYSER	2	31	0	4	0	0	0
							TOTAL	**152.204**
AUG	REFRIGERAT OR	1	31	24	0.2	133.9	40.2	93.744
	WASHING MACHINE	1	10	2	0.5	10	3	7
	LIGHT IN BEDROOM	6	31	6	0	13.39	0	13.392
	LIGHT IN HALL	3	31	6	0	6.696	0	6.696
	ELECTRIC GEYSER	3	31	1	4	372	112	260.4
							TOTAL	**381.232**

SEPT	REFRIGERATOR	1	30	24	0.2	129.6	38.9	90.72
	WASHING MACHINE	1	10	2	0.5	10	3	7
	LIGHT IN BEDROOM	6	30	6	0	12.96	0	12.96
	LIGHT IN HALL	3	30	6	0	6.48	0	6.48
	ELECTRIC GEYSER	3	30	1	4	360	108	252
							TOTAL	**369.16**
OCT	REFRIGERATOR	1	31	24	0.2	133.9	40.2	93.744
	WASHING MACHINE	1	10	2	0.5	10	3	7
	LIGHT IN BEDROOM	6	31	6	0	13.39	0	13.392
	LIGHT IN HALL	3	31	6	0	6.696	0	6.696
	ELECTRIC GEYSER	3	31	2	4	744	223	520.8
							TOTAL	**641.632**
NOV	HEATER	3	30	2	1.5	270	81	189
	REFRIGERATOR	1	30	24	0.2	129.6	38.9	90.72
	WASHING MACHINE	1	10	2	0.5	10	3	7
	LIGHT IN BEDROOM	6	30	7	0	15.12	0	15.12
	LIGHT IN HALL	3	30	7	0	7.56	0	7.56
	ELECTRIC GEYSER	3	30	2	4	720	216	504
							TOTAL	**813.4**
DEC	HEATER	3	31	4	1.5	558	167	390.6
	REFRIGERATOR	1	31	24	0.2	133.9	40.2	93.744
	WASHING MACHINE	1	10	2	0.5	10	3	7

	LIGHT IN BEDROOM	6	31	7	0	15.62	0	15.624
	LIGHT IN HALL	3	31	7	0	7.812	0	7.812
	ELECTRIC GEYSER	3	31	2	4	744	223	520.8
							TOTAL	**1035.58**

Table – 6.7 Monthly Comparison between Conventional Building and Green Building

MONTH	CONVENTIONAL BUILDING (kWh)	GREEN BUILDING(kWh)
JANUARY	2157.37	1035.58
FEBRUARY	1611.56	934.64
MARCH	1146.22	641.632
APRIL	553.6	369.16
MAY	606.75	145.26
JUNE	597.1	147.52
JULY	616.67	152.204
AUGUST	943.72	381.232
SEPTEMBER	913.6	369.16
OCTOBER	1146.22	641.632
NOVEMBER	1323.1	813.4
DECEMBER	2157.37	1035.58

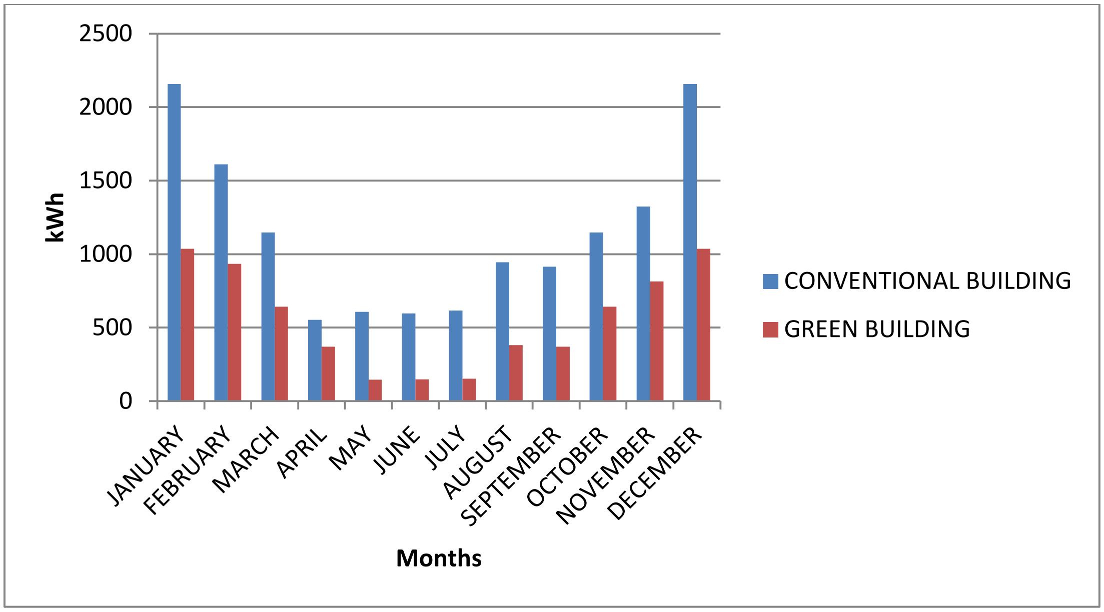


Fig – 6.5 Graphical Representation of Monthly Comparison of Energy of Conventional and Green Building

Table-6.8 Annual Electricity consumption of Conventional and Green Building

Building	kWh Per Year
Conventional Building	13773.28
Green Building	6667

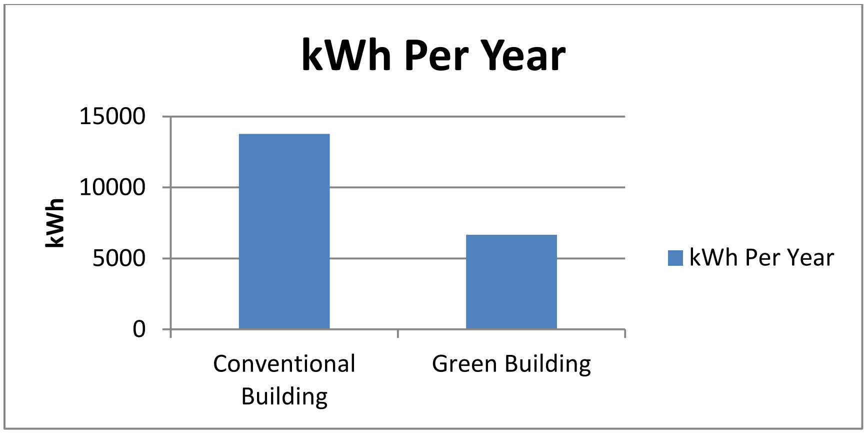


Fig – 6.6 Graphical representation of Energy Consumption per year of Conventional and Green Building

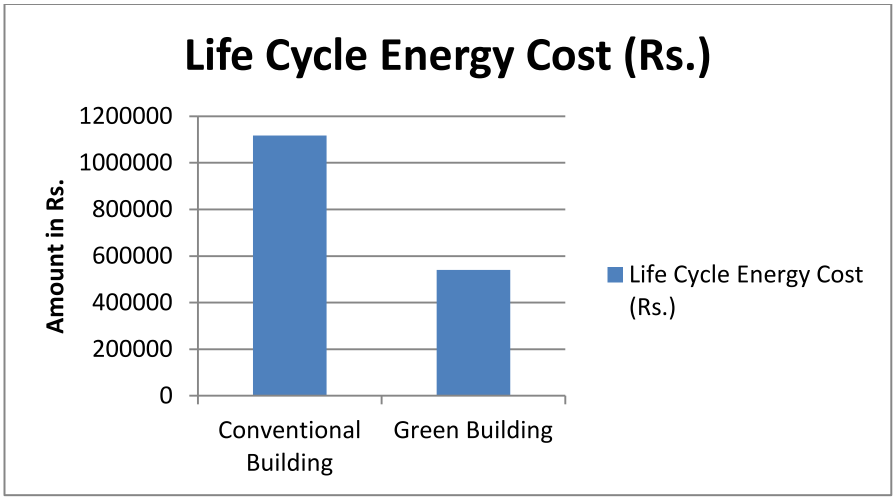


Fig – 6.7 Graphical representation of Life Cycle energy cost of Conventional Building and Green Building

Total Cost of Construction of Conventional Building = **Rs. 1812717**

Total Cost of Construction of Green Building = **Rs. 2212996**

Solar Panels Cost = Rs 60/Watt

Taking 8 Solar Panels with 1500 Watt Total Power = 1500x60=90000

Battery required for Solar Panels = Rs 11000/1200 Watt

Taking 2 Batteries , Total Cost of Batteries = 11000x2=22000

Solar DC to AC Converter = Rs 8000

Total Green Building Cost including Solar Panels = 2212996+90000+22000+8000= **Rs 2332996**

Extra Cost incurred to construct Green Building = Rs 2332996-1812717=**Rs 520279**

Annual Energy Requirement of Conventional Building = 13773.28 KWH

Life Cycle Energy Requirement of Conventional Building (3.7% Modified Discount Rate for 30 years) = **372242 kWh**

Life Cycle Energy Cost of Conventional Building (3Rs/kWh) =3x372242 = **Rs 1116726**

Annual Energy Requirement of Green Building = 6667 kWh

Life Cycle Energy Requirement of Green Building(3.7% Modified Discount Rate for 30 years) =**180180 kWh**

Life Cycle Energy Cost of Conventional Building (3 Rs/kWh) =3x180180 = **Rs 540540**

Total Life Cycle Energy Cost saving = Rs 1116726-540540 = **Rs 576186**

Payback period of extra cost incurred in constructing Green Building = **65 years** (Including Inflation Rate and Discount Rate)

For Calculation Refer to **ANNEXURE 3**

6.7 Water Efficiency

Table - 6.9 Daily water use pattern for an Individual

S.NO	ACTIVITY	WATER USAGE BY 1 PERSON (LITRES)
1	Bathing	20
2	Toilet (flush)	30
3	Drinking	5
4	Wash Basins	5
5	Wastage	2.5

Table - 6.10 Daily water use pattern for the family

S.NO	ACTIVITY	WATER USAGE BY FAMILY(LITRES)
1	Washing Clothes	60
2	Cleaning Utensils	30
3	Cleaning House	20
4	Gardening	20
5	Cooking	10
6	Car Washing	10

Table - 6.11 Daily water usage from rain water harvesting tank

S.NO	ACTIVITY	WATER UASGE (LITRES)
1	Toilet (flush)	180
2	Cleaning House	20
3	Gardening	20
4	Wash Basins	30
5	Car washing	10

Basic data required:

1. Average annual rainfall.
2. Size of catchment.
3. Drinking Water requirement.

Assuming that 6 member are residing in a family living in a building with a roof top area of 212.68 square meter. Daily water usage from rain water harvesting tank =260 Litres

Calculating the maximum amount of rainfall that can be harvested from the rooftop.

1. Area of roof top = 212.68 m^2.
2. Average annual rainfall = 1400mm (Shimla).
3. ^Runoff Coefficient = 0.85.
4. ^Coefficient for evaporation, spillage = 0.8.

212.68 Sqm roof top= Area of rooftop * Annual rainfall in meter*Runoff coefficient* Coefficient for evaporation, spillage.
= 212.68x 1.4x0.85x0.8
=202.47 cum= **202470 Litres**.
(^= denotes all the values obtained from CPWD manual for rain water harvesting).

The tank capacity has to be designed for entire year i.e. for 365 days
Requirement of family for entire year = 365 x 260= 94900 Litres.
For safety considerations the tank should be 20% larger than its requirement= 94900x1.2
= **113880 Litres**.

As per TCP (Town and Country Planning) Report of Himachal Pradesh:

Clause 12(ii) - Adequate provision for rain water harvesting structure, @ 20 Liters per M^2 of the roof top area, shall have to be made underground in the parks and open spaces and the same shall be used for the purposes.

So according to Clause12 (ii):- Rain Water Harvesting Tank Capacity= 20 litres/ m^2.

For our building = 212.68 Sqm x 20 Litres/m^2

= 4253.6 Litres= 4.253.

Provide diameter of tank = 1.5m

Assuming a circular tank: Area=$A = \frac{\pi}{4} * D^2$.

Area= $\frac{\pi}{4} * 1.5^2$ = 1.767 m^2.

Volume =4.253 m^3.

Height = Volume/ Area

4.253/1.767 = 2.4 m

Assuming a freeboard = 0.1m

Total Height= 2.4+0.1=2.5 m

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1 CONCLUSION

1. A Green Building designed for Cold and Cloudy Climate incorporates environmental consideration into every stage of the Building Construction and focuses on the design, construction, operation and maintenance phases.
2. Since the building is designed for Cold and Cloudy Climate, so in order to promote Heat gain in the Building, Solar passive housing Technology is incorporated in which Solar Panels, Trombe Wall, Double Glazed Windows, Sloped Glazing Roof, Deciduous Trees are installed in the Building.
3. Solar passive housing is one of the well tested and proven technology which is very useful for the climatic conditions of HP, in providing comfortable living conditions, besides saving 50-60% of energy required for winter space heating.
4. Moreover to reduce heat loss, proper orientation is provided. Roof is Insulated with Puffed Insulations which are easily available in Shimla. North and East face wall are provided with the Cavity Wall with AAC Blocks.
5. In order to ensure the sustainable use of water, Rain water Harvesting is being installed in the Building which is the practice of capturing, infiltrating or utilizing rainfall from roofs and collected in water storage tank.
6. Incorporating of all these features in the Green Building has resulted in the saving of around 51.59 % of energy per year.
7. However initially Cost of Construction of Green Building is 22% more than Conventional Building which will be recovered in 65 years i.e the payback period.
8. However a payback period is more. This is due to the Electricity cost in Shimla which is very less compare to other cities i.e it is Rs. 3/kWh.
9. The energy analysis and costing is done manually keeping in mind the external conditions such as geographical condition, topography, location etc.

7.2 FUTURE SCOPE

Energy analysis can be done by other softwares as well and one such software is AECOsim Energy Simulator. Many others techniques apart from the one used in this project like Solar Water Heaters, Green Roofing, various other insulating materials, glasses can also be incorporated in green buildings. The construction practice will be different for places with different geographical conditions and have to be carried out accordingly.

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APPENDIX

ANNEXURE 1

COST OF CONSTRUCTION OF CONVENTIONAL BUILDING

Table - 8.1 Volume Calculation for Excavation

Item No.	Excavation	Dimensions			No. of Units	Quantity(Cum)	Explanatory Notes
		Length (m)	Breadth (m)	Depth (m)			
1	For Main Wall	74.5	0.9	1	1	67.05	79-10*(0.9/2)
	For Partition Wall	46.34	0.7	0.7	1	22.71	54.94-12*0.3-14*0.35
	For Verandah Wall	13.47	0.4	0.45	1	2.42	14.37-2*(0.9/2)
	Staircase South	1.11	2.44	0.1	1	0.27	
	Staircase East	1.01	1.22	0.1	1	0.12	
	Total					92.58	

Table - 8.2 Cost Calculation for Excavation

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material		0	0	0.00	
2	Labour					
2.1	Mate	Mandays	0.06	363	21.78	For 1 Cum
2.2	Mazdoor	Mandays	0.62	363	225.06	For 1 Cum
3	Plant and Machinery		0	0	0.00	Manual Excavation
	Total				246.84	For 1 Cum
4	Water Charges				0.00	
5	Tools		3% of total cost		7.41	
6	Profit		10% of total cost		24.68	
	Total Excavation Cost for 1 Cum				278.93	
	Total Excavation Cost for 92.58 Cum				25821.94	

Table - 8.3 Volume Calculation for Lime Concrete Foundation

Item No.	Lime Concrete Foundation	Dimensions			No of Units	Quantity(Cum)	Explanatory Notes
		Length (m)	Breadth (m)	Depth (m)			
2	For Main Wall	74.5	0.9	0.3	1	20.12	79-10*(0.9/2)
	For Partition Wall	46.44	0.7	0.2	1	6.50	54.94-12*0.3-14*0.35
	For Verandah Wall	13.47	0.4	0.15	1	0.81	14.37-2*(0.9/2)
	Staircase South	1.11	2.44	0.1	1	0.27	
	Staircase East	1.01	1.22	0.1	1	0.12	
	Total					27.82	

Table - 8.4 Quantity of material required in Lime Concreting

Lime Concreting In Foundation with 40 mm gauge Brick Ballast	
White Lime : Surkhi : Brick Ballast = 1 : 2 : 6	
Wet Volume = 1 Cum	
Dry Volume = 1.4* W V	1.4 Cum
Vol Including Wastage = 1.1* D V	1.54 Cum
White Lime (Cum)	0.17
Surkhi (Cum)	0.34
Brick Ballast (Cum)	1.03

Table - 8.5 Cost Calculation for Lime Concrete Foundation

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	White Lime (dry hydrated lime)	Cum	0.17	5085.3	870.15	1 Cum = 2211 Kg = 22.11Quintal
					0.00	1 Cum = 22.11*230 = 5085.3 Rs
1.2	Carraige of Lime	Cum	0.17	106.49	18.22	Distance = 3 to 4 km
1.3	Surkhi	Cum	0.34	700	239.56	
1.4	Carraige of Surkhi	Cum	0.34	106.49	36.44	Distance = 3 to 4 km
1.5	Brick Ballast	Cum	1.03	650	667.33	
1.6	Carriage Of Brick Ballast	Cum	1.03	106.49	109.33	Distance = 3 to 4 km
2	Labour				0.00	
2.1	Mason	Mandays	0.1	435	43.50	For 1 Cum
2.2	Mazdoor	Mandays	2.65	363	961.95	For 1 Cum
2.3	Bhisti	Mandays	0.8	363	290.40	For 1 Cum
3	Plant and Machinery		0	0	0.00	
	Total				3236.88	For 1 Cum
4	Water Charges		1.5% of total cost		48.55	
5	Tools		3% of total cost		97.11	
6	Profit		10% of total cost		323.69	
	Total Lime Concreting Cost for 1 Cum				3706.23	
	Total Lime Concreting Cost for 27.82 Cum				103103.18	

Table - 8.6 Volume Calculation for Brickwork in Foundation

Item No.	**Brickwork in Foundation**	Dimensions			No. of Units	Quantity(Cum)	Explanatory Notes
		Length (m)	Breadth (m)	Depth (m)			
3	Main wall						
	60cm thick	76	0.6	0.20	1	9.12	79-10*(0.6/2)
	50cm thick	76.5	0.5	0.20	1	7.65	79-10*(0.5/2)
	40cm thick	77	0.4	1.06	1	32.71	79-10*(0.4/2)
	Partition wall						
	40cm thick	49.14	0.4	0.20	1	3.93	54.94-12*(0.5/2)-14*(0.4/2)
	30cm thick	50.44	0.3	1.06	1	16.07	54.94-12*(0.4/2)-14*(0.3/2)
	Verandah wall						
	30cm thick	14.07	0.3	1.06	1	4.48	14.37-2*(0.3/2)
	Total					73.96	

Table - 8.7 Quantity of Material required for Brickwork in Foundation

Volume	1 Cum				
Nominal size of bricks	200*100*100	2000000 mm^3			
Brick size(without mortar)	190*90*90	1539000 mm^3			
Mortar volume for 1 Brick		461000 mm^3			
Total no of bricks		500			
Mortar volume		230500000 mm^3	0.231	(Cum)	(Wet volume)
Dry volume			0.288	(Cum)	D.V = 1.25* W.V
Volume inc .wastage			0.316	(Cum)	Wastage = 1.1 * D.V
Cement volume			0.053	(Cum)	
Sand volume			0.264	(Cum)	Cement:Sand for brick work=1:6
Cement weight	1Cum=1.44 Tons		0.076	(Tons)	First Class Brick

Table -8.8 Cost Calculation for Brickwork in Foundation

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Bricks	per brick	500	3.3	1650	Rate 1000 bricks = 3300
1.2	Cement	Cum	0.053	9072	478.17	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
1.3	Sand	Cum	0.264	700	184.48	
1.3	Carraige of Bricks	per brick	500	0.284	141.98	Rates 1000 bricks = 283.96 for distance 3 to 4 km
1.4	Carraige of Cement	Cum	0.053	136.29	7.18	Rate 1 Cum=1.44*94.65=136.29 Rs for Distance = 3 to 4 km
1.5	Carraige of Sand	Cum	0.264	106.49	28.06	Distance = 3 to 4 km
2	Labour					
	Mason	Mandays	0.250	435	108.75	For 1 Cum
	Mazdoor	Mandays	0.400	363	145.2	For 1 Cum
	Bhisti	Mandays	0.100	363	36.3	For 1 Cum
3	Plant and Machinery		0	0	0	
	Total				2780.13	For 1 Cum
4	Water Charges		1.5% of total cost		41.70	
5	Tools		3% of total cost		83.40	
6	Profit		10% of total cost		278.01	
	Total Brick work in Foundation Cost for 1 Cum				3183.25	
	Total Brick work in Foundation Cost for 73.96 Cum				235444.60	

Table - 8.9 Volume Calculation for Earthwork in Filling Plinth

Item No.	Earthwork in Filling Plinth	Dimensions			No. of Units	Quantity(Cum)
		Length (m)	Breadth (m)	Depth (m)		
4	Bedroom(5.77*3.48)	5.77	3.48	0.76	1	15.29
	Bedroom(5.56*3.48)	5.56	3.48	0.76	1	14.75
	Bedroom(5.56*3.78)	5.56	3.78	0.76	1	16.04
	Toilet(1.47*3.3)	1.47	3.30	0.76	3	11.11
	Kitchen(3.66*3.25)	3.66	3.25	0.76	1	9.06
	Drawing(5.77*3.78)	5.77	3.78	0.76	1	16.63
	Study room(3.66*3.33)	3.66	3.33	0.76	1	9.27
	Bathroom(2.22*1.3)	2.22	1.30	0.76	1	2.19
	Sink(1.42*1.30)	1.42	1.30	0.76	1	1.40
	Hall					70.69
	Verandah	11.51	1.52	0.76	1	13.36
	Total					179.80

Table - 8.10 Cost Calculation for Earthwork in Filling Plinth

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material		0	0	0	
2	Labour					
2.1	Mate	Mandays	0.02	363	7.26	For 1 Cum
2.2	Mazdoor	Mandays	0.25	363	90.75	For 1 Cum
3	Plant and Machinery		0	0	0	
	Total				98.01	For 1 Cum
4	Water Charges				0	
5	Tools		3% of total cost		2.94	
6	Profit		10% of total cost		9.80	
	Total Earth Work in Filling Plinth Cost for 1 Cum				110.75	
	Total Earth Work in Filling Plinth Cost for 179.80 Cum				19913.40	

Table - 8.11 Area Calculation of 2.5cm thick DPC

Item No.	**2.5cm thick DPC**	Dimensions			No. of Units	Quantity(Sqm)	Explanatory Notes
		Length (m)	Breadth (m)	Depth (m)			
5	Main Wall	67.75	0.225		1	15.244	79-10*(0.225/2)
	Partition Wall	52.89	0.1		1	5.289	54.94-12*(0.225/2)-14*(0.1/2)
	Verandah Wall	14.145	0.225		1	3.183	14.37-2*(0.225/2)
	Total					23.715	

Table -8.12 Cost Calculation of DPC

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material		0	0	0	
1.1	DPC	Sqm	1	257.8	257.8	
2	Labour					
2.1	Mason	Mandays	0.1	435	43.5	For 1 Sqm
2.2	Mazdoor	Mandays	0.1	363	36.3	For 1 Sqm
2.3	Bhisti	Mandays	0.01	363	3.63	For 1 Sqm
3	Plant and Machinery		0	0	0	
	Total				341.23	For 1 sqm
4	Water Charges		1.5% of total cost		5.12	
5	Tools		3% of total cost		10.24	
6	Profit		10% of total cost		34.12	
	Total DPC Cost for 1 Sqm				390.71	
	Total DPC Cost for 23.715 Sqm				9265.65	

Table - 8.13 Volume Calculation for Casting Column

Item No.	Column	Dimensions			No. of Units	Quantity(Cum)	Cross section Area (b*d) (Sqm) for 1 Column	Providing 2.5% reinforcement of Cross Sectional Area (Sqm)	Reinforcement for given length	Reinforcement in Kg for 1 column	Reinforcement in kg for 1 Cum	Reinforcement for given quantity in kg
		Length (m)	Breadth (m)	Depth (m)								
6	Main wall	3.35	0.225	0.225	10	1.696	0.051	0.00127	0.00424	33.283	196.25	332.83
	Partition wall	3.35	0.225	0.225	4	0.678	0.051	0.00127	0.00424	33.283	196.25	133.13
	Deduction											
	Due to reinforcement					-0.059						
	Total					2.315						465.96

Table – 8.14 Quantity of Material required for Casting Column and Area of Formwork

1Cum=1440 Kg		
1Cum=1.44 Tons		
Concrete Mix=1:1.5:3		
Volume	Cum	1
Dry Volume = 1.25*Volume	Cum	1.25
Volume including wastage = 1.1*D V	Cum	1.375
Cement	Cum	0.25
Sand	Cum	0.375
Aggregates	Cum	0.75
Cement	Tonnes	0.36
Formwork		
Area= 10*0.225*3.35 (For 10 column in Main walls)	Sqm	7.538
Area=4*0.225*3.35 (For 4 column in Partition walls)	Sqm	3.015
Total Area	Sqm	10.553

Table - 8.15 Cost Calculation for Casting Column

S.No	Description	Unit	Quantity	Rate	Amount (Rs)	Remarks
1	Material					
1.1	Concreting					
	Cement	Cum	0.25	9072	2268	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
	Sand	Cum	0.375	700	262.5	For 1 Cum
	Aggregates	Cum	0.75	1050	787.5	For 1 Cum Size vary from 25 to 50 mm
	Carraige of Cement	Cum	0.25	136.3	34.07	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 k
	Carraige of Sand	Cum	0.375	106.5	39.93	Distance 3 to 4 km
	Carraige of Aggregates	Cum	0.75	106.5	79.87	Distance 3 to 4 km
1.2	FORMWORK (Hire Charges include Labour)					
	For Column	Sqm	1	453.4	453.35	
1.3	REINFORCEMENT					
	Steel Bars	kg	1	64.95	64.95	
	Carriage of Steel	kg	1	0.947	0.95	Distance 3 to 4 km
2	Labour					
2.1	Concreting					
	Mason	Mandays	0.23	435	100.05	For 1 Cum
	Mazdoor	Mandays	3.5	363	1270.5	For 1 Cum
	Bhisti	Mandays	0.9	363	326.7	For 1 Cum
	Mixer Operator	Mandays	0.1	363	36.3	For 1 Cum
2.2	REINFORCEMENT					
	Bar bender	Mandays	0.01	329	3.29	For 1 kg
	Mazdoor	Mandays	0.01	363	3.63	For 1 kg
3	Plant and Machinery					
	Mixer	Days	1	800	800	
	Vibrator	Days	1	350	350	
	Total Cost for Concreting				5205.43	For 1 Cum
	Plant and machinery for 1 day				1150	
	Plant and machinery for 5 day				5750	
	Water Charges		1.5% of total cost		78.08	
	Tools		3% of total cost		156.16	
	Profit		10% of total cost		520.54	
	Total Cost of Concreting for 1 Cum				11710.21	
	Total Cost of Concreting for 2.315 Cum				19547.89	
	Total Cost of Formwork (Hire Charges) including labour				453.35	For 1 Sqm
	Total Cost of Formwork (Hire Charges) including labour for 10.553 Sqm				4783.98	
	Total Cost of Reinforcement				72.82	For 1 kg
	Water Charges		1.5% of total cost		1.09	
	Tools		3% of total cost		2.18	
	Profit		10% of total cost		7.28	
	Total Cost of Reinforcement for 1 Kg				83.37	
	Total Cost of Reinforcement for 465.96 Kg				38849.36	
	Total Column Casting Cost				63181.23	

Table - 8.16 Volume Calculation for Casting Beams

Item No.	Beams	Dimensions			No. of Units	Quantity(Cum)	Cross section Area (b*d) (Sqm) for 1 Column	Providing 2.5% reinforcement of cross sectional area (Sqm)	Reinforcement for given length	Reinforcement in Kg for given beam
		Length (m)	Breadth (m)	Depth (m)						
7	Main Walls	98.33	0.225	0.225	1	4.978	0.0506	0.00127	0.124449	976.924
	Deduction									
	Due to column	0.225	0.225	0.225	10	-0.114	0.0506	0.00127	0.000285	-22.354
	Due to reinforcement					-0.122				
	Total					4.742				954.570

Table – 8.17 Quantity of Material required for Casting Beams and Area of Formwork

1Cum=1440Kg		
1Cum=1.44 Tons		
Concrete Mix=1:1.5:3		
Volume =	Cum	1
Dry Volume = 1.25*Volume	Cum	1.25
Volume including wastage = 1.1*D V	Cum	1.375
Cement	Cum	0.25
Sand	Cum	0.375
Aggregates	Cum	0.75
Cement	Tonnes	0.36
Formwork		
Area=98.33*0.225	Sqm	22.124

Table - 8.18 Cost Calculation for Casting Beams

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	CONCRETING					
	Cement	Cum	0.25	9072	2268	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
	Sand	Cum	0.375	700	262.5	For 1 Cum
	Aggregates	Cum	0.75	1050	787.5	For 1 Cum Size vary from 25 to 50 mm
	Carraige of Cement	Cum	0.25	136.296	34.074	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
	Carraige of Sand	Cum	0.375	106.49	39.93375	Distance 3 to 4 km
	Carraige of Aggregates	Cum	0.75	106.49	79.8675	Distance 3 to 4 km
1.2	FORMWORK (Hire Charges include Labour)					
	For Column	Sqm	1	453.35	453.35	
1.3	REINFORCEMENT					
	Steel Bars	kg	1	64.95	64.95	
	Carriage of Steel	kg	1	0.9465	0.9465	Distance 3 to 4 km
2	Labour					
2.1	CONCRETING					
	Mason	Mandays	0.23	435	100.05	For 1 Cum
	Mazdoor	Mandays	3.5	363	1270.5	For 1 Cum
	Bhisti	Mandays	0.9	363	326.7	For 1 Cum
	Mixer Operator	Mandays	0.1	363	36.3	For 1 Cum
2.2	REINFORCEMENT					
	Bar bender	Mandays	0.01	329	3.29	For 1 kg
	Mazdoor	Mandays	0.01	363	3.63	For 1 kg
3	Plant and Machinery					
	Mixer	Days	1	800	800	
	Vibrator	Days	1	350	350	
	Total Cost of Concreting				5205.43	For 1 Cum
	Plant and machinery for 1 day				1150.00	
	Plant and machinery for 5 day				5750.00	
	Water Charges		1.5% of total cost		78.08	
	Tools		3% of total cost		156.16	
	Profit		10% of total cost		520.54	
	Total Cost of Concreting for 1 Cum				5960.21	
	Total Cost of Concreting for 4.74 Cum				34001.40	
	Total Cost of Formwork (Hire Charges) including labour				453.35	For 1 Sqm
	Total Cost of Formwork (Hire Charges) including labour for 22.124 Sqm				10029.92	
	Total Cost of Reinforcement				72.82	For 1 kg
	Water Charges		1.5% of total cost		1.09	
	Tools		3% of total cost		2.18	
	Profit		10% of total cost		7.28	
	Total Cost of Reinforcement for 1 Kg				83.37	
	Total Cost of Reinforcement for 954.57 Kg				79587.17	
	Total Beam Casting Cost				123618.49	

Table - 8.19 Volume Calculation for Superstructure Brickwork

Item No.	**Superstructure Brickwork**	Dimensions			No. of Units	Quantity(Cum)	Explanatory Notes
		Length (m)	Breadth (m)	Height (m)			
	Main Wall	67.75	0.225	3.125	1	47.637	79-10*(0.225/2)
	Partition Wall	52.89	0.1	3.35	1	17.718	54.94-12*(0.225/2)-14*(0.1/2)
	First floor Wall	24.77	0.225	2.44	1	13.599	25.22-4*0.225/2
	Deductions						
	D (rooms)	1.1	0.225	2.1	4	-2.079	
	D (rooms) 2	1.1	0.1	2.1	6	-1.386	
	D (toilet)	0.71	0.1	2.1	8	-1.193	
	D (main door)	2.1	0.225	2.1	1	-0.992	
	W (rooms)	1.524	0.225	1.5	10	-5.144	
	W (toilet)	0.6	0.225	0.91	4	-0.491	
	W (hall)	3.048	0.225	3.65	1	-2.503	
8							
	Lintels						
	D (rooms)	1.1	0.225	0.15	4	-0.149	
	D (rooms) 2	1.1	0.1	0.15	6	-0.099	
	D (toilet)	0.71	0.1	0.15	8	-0.085	
	D (main door)	2.1	0.225	0.15	1	-0.071	
	W (rooms)	1.524	0.225	0.15	10	-0.514	
	W (toilet)	0.6	0.225	0.15	4	-0.081	
	W (hall)	3.048	0.225	0.15	1	-0.103	
	Column					-2.370	
	Total					61.694	

Table - 8.20 Quantity of Material required for Superstructure brickwork

Volume	1 Cum				
Nominal size of bricks	200*100*100	2000000 mm^3			
Brick size(without mortar)	190*90*90	1539000 mm^3			
Mortar volume for 1 Brick		461000 mm^3			
Total no of bricks		500			
Mortar volume		230500000 mm^3	0.231	(Cum)	(Wet volume)
Dry volume			0.288	(Cum)	D.V = 1.25* W.V
Volume inc .wastage			0.316	(Cum)	Wastage = 1.1 * D.V
Cement volume			0.053	(Cum)	
Sand volume			0.264	(Cum)	Cement:Sand for brick work=1:6
Cement weight	1Cum=1.44 Tons		0.076	(Tons)	First Class Brick

Table - 8.21 Cost Calculation for Brickwork in Superstructure

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Bricks	per brick	500	3.3	1650	Rate 1000 bricks = 3300
1.2	Cement	Cum	0.05271	9072	478.17	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
1.3	Sand	Cum	0.26354	700	184.48	
1.3	Carraige of Bricks	per brick	500	0.28396	141.98	Rates 1000 bricks = 283.96 for distance 3 to 4 km
1.4	Carraige of Cement	Cum	0.05271	136.3	7.18	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
1.5	Carraige of Sand	Cum	0.26354	106.49	28.06	Distance = 3 to 4 km
2	Labour					
	Mason	Mandays	0.25	435	108.75	For 1 Cum
	Mazdoor	Mandays	0.4	363	145.2	For 1 Cum
	Bhisti	Mandays	0.1	363	36.3	For 1 Cum
3	Plant and Machinery		0	0	0	
	Total				2780.13	For 1 Cum
4	Water Charges		1.5% of total cost		41.70	
5	Tools		3% of total cost		83.40	
6	Profit		10% of total cost		278.01	
	Total Brick work in Superstructure Cost for 1 Cum				3183.25	
	Total Brick work in Superstructure Cost for 61.69 Cum				196374.47	

Table – 8.22 Volume Calculation for Casting Slab

Item No.	Slab	Dimensions			No. of Units	Quantity(Cum)	No. of bars taking spacing as 200mm		Taking 10mm dia bar , DxD/162	Total reinforcement in kg providing 50mm cover on both sides
		Length(m)	Breadth(m)	Depth(m)						
9	Slab	21.8	13.25	0.1	1	28.885	No. of bars along length	109.5	0.6173	1480.28
							No. of bars along breadth	66.75	0.6173	550.07
	Deduction									
	Due to reinforcement					-0.2586				
	Total					28.6264				2030.35

Table - 8.23 Quantity of Materials required for Casting Slab and Area of Shuttering

1Cum=1440Kg		
1Cum=1.44 Tons		
Concrete Mix=1:1.5:3		
Volume	Cum	1
Dry Volume = 1.25*Volume	Cum	1.25
Volume including wastage = 1.1*D V	Cum	1.375
Cement	Cum	0.25
Sand	Cum	0.375
Aggregates	Cum	0.75
Cement	Tonnes	0.36
Shuttering		
Area (Sqm)	21.8*13.25	288.85

Table - 8.24 Cost Calculation for Casting Slab

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	CONCRETING					
	Cement	Cum	0.25	9072	2268.00	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
	Sand	Cum	0.375	700	262.50	For 1 Cum
	Aggregates	Cum	0.75	1050	787.50	For 1 Cum Size vary from25 to 50 mm
	Carraige of Cement	Cum	0.25	228.11	57.03	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
	Carraige of Sand	Cum	0.375	106.49	39.93	Distance 3 to 4 km
	Carraige of Aggregates	Cum	0.75	106.49	79.87	Distance 3 to 4 km
1.2	SHUTTERING					
	For Slab	Sqm	1	401.65	401.65	
1.3	REINFORCEMENT					
	Steel Bars	kg	1	64.95	64.95	
	Carriage of Steel	kg	1	0.95	0.95	Distance 3 to 4 km
2	Labour					
2.1	CONCRETING					
	Mason	Mandays	0.23	435	100.05	For 1 Cum
	Mazdoor	Mandays	3.5	363	1270.50	For 1 Cum
	Bhisti	Mandays	0.9	363	326.70	For 1 Cum
	Mixer Operator	Mandays	0.1	363	36.30	For 1 Cum
2.2	REINFORCEMENT					
	Bar bender	Mandays	0.01	329	3.29	For 1 kg
	Mazdoor	Mandays	0.01	363	3.63	For 1 kg
3	Plant and Machinery					
	Mixer	Days	1	800	800.00	
	Vibrator	Days	1	350	350.00	
	Total Cost of Concreting				5228.38	For 1 Cum
	Plant and machinery for 1 day				1150.00	
	Plant and machinery for 15 day				17250.00	
	Water Charges		1.5% of total cost		78.43	
	Tools		3% of total cost		156.85	
	Profit		10% of total cost		522.84	
	Total Cost of Concreting for 1 Cum				5986.49	
	Total Cost of Concreting for 28.626 Cum				188619.34	
	Total Cost of Shuttering (Hire Charges) including labour				401.65	For 1 Sqm
	Total Cost of Shuttering (Hire Charges) including labour for 288.85 Sqm				116016.60	
	Total Cost of Reinforcement				72.82	For 1 kg
	Water Charges		1.5% of total cost		1.09	
	Tools		3% of total cost		2.18	
	Profit		10% of total cost		7.28	
	Total Cost of Reinforcement for 1 Kg				83.37	
	Total Cost of Reinforcement for 2030 Kg				169251.03	
	Total Slab Casting Cost				473886.97	

Table-8.25 Volume Calculation for Wood Work

Item No.	Wood work	Dimensions			No. of Units	Quantity(Cum)
		Length (m)	Breadth (m)	Height (m)		
10						
	D (rooms)	1	0.038	2.1	4	0.319
	D (rooms 2)	1	0.038	2.1	6	0.479
	D (toilet)	0.61	0.038	2.1	8	0.389
	D (main door)	2	0.038	2.1	1	0.160
	Frames					
	D (rooms)	0.1	0.1	2.1	4	0.084
	D (rooms 2)	0.1	0.1	2.1	6	0.126
	D (toilet)	0.1	0.1	2.1	8	0.168
	D (main door)	0.1	0.1	2.1	1	0.021
	W (rooms)	0.3048	0.1	0.3048	10	0.093
	W (toilet)	0.3048	0.1	0.3048	4	0.037
	W (hall)	0.3048	0.1	0.3048	1	0.009
	Total					1.885

Table -8.26 Cost Calculation for Wood Work

S.No	Description	Unit	Quantity	Rate	Amount(Rs.)	Remarks
1	Material					
1.1	Sal wood	Cum	1	33160	33160	10 Cudm = 331.6 Rs
1.2	Carriage Of Timber	Cum	1	121.7	121.7	Distance = 3 to 4 km
2	Labour					
2.1	Carpenter	Mandays	20	399	7980	For 1 Cum
2.2	Mazdoor	Mandays	2	363	726	For 1 Cum
3	Plant and Machinery		0	0	0	
	Total				41987.7	For 1 Cum
	Water Charges		0	0	0	
	Tools		3% of total cost		1259.631	
	Profit		10% of total cost		4198.77	
	Total Wood Work Cost for 1 Cum				47446.101	
	Total Wood Work Cost For 1.885 Cum				89435.90	

Table-8.27 Area Calculation for Glass Work

Item No.	Glass work	Dimensions		No. of Units	Quantity(Sqm)
		Length (m)	Height (m)		
11					
	W (rooms)	1.22	1.22	10	14.88
	W (toilet)	0.3048	0.61	4	0.74
	W (hall)	2.74	3.35	1	9.18
	Total				24.81

Table - 8.28 Cost Calculation for Glass Work

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Glass (Single Glazed)	Sqm	1	1900	1900	
2	Labour					
2.1	Glazier	Mandays	0.2	399	79.8	For 1 Cum
2.2	Mazdoor	Mandays	0.01	363	3.63	For 1 Cum
3	Plant and Machinery		0	0	0	
	Total				1983.43	For 1 Cum
	Water Charges		0	0	0	
	Tools		3% of total cost		59.50	
	Profit		10% of total cost		198.34	
	Total Glass Work for 1 Sqm				2241.28	
	Total Glass Work Cost For 24.8 Sqm				55583.64	

Table - 8.29 Volume Calculation of Lintel over Doors and Windows

Item No.	**Lintel over doors and windows**	Dimensions			No. of Units	Quantity(Cum)
		Length (m)	Breadth (m)	Depth (m)		
12	D (rooms)	1.1	0.225	0.15	4	0.149
	D (rooms) 2	1.1	0.1	0.15	6	0.099
	D (toilet)	0.71	0.1	0.15	8	0.085
	D (main door)	2.1	0.225	0.15	1	0.071
	W (rooms)	1.524	0.225	0.15	10	0.514
	W (toilet)	0.6	0.225	0.15	4	0.081
	W (hall)	3.048	0.225	0.15	1	0.103
	Total					0.999

Table - 8.30 Quantity of Material required for Lintel over Doors and Windows

Volume	1 Cum
Dry Volume = 1.25*Volume	1.25 Cum
Volume including wastage = 1.1*D V	1.375 Cum
Cement : Sand = 1:3	
Cement (Cum)	0.34375
Sand (Cum)	1.03125

Table - 8.31 Cost Calculation of Lintel over Doors and Windows

S.No	Description	Unit	Quantity	Rate	Amount (Rs	Remarks
1	Material					
1.1	Cement	Cum	0.34375	9072	3118.5	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
1.2	Sand	Cum	1.03125	700	721.88	For 1 Cum
1.3	Carriage Of Cement	Cum	0.34375	136.3	46.85	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 k
1.4	Carriage Of Sand	Cum	1.03125	106.49	109.82	Distance = 3 to 4 km
2	Labour					
2.1	Mazdoor	Mandays	0.75	363	272.25	For 1 Cum
2.2	Bhisti	Mandays	0.07	363	25.41	For 1 Cum
3	Plant and Machinery		0	0	0	
	Total				4294.71	For 1 Cum
	Water Charges		1.5% of total cost		64.42	
	Tools		3% of total cost		128.84	
	Profit		10% of total cost		429.47	
	Total Lintel Cost for 1 Cum				4917.44	
	Total Lintel Cost for 1 Cum				4917.44	

Table - 8.32 Area calculation of Floor Finishing

Item No.	**Floor Finishing**	Dimensions		No. of Units	Quantity(Sqm)
		Length (m)	Breadth (m)		
13	Bedroom(5.77*3.48)	5.77	3.48	1	20.06
	Bedroom(5.56*3.48)	5.56	3.48	1	19.36
	Bedroom(5.56*3.78)	5.56	3.78	1	21.05
	Toilet(1.47*3.3)	1.47	3.30	3	14.58
	Kitchen(3.66*3.25)	3.66	3.25	1	11.90
	Drawing(5.77*3.78)	5.77	3.78	1	21.82
	Study room(3.66*3.33)	3.66	3.33	1	12.17
	Bathroom(2.22*1.3)	2.22	1.30	1	2.88
	Sink(1.42*1.30)	1.42	1.30	1	1.84
	Hall				92.77
	Verandah	11.51	1.52	1	17.54
	Doors (Rooms)	1.1	0.225	2	0.50
	Doors (Rooms 2)	1.1	0.1	6	0.66
	Doors (Toilet)	0.71	0.1	8	0.57
	Door (Main)	2.1	0.225	1	0.47
	Total				238.16

Table - 8.33 Quantity of material required for Floor Finishing

22mm Thick Tile flooring on 20mm thick cement mortar(1:4)	
Volume of Mortar (238.16*0.020)cum	4.7632
Taking Volume	1 Cum
Dry Volume = 1.25*Volume	1.25 Cum
Volume including wastage = 1.1*D V	1.375 Cum
Cement : Sand = 1:4	
Cement (Cum)	0.275
Sand (Cum)	1.1

Table - 8.34 Cost Calculation of Floor Finishing

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Cement	Cum	0.275	9072	2494.8	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
1.2	Sand	Cum	1.1	700	770	For 1 Cum
1.3	Carriage Of Cement	Cum	0.275	228.107	62.729	1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
1.4	Carriage Of Sand	Cum	1.1	106.49	117.139	Distance = 3 to 4 km
1.5	Tiles	Sqm	1	250	250	Chequered terrazo tiles with graded marble chips
2	Labour					
2.1	Mason	Mandays	0.08	435	34.8	For 1 Sqm
2.2	Mazdoor	Mandays	0.12	363	43.56	For 1 Sqm
2.3	Bhisti	Mandays	0.1	363	36.3	For 1 Sqm
3	Plant and Machinery		0	0	0	
	Total Cost of Mortar Material				3444.67	For 1 Cum
	Water Charges		1.5% of total cost		51.67	
	Tools		3% of total cost		103.34	
	Profit		10% of total cost		344.47	
	Total Cost of Material for 1 Cum				3944.15	
	Total Cost For Material for 4.7632 Cum				18786.75	
	Total Cost of Tiles and Labour				364.66	For 1 Sqm
	Water Charges		1.5% of total cost		5.47	
	Tools		3% of total cost		10.94	
	Profit		10% of total cost		36.47	
	Total Cost of tiles and Labour for 1 Sqm				417.54	
	Total Cost of tiles and Labour for 238.16 Sqm				99440.30	
	Total Floor Finish Cost				118227.05	

Table - 8.35 Area Calculation of Cement Plastering

Item No.	**Cement Plastering**	Dimensions		No. of Units	Quantity (Sqm)	Explanatory Notes
		Length (m)	Height (m)			
14	Outer Walls					
	Outer West Wall	11.137	4.115	1	45.828	
	Outer East Wall	11.137	3.353	1	37.341	
	Outer North and South Wall	20.345	4.115	2	167.435	
	First floor Walls	26.136	2.438	1	63.730	
	Verandah Wall	13.881	0.762	1	10.577	
	Inner Walls					
	Bedroom(5.77*3.48)	18.492	3.353	1	61.999	L = 5.77+5.77+3.48+3.48
	Bedroom(5.56*3.48)	18.085	3.353	1	60.635	L = 5.56+5.56+3.48+3.48
	Bedroom(5.56*3.78)	18.695	3.353	1	62.679	L = 5.56+5.56+3.78+3.78
	Toilet(1.47*3.3)	9.546	3.353	3	96.021	L = 1.47+1.47+3.3+3.3
	Kitchen(3.66*3.25)	13.820	3.353	1	46.334	L = 3.66+3.66+3.25+3.25
	Drawing(5.77*3.78)	19.101	3.353	1	64.043	L = 5.77+5.77+3.78+3.78
	Study room(3.66*3.33)	14.068	3.353	1	47.166	L = 3.66+3.66+3.33+3.33
	Bathroom(2.22*1.3)	7.035	3.353	1	23.586	L = 2.22+2.22+1.3+1.3
	Sink(1.42*1.30)	5.432	3.353	1	18.211	L = 1.42+1.42+1.3+1.3
	Hall	46.177	3.353	1	154.823	
	First floor walls	24.562	2.438	1	59.891	
	Ceiling	22.009	13.246	1	291.532	
	Total				1311.832	
	Deductions					
	D (rooms)	1.0668	2.1336	4	-18.209	Deduction should be from sides , so quantity = length * breadth * unit * 2
	D (rooms) 2	1.0668	2.1336	6	-27.313	
	D (toilet)	0.710184	2.1336	8	-24.244	
	D (main door)	2.1336	2.1336	1	-9.104	
	W (rooms)	1.524	1.524	10	-46.452	
	W (toilet)	0.6096	0.9144	4	-4.459	
	W (hall)	3.048	3.6576	1	-22.297	
	Total				1159.754	

Table - 8.36 Quantity of Materials required for Cement Plastering

Area	Sqm	1159.75
Thickness	m	0.012
Volume of Mortar = Area*Thickness	Cum	13.917
Taking Volume =	Cum	1
Dry Volume = 1.25*Volume	Cum	1.25
Volume including wastage = 1.1*D V	Cum	1.375
Cement : Sand = 1:4		
Cement	Cum	0.275
Sand	Cum	1.1

Table - 8.37 Cost Calculation of Cement Plastering

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Cement	Cum	0.275	9072	2494.8	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
1.2	Sand	Cum	1.1	700	770	For 1 Cum
1.3	Carriage Of Cement	Cum	0.275	228.107	62.729	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
1.4	Carriage Of Sand	Cum	1.1	106.49	117.139	Distance = 3 to 4 km
2	Labour					
2.1	Mason	Mandays	0.08	435	34.8	For 1 Sqm
2.2	Mazdoor	Mandays	0.1	363	36.3	For 1 Sqm
3	Plant and Machinery		0	0	0	
	Total Cost of Material				3444.668	For 1 Cum
	Water Charges		1.5% of total cost		51.670	
	Tools		3% of total cost		103.340	
	Profit		10% of total cost		344.467	
	Total Cost of Material for 1 Cum				3944.145	
	Total Cost of Material for 13.917Cum				54890.669	
	Total Cost of Labour				71.1	For 1 Sqm
	Water Charges		1.5% of total cost		1.067	
	Tools		3% of total cost		2.133	
	Profit		10% of total cost		7.11	
	Total Cost of Labour for 1 Sqm				81.410	
	Total Cost of Labour for 1160 Sqm				94435.02	
	Total Cement Plastering Cost				149325.689	

Table - 8.38 Area Calculation of Painting and Polishing

Item No.	**Painting and Polishing**	Dimensions		No. of Units	Quantity (Sqm)	Explanatory Notes
		Length (m)	Height (m)			
15	Outer Walls					
	Outer West Wall	11.137	4.115	1	45.828	
	Outer East Wall	11.137	3.353	1	37.341	
	Outer North and South Wall	20.345	4.115	2	167.435	
	First floor Walls	26.136	2.438	1	63.730	
	Verandah Wall	13.881	0.762	1	10.577	
	Inner Walls					
	Bedroom(5.77*3.48)	18.492	3.353	1	61.999	L = 5.77+5.77+3.48+3.48
	Bedroom(5.56*3.48)	18.085	3.353	1	60.635	L = 5.56+5.56+3.48+3.48
	Bedroom(5.56*3.78)	18.695	3.353	1	62.679	L = 5.56+5.56+3.78+3.78
	Toilet(1.47*3.3)	9.546	3.353	3	96.021	L = 1.47+1.47+3.3+3.3
	Kitchen(3.66*3.25)	13.820	3.353	1	46.334	L = 3.66+3.66+3.25+3.25
	Drawing(5.77*3.78)	19.101	3.353	1	64.043	L = 5.77+5.77+3.78+3.78
	Study room(3.66*3.33)	14.068	3.353	1	47.166	L = 3.66+3.66+3.33+3.33
	Bathroom(2.22*1.3)	7.035	3.353	1	23.586	L = 2.22+2.22+1.3+1.3
	Sink(1.42*1.30)	5.432	3.353	1	18.211	L = 1.42+1.42+1.3+1.3
	Hall	46.177	3.353	1	154.823	
	First floor walls	24.562	2.438	1	59.891	
	Ceiling	22.009	13.246	1	291.532	
	Total				1311.832	
	Deductions					
	W (rooms)	1.219	1.219	10	-29.729	Deduction would be from both sides L*B*2*no of unit
	W (toilet)	0.305	0.610	4	-1.486	
	W (hall)	2.743	3.353	1	-18.395	
	Total				1262.222	

Table - 8.39 Cost calculation of Painting and polishing

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Primer	Sqm	1	8.625	8.625	1 Sqm = 0.75 litre = 0.75*115 = 8.625 Rs
1.2	Paint	Sqm	1	22.5	22.500	1 Sqm = 0.125 litre = 0.125*180 = 22.5 Rs
2	Labour					
2.1	Painter	Mandays	0.08	399	31.920	For 1 Sqm
2.2	Mazdoor	Mandays	0.04	363	14.520	For 1 Sqm
3	Plant and Machinery		0	0	0.000	
	Total				100.065	For 1 Sqm and 2 coat of paint
	Water Charges		1.5% of total cost		1.501	
	Tools		3% of total cost		3.002	
	Profit		10% of total cost		10.007	
	Total Painting Cost for 1 Sqm				114.574	
	Total Painting Cost for 1262.2 Sqm				144618.131	

ANNEXURE 2

COST OF CONSTRUCTION OF GREEN BUILDING

Table - 9.1 Volume Calculation for Excavation

Item No.	Excavation	Dimensions			No of Units	Quantity(Cum)	Explanatory Notes
		Length(m)	Breadth (m)	Depth (m)			
1	For Main Wall	14.63	0.9	1	1	13.16	17.627-3*0.5-1*0.6-2*0.45
	For Partition Wall	44.77	0.7	0.7	1	21.94	54.07-4*0.35-14*0.35-4*0.45-4*0.3
	For Verandah Wall	13.47	0.4	0.45	1	2.42	14.37-2*(0.9/2)
	For Trombe Wall	27.3	1	1	1	27.30	29-1*0.5-2*0.6
	For Cavity Wall	31.06	1.2	1.2	1	44.73	31.66-0.6
	Staircase South	1.11	2.44	0.1	1	0.27	
	Staircase East	1.01	1.22	0.1	1	0.12	
	Total					109.95	

Table – 9.2 Cost Calculation for Excavation

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material		0	0	0	
2	Labour					
2.1	Mate	Mandays	0.06	363	21.78	For 1 Cum
2.2	Mazdoor	Mandays	0.62	363	225.06	For 1 Cum
3	Plant and Machinery		0	0	0	Manual Excavation
	Total				246.84	For 1 Cum
4	Water Charges				0	
5	Tools		3% of total cost		7.4052	
6	Profit		10% of total cost		24.684	
	Total Excavation Cost for 1 Cum				278.9292	
	Total Excavation Cost for 109.95 Cum				30667.33	

Table - 9.3 Volume calculation for Lime Concrete Foundation

Item No.	**Lime Concrete Foundation**	Dimensions			No. of Units	Quantity(Cum)	Explanatory Notes
		Length (m)	Breadth (m)	Depth (m)			
2	For Main Wall	14.63	0.9	0.3	1	3.95	17.627-3*0.5-1*0.6-2*0.45
	For Partition Wall	44.77	0.7	0.2	1	6.27	54.07-4*0.35-14*0.35-4*0.45-4*0.3
	For Verandah Wall	13.47	0.4	0.05	1	0.27	14.37-2*(0.9/2)
	For Trombe Wall	27.30	1	0.3	1	8.19	29-1*0.5-2*0.6
	For Cavity Wall	31.06	1.2	0.3	1	11.18	31.66-0.6
	Staircase South	1.11	2.44	0.1	1	0.27	
	Staircase East	1.01	1.22	0.1	1	0.12	
	Total					30.25	

Table - 9.4 Quantity of Materials Required in Lime Concreting

Lime Concreting In Foundation with 40 mm gauge Brick Ballast	
White Lime : Surkhi : Brick Ballast = 1 : 2 : 6	
Wet Volume = 1 Cum	
Dry Volume = 1.4* W V	1.4 Cum
Vol Including Wastage = 1.1* D V	1.54 Cum
White Lime (Cum)	0.17
Surkhi (Cum)	0.34
Brick Ballast (Cum)	1.03

Table - 9.5 Cost Calculation for Lime Concrete Foundation

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	White Lime (Dry Hydrated lime)	Cum	0.17	5085.3	870.15	1 Cum = 2211 Kg = 22.11Quintal
						1 Cum = 22.11*230 = 5085.3 Rs
1.2	Carraige of Lime	Cum	0.17	106.49	18.22	Distance = 3 to 4 km
1.3	Surkhi	Cum	0.34	700	239.56	
1.4	Carraige of Surkhi	Cum	0.34	106.49	36.44	Distance = 3 to 4 km
1.5	Brick Ballast	Cum	1.03	650	667.33	
1.6	Carriage Of Brick Ballast	Cum	1.03	106.49	109.33	Distance = 3 to 4 km
2	Labour					
2.1	Mason	Mandays	0.1	435	43.50	For 1 Cum
2.2	Mazdoor	Mandays	2.65	363	961.95	For 1 Cum
2.3	Bhisti	Mandays	0.8	363	290.40	For 1 Cum
3	Plant and Machinery		0	0	0.00	
	Total				3236.88	For 1 Cum
4	Water Charges		1.5% of total cost		48.55	
5	Tools		3% of total cost		97.11	
6	Profit		10% of total cost		323.69	
	Total Lime Concreting Cost for 1 Cum				3706.23	
	Total Lime Concreting Cost for 30.25 Cum				112113.55	

Table-9.6 Volume Calculation for Brickwork in Foundation

Item No.	Brickwork in Foundation	Dimensions			No of Units	Quantity(Cum)	Explanatory Notes
		Length (m)	Breadth (m)	Depth (m)			
3	Main Wall						
	60cm thick	15.53	0.6	0.20	1	1.86	17.627-3*0.35-1*0.45-2*0.3
	50cm thick	15.83	0.5	0.20	1	1.58	17.627-3*0.3-1*0.4-2*0.25
	40cm thick	16.13	0.4	1.06	1	6.85	17.627-3*0.25-1*0.35-2*0.2
	Partition Wall						
	40cm thick	49.14	0.4	0.20	1	3.93	54.07-4*0.25-14*0.2-4*0.3-4*0.4
	30cm thick	48.77	0.3	1.06	1	15.54	54.07-4*0.2-14*0.15-4*0.25-4*0.35
	Trombe Wall						
	70cm thick	27.75	0.7	0.20	1	3.89	29-1*0.35-2*0.45
	60cm thick	27.90	0.6	0.20	1	3.35	29-1*0.3-2*0.4
	50cm thick	28.05	0.5	1.06	1	14.89	29-1*0.25-2*0.35
	Cavity Wall						
	90cm thick	31.21	0.9	0.20	1	5.62	31.66-0.45
	80cm thick	31.26	0.8	0.20	1	5.00	31.66-0.4
	70cm thick	31.31	0.7	1.06	1	23.28	31.66-0.35
	Verandah Wall						
	30cm thick	14.07	0.3	1.06	1	4.48	14.37-2*0.3/2
	Total					90.27	

Table - 9.7 Quantity of materials required for Brickwork in Foundation

Volume	1 Cum				
Nominal size of bricks	200*100*100	2000000 mm^3			
Brick size(without mortar)	190*90*90	1539000 mm^3			
Mortar volume for 1 Brick		461000 mm^3			
Total no of bricks		500			
Mortar volume		230500000 mm^3	0.231	(Cum)	(Wet volume)
Dry volume			0.288	(Cum)	D.V = 1.25* W.V
Volume inc .wastage			0.316	(Cum)	Wastage = 1.1 * D.V
Cement volume			0.053	(Cum)	
Sand volume			0.264	(Cum)	Cement:Sand for brick work=1:6
Cement weight	1Cum=1.44 Tons		0.076	(Tons)	First Class Brick

Table - 9.8 Cost Calculation for Brickwork in Foundation

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remark
1	Material					
1.1	Bricks	per brick	500	3.3	1650	Rate 1000 bricks = 3300
1.2	Cement	Cum	0.053	9072	478.17	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
1.3	Sand	Cum	0.264	700	184.479	
1.3	Carraige of Bricks	per brick	500	0.28396	141.980	Rates 1000 bricks = 283.96 for distance 3 to 4 km
1.4	Carraige of Cement	Cum	0.053	136.29	7.184	Rate 1 Cum=1.44*94.65=136.29 Rs for Distance = 3 to 4 km
1.5	Carraige of Sand	Cum	0.264	106.49	28.065	Distance = 3 to 4 km
2	Labour					
	Mason	Mandays	0.25	435	108.75	For 1 Cum
	Mazdoor	Mandays	0.4	363	145.2	For 1 Cum
	Bhisti	Mandays	0.1	363	36.3	For 1 Cum
3	Plant and Machinery		0	0	0	
	Total				2780.127	For 1 Cum
4	Water Charges		1.5% of total cost		41.702	
5	Tools		3% of total cost		83.404	
6	Profit		10% of total cost		278.013	
	Total Brick work in Foundation Cost for 1 Cum				3183.246	
	Total Brick work in Foundation Cost for 90.27 Cum				287351.6022	

Table - 9.9 Volume Calculation for Earthwork in Filling Plinth

Item No.	**Earthwork in filling plinth**	Dimensions			No. of Units	Quantity(Cum)
		Length(m)	Breadth (m)	Depth (m)		
4	Bedroom(5.51*3.4)	5.52	3.40	0.76	2	28.62
	Bedroom(5.51*3.53)	5.52	3.53	0.76	1	14.84
	Toilet(1.47*3.048)	1.47	3.05	0.76	3	10.26
	Kitchen(3.65*3.25)	3.66	3.25	0.76	1	9.06
	Drawing(5.51*3.53)	5.52	3.53	0.76	1	14.84
	Study room(3.67*3.22)	3.67	3.23	0.76	1	9.02
	Bathroom(2.14*1.29)	2.15	1.30	0.76	1	2.12
	Sink(1.42*1.29)	1.42	1.30	0.76	1	1.40
	Hall					68.85
	Verandah	11.51	1.52	0.76	1	13.36
	Total					172.38

Table – 9.10 Cost Calculation for Earthwork in Filling Plinth

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material		0	0	0	
2	Labour					
2.1	Mate	Mandays	0.02	363	7.26	For 1 Cum
2.2	Mazdoor	Mandays	0.25	363	90.75	For 1 Cum
3	Plant and Machinery		0	0	0	
	Total				98.01	For 1 Cum
4	Water Charges				0	
5	Tools		3% of total cost		2.94	
6	Profit		10% of total cost		9.80	
	Total Earth Work in Filling Plinth Cost for 1 Cum				110.75	
	Total Earth Work in Filling Plinth Cost for 172.38 Cum				19091.31	

Table - 9.11 Area Calculation of 2.5cm thick DPC

Item No.	**2.5cm thick DPC**	Dimensions			Unit	Quantity(Sqm)	Explanatory Notes
		Length (m)	Breadth (m)	Depth (m)			
5	Main wall	16.7	0.225		1	3.76	17.627-2*0.112-1*0.24-3*0.15
	Partition wall	51.36	0.1		1	5.14	54.07-4*0.112-14*0.1/2-4*0.24-4*0.15
	Verandah wall	14.145	0.225		1	3.18	14.37-2*(0.225/2)
	Trombe wall	28.37	0.3		1	8.51	29-1*0.15-2*0.24
	Cavity wall	31.42	0.48		1	15.08	31.66-1*0.24
	Total					35.67	

Table – 9.12 Cost Calculation of DPC

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material		0	0	0	
1.1	DPC	Sqm	1	257.8	257.8	
2	Labour					
2.1	Mason	Mandays	0.1	435	43.5	For 1 Sqm
2.2	Mazdoor	Mandays	0.1	363	36.3	For 1 Sqm
2.3	Bhisti	Mandays	0.01	363	3.63	For 1 Sqm
3	Plant and Machinery		0	0	0	
	Total				341.23	For 1 sqm
4	Water Charges		1.5% of total cost		5.12	
5	Tools		3% of total cost		10.24	
6	Profit		10% of total cost		34.12	
	Total DPC Cost for 1 Sqm				390.71	
	Total DPC Cost for 35.67 Sqm				13936.57	

Table - 9.13 Volume Calculation for Casting Column

Item No.	Columns	Dimensions			No.of Units	Quantity(Cum)	Cross section Area (b*d) (Sqm) for 1 Column	Providing 2.5% reinforcement of cross sectional area (Sqm)	Reinforcement for given length	Reinforcement in Kg for 1 column	Reinforcement in kg for 1	Reinforcement for given quantity in kg
		Length (m)	Breadth (m)	Depth (m)								
6	Trombe wall	3.35	0.225	0.225	4	0.678	0.051	0.00127	0.00424	33.283	196.25	133.13
	Cavity wall	3.35	0.3	0.3	6	1.809	0.09	0.00225	0.00754	59.169	196.25	355.02
	Partition wall	3.35	0.225	0.225	4	0.678	0.051	0.00127	0.00424	33.283	196.25	133.13
	Deduction											
	Due to reinforcement					0.079						
	Total					3.087						621.278

Table - 9.14 Quantity of Material required for Casting Column and Area of Formwork

1Cum=1440Kg		
1CUM=1.44 Tons		
Concrete Mix=1:1.5:3	Cum	9.48
Volume = 1Cum		
Dry Volume = 1.25*Volume	Cum	1.25
Volume including wastage = 1.1*D V	Cum	1.375
Cement	Cum	0.25
Sand	Cum	0.375
Aggregates	Cum	0.75
Cement	Tonnes	0.36
Formwork		
Area= 6*0.3*3.35 (For 10 column in Cavity wall)	Sqm	6.03
Area= 4*0.225*3.35 (For 10 column in Trombe wall)	Sqm	3.015
Area=4*0.225*3.35 (For 4 column in Partition wall)	Sqm	3.015
Total Area	Sqm	12.06

Table 9.15 Cost Calculation for Casting Column

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	CONCRETING					
	Cement	Cum	0.25	9072	2268	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
	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
	Carraige of Cement	Cum	0.25	136.3	34.07	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
	Carraige of Sand	Cum	0.375	106.5	39.93	Distance 3 to 4 km
	Carraige of Aggregates	Cum	0.75	106.5	79.87	Distance 3 to 4 km
1.2	FORMWORK (Hire Charges include Labour)					
	For Column	Sqm	1	453.4	453.35	
1.3	REINFORCEMENT					
	Steel Bars	kg	1	64.95	64.95	
	Carriage of Steel	kg	1	0.947	0.947	Distance 3 to 4 km
2	Labour					
2.1	CONCRETING					
	Mason	Mandays	0.23	435	100.05	For 1 Cum
	Mazdoor	Mandays	3.5	363	1270.5	For 1 Cum
	Bhisti	Mandays	0.9	363	326.7	For 1 Cum
	Mixer Operator	Mandays	0.1	363	36.3	For 1 Cum
2.2	REINFORCEMENT					
	Bar bender	Mandays	0.01	329	3.29	For 1 kg
	Mazdoor	Mandays	0.01	363	3.63	For 1 kg
3	Plant and Machinery					
	Mixer	Days	1	800	800	
	Vibrator	Days	1	350	350	
	Total Cost of Concreting				5205.425	For 1 Cum
	Plant and machinery for 1 day				1150	
	Plant and machinery for 5 day				5750	
	Water Charges		1.5% of total cost		78.081	
	Tools		3% of total cost		156.163	
	Profit		10% of total cost		520.543	
	Total Cost of Concreting for 1 Cum				5960.212	
	Total Cost of Concreting for 3.087 Cum				24149.174	
	Total Cost of Formwork (Hire Charges) including labour				453.35	For 1 Sqm
	Total Cost of Formwork (Hire Charges) including labour for 12.06 Sqm				5467.401	
	Total Cost of Reinforcement				72.817	For 1 kg
	Water Charges		1.5% of total cost		1.092	
	Tools		3% of total cost		2.184	
	Profit		10% of total cost		7.282	
	Total Cost of Reinforcement for 1 Kg				83.375	
	Total Cost of Reinforcement for 621.278 Kg				51798.986	
	Total Column Casting Cost				81415.56	

Table - 9.16 Volume Calculation for Casting Beams

Item No.	Beams	Dimensions			No. of Units	Quantity(Cum)	Cross section Area (b*d) (Sqm) for 1 Column	Providing 2.5% reinforcement of cross sectional area (Sqm)	Reinforcement for given length	Reinforcement in Kg for given beam
		Length (m)	Breadth (m)	Depth (m)						
7	Main Walls	98.33	0.225	0.225	1	4.978	0.0506	0.00127	0.124449	976.924
	Deduction									
	Due to column	0.225	0.225	0.225	10	-0.114	0.0506	0.00127	0.000285	-22.354
	Due to reinforcement					-0.122				
	Total					4.742				954.570

Table -9.17 Quantity of materials required for casting Beams and area of Formwork

1Cum=1440Kg		
1Cum=1.44 Tons		
Concrete Mix=1:1.5:3		
Volume =	Cum	1
Dry Volume = 1.25*Volume	Cum	1.25
Volume including wastage = 1.1*D V	Cum	1.375
Cement	Cum	0.25
Sand	Cum	0.375
Aggregates	Cum	0.75
Cement	Tonnes	0.36
Formwork		
Area=98.33*0.225	Sqm	22.124

Table – 9.18 Cost Calculation for Casting Beams

S.No	Description	Unit	Quantity	Rate	Amount	Remark
1	Material					
1.1	RCC					
	Cement	Cum	0.25	9072	2268	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
	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
	Carraige of Cement	Cum	0.25	136.296	34.074	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
	Carraige of Sand	Cum	0.375	106.49	39.93375	Distance 3 to 4 km
	Carraige of Aggregates	Cum	0.75	106.49	79.8675	Distance 3 to 4 km
1.2	FORMWORK (Hire Charges include Labour)					
	For Column	Sqm	1	453.35	453.35	
1.3	REINFORCEMENT					
	Steel Bars	kg	1	64.95	64.95	
	Carriage of Steel	kg	1	0.9465	0.9465	Distance 3 to 4 km
2	Labour					
2.1	RCC					
	Mason	Mandays	0.23	435	100.05	For 1 Cum
	Mazdoor	Mandays	3.5	363	1270.5	For 1 Cum
	Bhisti	Mandays	0.9	363	326.7	For 1 Cum
	Mixer Operator	Mandays	0.1	363	36.3	For 1 Cum
2.2	REINFORCEMENT					
	Bar bender	Mandays	0.01	329	3.29	For 1 kg
	Mazdoor	Mandays	0.01	363	3.63	For 1 kg
3	Plant and Machinery					
	Mixer	Days	1	800	800	
	Vibrator	Days	1	350	350	
	Total Cost of RCC				5205.42525	For 1 Cum
	Plant and machinery for 1 day				1150	
	Plant and machinery for 5 day				5750	
	Water Charges		1.5% of total cost		78.08137875	
	Tools		3% of total cost		156.1627575	
	Profit		10% of total cost		520.542525	
	Total Cost of RCC for 1 Cum				5960.211911	
	Total Cost of RCC for 4.74 Cum				34001.40446	
	Total Cost of Formwork (Hire Charges) including labour				453.35	For 1 Sqm
	Total Cost of Formwork (Hire Charges) including labour for 22.124 Sqm				10029.9154	
	Total Cost of Reinforcement				72.8165	For 1 kg
	Water Charges		1.5% of total cost		1.0922475	
	Tools		3% of total cost		2.184495	
	Profit		10% of total cost		7.28165	
	Total Cost of Reinforcement for 1 Kg				83.3748925	
	Total Cost of Reinforcement for 954.57 Kg				79587.17113	
	Total Beam Casting Cost				123618.491	

Table - 9.19 Volume Calculation for Superstructure Walls

Item No.	Superstructure	Dimensions			No. of Units	Quantity(Cum)	Explanatory Notes
		Length (m)	Breadth (m)	Height (m)			
8	Brickwork						
	Main Wall	16.7	0.225	3.35	1	12.588	17.627-2*0.112-1*0.24-3*0.15
	Partition Wall	51.36	0.1	3.35	1	17.206	54.07-4*0.112-14*0.1/2-4*0.24-4*0.15
	First Floor Wall						
	Lower portion	32.43	0.225	2.44	1	17.804	32.88-4*(0.225/2)
	Upper portion	18.18	0.225	3.2	1	6.545	
	Trombe Wall	28.66	0.225	3.125	1	20.152	29-1*(0.225/2)-2*(0.225/2)
	Cavity Wall	31.42	0.225	3.125	1	22.092	31.66-1*0.24
	Deductions						
	D (rooms)	1.1	0.225	2.1	4	-2.079	
	D (rooms) 2	1.1	0.1	2.1	6	-1.386	
	D (toilet)	0.71	0.1	2.1	8	-1.193	
	D (main door)	2.1	0.225	2.1	1	-0.992	
	W (rooms)	1.524	0.225	1.5	10	-5.144	
	W (toilet)	0.6	0.225	0.91	4	-0.491	
	W (hall)	3.048	0.225	3.65	1	-2.503	
	Lintels						
	D (rooms)	1.1	0.225	0.15	4	-0.149	
	D (rooms) 2	1.1	0.1	0.15	6	-0.099	
	D (toilet)	0.71	0.1	0.15	8	-0.085	
	D (main door)	2.1	0.225	0.15	1	-0.071	
	W (rooms)	1.524	0.225	0.15	10	-0.514	
	W (toilet)	0.6	0.225	0.15	4	-0.081	
	W (hall)	3.048	0.225	0.15	1	-0.103	
	Openings	0.45	0.45	0.225	11	-0.501	
	Column					-3.165	
	Total					77.830	
						Sqm	
	Glass Work in Trombe wall	28.66		3.35	1	96.011	
	Deductions						
	W(rooms)	1.524		1.524	6	-13.935	
	W(toilets)	0.6		0.91	2	-1.092	
	Total					80.984	
	Concrete Blocks in Cavity wall	31.42	0.225	3.35	1	23.683	
	Deductions						
	W(rooms)	1.524	0.225	1.524	4	-2.090	
	W(toilets)	0.6	0.225	0.91	2	-0.246	
	W(hall)	3.35	0.225	2.1	1	-1.583	
	Total					19.764	

Table – 20 Quantity of material required for Superstructure Brickwork

Volume	1 Cum				
Nominal size of bricks	200*100*100	2000000 mm^3			
Brick size(without mortar)	190*90*90	1539000 mm^3			
Mortar volume for 1 Brick		461000 mm^3			
Total no of bricks		500			
Mortar volume		230500000 mm^3	0.231	(Cum)	(Wet volume)
Dry volume			0.288	(Cum)	D.V = 1.25* W.V
Volume inc .wastage			0.316	(Cum)	Wastage = 1.1 * D.V
Cement volume			0.053	(Cum)	
Sand volume			0.264	(Cum)	Cement:Sand for brick work=1:6
Cement weight	1Cum=1.44 Tons		0.076	(Tons)	First Class Brick

Table - 9.21 Quantity of material required for AAC Work in Superstructure

Volume	1 Cum				
Nominal size of Concrete Block (AAC Block)	390*200*190	14820000 mm^2			
Concrete Block(without mortar)	380*190*180	12996000 mm^2			
Mortar volume for 1 Block		1824000 mm^2			
Total no of Concrete Blocks		68			
Mortar volume		124032000 mm^2	0.124	(Cum)	(Wet volume)
Dry volume			0.155	(Cum)	D.V = 1.25* W.V
Volume inc .wastage			0.171	(Cum)	Wastage = 1.1 * D.V
Cement volume			0.028	(Cum)	
Sand volume			0.142	(Cum)	Cement:Sand for Concrete block=1:6
Cement weight	1 Cum =1.44 Tons		0.041	(Ton)	First Class Brick

Table – 9.22 Cost Calculation for Constructing Superstructure Walls

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Bricks	per brick	500	3.3	1650	Rate 1000 bricks = 3300
1.2	Cement	Cum	0.05271	9072	478.17	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
1.3	Sand	Cum	0.26354	700	184.4791667	
1.3	Carraige of Bricks	per brick	500	0.28396	141.98	Rates 1000 bricks = 283.96 for distance 3 to 4 km
1.4	Carraige of Cement	Cum	0.05271	136.3	7.184145833	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
1.5	Carraige of Sand	Cum	0.26354	106.49	28.06458758	Distance = 3 to 4 km
2	Labour					
	Mason	Mandays	0.25	435	108.75	For 1 Cum
	Mazdoor	Mandays	0.4	363	145.2	For 1 Cum
	Bhisti	Mandays	0.1	363	36.3	For 1 Cum
3	Plant and Machinery		0	0	0	
	Total				2780.1279	For 1 Cum
4	Water Charges		1.5% of total cost		41.7019185	
5	Tools		3% of total cost		83.403837	
6	Profit		10% of total cost		278.01279	
	Total Brick work in Superstructure Cost for 1 Cum				3183.246446	
	Total Brick work in Superstructure Cost for 77.830 Cum				247752.0709	
S.No	Description	Unit	Quantity	Rate	Amount	Remark
1	Material					
1.1	AAC Blocks	Cum	1	3200	3200	Rate=3200 for 68 Blocks i.e in 1 Cum
1.2	Cement	Cum	0.02842	9072	257.862528	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
1.3	Sand	Cum	0.14212	700	99.484	
1.3	Carraige of Blocks	per brick	500	0.28396	141.98	Rates 1000 bricks = 283.96 for distance 3 to 4 km
1.4	Carraige of Cement	Cum	0.02842	136.3	3.8741912	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
1.5	Carraige of Sand	Cum	0.26354	106.49	28.06458758	Distance = 3 to 4 km
2	Labour					
	Mason	Mandays	0.25	435	108.75	For 1 Cum
	Mazdoor	Mandays	0.4	363	145.2	For 1 Cum
	Bhisti	Mandays	0.1	363	36.3	For 1 Cum
3	Plant and Machinery		0	0	0	
	Total				4021.515307	For 1 Cum
4	Water Charges		1.5% of total cost		60.3227296	
5	Tools		3% of total cost		120.6454592	
6	Profit		10% of total cost		402.1515307	
	Total Concrete Block in Superstructure Cost for 1 Cum				4604.635026	
	Total Concrete Block in Superstructure Cost for 19.76 Cum				90987.58812	
S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Glass Sheet in trombe wall	Sqm	1	345	345	
	Glass Sheet for 80.98 Sqm				27938.1	
	Total Walls Construction Cost				366677.759	

Table – 9.23 Volume Calculation for Casting Slab

Item No.	Slab	Dimensions			No. of Units	Quantity(Cum)	No. of bars taking spacing as 200mm		Taking 10mm dia bar , $D^2/162$	Total reinforcement in kg providing 50mm cover on both sides
		Length (m)	Breadth (m)	Depth (m)						
9	Slab	13.258	6	0.1	1	7.955	No. of bars along length	66.79	0.617	550.729
							No. of bars along breadth	30.5	0.617	114.846
		13.258	6.6	0.1	1	8.750	No. of bars along length	66.79	0.617	550.729
							No. of bars along breadth	33.5	0.617	138.549
		9.32	4.9	0.1	1	4.567	No. of bars along length	47.1	0.617	273.878
							No. of bars along breadth	25	0.617	77.160
	Deduction									
	Due to reinforcement					-0.217				
	Total					21.055				1705.891

Table – 9.24 Quantity of Material required for Casting Slab, Area of Shuttering and Area of Skylight Roof

1Cum=1440 Kg		
1Cum=1.44 Tons		
Concrete Mix=1:1.5:3	Cum	21.055
Volume = 1Cum		
Dry Volume = 1.25*Volume	Cum	1.25
Volume including wastage = 1.1*D V	Cum	1.375
Cement	Cum	0.25
Sand	Cum	0.375
Aggregates	Cum	0.75
Cement	Tonnes	0.36
Shuttering		
Area (Sqm)		212.71
Skylight Roof		
Area (Sqm)		82.98

Table – 9.25 Cost Calculation for Casting Slab

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	CONCRETING					
	Cement	Cum	0.25	9072	2268	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
	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
	Carraige of Cement	Cum	0.25	228.11	57.03	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
	Carraige of Sand	Cum	0.375	106.49	39.934	Distance 3 to 4 km
	Carraige of Aggregates	Cum	0.75	106.49	79.868	Distance 3 to 4 km
1.2	Skylight Roof	Sqm	1	500	500	
1.3	Puffed Insulations	Sqm	1	600	600	
1.4	SHUTTERING					
	For Slab	Sqm	1	401.65	401.65	
1.5	REINFORCEMENT					
	Steel Bars	kg	1	64.95	64.95	
	Carriage of Steel	kg	1	0.947	0.947	Distance 3 to 4 km
2	Labour					
2.1	RCC					
	Mason	Mandays	0.23	435	100.05	For 1 Cum
	Mazdoor	Mandays	3.5	363	1270.5	For 1 Cum
	Bhisti	Mandays	0.9	363	326.7	For 1 Cum
	Mixer Operator	Mandays	0.1	363	36.3	For 1 Cum
2.2	REINFORCEMENT					
	Bar bender	Mandays	0.01	329	3.29	For 1 kg
	Mazdoor	Mandays	0.01	363	3.63	For 1 kg
3	Plant and Machinery					
	Mixer	Days	1	800	800	
	Vibrator	Days	1	350	350	
	Total Cost of Concreting				5228.378	For 1 Cum
	Plant and machinery for 1 day				1150	
	Plant and machinery for 15 day				17250	
	Water Charges		1.5% of total cost		78.426	
	Tools		3% of total cost		156.851	
	Profit		10% of total cost		522.838	
	Total Cost of Concreting for 1 Cum				5986.493	
	Total Cost of Concreting for 21.055 Cum				143295.6031	
	Total Cost of Shuttering (Hire Charges) including labour				401.65	For 1 Sqm
	Total Cost of Shuttering (Hire Charges) including labour for 212.71 Sqm				85434.9715	
	Total Cost of Reinforcement				72.817	For 1 kg
	Water Charges		1.5% of total cost		1.092	
	Tools		3% of total cost		2.184	
	Profit		10% of total cost		7.282	
	Total Cost of Reinforcement for 1 Kg				83.375	
	Total Cost of Reinforcement for 1706 Kg				142237.567	
	Total Cost of Skylight roof of 1 Sqm				500	
	Total Cost of Skylight roof of 82.98 Sqm				41490	
	Total Cost of Insulation of 1 Sqm				600	
	Total Cost of Insulation of 212.71 Sqm				127626	
	Total Slab Casting Cost				540084.1412	

Table - 9.26 Volume Calculation for Wood Work

Item No.	**Wood work**	Dimensions			No. of Units	Quantity(Cum)
		Length (m)	Breadth (m)	Height (m)		
	D (rooms)	1	0.038	2.1	4	0.319
	D (rooms 2)	1	0.038	2.1	6	0.479
	D (toilet)	0.61	0.038	2.1	8	0.389
	D (main door)	2	0.038	2.1	1	0.160
	Frames					
	D (rooms)	0.1	0.1	2.1	4	0.084
10	D (rooms 2)	0.1	0.1	2.1	6	0.126
	D (toilet)	0.1	0.1	2.1	8	0.168
	D (main door)	0.1	0.1	2.1	1	0.021
	W (rooms)	0.3048	0.1	0.3048	10	0.093
	W (toilet)	0.3048	0.1	0.3048	4	0.037
	W (hall)	0.3048	0.1	0.3048	1	0.009
	Total					1.885

Table -9.27 Cost Calculation for Wood Work

S.No	Description	Unit	Quantity	Rate	Amount(Rs.)	Remarks
1	Material					
1.1	Sal wood	Cum	1	33160	33160	10 Cudm = 331.6 Rs
1.2	Carriage Of Timber	Cum	1	121.7	121.7	Distance = 3 to 4 km
2	Labour					
2.1	Carpenter	Mandays	20	399	7980	For 1 Cum
2.2	Mazdoor	Mandays	2	363	726	For 1 Cum
3	Plant and Machinery		0	0	0	
	Total				41987.7	For 1 Cum
	Water Charges		0	0	0	
	Tools		3% of total cost		1259.631	
	Profit		10% of total cost		4198.77	
	Total Wood Work Cost for 1 Cum				47446.101	
	Total Wood Work Cost For 1.885 Cum				89435.90	

Table - 9.28 Area calculation for Glass Work

Item No.	**Glass work**	Dimensions		No. of Units	Quantity(Sqm)
		Length (m)	Height (m)		
	W (rooms)	1.22	1.22	10	14.88
11	W (toilet)	0.3048	0.61	4	0.74
	W (hall)	2.74	3.35	1	9.18
	Total				24.81

Table - 9.29 Cost Calculation of Glass Work

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Glass (Double Glazed)	Sqm	1	4090.95	4090.95	
2	Labour					
2.1	Glazier	Mandays	0.2	399	79.8	For 1 Sqm
2.2	Mazdoor	Mandays	0.01	363	3.63	For 1 Sqm
3	Plant and Machinery		0	0	0	
	Total				4174.38	For 1 Cum
	Water Charges		0	0	0	
	Tools		3% of total cost		125.2314	
	Profit		10% of total cost		417.438	
	Total Glass Work for 1 Sqm				4717.0494	
	Total Glass Work Cost For 24.8 Sqm				116982.825	

Table - 9.30 Volume Calculation of Lintel over Doors and Windows

Item No.	**Lintel over doors and windows**	Dimensions			No. of Units	Quantity(Cum)
		Length (m)	Breadth (m)	Depth (m)		
12	D (rooms)	1.1	0.225	0.15	4	0.149
	D (rooms) 2	1.1	0.1	0.15	6	0.099
	D (toilet)	0.71	0.1	0.15	8	0.085
	D (main door)	2.1	0.225	0.15	1	0.071
	W (rooms)	1.524	0.225	0.15	10	0.514
	W (toilet)	0.6	0.225	0.15	4	0.081
	W (hall)	3.048	0.225	0.15	1	0.103
	Total					0.999

Table - 9.31 Quantity of Materials required for Lintel over Doors and Windows

Volume	1 Cum
Dry Volume = 1.25*Volume	1.25 Cum
Volume including wastage = 1.1*D V	1.375 Cum
Cement : Sand = 1:3	
Cement (Cum)	0.34375
Sand (Cum)	1.03125

Table - 9.32 Cost Calculation of Lintel over doors and windows

S.No	Description	Unit	Quantity	Rate	Amount (Rs	Remarks
1	Material					
1.1	Cement	Cum	0.34375	9072	3118.5	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
1.2	Sand	Cum	1.03125	700	721.88	For 1 Cum
1.3	Carriage Of Cement	Cum	0.34375	136.3	46.85	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 k
1.4	Carriage Of Sand	Cum	1.03125	106.49	109.82	Distance = 3 to 4 km
2	Labour					
2.1	Mazdoor	Mandays	0.75	363	272.25	For 1 Cum
2.2	Bhisti	Mandays	0.07	363	25.41	For 1 Cum
3	Plant and Machinery		0	0	0	
	Total				4294.71	For 1 Cum
	Water Charges		1.5% of total cost		64.42	
	Tools		3% of total cost		128.84	
	Profit		10% of total cost		429.47	
	Total Lintel Cost for 1 Cum				4917.44	
	Total Lintel Cost for 1 Cum				4917.44	

Table - 9.33 Area Calculation of Floor Finishing

Item No.	**Floor Finishing**	Dimensions		No. Of Units	Quantity(Sqm)
		Length (m)	Breadth (m)		
	Bedroom(5.51*3.4)	5.517	3.404	2	37.556
	Bedroom(5.51*3.53)	5.517	3.530	1	19.477
	Toilet(1.47*3.048)	1.472	3.048	3	13.462
	Kitchen(3.65*3.25)	3.658	3.252	1	11.895
	Drawing(5.51*3.53)	5.517	3.530	1	19.477
	Study room(3.67*3.22)	3.670	3.226	1	11.839
	Bathroom(2.14*1.29)	2.146	1.295	1	2.780
13	Sink(1.42*1.29)	1.420	1.295	1	1.840
	Hall				88.69
	Verandah	11.506	1.524	1	17.535
	Doors (Rooms)	1.1	0.225	2	0.50
	Doors (Rooms 2)	1.1	0.1	6	0.66
	Doors (Toilet)	0.71	0.1	8	0.57
	Door (Main)	2.1	0.225	1	0.47
	Total				226.747

Table - 9.34 Quantity of Material required for Floor Finishing

12.5mm Thick PVC Tile flooring on 20mm thick Cement Mortar(1:4)	
Volume of mortar 226.747*0.020)Cum	4.53494
Taking Volume	1 Cum
Dry Volume = 1.25*Volume	1.25 Cum
Volume including wastage = 1.1*D V	1.375 Cum
Cement : Sand = 1:4	
Cement (Cum)	0.275
Sand (Cum)	1.1

Table - 9.35 Cost Calculation of Floor Finishing

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Cement	Cum	0.275	9072	2494.8	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
1.2	Sand	Cum	1.1	700	770	For 1 Cum
1.3	Carriage Of Cement	Cum	0.275	228.107	62.729	1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
1.4	Carriage Of Sand	Cum	1.1	106.49	117.139	Distance = 3 to 4 km
1.5	Tiles	Sqm	1	470	470	PVC Laminated Gypsum Tiles
2	Labour					
2.1	Mason	Mandays	0.08	435	34.8	For 1 Sqm
2.2	Mazdoor	Mandays	0.12	363	43.56	For 1 Sqm
2.3	Bhisti	Mandays	0.1	363	36.3	For 1 Sqm
3	Plant and Machinery		0	0	0	
	Total Cost of Mortar Material				3444.668	For 1 Cum
	Water Charges		1.5% of total cost		51.670	
	Tools		3% of total cost		103.340	
	Profit		10% of total cost		344.467	
	Total Cost of Material for 1 Cum				3944.145	
	Total Cost For Material for 4.49 Cum				17709.212	
	Total Cost of Tiles and Labour				584.66	For 1 Sqm
	Water Charges		1.5% of total cost		8.77	
	Tools		3% of total cost		17.54	
	Profit		10% of total cost		58.47	
	Total Cost of tiles and Labour for 1 Sqm				669.44	
	Total Cost of tiles and Labour for 224.54 Sqm				150315.09	
	Total Floor Finish Cost				168024.304	

Table - 9.36 Area Calculation of Cement Plastering

Item No.	**Cement Plastering**	Dimensions		No. of Units	Quantity(Sqm)	Explanatory Notes
		Length (m)	Height (m)			
	Outer Walls					
	Outer West Wall	11.14	4.11	1	45.83	
	Outer East Wall	11.14	3.35	1	37.34	
	Outer North and South wall	20.35	4.11	2	167.43	
	First floor Walls					
	Lower Portion	34.50	2.44	1	84.12	
	Upper Portion	18.64	3.20	1	29.82	
	Verandah Wall	13.88	0.76	1	10.58	
	Inner Walls					
	Bedroom(5.51*3.4)	17.84	3.35	2	59.81	L = 5.51+5.51+3.4+3.4
	Bedroom(5.51*3.53)	18.09	3.35	1	60.66	L = 5.51+5.51+3.53+3.53
	Toilet(1.47*3.048)	9.04	3.35	3	30.31	L =1.47+1.47+3.048+3.048
	Kitchen(3.65*3.25)	13.82	3.35	1	46.33	L = 3.65+3.65+3.25+3.25
	Drawing(5.51*3.53)	18.09	3.35	1	60.66	L = 5.51+5.51+3.53+3.53
	Study room(3.67*3.22)	13.79	3.35	1	46.23	L = 3.67+3.67+3.22+3.22
	Bathroom(2.14*1.29)	14.07	3.35	1	47.17	L = 2.14+2.14+1.29+1.29
14	Sink(1.42*1.29)	6.88	3.35	1	23.08	L =1.42+1.42+1.29+1.29
	Hall	45.90	3.35	1	153.89	
	First floor Walls					
	Lower Portion	32.15	2.44	1	78.39	
	Upper Portion	17.72	3.20	1	28.35	
	Ceiling				212.65	
	Total				1222.66	
	Deductions					
	D (rooms)	1.07	2.13	4	-18.21	Deduction should be from sides , so quantity = length * breadth * unit * 2
	D (rooms) 2	1.07	2.13	6	-27.31	
	D (toilet)	0.71	2.13	8	-24.24	
	D (main door)	2.13	2.13	1	-9.10	
	W (rooms)	1.52	1.52	10	-46.45	
	W (toilet)	0.61	0.91	4	-4.46	
	W (hall)	3.05	3.66	1	-22.30	
	Total				1070.59	

Table - 9.37 Quantity of Materials required for Cement Plastering

Area	Sqm	1070.6
Thickness	m	0.012
Volume of Mortar = Area*Thickness	Cum	12.847
Taking Volume =	Cum	1
Dry Volume = 1.25*Volume	Cum	1.25
Volume including wastage = 1.1*D V	Cum	1.375
Cement : Sand = 1:4		
Cement	Cum	0.275
Sand	Cum	1.1

Table – 9.38 Cost Calculation of Cement Plastering

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Cement	Cum	0.275	9072	2494.8	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9072 Rs
1.2	Sand	Cum	1.1	700	770	For 1 Cum
1.3	Carriage Of Cement	Cum	0.275	228.11	62.73	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
1.4	Carriage Of Sand	Cum	1.1	106.49	117.139	Distance = 3 to 4 km
2	Labour					
2.1	Mason	Mandays	0.08	435	34.8	For 1 Sqm
2.2	Mazdoor	Mandays	0.1	363	36.3	For 1 Sqm
3	Plant and Machinery		0	0	0	
	Total Cost of Material				3444.668	For 1 Cum
	Water Charges		1.5% of total cost		51.670	
	Tools		3% of total cost		103.340	
	Profit		10% of total cost		344.467	
	Total Cost of Material for 1 Cum				3944.145	
	Total Cost of Material for 12.847 Cum				50670.433	
	Total Cost of Labour				71.1	For 1 Sqm
	Water Charges		1.5% of total cost		1.067	
	Tools		3% of total cost		2.133	
	Profit		10% of total cost		7.110	
	Total Cost of Labour for 1 Sqm				81.410	
	Total Cost of Labour for 1070.6 Sqm				87157.011	
	Total Cement Plastering Cost				137827.444	

Table – 9.39 Area Calculation for Painting and Polishing

Item No.	Painting and Polishing	Dimensions		No. of Units	Quantity(Sqm)	Explanatory Notes
		Length (m)	Height (m)			
15	Outer Walls					
	Outer west Wall	11.14	4.11	1	45.83	
	Outer east Wall	11.14	3.35	1	37.34	
	Outer north and south Wall	20.35	4.11	2	167.43	
	First floor Walls					
	Lower Portion	34.50	2.44	1	84.12	
	Upper Portion	18.64	3.20	1	29.82	
	Verandah wall	13.88	0.76	1	10.58	
	Inner Walls					
	Bedroom(5.51*3.4)	17.84	3.35	2	59.81	L = 5.51+5.51+3.4+3.4
	Bedroom(5.51*3.53)	18.09	3.35	1	60.66	L = 5.51+5.51+3.53+3.53
	Toilet(1.47*3.048)	9.04	3.35	3	30.31	L =1.47+1.47+3.048+3.048
	Kitchen(3.65*3.25)	13.82	3.35	1	46.33	L = 3.65+3.65+3.25+3.25
	Drawing(5.51*3.53)	18.09	3.35	1	60.66	L = 5.51+5.51+3.53+3.53
	Study room(3.67*3.22)	13.79	3.35	1	46.23	L = 3.67+3.67+3.22+3.22
	Bathroom(2.14*1.29)	14.07	3.35	1	47.17	L = 2.14+2.14+1.29+1.29
	Sink(1.42*1.29)	6.88	3.35	1	23.08	L =1.42+1.42+1.29+1.29
	Hall	45.90	3.35	1	153.89	
	First floor Walls					
	Lower Portion	32.15	2.44	1	78.39	
	Upper Portion	17.72	3.20	1	28.35	
	Ceiling				212.65	
	Total				1222.66	
	Deductions					
	W (rooms)	1.22	1.22	10	-29.73	Deduction should be from sides
	W (toilet)	0.30	0.61	4	-1.49	, so quantity = length * breadth
	W (hall)	2.74	3.35	1	-18.39	* unit * 2
	Total				1173.05	

Table -9.40 Cost Calculation for Painting and Polishing

S.No	Description	Unit	Quantity	Rate	Amount (Rs	Remarks
1	Material					
1.1	Primer	Sqm	1	8.625	8.625	1 Sqm = 0.75 litre = 0.75*115 = 8.625 Rs
1.2	Paint	Sqm	1	22.5	22.5	1 Sqm = 0.125 litre = 0.125*180 = 22.5 Rs
2	Labour					
2.1	Painter	Mandays	0.08	399	31.92	For 1 Sqm
2.2	Mazdoor	Mandays	0.04	363	14.52	For 1 Sqm
3	Plant and Machinery		0	0	0	
	Total				100.065	For 1 Sqm and 2 coat of paint
	Water Charges		1.5% of total cost		1.500975	
	Tools		3% of total cost		3.00195	
	Profit		10% of total cost		10.0065	
	Total Painting Cost for 1 Sqm				114.57443	
	Total Painting Cost for 1173.05 Sqm				134401.53	

ANNEXURE 3

DETERMINATION OF PAYBACK PERIOD USING PRESENT VALUE CONCEPT

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

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

Extra Cost Incurred = Rs. 520279

Inflation Rate = 8%

Interest Rate = 12%

Modified Discount Rate = 3.7%

Table – 10.1 Determination of Payback Period

Year	Net Savings (Rs.)	Net Present Value (Rs.)	Cumulative Net Present Value (Rs.)	Remaining Cash Need to recover Investment in present value
0	0	0	0	520279
1	21318	20557	20557	499722
2	21318	19824	40381	479898
3	21318	19117	59498	460781
4	21318	18435	77932	442347
5	21318	17777	95709	424570
6	21318	17142	112852	407427
7	21318	16531	129382	390897
8	21318	15941	145323	374956
9	21318	15372	160696	359583
10	21318	14824	175520	344759
11	21318	14295	189814	330465
12	21318	13785	203599	316680
13	21318	13293	216892	303387

14	21318	12819	229711	290568
15	21318	12361	242072	278207
16	21318	11920	253993	266286
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56	21318	2787	500838	19441
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