“MODELLING AND COMPARISON OF GREEN BUILDING WITH CONVENTIONAL BUILDING”

A PROJECT

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

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Under the supervision of

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June, 2016

CERTIFICATE

This is to certify that the work which is being presented in the project title **"MODELLING AND COMPARISON OF GREEN BUILDING WITH CONVENTIONAL BUILDING"** in partial fulfilment of the requirements for the award of the degree of Bachelor of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **OSHEEN AGGARWAL (121616**) **& MD. NASIRUDDIN (121647**) during a period from July 2015 to June 2016 under the supervision of **Mr. SANTU KAR** Assistant Professor & **Dr. RAJIV GANGULY** Associate Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

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ABSTRACT

This report aims at studying the different features of a Green Building and preparing a 2D model in AUTOCAD and 3D model in REVIT of Conventional Building and Green Building.

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. The green building has incorporated with various parameters for energy savings and modelled in the software Autodesk REVIT. REVIT efficiently integrates environmental analysis into the design and delivery of high-performance buildings. In this project, conventional building and green buildings are modelled for a hot and humid tropical type of climate. A comparison between the conventional building and green building is done on the basis of material cost and energy cost.

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Chapter -1

INTRODUCTION

1.1 GENERAL

Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building.

Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

Efficiently using energy, water, and other resources Protecting occupant health and improving employee productivity Reducing waste, pollution and environmental degradation For example, green buildings may incorporate sustainable materials in their construction (e.g., reused, recycled-content, or made from renewable resources); create healthy indoor environments with minimal pollutants (e.g., reduced product emissions); and/or feature landscaping that reduces water usage (e.g., by using native plants that survive without extra watering).

1.2 NEED FOR STUDY

Real estate development uses about 40% of the energy and it is one of the prime contributors to global warming due to the emission of Green House Gas (GHG) caused by the energy used. Therefore there is an extreme need to develop green buildings. The concept of sustainable development can be traced to the energy (especially fossil oil) crisis and environmental pollution concerns of the 1960s and 1970s.

Green building brings together a vast array of practices, techniques, and skills to reduce and ultimately eliminate the impacts of buildings on the environment and human health. It often emphasizes taking advantage of renewable resources, e.g., using sunlight through passive solar, active solar, and photovoltaic equipment, and using plants and trees through green roofs, rain gardens, and reduction of rainwater run-off. Many other techniques are used, such as using low-impact building materials or using packed gravel or permeable concrete instead of conventional concrete or asphalt to enhance replenishment of ground water.

While the practices or technologies employed in green building are constantly evolving and may differ from region to region, fundamental principles persist from which the method is derived: siting and structure design efficiency, energy efficiency, water efficiency, materials efficiency, indoor environmental quality enhancement, operations and maintenance optimization and waste and toxics reduction. The essence of green building is an optimization of one or more of these principles. Also, with the proper synergistic design, individual green building technologies may work together to produce a greater cumulative effect.

On the aesthetic side of green architecture or sustainable design is the philosophy of designing a building that is in harmony with the natural features and resources surrounding the site. There are several key steps in designing sustainable buildings: specify 'green' building materials from local sources, reduce loads, optimize systems, and generate on-site renewable energy.

1.3 OBJECTIVES

- To study different features of a Green Building
- To prepare a 2D model in AUTOCAD as well as 3D model in REVIT software of Conventional building and Green building.
- To compare Conventional building with Green Building on the basis of material cost and Energy cost

1.4 SCOPE OF THE PROJECT

The scope of this project is to prepare a model of green building highlighting all the efficient features favoring the environment using AUTOCAD software and REVIT software in a hot and humid climate. Energy analysis is done manually as well as through software. A comparison of material cost and energy cost will be done between conventional building and green building.

Chapter-2

LITERATURE REVIEW

2.1 GENERAL

A green building incorporates environmental considerations into every stage of the building construction and focuses on the design, construction, operation and maintenance phases. The key process difference between green and conventional buildings is the concept of integration, whereby a multi-disciplinary team of building professionals work together from the pre-design phase through post-occupancy to optimize the building for environmental sustainability, performance, and cost saving.The following pages summarize key principles, strategies and technologies which are associated with the major elements of green building design.

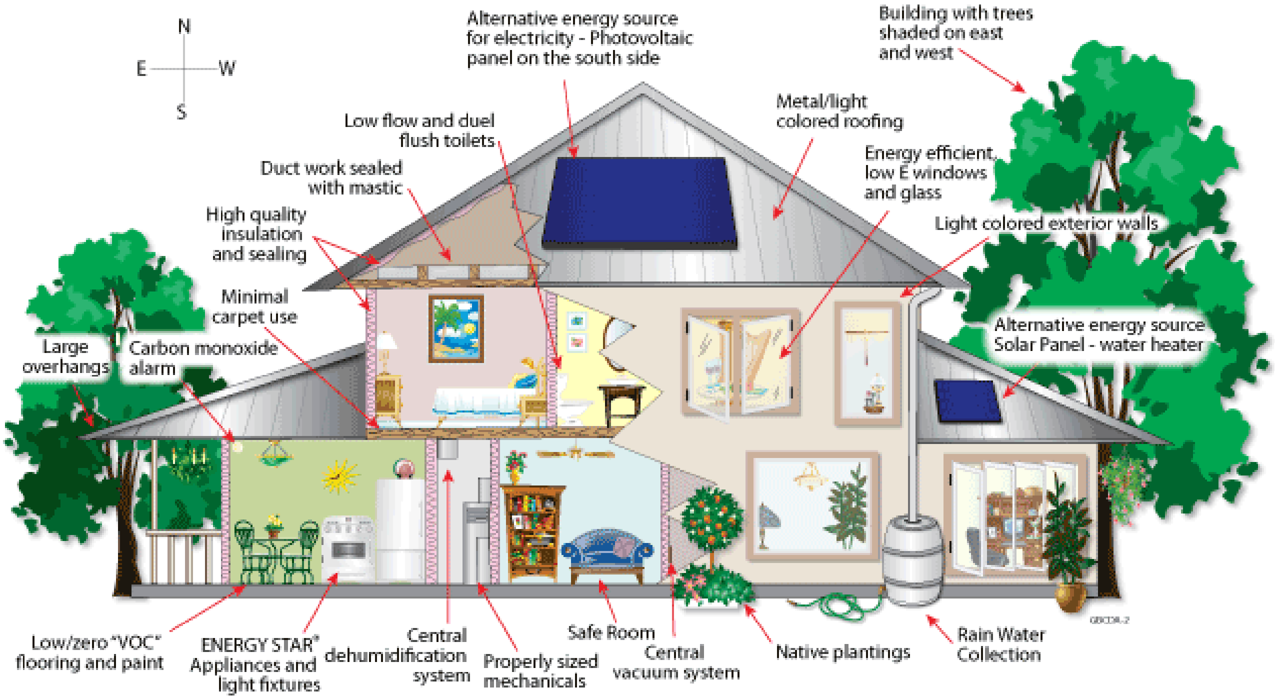

Fig. 2.1 Feature of Green Building

2.2 ENERGY EFFICIENT LANDSCAPING

It is a type of landscaping designed for the purpose of conserving energy. There is a distinction between the embedded energy of materials and constructing the landscape, and the energy consumed by the maintenance and operations of a landscape.[4]

Design techniques include:

1) Planting trees for the purpose of providing shade, which reduces cooling costs. Planting or building windbreaks to slow winds near buildings, which reduces heat loss.
2) Wall sheltering, where shrubbery or vines are used to create a windbreak directly against a wall.
3) Earth sheltering and positioning buildings to take advantage of natural landforms as windbreaks.
4) Green roofs that cool buildings with extra thermal mass and evapotranspiration.
5) Reducing the heat island effect with pervious paving, high albedo paving, shade, and minimizing paved areas.
6) Site lighting with full cut off fixtures, light level sensors, and high efficiency fixtures

Energy-efficient landscaping techniques include using local materials, on-site composting and chipping to reduce green waste hauling, hand tools instead of gasoline-powered, and also may involve using drought-resistant plantings in arid areas, buying stock from local growers to avoid energy in transportation, and similar techniques. [5]

2.3 BUILDING SHAPE

The surface area to volume (S/V) ratio (the three dimensional extrapolation of the perimeter to area ratio) is an important factor determining heat loss and gain. The greater the surface area the more the heat gain/ loss through it. So small S/V ratios imply minimum heat gain and minimum heat loss. To minimize the losses and gains through the fabric of a building a compact shape is desirable. The most compact orthogonal building would then be a cube. This configuration, however, may place a large portion of the floor area far from perimeter daylighting. Contrary to this, a building massing that optimizes daylighting and ventilation would be elongated so that more of the building area is closer to the perimeter. While this may appear to compromise the thermal performance of the building, the electrical load and cooling load savings achieved by a well-designed daylighting system will more than compensate for the increased fabric losses.

In hot dry climates S/V ratio should be as low as possible as this would minimize heat gain. In cold-dry climates also S/V ratios should be as low as possible to minimize heat losses. In warm-humid climates the prime concern is creating airy spaces. This might not necessarily minimize the S/V ratio. Further, the materials of construction should be such that they do not store heat.

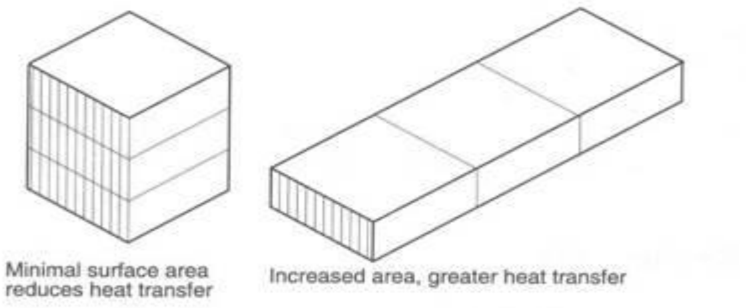

Fig.2.2 Surface to Volume Ratio

2.4 Location of water bodies

1) Water is a good modifier of microclimate. It takes up a large amount of heat in evaporation and causes significant cooling especially in hot and dry climate.
2) In humid climates, water should be avoided as it adds to humidity.
3) Water has been used effectively as modifier of microclimate in the (Water and Land Management Institute) Building complex in Bhopal.

2.5 Orientation of building

Building orientation refers to the way a building is situated on a site and the positioning of windows, rooflines, and other features. A building oriented for solar design takes advantage of passive and active solar strategies. Passive solar strategies use energy from the sun to heat and illuminate buildings. Active solar systems use solar collectors and additional electricity to power pumps or fans to distribute the sun's energy. Heat is absorbed and transferred to another location for immediate heating or for storage for use later. Water, antifreeze or sometimes air circulates to transfer heat.

Unlike active solar strategies, a passive design does not involve the use of mechanical and electrical devices, such as pumps, fans, or electrical controls Passive solar heating makes use of the building components to collect, store, distribute, and control solar heat gains to reduce the demand for fossil fuel-powered space heating.

Passive solar heating strategies also provide opportunities for daylighting and views to the outdoors through well -positioned windows. The goal of passive design is to maximize solar gap in while minimizing conductance.

Passive cooling removes or rejects heat from the building, keeping temperatures cool. Avoiding any mechanical operations to moderate temperature achieves energy and cost savings by alleviating the cooling load demanded. Shading devices can also reduce unwanted solar gains by blocking the sun during the summer months, while natural ventilation, which relies on natural airflow and breezes, can reduce the need for mechanical cooling when the building is occupied.

The following five elements constitute a complete passive solar design. Each performs a separate function, but all five must work together for the design to be successful: aperture, absorber, thermal mass, distribution, and control. [6]

How to Optimize Building Orientation

It is best to incorporate passive solar systems into a building during the initial design. Passive solar systems utilize basic concepts incorporated into the architectural design of the building. They usually consist of:-

- Rectangular floor plans elongated on an east-west axis
- Glazed south-facing wall.
- Thermal storage medium exposed to the solar radiation
- Light shelves/overhangs or other shading devices which sufficiently shade the south-facing elevation from the summer sun; south elevation overhangs should be horizontal while east and west elevations usually require both horizontal and vertical overhangs.
- Windows on the east and west walls, and preferably none on the north walls.

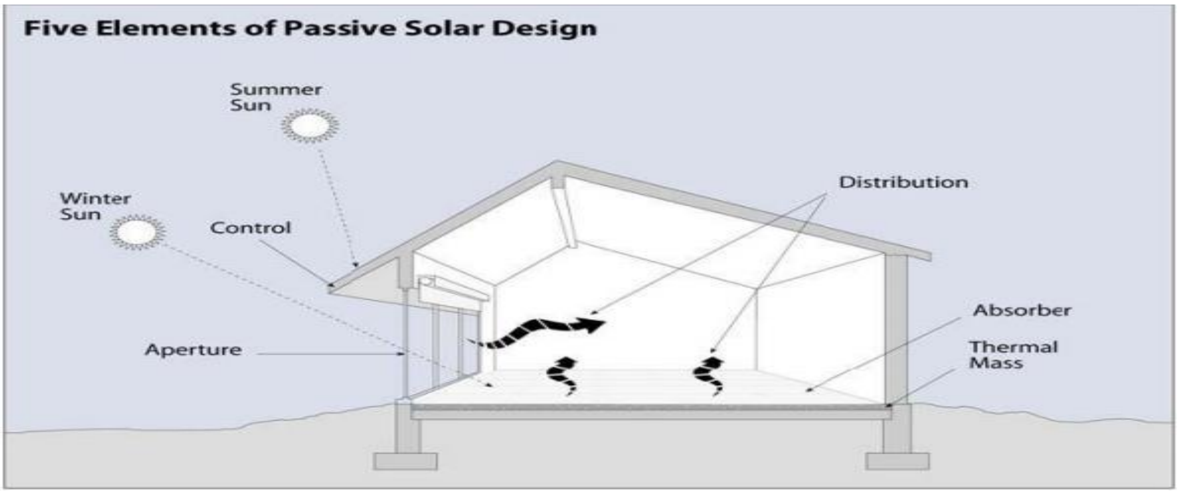

Fig.2.3 Passive Solar design

In addition to passive solar and energy -conserving strategies, active solar systems can be integrated into a building's design and systems. Buildings designed to serve as active solar collectors should not be shaded by nearby trees or buildings and should have solar arrays or roof area facing south. Both passive and active solar collectors should be oriented at the angle of your location’s latitude (in New Jersey y, this is approximately 40°N).

2.6 BUILDING ENVELOPE AND FENESTRATION

The building envelope and components are key determination of the amount of heat gain or loss and wind that enters inside. The primary elements affecting the performance of a building envelope are:-

1) Materials and Construction techniques
2) Roof
3) Walls
4) Trombe wall

2.6.1 Material with low embodied energy

The total amount of energy required to manufacture a product should be as little as possible. This includes considering resource excavation and extraction from the Earth, use of manmade materials in production, and complexity of manufacture. The simpler the process, the less harm done to the environment.
Recyclable: Products are manufactured all or in part with recycled materials, and can also be recycled themselves after use. Using recycled products, or products with recycled content helps the environment and the economy in several ways.
Use Renewable Resources. Products are manufactured with resources that are renewable (i.e. wood or solar power) rather than non-renewable (i.e. fossil fuels). Depletion of the earth's resources is occurring at an alarming rate. As we continue to extract raw materials from the earth, entire ecosystems are affected, causing species to become extinct. Fossil fuels are not unlimited; we will run out of them eventually. By utilizing renewable energies, such as wind, solar, tidal, as well as renewable products, such as wood, grasses or soil, we can lessen the impact on biodiversity and ecosystems. [3]

Locally or Regionally Produced**:** Products are manufactured closer to their use, causing less pollution in transportation, and also helping to support regional economies. Using building products that are manufactured within a 500-mile radius of use can help lessen air pollution from transport vehicles. Local economies are also given a boost, contributing to the prosperity and economic health of a community.

Energy Efficient: Products use as little energy as possible. Construction and operation of buildings produces almost half of the world's energy use. With a few key strategies, designers and builders can reduce energy loads on structures, reducing energy requirements and the strain on natural resources. Proper siting for maximum solar orientation, operable windows for natural cross-ventilation (eliminating or lessening the need for air conditioning), insulation with higher R-values, water-saving devices and more efficient appliances can all work to lessen energy needs. Consideration of alternate energy source use, such as wind, solar and tidal power, can help alleviate reliance on traditional fossil fuel sources.[7]

Low Environmental Impact: Products do not harm the environment, pollute air or water, or cause damage to the earth, its inhabitants and its ecosystems in their manufacture, use or disposal. They are non-toxic and contribute to good indoor air quality. Worldwide industrial production uses billions of tons of raw materials every year, some irreplaceable or finite. Pollution caused in excavation, manufacture, use or disposal of a product can have untold consequences on the Earth's ecosystem. Poor indoor air quality caused by product off gassing or VOC emission costs billions in medical bills and lost productivity to companies every year. Manufacture and use of green building products should strive to lessen the impacts on the Earth.

Minimize Waste: Products produce as little waste as possible in their manufacture, use and disposal. Buildings are tremendous generators of waste. In America, enough garbage is produced every day to fill 63,000 garbage trucks. Landfills are overflowing, especially with construction waste, which accounts for 40% of the usage at landfills. By utilizing methods of reuse and recycling of scrap and trimmings, employing strategies that minimize waste through the life cycle of a product, manufacturers can radically reduce the amount of products that are put into the waste stream.

2.6.2 Roof

The roof receives significant solar radiation and plays an important role in heat gain/losses, delighting, and ventilation. Depending on the climatic needs, proper roof treatment is essential. In hot region, the roof should have enough insulating properties to minimize heat gains. A few roof protection methods are as follows:-

- A green roof system consists of an assembly of materials and plants installed on a roof (or a flat roof) with the aim of ensuring the sustainability of the vegetation and the building. One of the most important elements in a roof is the bearing structure (concrete slab, steel decking, timber panels, etc.)
- A waterproofing membrane, which is also root-proof, is indispensable to guarantee a lasting system.

• Thermal insulation, generally placed underneath the waterproofing membrane, completes the roof build-up.

Fig.2.4 Component of Green Roof

2.6.3 Walls

Walls are a major part of the building envelope and receive large amount of solar radiation. The heat storage capacity and heat conduction property of walls are key to meeting desired thermal comfort conditions. The wall thickness, material, and finishes can be chosen based on the heating and cooling needs of the building. Appropriate thermal insulation and air cavities in walls reduce heat transmission into the building, which is the primary aim in a hot region. [5]

Types of walls

Air cavities walls: - Is used to reduce heat loss through a cavity wall by filling the air space with material that inhibits heat transfer. This immobilizes the air within the cavity (air is still the actual insulator), preventing convection, and can substantially reduce space heating costs. [6]

Rat Trap Bond Masonry (Rtb) Walls

A "Rat-Trap Bond" is a type of wall brick masonry bond in which bricks are laid on edge (i.e. the height of each course in case of a brick size 230x110x75 mm, will be 110 mm plus mortar thickness) such that the shiner and rowlock are visible on the face of masonry as shown below.

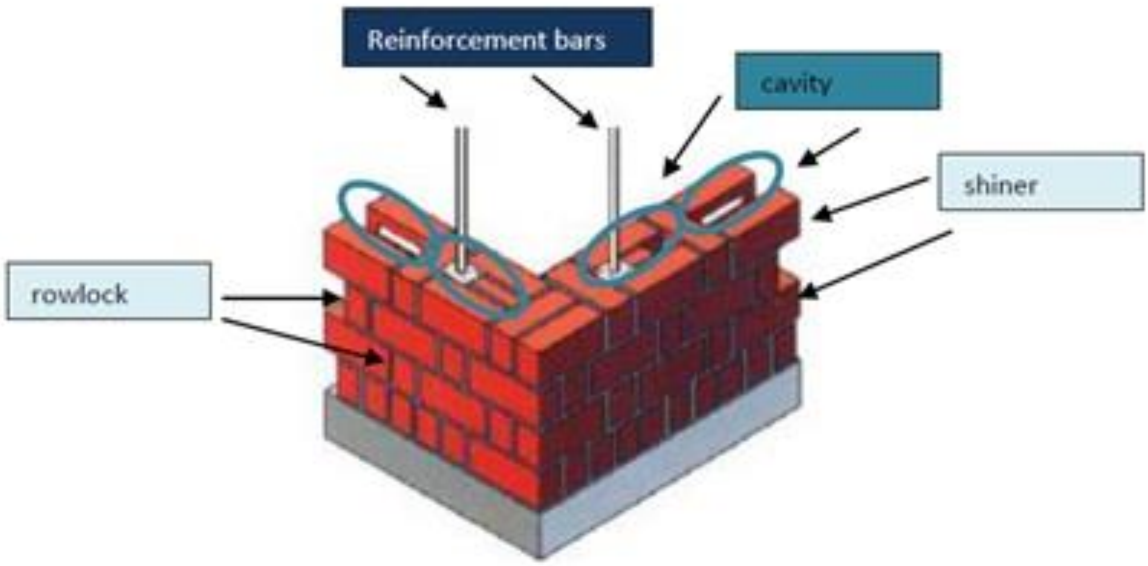

Fig.2.5 cavity wall

This gives the wall with an internal cavity bridged by the rowlock. This is the major reason where virgin materials like brick clay and cement can be considerably saved. This adds this technology to the list of Green building technologies and sustainability for an appropriate option as against conventional solid brick wall masonry.

This cavity adds an added advantage as it adds a Green building feature of help maintain improved thermal comfort and keep the interiors colder than outside and vice versa.

The Rat trap bond construction is a modular type of masonry construction. Due care must be taken while designing the wall lengths and heights for a structure. The openings and wall dimensions to be in multiples of the module. Also the course below sill and lintel to be a solid course by placing bricks on edge. The masonry on the sides of the openings also to be solid as will help in fixing of the opening frame.

2.6.4 Trombe wall

Is a passive solar building design where a wall is built on the winter sun side of a building with a glass external layer and a high heat capacity internal layer separated by a layer of air. Heat in close to UV spectrum passes through the glass almost unhindered then is absorbed by the wall that then re-radiates in the far infrared spectrum which does not pass back through the glass easily, hence heating the inside of the building. Trombe walls are commonly used to absorb heat during sunlit hours of winter then slowly release the heat over night.

Trombe walls work on the basic greenhouse principle that heat from the sun in the form of near-visible shorter-wavelength higher-energy ultraviolet radiation passes through glass largely unimpeded.

When this radiation strikes objects the energy is absorbed and then re-emitted in the form of longer-wavelength infra-red radiation that does not pass through glass as readily. Hence heat becomes trapped and builds up in an enclosed structure with high internal heat capacity and glass surfaces that face the sun.

The clearer the glass in front of a Trombe wall appears in the UV spectrum the more short wave radiation will penetrate and the more reflective or non-transparent the glass appears in the infra-red spectrum the less re-emitted heat will be escape.

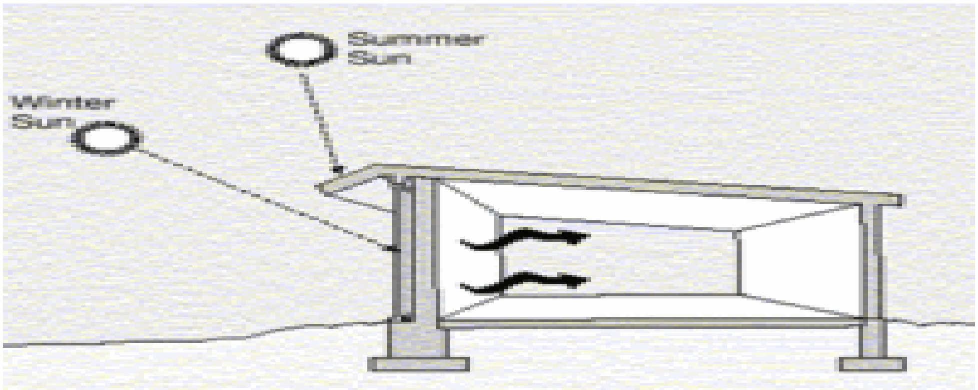

Fig.2.6 Trombe wall

Application of green building concepts can yield for savings during the construction Process:

- Lower energy costs, by monitoring usage, installing energy-efficient lamps and fixtures, and using occupancy sensors to control lighting fixtures;
- Lower water costs, by monitoring consumption and reusing storm water and/or construction wastewater where possible;
- Lower site-clearing costs, by minimizing site disruption and movement of earth and installation of artificial systems;
- Lower landfill dumping fees and associated hauling charges, through reuse and recycling of construction and demolition debris;
- Lower materials costs, with more careful purchase and reuse of resources and materials;
- Possible earnings from sales of reusable items removed during building demolition; and
- Fewer employee health problems resulting from poor indoor air quality.

This listing suggests some possible areas for cost savings; the project team can identify other possibilities through a cooperative and integrated team approach. The contractor can also improve relations with the community and building owner by viewing them as part of the team effort to implement environmentally sound construction measures.

2.6.5 Tropical Skylight

The central dining space was roofed over with what has come to be called as the ‘tropical skylight’. This is a skylight suitable for atria in tropical climates. It consists of the glazing being placed vertically, facing north and south, and covering the roof so that direct summer solar gain is avoided while winter un streams into the space. The proper design of overhangs and glazing allows this geometry to be adapted to all tropical climates, and can be recommended instead of the horizontally glazed skylights which are an attractive but an unsuitable design feature for our climate.[9]

Fig.2.7 Tropical Skylight

2.6.6 Window material

Solar control glazing objective is to control the entry of solar heat and light into the buildings. These are essentially non-selective metallic films, which are deposited on glass or polymer substrates. Though these glazing are one of the earlier developments, but recently new material combinations and coating processes have contributed to the development of unique products. In these techniques, solar control is achieved either by absorptive process or by reflective process.

2.7 STRUCTURE DESIGN EFFICIENCY

The foundation of any construction project is rooted in the concept and design stages. The concept stage, in fact, is one of the major steps in a project life cycle, as it has the largest impact on cost and performance. In designing environmentally optimal buildings, the objective is to minimize the total environmental impact associated with all life-cycle stages of the building project. However, building as a process is not as streamlined as an industrial process, and varies from one building to the other, never repeating itself identically. In addition, buildings are much more complex products, composed of a multitude of materials and components each constituting various design variables to be decided at the design stage. A variation of every design variable may affect the environment during all the building's relevant life-cycle stages.[3]

2.8 ENERGY EFFICIENCY

Green buildings often include measures to reduce energy consumption – both the embodied energy required to extract, process, transport and install building materials and operating energy to provide services such as heating and power for equipment.

As high-performance buildings use less operating energy, embodied energy has assumed much greater importance – and may make up as much as 32% of the overall life cycle energy consumption. Studies such as the U.S. LCI Database Project show buildings built primarily with wood will have a lower embodied energy than those built primarily with brick, concrete, or steel.

To reduce operating energy use, designers use details that reduce air leakage through the building envelope (the barrier between conditioned and unconditioned space). They also specify high-performance windows and extra insulation in walls, ceilings, and floors. Another strategy, passive solar building design, is often implemented in low-energy homes. Designers orient windows and walls and place awnings, porches, and trees to shade windows and roofs during the summer while maximizing solar gain in the winter. In addition, effective window placement (daylighting) can provide more natural light and lessen the need for electric lighting during the day. Solar water heating further reduces energy costs. Onsite generation of renewable energy through solar power, wind power, hydro power, or biomass can significantly reduce the environmental impact of the building. Power generation is generally the most expensive feature to add to a building.[3]

2.9 WATER EFFICIENCY

Reducing water consumption and protecting water quality are key objectives in sustainable building. One critical issue of water consumption is that in many areas, the demands on the supplying aquifer exceed its ability to replenish itself. To the maximum extent feasible, facilities should increase their dependence on water that is collected, used, purified, and reused on-site. The protection and conservation of water throughout the life of a building may be accomplished by designing for dual plumbing that recycles water in toilet flushing or by using water for washing of the cars. Waste-water may be minimized by utilizing water conserving fixtures such as ultra-low flush toilets and low-flow shower heads. Bidets help eliminate the use of toilet paper, reducing sewer traffic and increasing possibilities of re-using water on-site. Point of use water treatment and heating improves both water quality and energy efficiency while reducing the amount of water in circulation. The use of non-sewage and greywater for on-site use such as site-irrigation will minimize demands on the local aquifer.[6]

2.10 MATERIALS EFFICIENCY

Building materials typically considered to be 'green' include lumber from forests that have been certified to a third-party forest standard, rapidly renewable plant materials like bamboo and straw, dimension stone, recycled stone, recycled metal (see: copper sustainability and recyclability), and other products that are non-toxic, reusable, renewable, and/or recyclable(1). For concrete a high performance or Roman self-healing concrete is available. The EPA (Environmental Protection Agency) also suggests using recycled industrial goods, such as coal combustion products, foundry sand, and demolition debris in construction projects. Energy efficient building materials and appliances are promoted in the United States through energy rebate programs.

2.11 INDOOR ENVIRONMENTAL ENHANCEMENT

Indoor Air Quality seeks to reduce volatile organic compounds, or VOCs, and other air impurities such as microbial contaminants. Buildings rely on a properly designed ventilation system (passively/naturally or mechanically powered) to provide adequate ventilation of cleaner air from outdoors or recirculate, filtered air as well as isolated operations (kitchens, dry cleaners, etc.) from other occupancies. During the design and construction process choosing construction materials and interior finish products with zero or low VOC emissions will improve IAQ. Most building materials and cleaning/maintenance products emit gases, some of them toxic, such as many VOCs including formaldehyde. These gases can have a detrimental impact on occupants' health, comfort, and productivity. Avoiding these products will increase a building's IEQ. [5]

2.12 WASTE REDUCTION

Green architecture also seeks to reduce waste of energy, water and materials used during construction. For example, in California nearly 60% of the state's waste comes from commercial buildings during the construction phase; one goal should be to reduce the amount of material going to landfills. Well-designed buildings also help reduce the amount of waste generated by the occupants as well, by providing on-site solutions such as compost bins to reduce matter going to landfills.

To reduce the amount of wood that goes to landfill, Neutral Alliance (a coalition of government, NGOs and the forest industry) created the website dontwastewood.com. The site includes a variety of resources for regulators, municipalities, developers, contractors, owner/operators and individuals/homeowners looking for information on wood recycling.

When buildings reach the end of their useful life, they are typically demolished and hauled to landfills. Deconstruction is a method of harvesting what is commonly considered "waste" and reclaiming it into useful building material. Extending the useful life of a structure also reduces waste – building materials such as wood that are light and easy to work with make renovations easier.

To reduce the impact on wells or water treatment plants, several options exist. "Greywater", wastewater from sources such as dishwashing or washing machines, can be used for subsurface irrigation, or if treated, for non-potable purposes, e.g., to flush toilets and wash cars.(3) Rainwater collectors are used for similar purposes.

Centralized wastewater treatment systems can be costly and use a lot of energy. An alternative to this process is converting waste and wastewater into fertilizer, which avoids these costs and shows other benefits. By collecting human waste at the source and running it to a semi-centralized biogas plant with other biological waste, liquid fertilizer can be produced. This concept was demonstrated by a settlement in Lubbock Germany in the late 1990s. Practices like these provide soil with organic nutrients and create carbon sinks that remove carbon dioxide from the atmosphere, offsetting greenhouse emission. Producing artificial fertilizer is also more costly in energy than this process.[3]

2.13 MODELLING OF BUILDING USING REVIT

Revit was intended to allow architects and other building professionals 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 became known as Building Information Modeling or BIM. The Revit work environment allows users to manipulate whole buildings or assemblies (in the project environment) or individual 3D shapes (in the family editor environment). Modeling tools can be used with pre-made solid objects or imported geometric models. There are many categories of objects ('families' in Revit terminology), which divide into three groups:

- System Families, such as walls, floors, roofs and ceilings which are built inside a project
- Loadable Families / Components, which are built with primitives (extrusions, sweeps, etc.) separately from the project and loaded into a project for use
- In-Place Families, which are built in-situ within a project with the same toolset as loadable components

REVIT software is specifically built for Building Information Modeling (BIM), empowering design and construction professionals to bring ideas from concept to construction with a coordinated and consistent model-based approach. Revit is a single application that includes features for architectural design, structural engineering, and construction. It allows to design a building and structure and its components in 3D, annotate the model with 2D drafting elements and access building information from the building models database. The Revit work environment allows users to manipulate whole buildings or assemblies (in the project environment) or individual 3D shapes (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. All the building elements have inherent relationship with each other, which is tracked, managed and maintained by the computer. Using the 3D elements of Revit, we can visualize the architectural or interior with respect to its scale, volume, and proportions. This enables us to study design alternatives and develop superior quality design solutions. Autodesk Revit Architecture automates routine drafting and coordination tasks and assists in reducing errors in documentation. This, in turn, saves time, improves the speed of documentation, and lowers the cost for users.

2.14 TERI-GRIHA rating system

A green building rating system is an evaluation tool that measures environmental performance of a building through its life cycle. It usually comprises of a set of criteria covering various parameters related to design, construction and operation of a green building. Rating programmes would help projects to address all aspects related to environment and are an effective tool to measure the performance of the building / project.

Two rating systems are followed in India:

- LEED India (Leadership in Energy & Environmental Design)
- GRIHA – (Green Rating for Integrated Habitat Assessment) National Rating System

GRIHA evaluates projects on the following 14 criteria:

1) Reduce UHIE and maintain native vegetation cover on site.
2) Passive architectural design and systems.
3) Good fenestration design for reducing direct heat gain and glare while maximizing daylight penetration.
4) Efficient artificial lighting system.
5) Thermal efficiency of building envelope.
6) Use of energy efficient appliances.
7) Use of renewable energy on site
8) Reduction in building and landscape water demand.
9) Rainwater harvesting
10) Generate resource from waste.
11) Reduce embodied energy of building.
12) Use of low-energy materials in interiors.
13) Adoption of green Lifestyle.
14) Innovation

Chapter 3
Case study of different Green Buildings

3.1 OFFICE BUILDING IN GURGAON

The glass used is an insulated glass commonly known as double glazing in which glass window panes separated by a vacuum or gas filled space to reduce heat transfer across a part of the building envelope. As the north east phase of the building faces the maximum of sunlight during the day time so to avoid the heat strokes insulated glass is used that will block some portion of heat and allows light to transmit through it.

The extreme left portion of the front east phase is provided with a vertical series of louvers for ventilation and same is the case in all the elevations, as we can see in elevation at C also, louvers are provided for ventilation which further adds to the aesthetic sense of the building. Infact, in elevation at C insulated glass is there as after mid noon this phase will be facing the maximum of sun. Wooden panels are used to avoid heating of the walls. Green Roofing is provided on almost every block of the building's front phase to avoid getting them heat up.

The building is so designed that each floor or block receives the maximum possible natural light possible using stepping technique which are shielded with insulated glass all over.

3.1.2 SUMMARY

After analyzing the building, we inferred that a place like Gurgaon is hot and dry and requires ventilation for proper inflow and outflow of the air. So we have provided louvers above doors and windows for the purpose of ventilation. The glass used is an insulated glass but in a residential building its not possible to use insulated glass so instead we will be using heat reflective glass to make it cost effective as well.

Fig.3.1 Office building in Gurgaon with front elevation

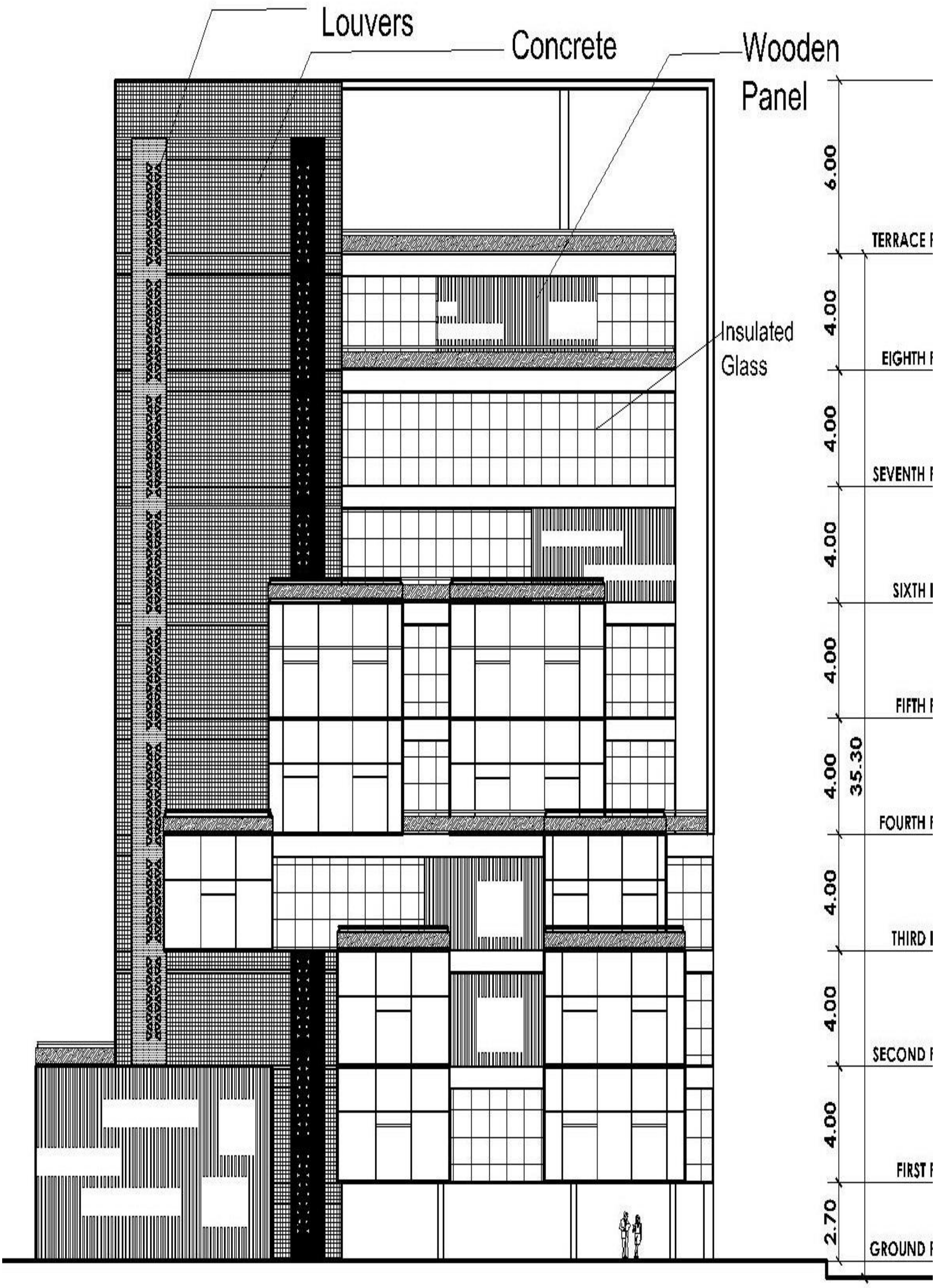

Fig.3.2 Auto cad of elevation at D section

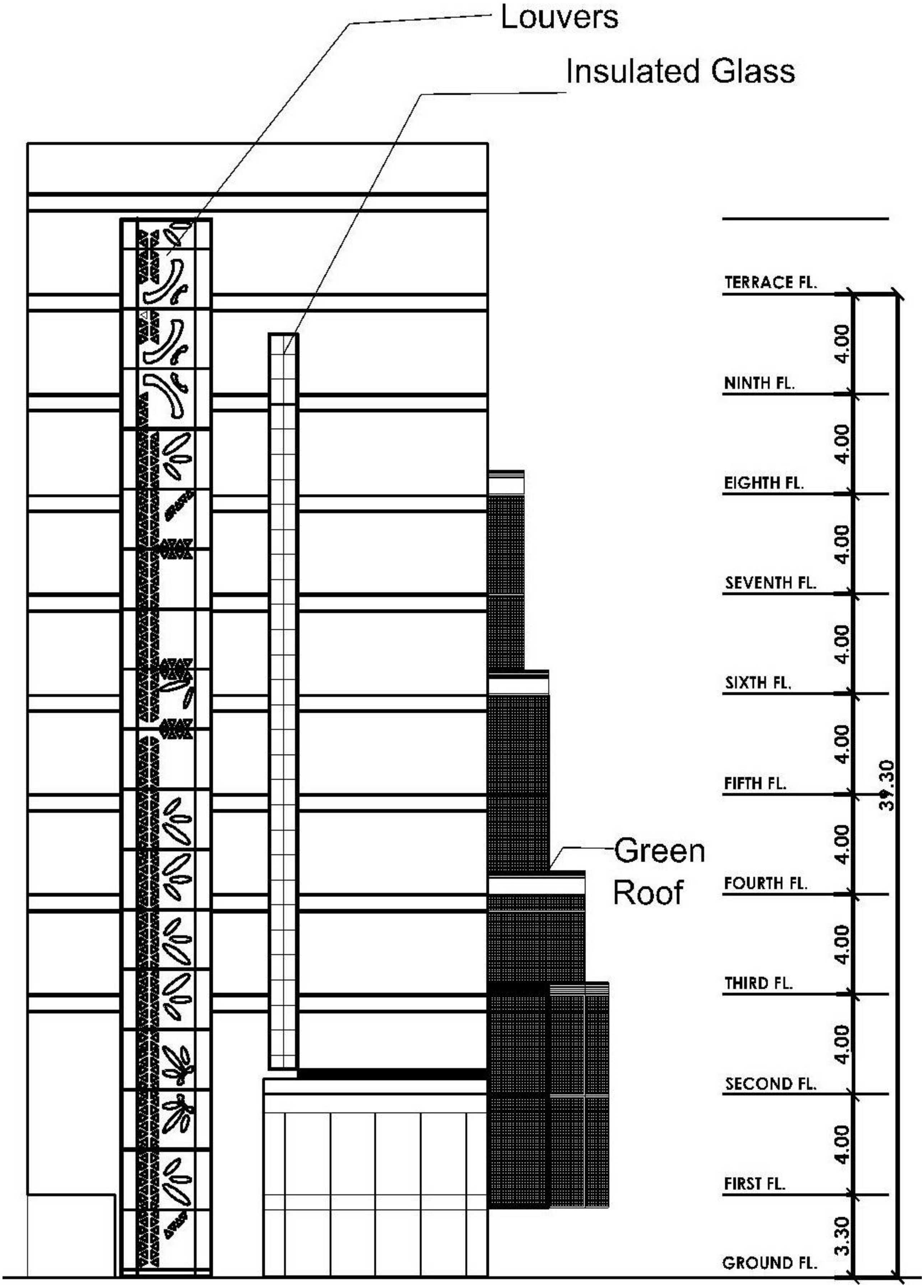

Fig.3.3 Auto cad of elevation at C section

3.2 OFFICE BUILDING OF WEST BENGAL RENEWABLE ENERGY DEVELOPMENT AGENCY, KOLKATA

The enormous amounts of energy consumed in office buildings are a cause for great concern. For this reason, the WBREDA decided to incorporate energy efficiency measures in the building design and to use appropriate non-conventional energy systems. To facilitate such energy efficiency measures, the building has been designed using the basic concepts of solar architecture. The building layout, internal planning, and selection of material have been carefully considered in order to reduce energy consumption.[9]

The south façade with light shelves for daylighting. The west façade is devoid of any fenestration to prevent direct gains.

Fig.3.4 Office building of West Bengal

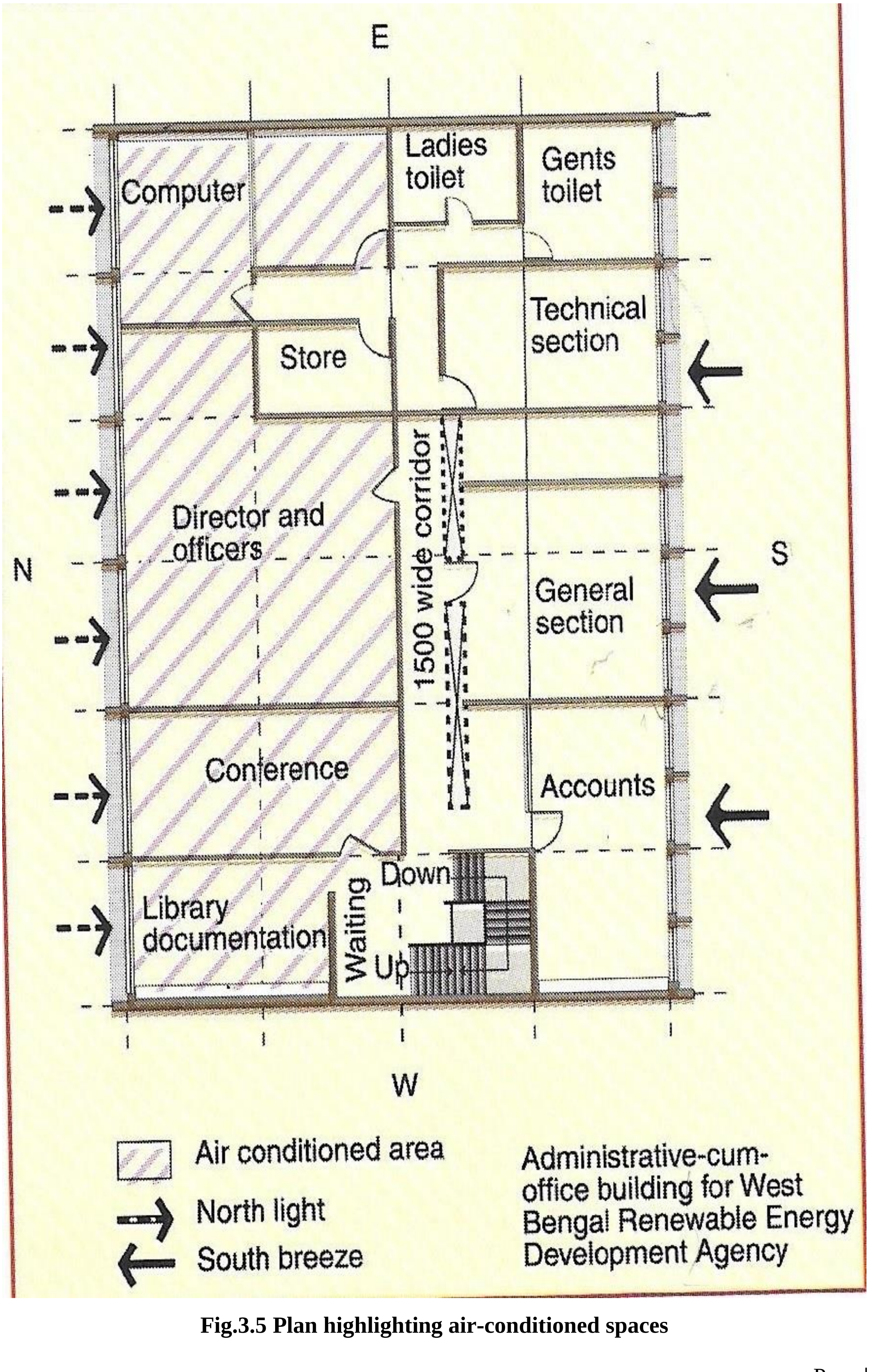

Fig.3.5 Plan highlighting air-conditioned spaces

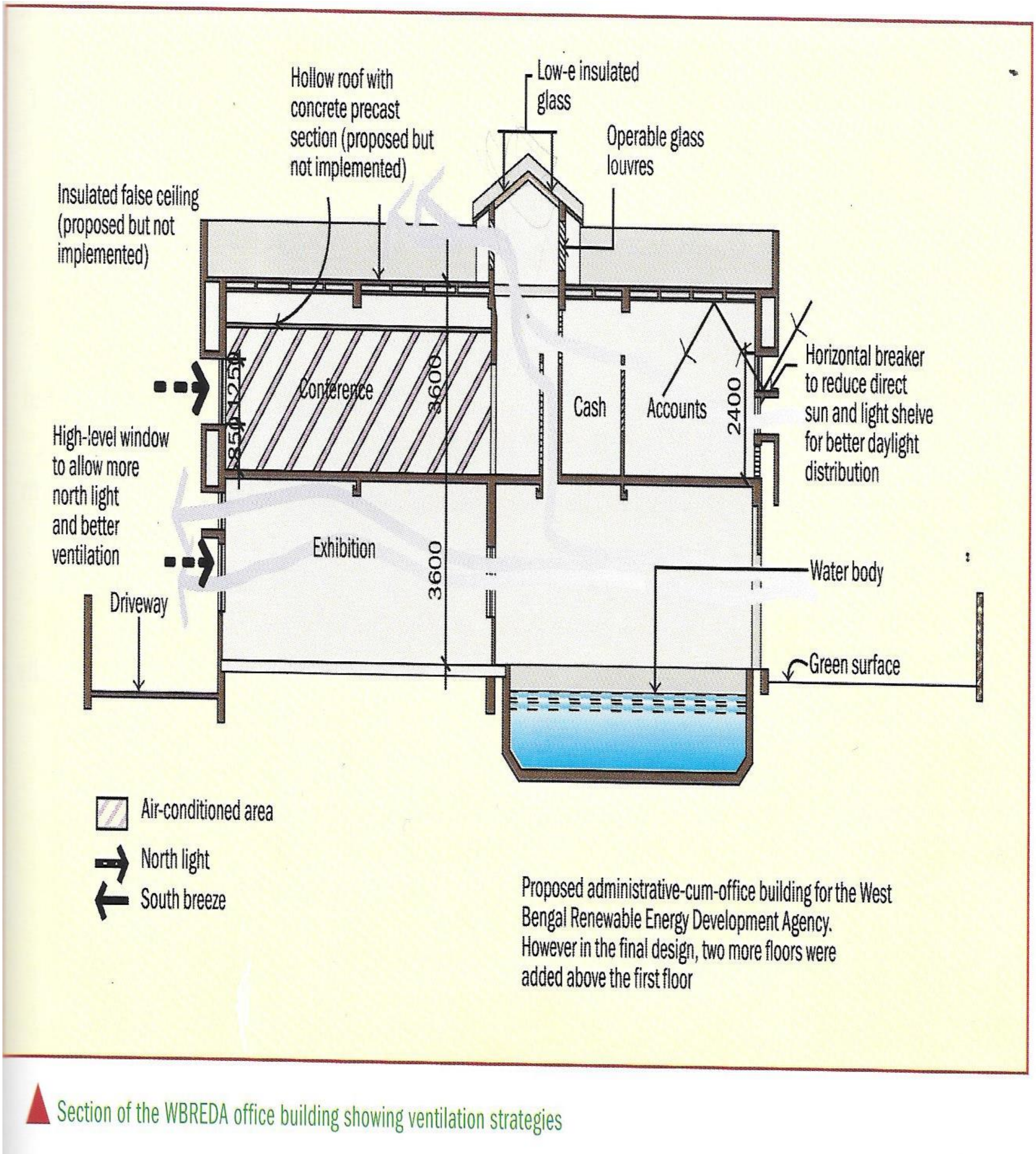

Fig.3.6 Section of the WBREDA showing ventilation

3.2.1 Design strategies

A study of Kolkata's climate shows that from April to September during the year, mechanical cooling of the building is required in order to provide thermal comfort. Various strategies have been incorporated to cool the building, where an effort has been made to use the on-site heat sources and sink to allow the heat exchange between the building and the surroundings. The energy consumption would be drastically reduced due to these design strategies. The basic design of the building has been conceived with the following main features.

3.2.2 Space Planning

The form of building plan has been conceived as a rectangle. Shorter sides of the rectangle are facing east and west to reduce heat gain. Air-conditioned areas are kept on northern side of the building. The walls on east and west face are devoid of fenestration. The areas which are not used frequently like stores, staircase, and toilets are placed on the eastern and western sides as buffer against direct solar heat.

3.2.3 Landscaping

The ground that faces the southern and eastern side of the building would be covered with grass or water to minimize heat gain from the surroundings. Use of vegetation and water bodies has been encouraged to modify the microclimate.

3.2.4 Ventilation

Non-air-conditioned areas are located on the southern side to take advantage of the prevailing wind during hot and humid period. For better cross-ventilation, a portion of the roof has been raised and used as solar chimney. Southern face of the wall has been protected by overhangs. These overhangs have been designed to function as light shelves for even distribution of daylight. The building is virtually divided into two parts: north and south blocks serviced by a corridor in between. To best utilize the prevailing south breeze, a water body has been created in the southern part of the building at the ground level, which has in turn increased the aesthetic value of the concept. The south breeze blowing over the water body gets trapped at the bottom of the building and the same is vented through the buildings with suitable cutouts, ventilators, windows, so that the cool south breeze can blow up to the deepest portion of the building. The calculated opening provided act as vent shaft taking care of the cross-flow of south wind and taking out the hot air from the non-air conditioned areas. The raised roof covered by low e-glass acts as a solar chimney and creates draft over the ventilation of the spaces.

3.2.5 Daylighting

The basic requirement of any lighting installation is to provide sufficient light in the right place at the required time. The windows provided on the north and south facades are adequately sized to provide sufficient daylight for most of the day and throughout the year except during the monsoon period. The sizes of the shading devices in the form of fixed louvers (overhangs, side fins) have been optimized on the basis of the solar geometry. The entry of daylight into the work areas is enhanced by providing a light-shelf in the south windows. All the circulation spaces like staircase, lobby and corridors are naturally lighted by way of raised roofing.

3.2.6 Insulation

By increasing the thermal resistance, conduction heat gains would have been reduced by the use of thermal insulation in the roof and walls. The insulated walls and roof not only lower the energy consumption but also allow lower mean radiant temperature to provide better thermal comfort. The insulation would have reduced the air conditioning load by 40%.

3.2.7 Glazing System

Air-tight double-glazed windows in the air-conditioned areas and single-glazed windows for non-air-conditioned areas were recommended to check the unwanted heat gains through infiltration throughout the building, and through conduction in the air-conditioned areas. Double glazed windows were expected to reduce the mechanical cooling load by about 12%. The raised roof acting as a solar chimney has a low e-glazing system to reduce heat gains.

3.2.8 SUMMARY

The technique we have used in our residential building after analyzing the properties of this buildings is the space planning. Our plan is rectangular in shape and the shorter sides of the rectangle are facing east and west direction to reduce the heat gain. Even the windows provided on the north and south facades are adequately sized to provide sufficient daylight for most of the year.

3.3 OFFICE-CUM-LABORATORY FOR THE WEST BENGAL POLLUTION CONTROL BOARD, KOLKATA

The building of the WBPCB has put to use a number of technologies that aim to promote a more sustainable built environment. Traditionally, the building and construction industry has been a major consumer of energy and natural resources. Hence, at the very outset, the WBPCB and the architects decided that, since the former was actively engaged in uplifting the environment, their office building should be an exemplary ‘environment-friendly building’. The architects thus took it as a challenge to design an energy-efficient building applying various energy and resource-efficient building systems.

Taking the reference to build window design and designed for integration of daylighting and to cut off direct radiation.[9]

3.3.1 Fenestration Design

The shading devices and window size and disposition vary according to the orientation of the walls. In addition, at the initial design stage, the architects ensured appropriate depth of the plan to maximize daylight penetration into the interior. The highlights of the solar passive features are optimum window disposition and sizing to allow maximum daylighting, while minimizing adverse thermal effects. However, indiscriminate increase of glazing area to achieve this is counterproductive of causing glare and over-heating of the building. The glare from uncontrolled daylight necessitates the use of curtains and blinds with resultant increase in use of artificial lighting and cooling load.

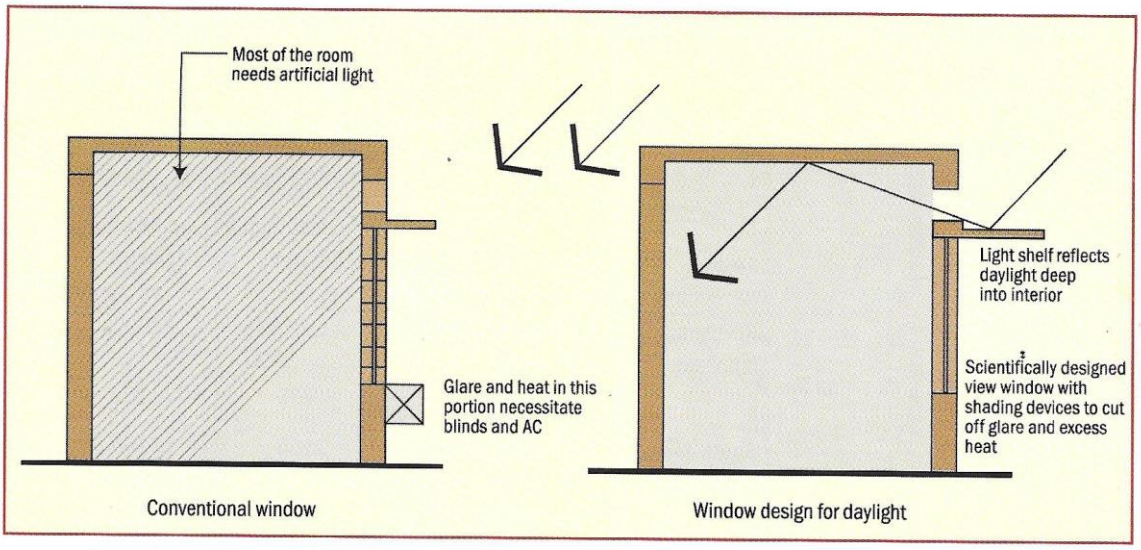

Diagram showing a conventional window design and window designed for integration of daylighting and to cut off direct radiation

Fig.3.7 Office-cum-laboratory of West Bengal-window design

3.3.2 SUMMARY

We have adopted fenestration designs from this building. In order to maximize daylight penetration into the interior we have provided light shelves above the windows. And also designed for integration of daylighting and to cut off direct radiation.

Chapter 4

MODELLING OF RESIDENTIAL BUILDING

4.1 Conventional Building Plan using Auto Cad

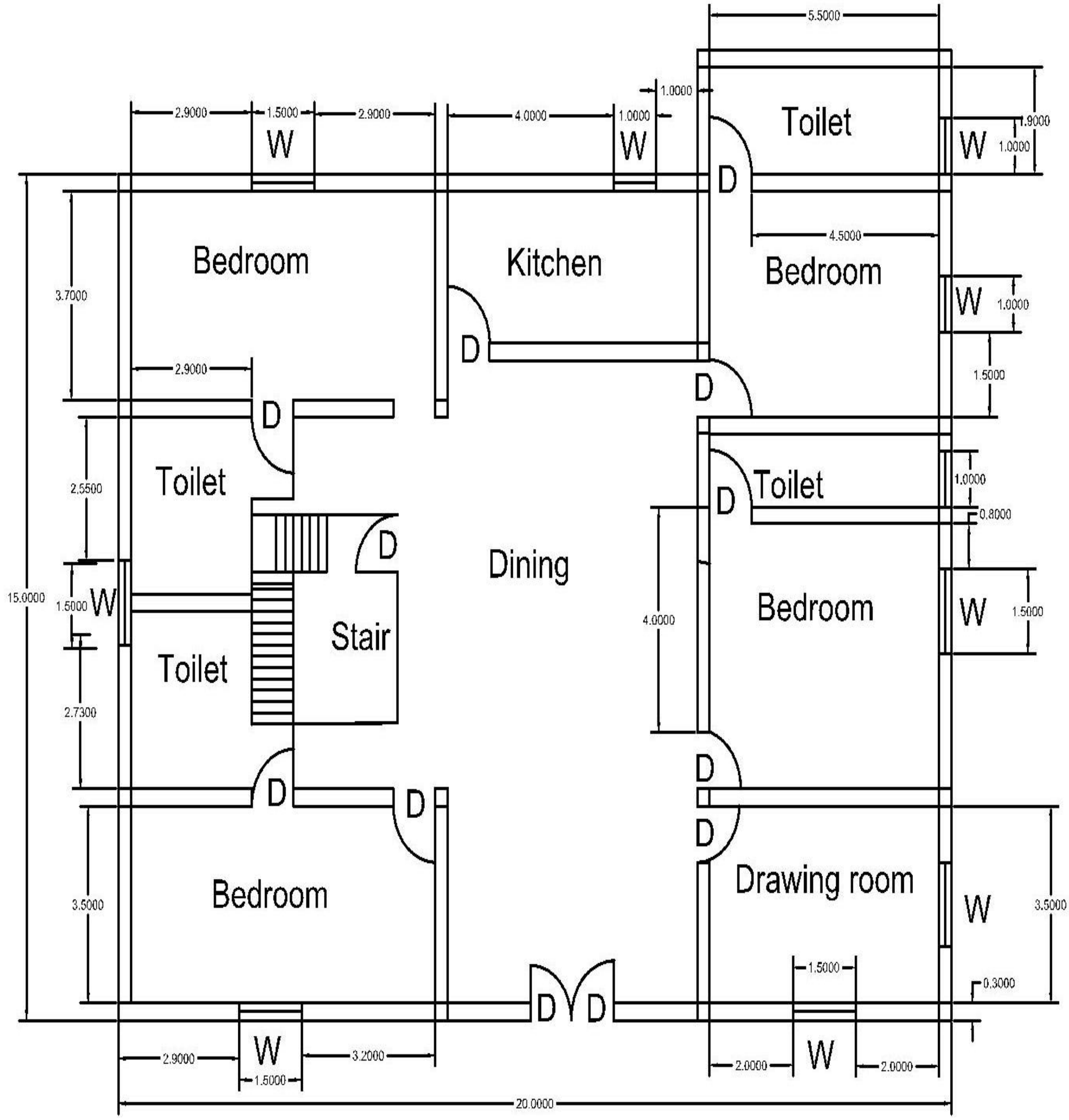

Fig.4.1 Plan of conventional building

4.2 Green Building Plan using Auto Cad

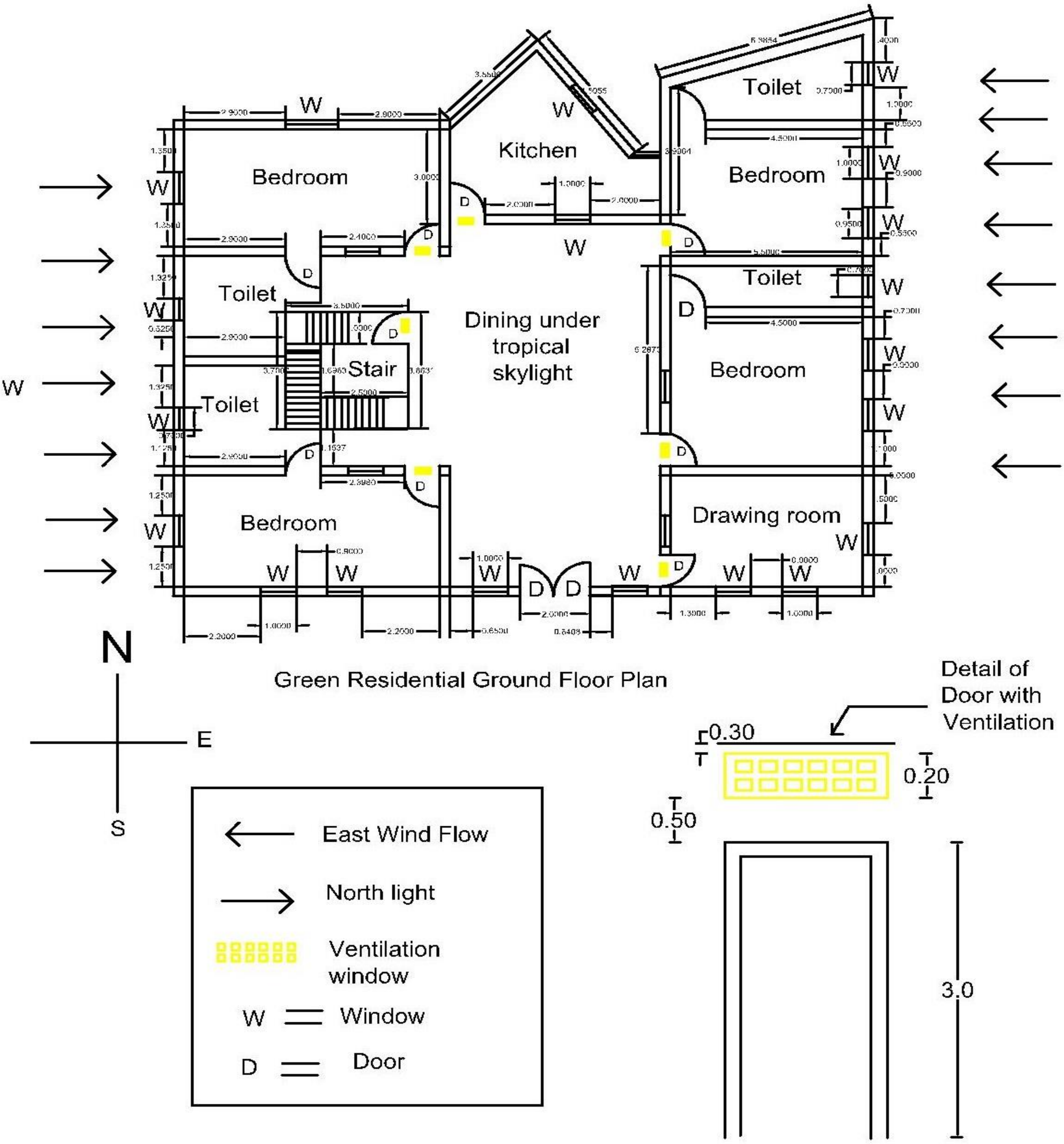

Fig.4.2 Plan of Green Building

A single story 20m X 15m rectangular building is to be made in hot and dry season like Delhi. The front elevation phasing south guides entry into the house that leads to the dining room which is the darkest area of the house. So in order to provide natural daylight and ventilation, tropical skylight is provided above the dining area which is 2m higher than the terrace height having air vents for inflow and outflow of air for proper ventilation and tent shaped roof is provided on the top whose top is painted with a Solar-Reflective Paint roof which has insulating properties that provides thermal cover to this skylight. Even walls are coated with this Solar-Reflective Paint to provide insulation. For ventilation, maximum windows are provided on the eastern side of the house because of the movement of wind from east to west. The fenestration design is used above the windows to cut off the direct glare of the sun into the room. The louvers are provided above the windows for inflow and outflow of air.

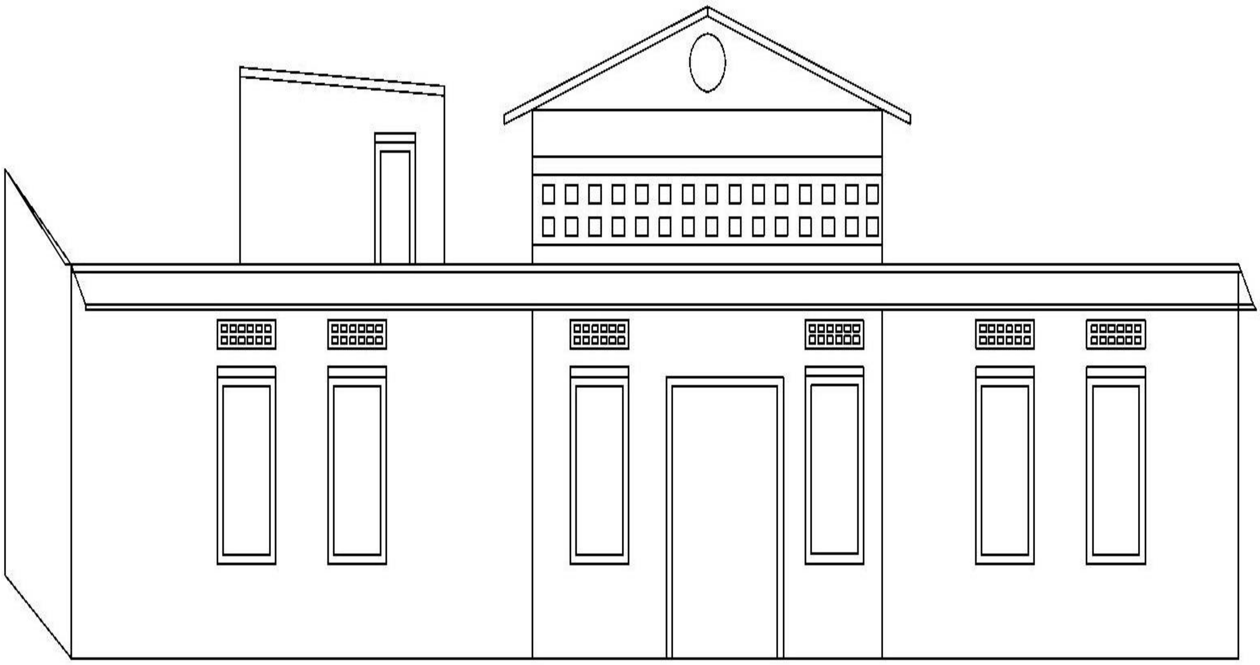

Fig.4.3 Front elevation South Phase

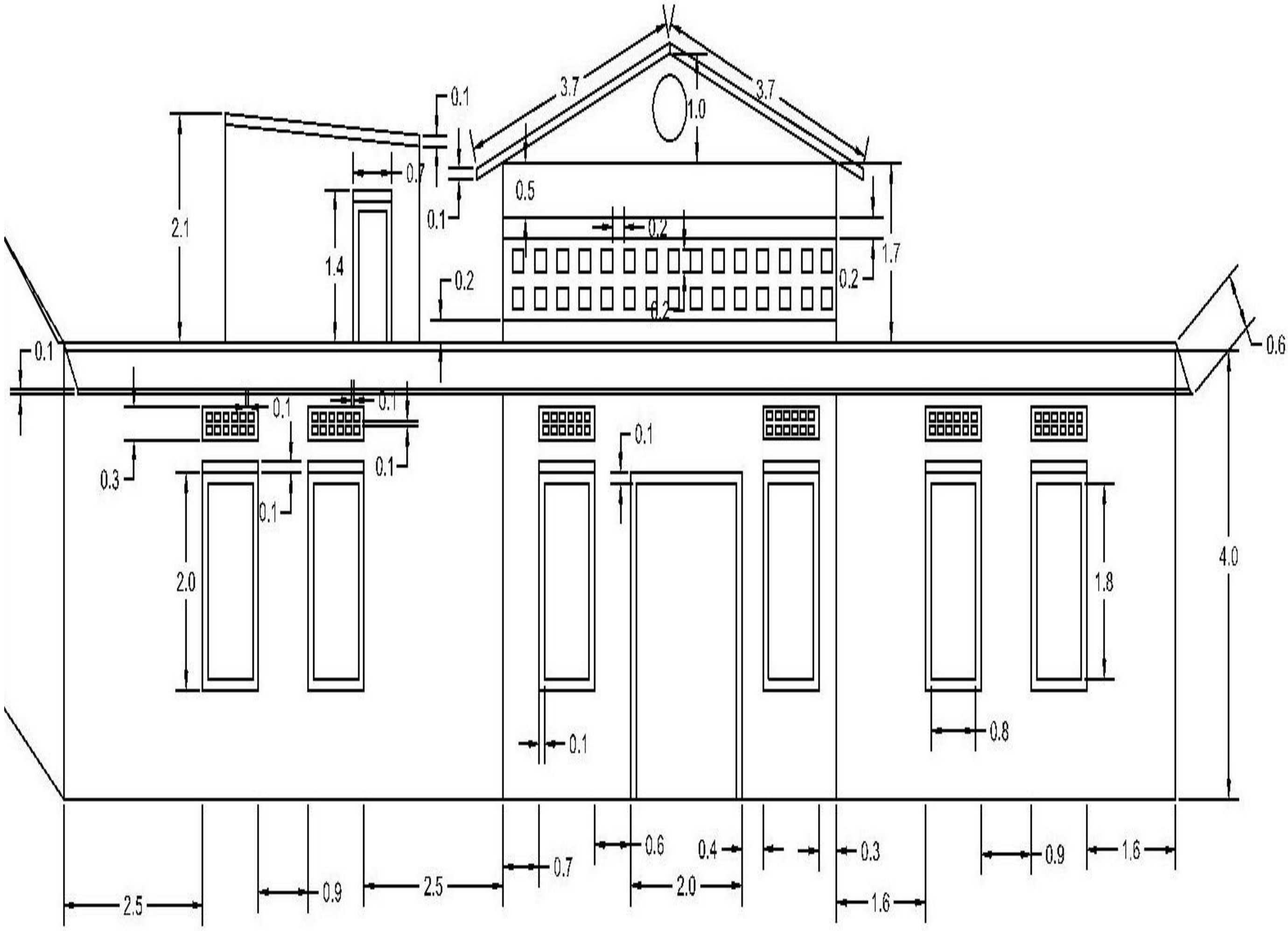

Fig.4.4 Front elevation South phase With Dimension

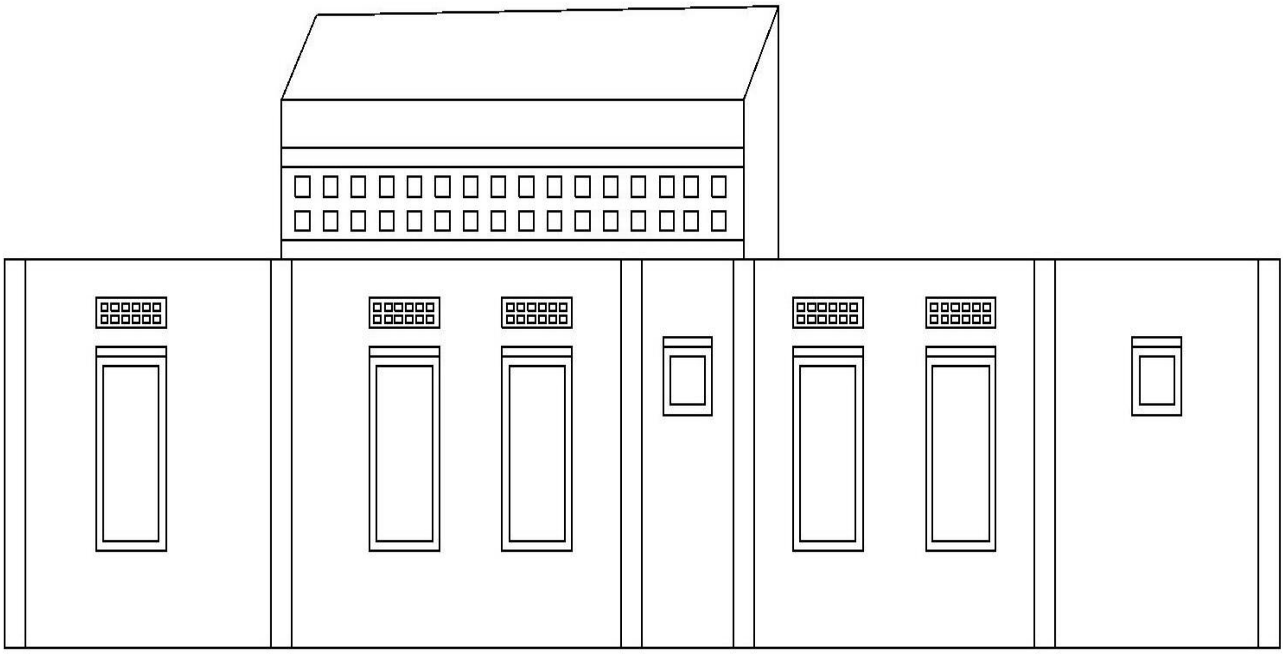

Fig.4.5 Side elevation east phase

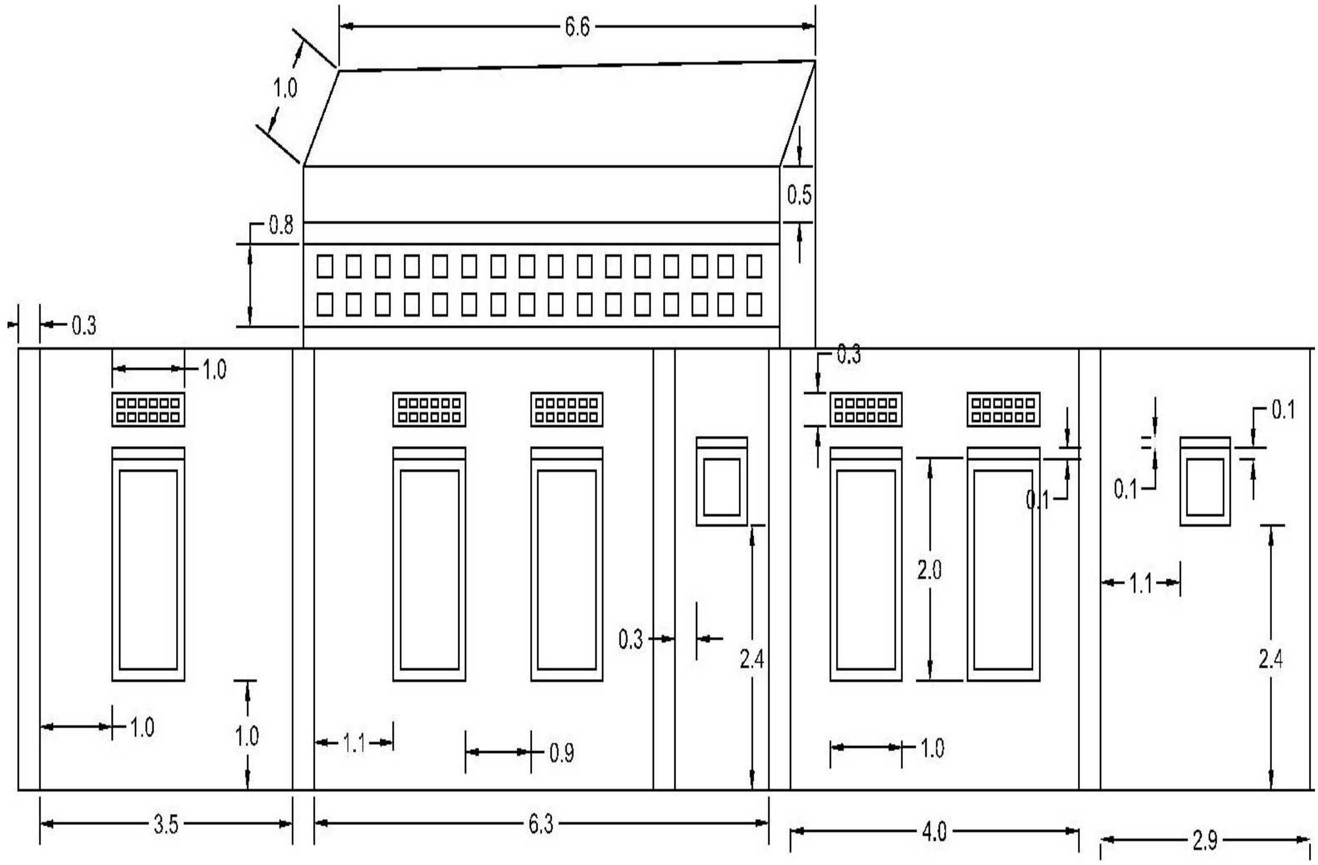

Fig.4.6 Side elevation east phase With Dimension

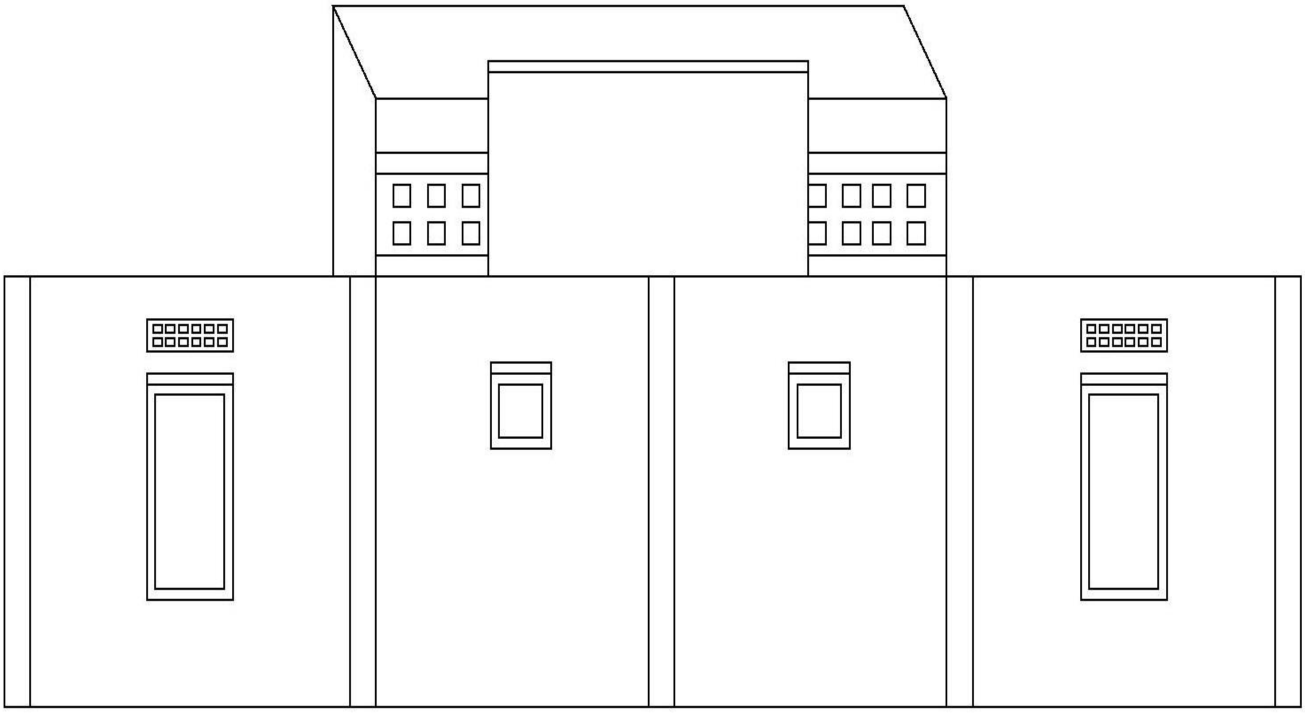

Fig.4.7 Side elevation east phase

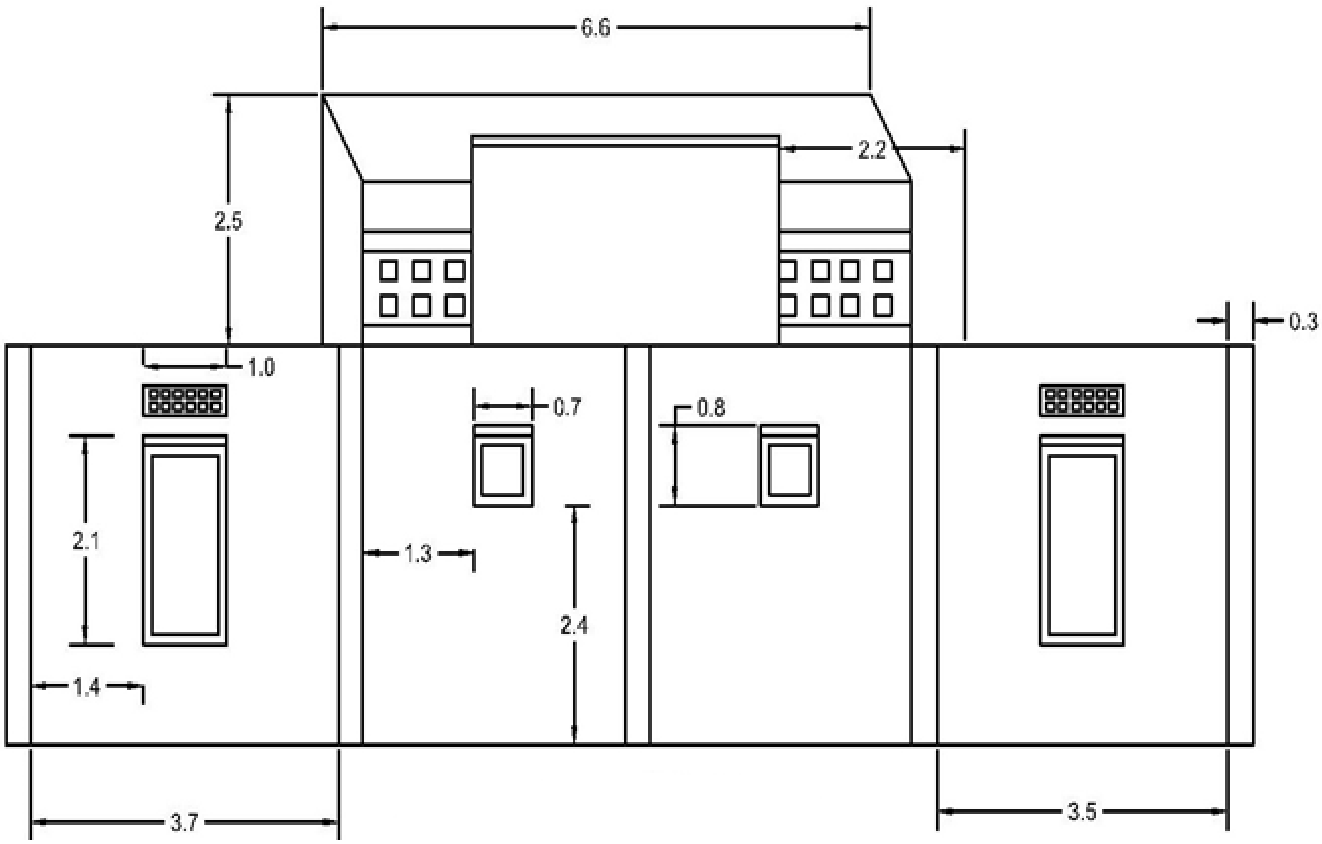

Fig.4.8 Side elevation east phase with Dimension

4.2 3D models in REVIT software

A south facing plan of 20m X 10m is taken to construct a single storey residential building in a hot and dry region. Using Autodesk Revit Architecture, the plan is modeled both in a traditional conventional technique and in an innovative energy efficient green building.

In conventional building we have used the regular brick masonry, mortar and concrete. The normal plane window glass is used and the roof is made of concrete. The doors are made up of wood. The outer wall is 225mm and inner wall is 115m. On the other hand we have used various energy efficient techniques that are and will be beneficial for the environment as well as the occupants to live a healthy and better life. The site planning played a very important role for better orientation. Shorter sides of the rectangle are facing east and west to reduce heat gain. The outer wall is made of AAC blocks i.e. Autoclaved Aerated Concrete Block that are produced by materials using silica sand, cement, lime, gypsum, fly-ash, water and aluminum powder. The inner wall is made up of regular brick masonry only. The columns are made up of concrete that contain fly ash that replaces 30%-40% of cement. The roof is made up of concrete and on it a layer of extruded polystyrene of thickness 60mm with high R-value and good moisture resistance. The solar control glass is used inside of the window frames and also the mechanized aluminum louvers are provided. The fenestration design or overhangs are provided over the windows and doors facing outside of the building to cut off the direct glare of the sun. For ventilation and daylighting, tropical skylight is built up that has mechanized louvers and the roof of skylight is covered with a plastic translucent sheet that will allow daylight to pass through along with preventing the heat strokes to enter from the skylight.

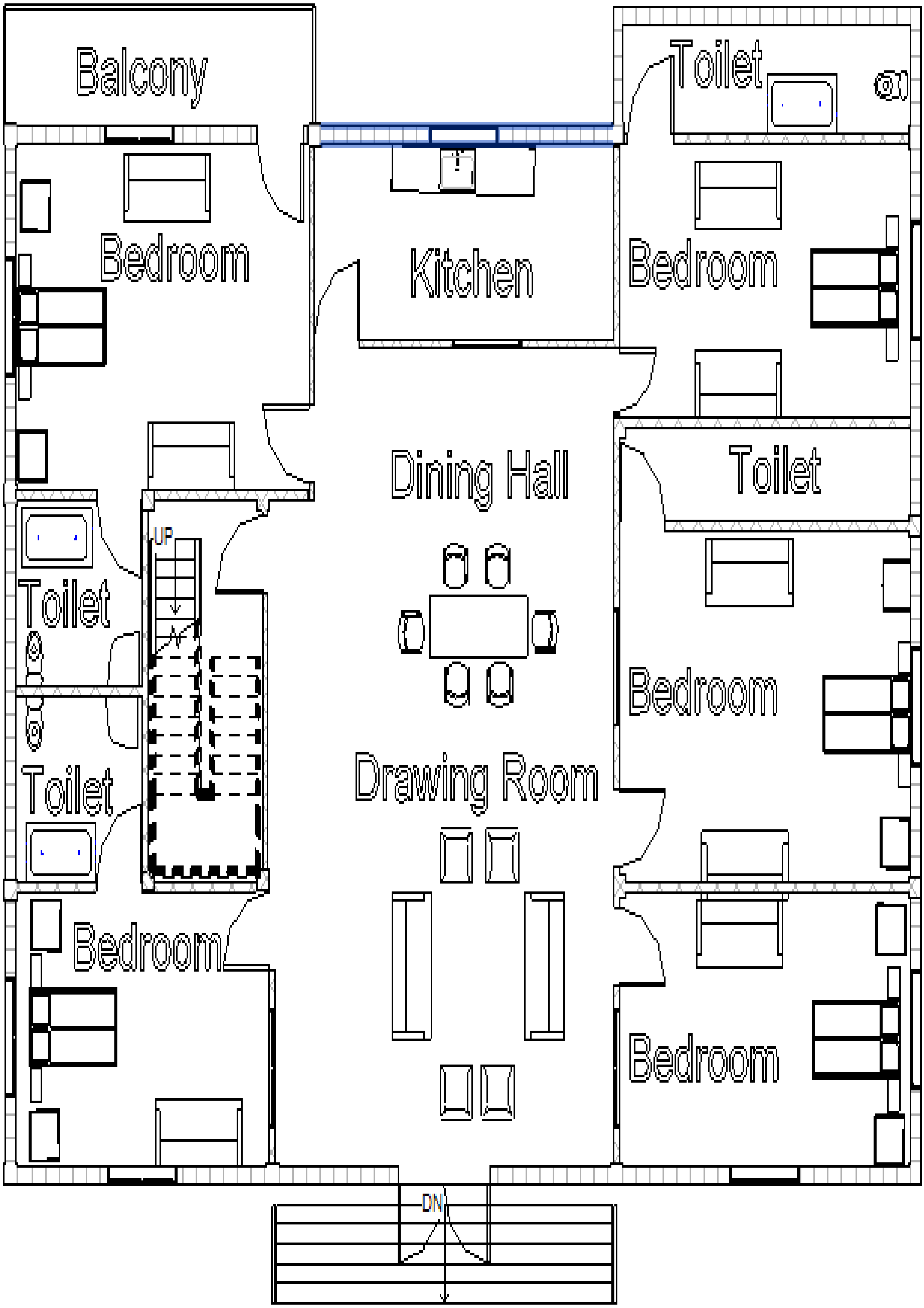

Fig.4.9 Plan of conventional building

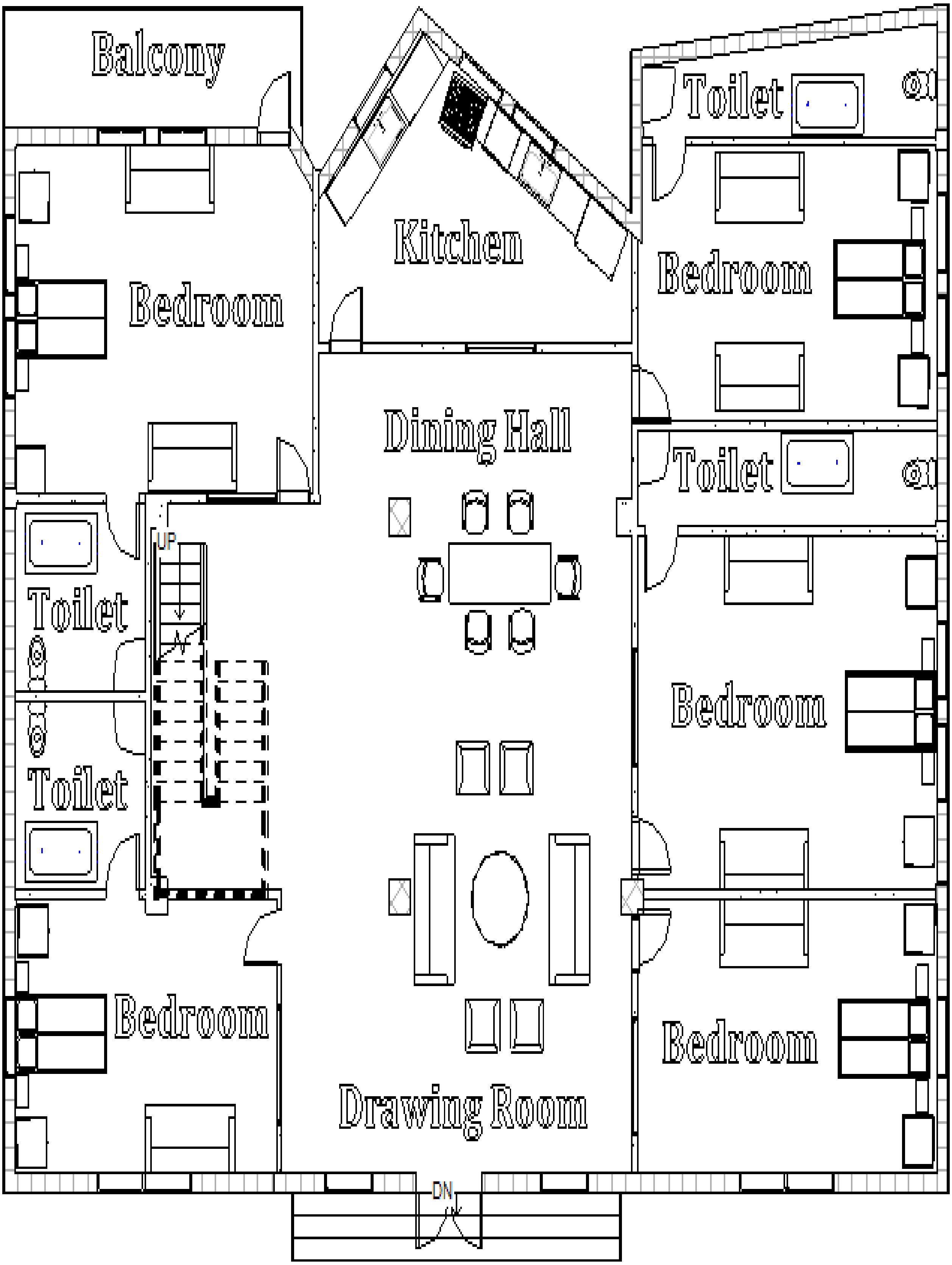

Fig.4.10 Plan of Green Building

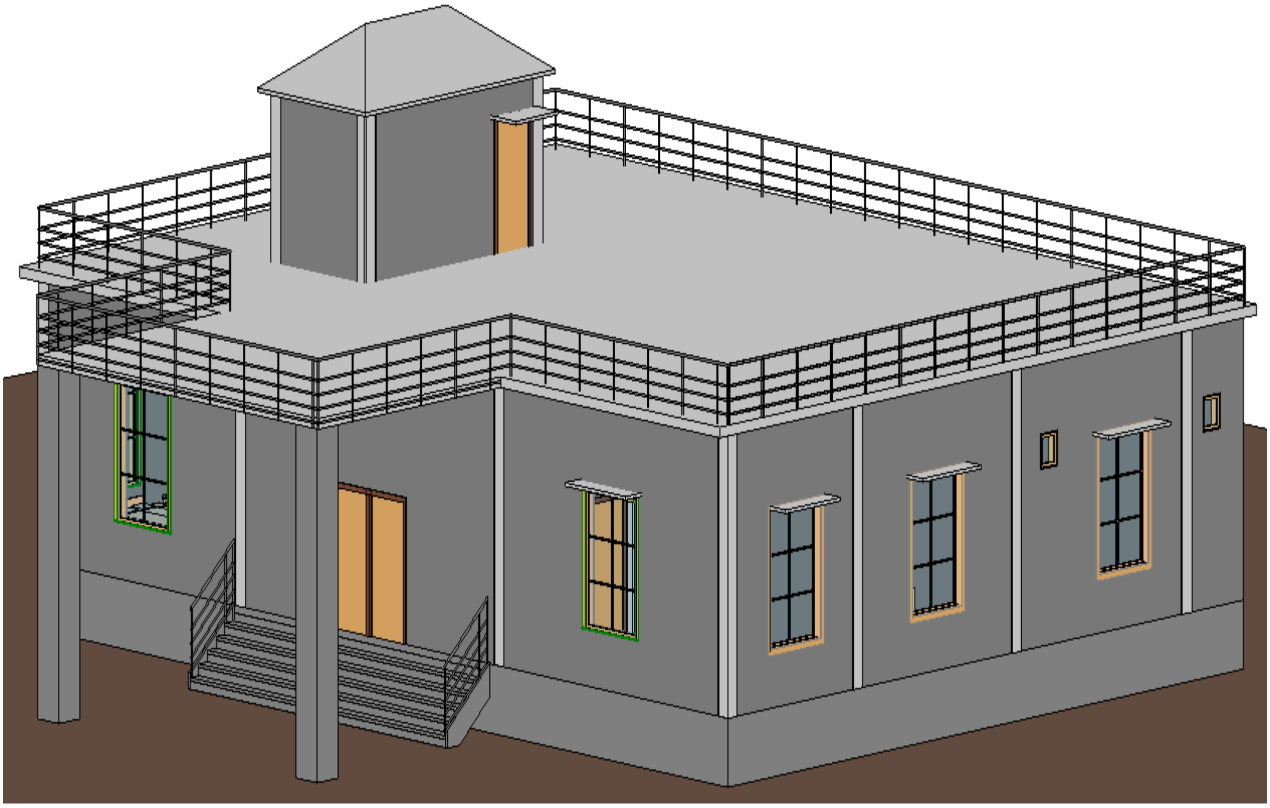

Fig.4.11 South East Elevation of Conventional Building

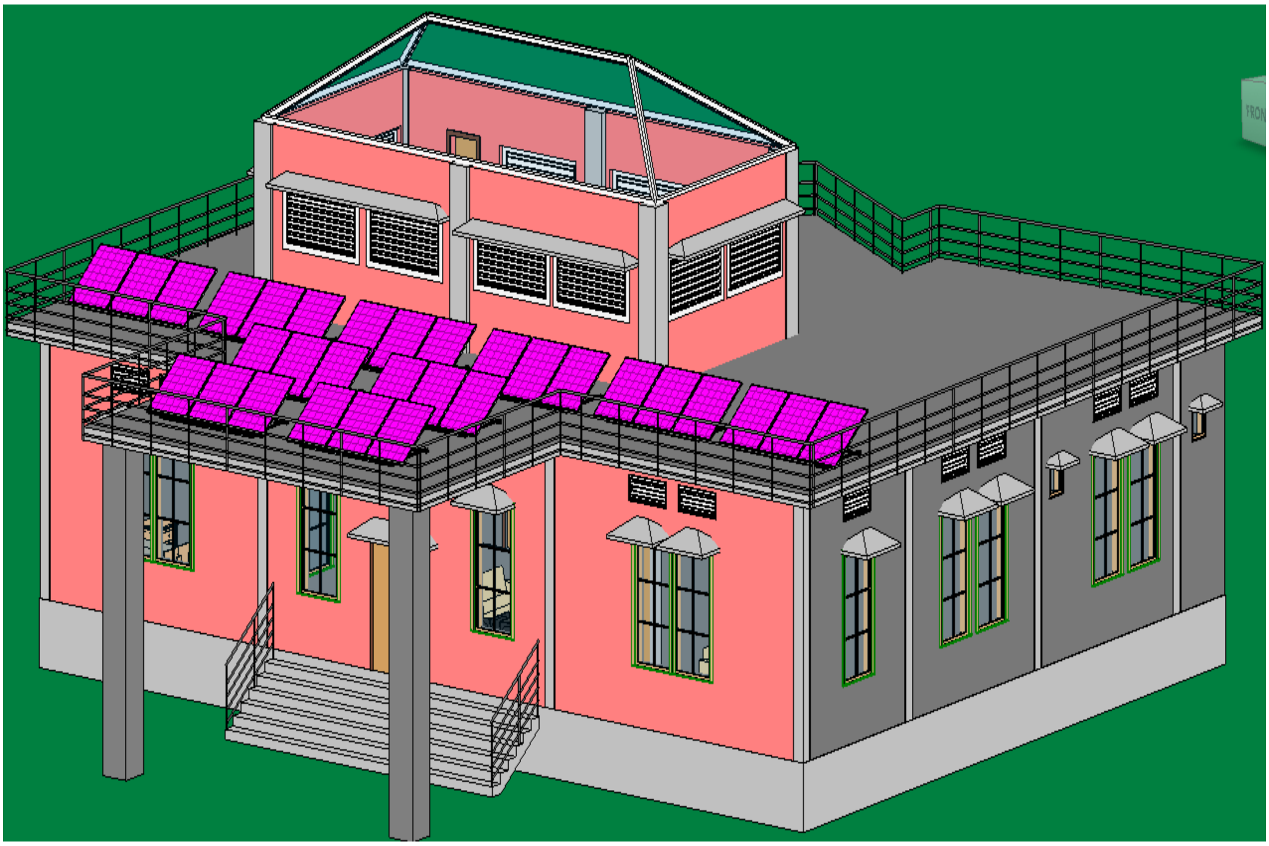

Fig.4.12 South East Elevation of Green Buildin

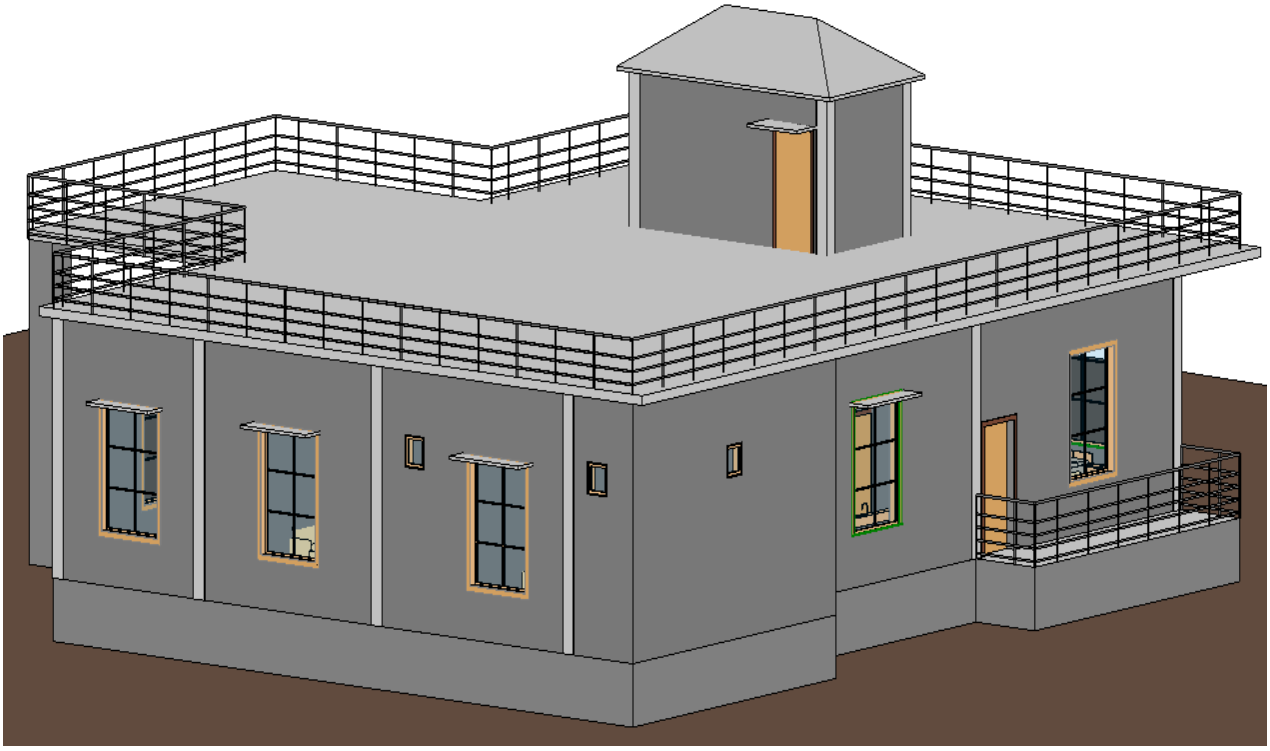

Fig.4.13 North East Elevation of Conventional Building

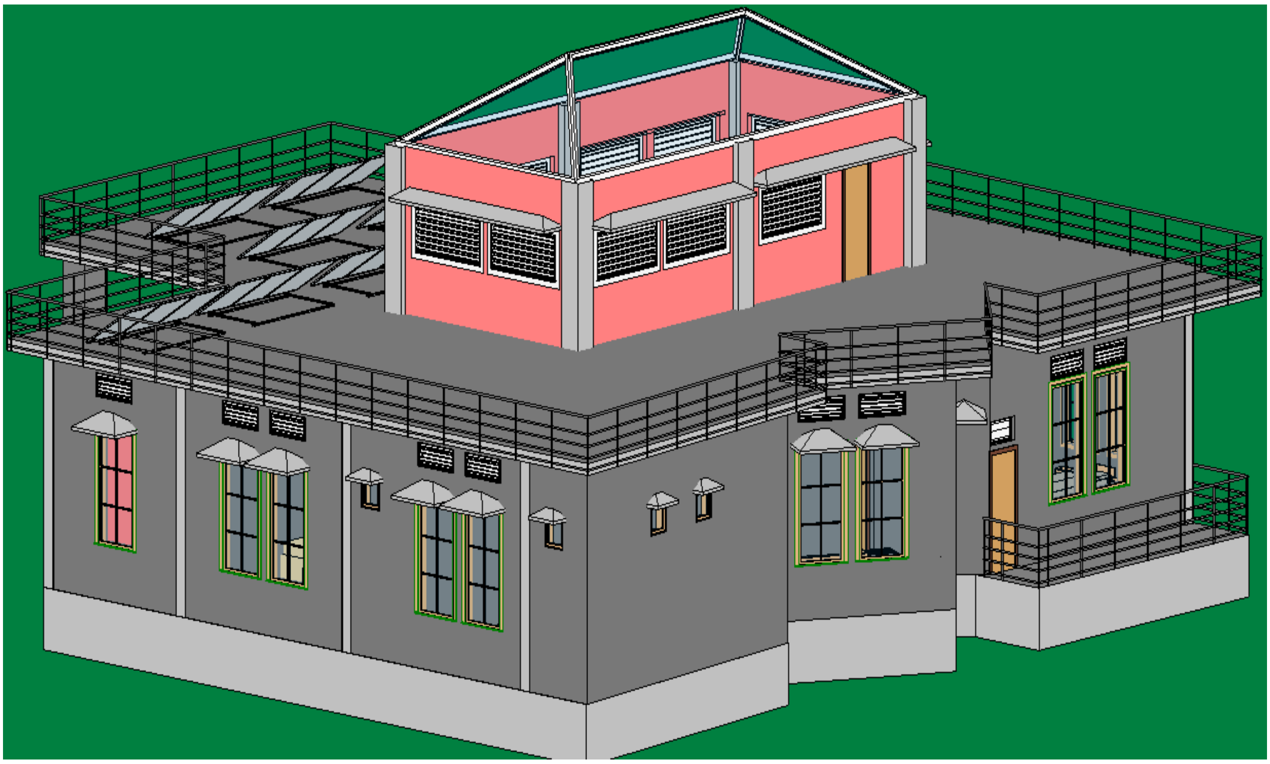

Fig.4.14 North East Elevation of Green Building

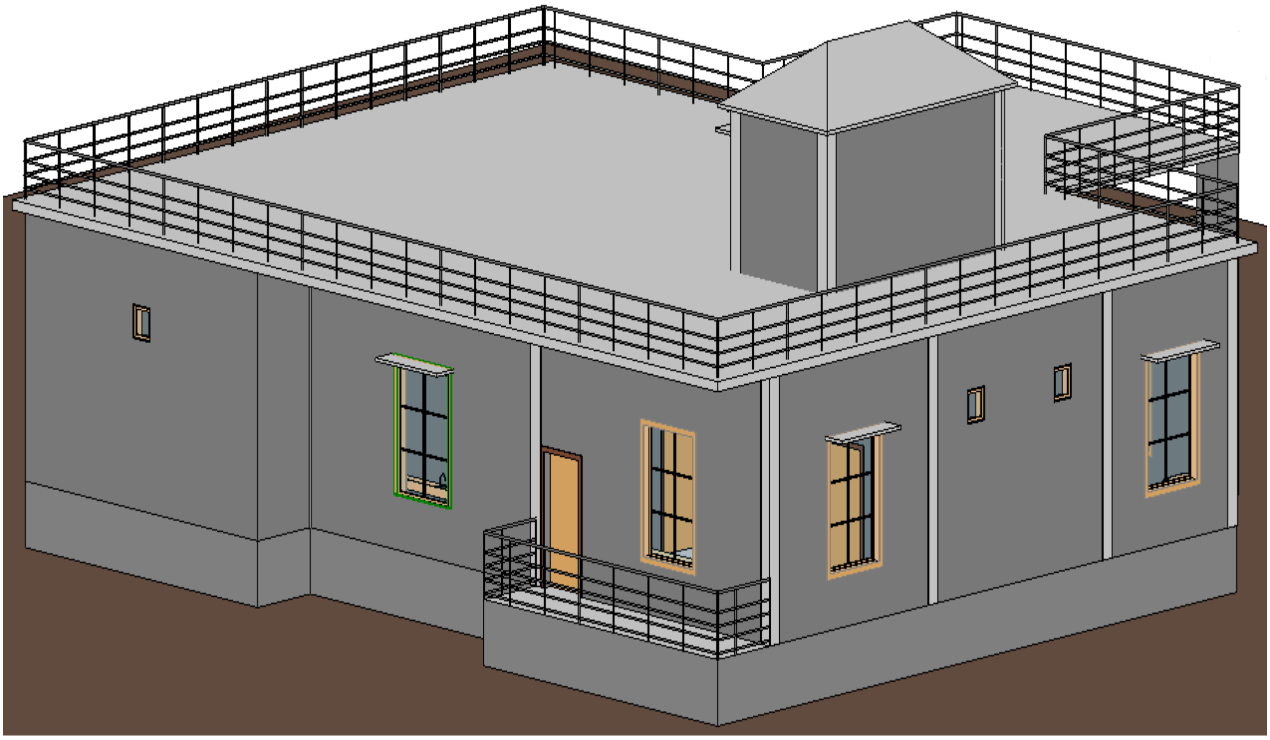

Fig.4.15 North West Elevation of Conventional Building

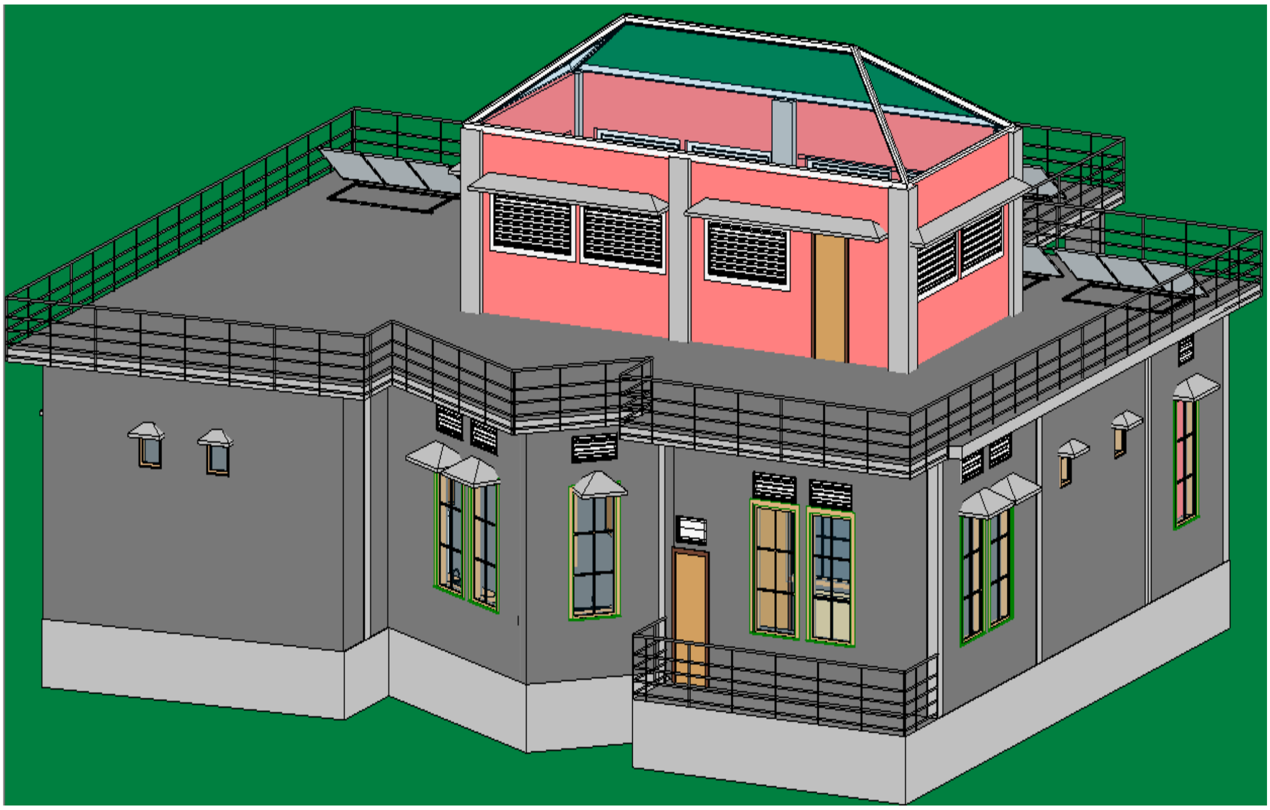

Fig.4.16 North West Elevation of Green Building

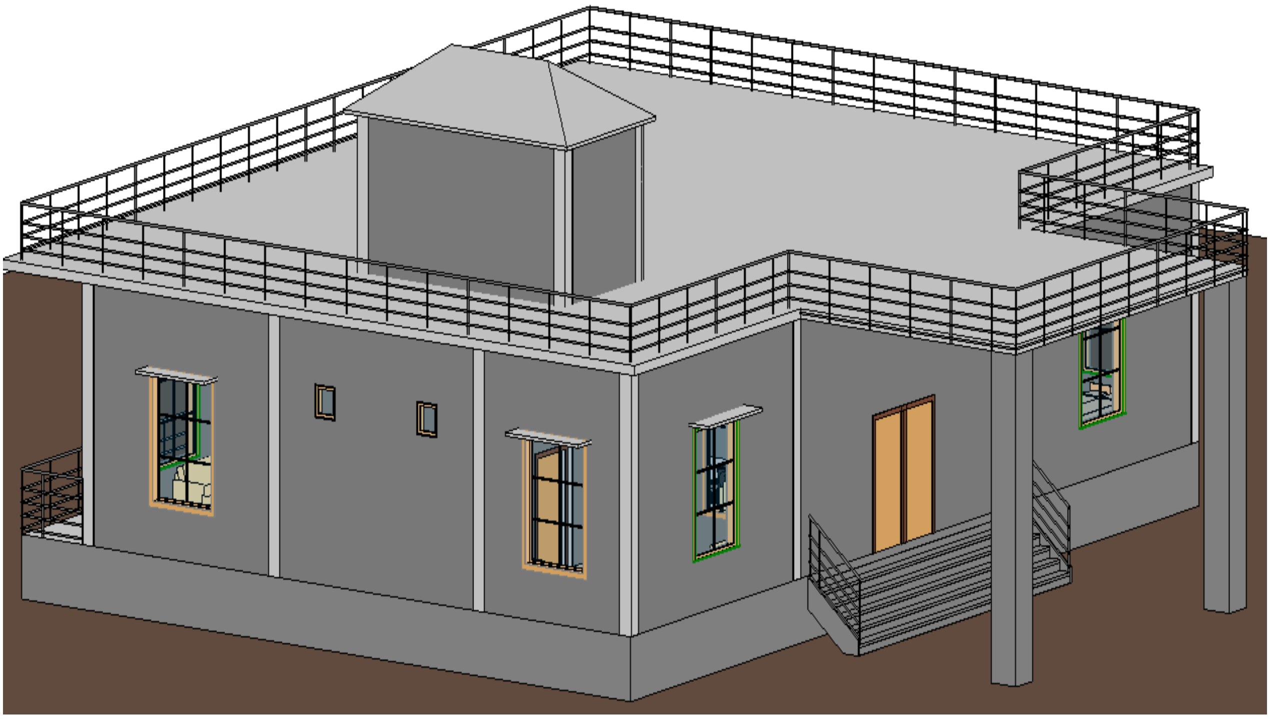

Fig.4.17 South West Elevation of Conventional Building.

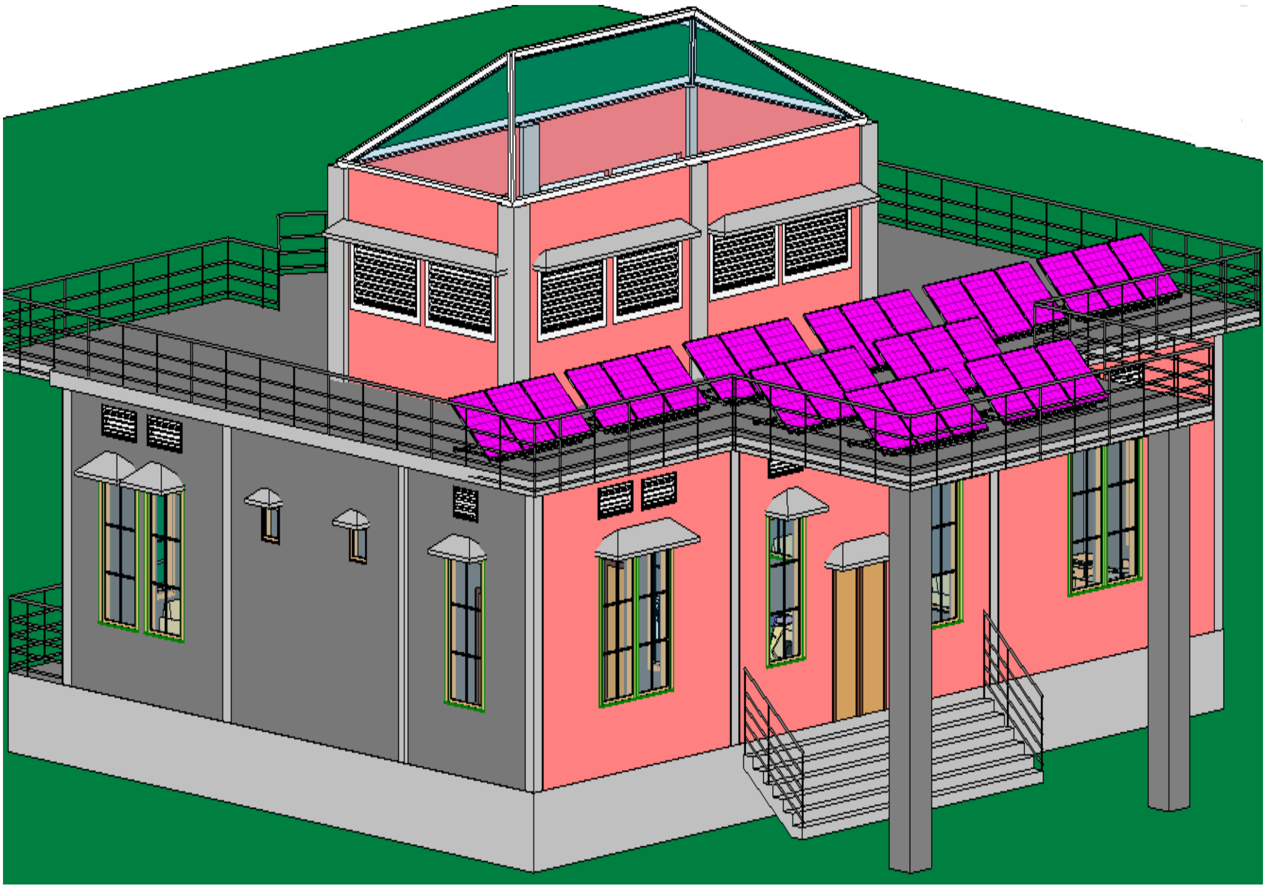

Fig.4.18 South west Elevation of Green Building

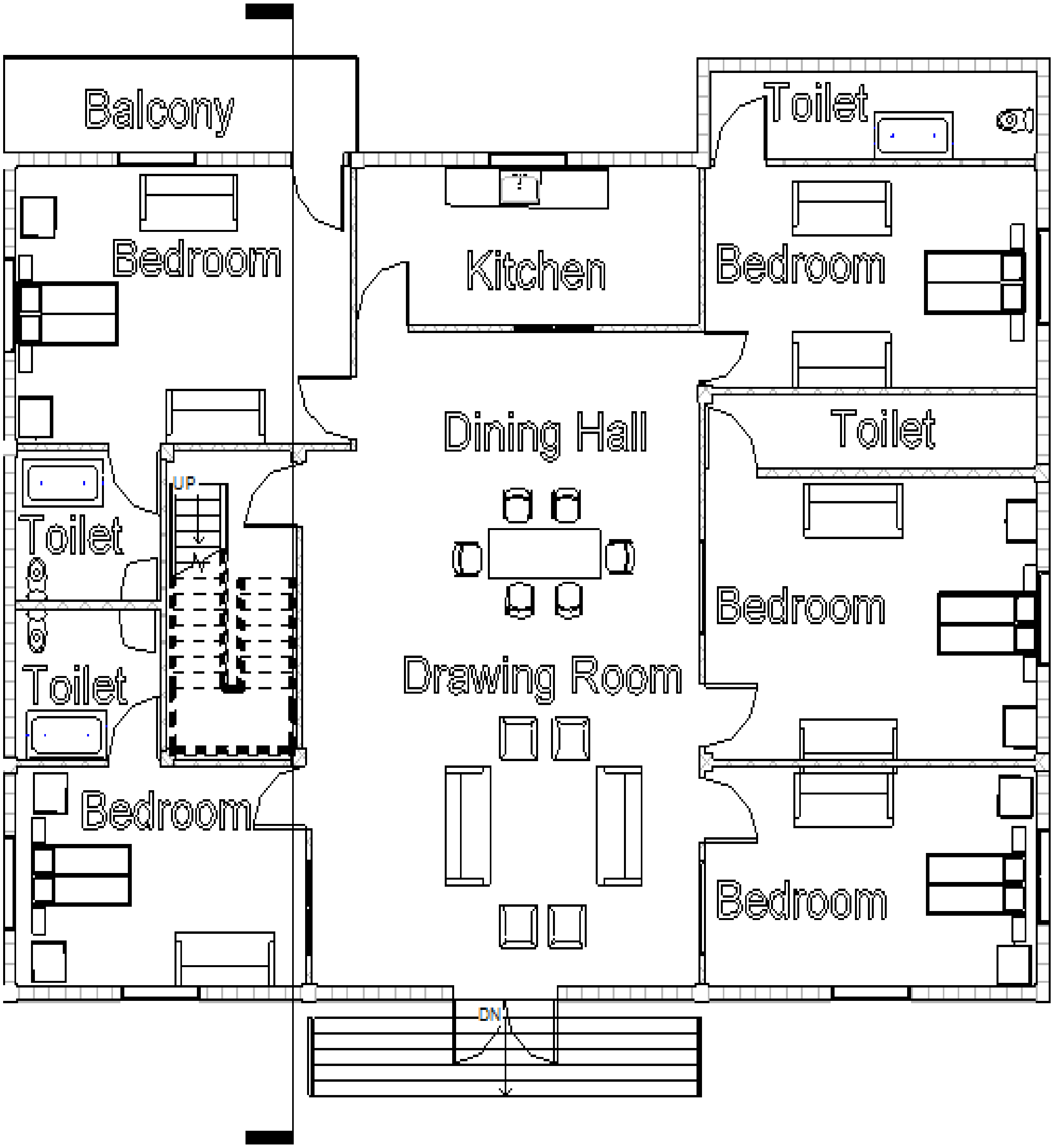

Fig.4.19 Section through Stair case Conventional Building

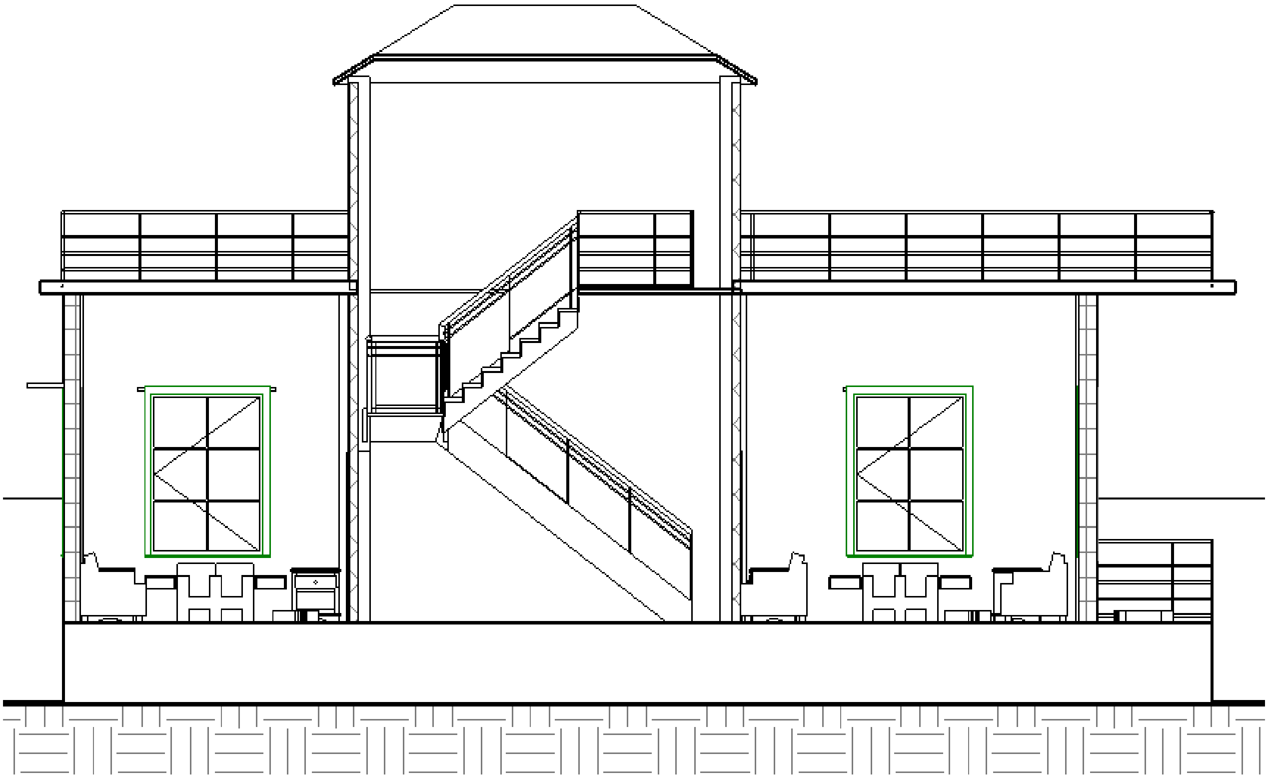

Fig.4.20 Sectional View of Stair Case Conventional Building

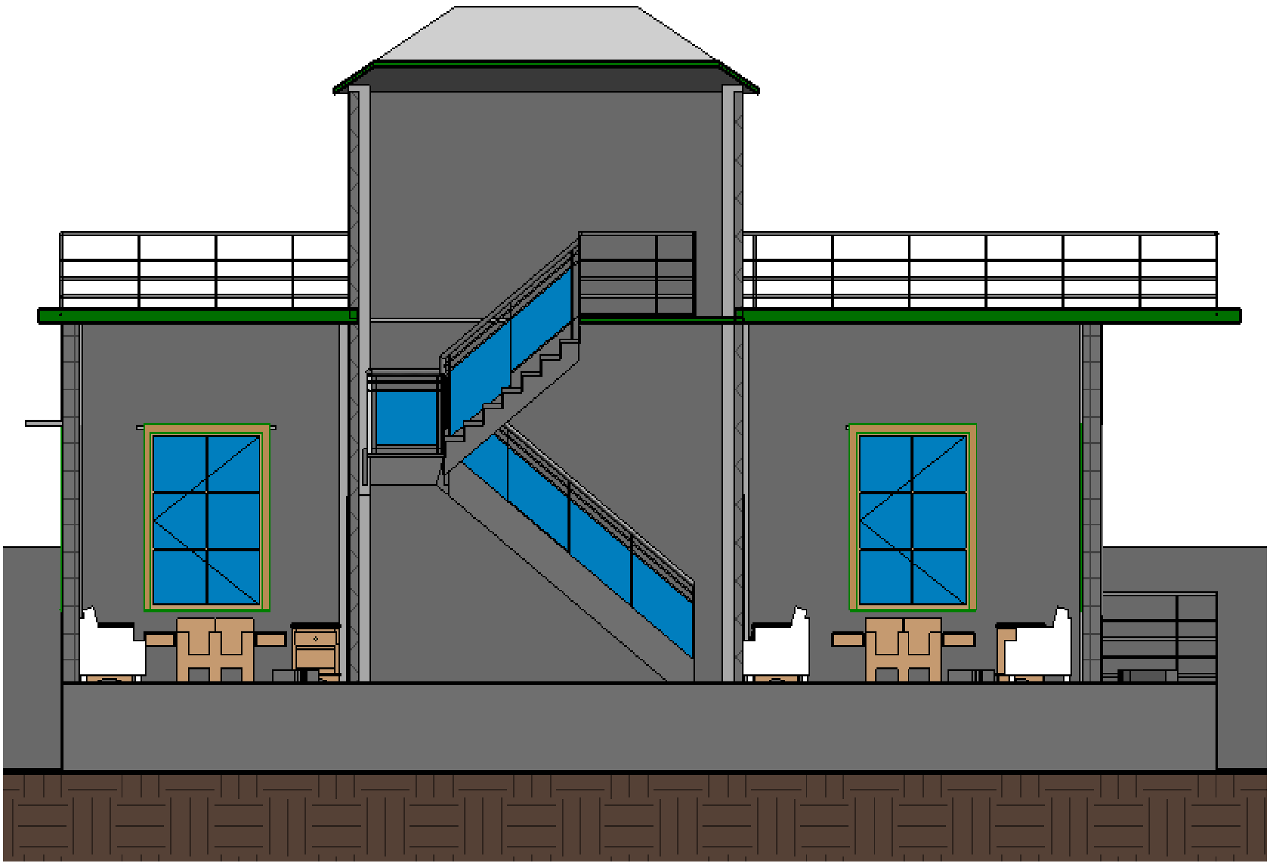

Fig.4.21 Sectional View of Stair Case Conventional Building

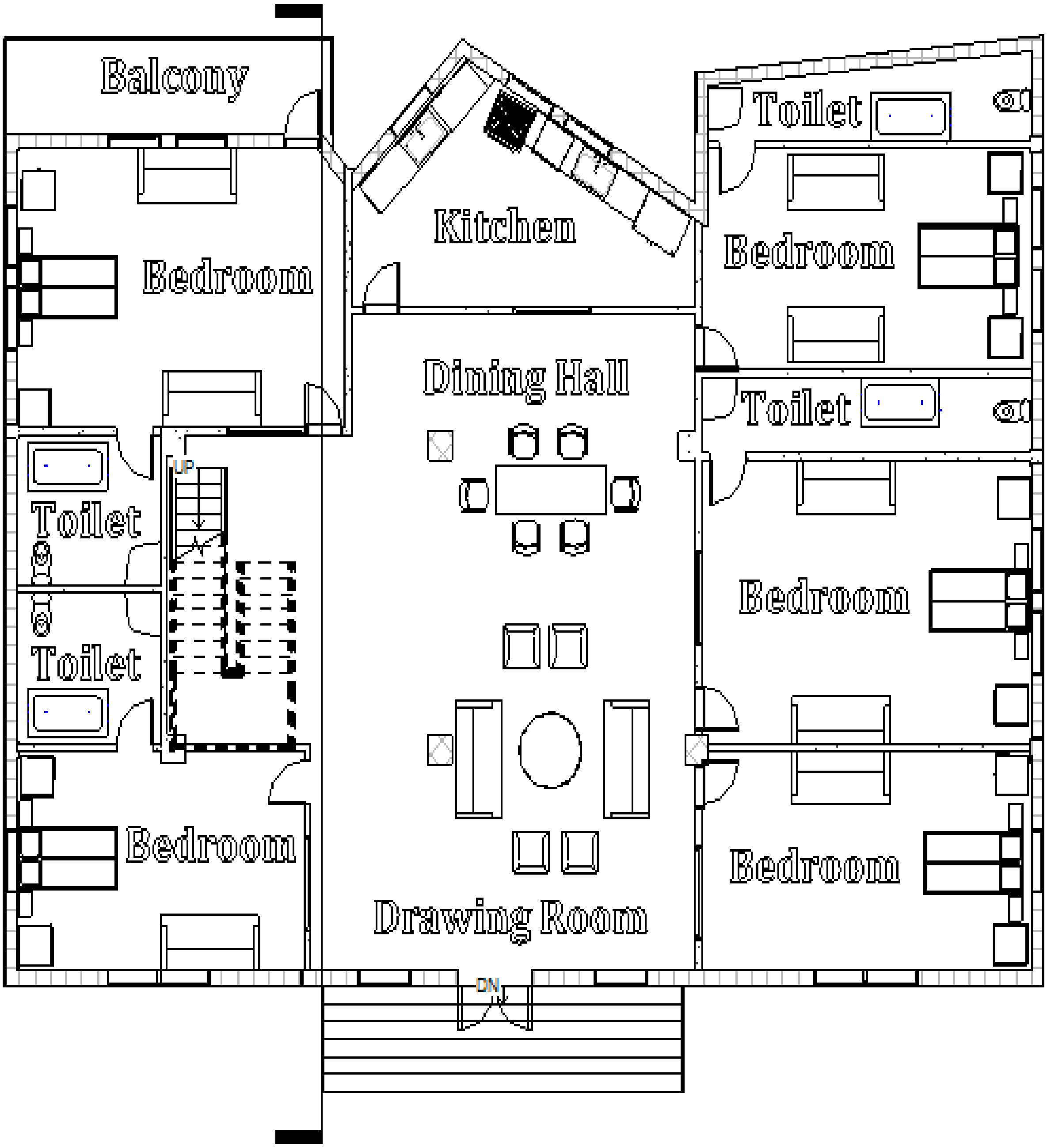

Fig.4.22 Section through Stair case Green Building

Fig.4.23 Sectional View of Stair Case Green Building

Fig.4.24 Sectional View of Stair case Green Building

Fig.4.25 Central hall of Conventional Building

Fig.4.26 Central hall of Green Building

Fig.4.27 Central hall of Green Building

Fig.4.28 Kitchen

4.2.1 Features included in Green Building

Builders, Architects and Service Consultants alike are constantly looking for ways to enhance energy-efficiency in buildings. Optimum level of building insulation not only helps lower monthly energy bills, but also adds to the overall comfort. Insulation helps maintain comfort temperature by reducing leakages. With the advent of green technologies and practices, today the potential to save energy by design can be as high as 40-50 %.Insulation in buildings is assuming tremendous importance and has a potential to reduce energy consumption to an extent of 5-8 %.

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.

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%

Extruded polystyrene (XPS):-Is a type of insulation material with a high R-value, good moisture resistance, high structural strength and low weight. Extruded polystyrene is used extensively as thermal insulation in industrial, commercial and residential construction. It is commonly used in wall and roof applications. The U-Value and R-Value of 10mm thick sheet is 2.10 and 0.47 respectively.

1. Durable and sturdy for long lasting applications
2. Lightweight and easy to handle
3. High compressive strength
4. Low moisture absorption
5. Long term retained R-values
6. Environmentally friendly - HCFC free

Polycarbonate Translucent sheet:-It is a versatile material used extensively as a rooflight glazing. It is very resistant to impact, transmits high levels of light, is relatively easy to use and it has a good fire rating. Polycarbonate is one of the newer plastics to be used in the construction industry around the world.

Sheet form Polycarbonate (PC) comes in two sheet forms, each with its own particular characteristics and properties: Solid (flat or domed) polycarbonate offers good optical clarity and superb workability. It can be cold-curved on site, is suitable for use with a variety of glazing bar systems, and can be moulded into various shapes such as domes and pyramids.

Columns:-They are made up of concrete using fly ash in the ratio 1:2:4. First of all, the spherical shape of fly ash creates a ball bearing effect in the mix, improving workability without increasing water requirements. Fly ash also improves the pump-ability of concrete by making it more cohesive and less prone to segregation. The spherical shape improves the pump-ability by decreasing the friction between the concrete and the pump line. In addition, some fly ashes have been shown to significantly decrease heat generation as the concrete hardens and strengthens. Fly ash, as do all pozzolanic materials, generally provide increased concrete strength gain for much longer periods than mixes with portland cement only.

The biggest reason to use fly ash in concrete is the increased life cycle expectancy and increase in durability associated with its use. During the hydration process, fly ash chemically reacts with the calcium hydroxide forming calcium silicate hydrate and calcium aluminate, which reduces the risk of leaching calcium hydroxide and concrete's permeability. Fly ash also improves the permeability of concrete by lowering the water-to-cement ratio, which reduces the volume of capillary pores remaining in the mass. The spherical shape of fly ash improves the consolidation of concrete, which also reduces permeability.

Other benefits of fly ash in concrete include resistance to corrosion of concrete reinforcement, attack from Alkali-silica reaction, sulfate attack and acids and salt attack.
The use of high volume fly ash concrete has gained increasing acceptance by structural engineers and architects from an environmental standpoint, as well as the life cycle cost approach. When designing and specifying concrete for strength and durability, the proper selection of constituent materials depends on the exposure conditions, type of structure and intended use. For applications such as footings, columns, walls and beams, where surface exposure is minimal, high volume fly ash concrete mixes may be used effectively. For mass concrete placements such as mat or raft foundations, the use of even higher quantities of fly ash is recommended.

Solar control glass:-It plays a unique and important role in building design and the environment. It affects design, appearance, thermal performance and occupant comfort. The selection of the right glass is a crucial component of the design process. India being a tropical country, we need to be careful while selecting a glass. Selection of glass has become more complex since a variety of glasses are available to choose from, ranging from performance to aesthetics. The properties of glass have also become multifaceted, able to perform a wide variety of functions, like Solar Control to Thermal Insulation. Solar and thermal performance will often be a high priority decision along with appearance (color, transparency and reflectivity). AIS products can help architects achieve LEED/IGBC or GRIHA certification for their projects in a number of areas such as energy performance, recycled content, regional material, daylight and views.

A Green building is one which conserves energy and preserves natural resources.
Solar control glass plays a very important role on green buildings. They cut the heat , allow optimum light inside the building . Thus saving air conditioning cost and cost of artificial lighting. These are glass solutions for green building rating as per ECBC norms. These glass products enable green ratings like LEED and GRIHA. For any green building rating, the glass used on the façades/windows should comply with performance parameters. Read on to learn about products range and performance parameters and how to choose glass.

By using energy efficient Glass in buildings, we gain by

1. Reducing operating energy.
2. Saving on energy, cooling and lighting cost by 25-40%
3. Earning you a payback in 3-4 years
4. Increasing the asset value of the building

Solar Control Glass is the best green building glass for Commercial and Large Residential Buildings.

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.

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 R-value 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.

3. Solar gain: (also known as solar heat gain or passive solar gain) refers to the increase in temperature in a space, object or structure that results from solar radiation. The amount of solar gain increases with the strength of the sunlight, and with the ability of any intervening material to transmit or resist the radiation.

4. Light transmission: This is a measure of light entering through the glass into the building. A good green building glass will allow optimal light transmission. It is the fraction of visible light energy that makes it through the window glass. The higher the fraction, the more visible light will reach into the room. Maximizing VT while getting the right combination of U-factor and SHGC, particularly with low e coatings, can be challenging. All three properties must be considered and balanced to evaluate window performance. NFRC ratings for U-factor and SHGC are whole window ratings, not glass only ratings.

The lower the U-value, shading co-efficient and relative heat gain the more energy efficient the building.

A low e coating is a thin, nearly invisible metallic coating on glass that lowers the emissivity of the glass. The effect of the coating is to lower a window's U-factor, improving its performance as a thermal insulator. There are at least two major categories of low e coatings: soft coat low e (also known as vacuum deposition or sputtered low e) and hard coat low e (also known as paralytic

low-e). Within each category, different formulations are possible. Spectrally selective low e coatings are formulated to achieve a low SHGC.
Which type of low e coating has been applied by the glazing manufacturer is not important as long as the window's NFRC label verifies that the window's U-factor and SHGC are appropriate for the window's purpose. A low e window designed for the south wall of a passive solar house should have a low U-factor coupled with a high SHGC. The National Fenestration Rating Council (NFRC) rates windows on three criteria: U-factor, SHGC, and visual transmittance (VT).

The shading devices and window size and disposition vary according to the orientation of the walls. In addition, at the initial design stage, the architects ensured appropriate depth of the plan to maximize daylight penetration into the interior. The highlights of the solar passive features are optimum window disposition and sizing to allow maximum daylighting, while minimizing adverse thermal effects. However, indiscriminate increase of glazing area to achieve this is counterproductive of causing glare and over-heating of the building. The glare from uncontrolled daylight necessitates the use of curtains and blinds with resultant increase in use of artificial lighting and cooling load.

4.2.2 Daylight Orientation

Sun path orientation at different timings of the day to analyses the position of sun and then adjusting the orientation of windows and doors and also the design of fenestration accordingly to cut off the direct glare of sun during summers and allowing sunlight during winter season. We have taken 21^{st} June, the biggest day of summer season and 21st December, shortest day to study the sun path during winter season.

Study of SunPath in 21st June at Different Time and Orientation in Green Building

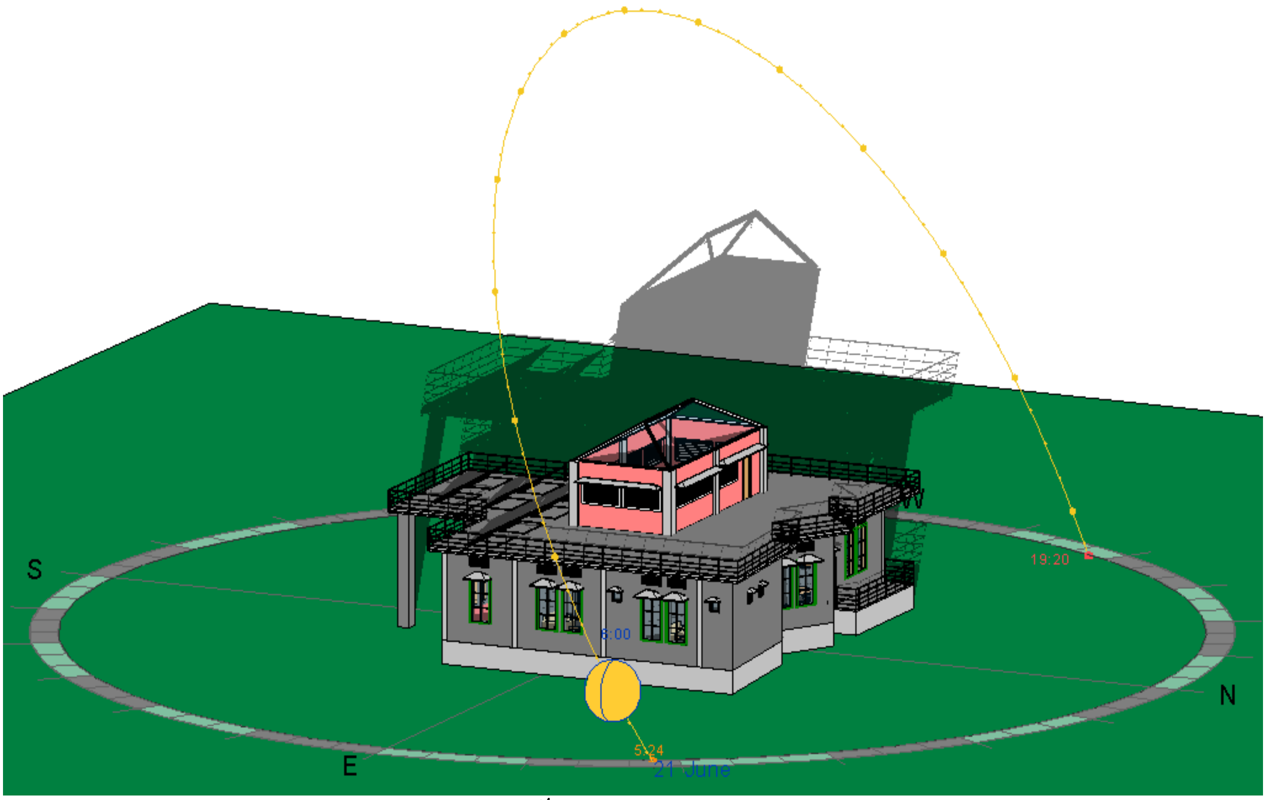

Fig.4.29 at 6:00 am 21st June North East direction top view

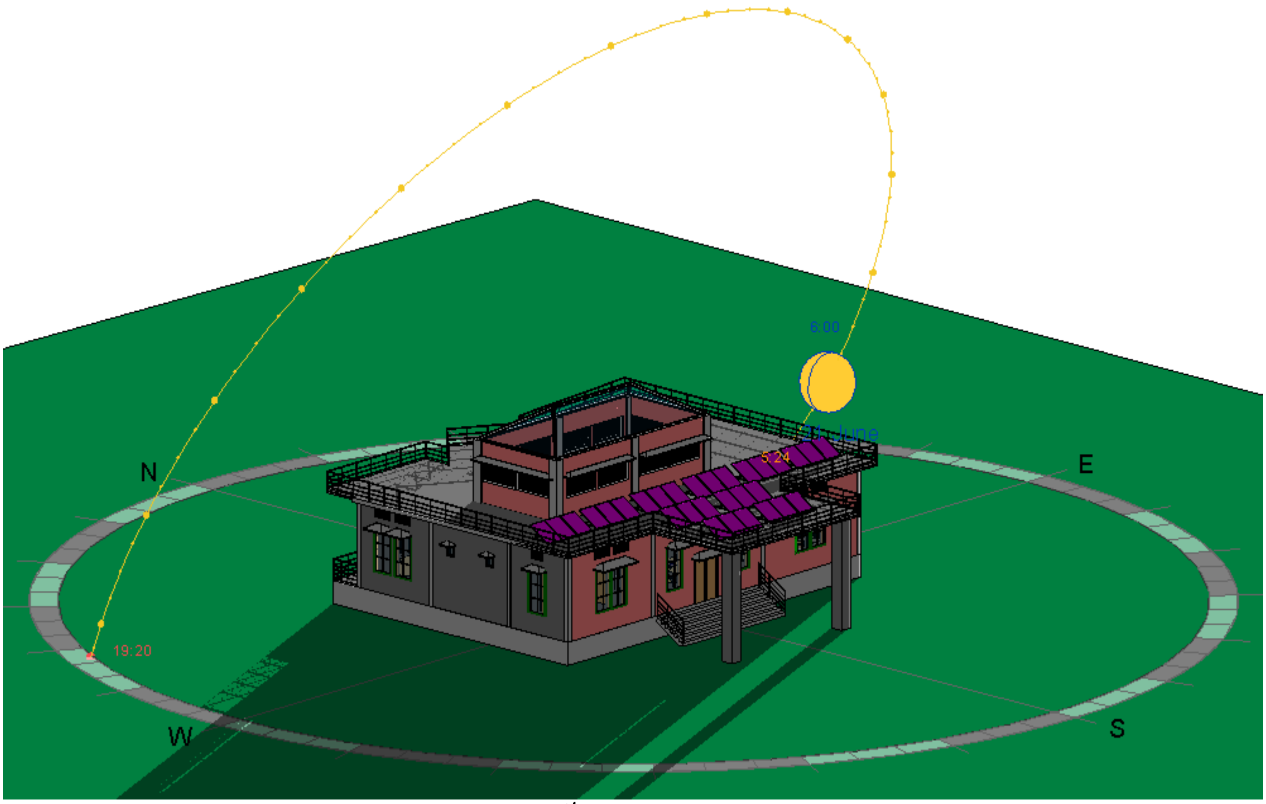

Fig.4.30 at 6:00 am 21st June South West direction top view

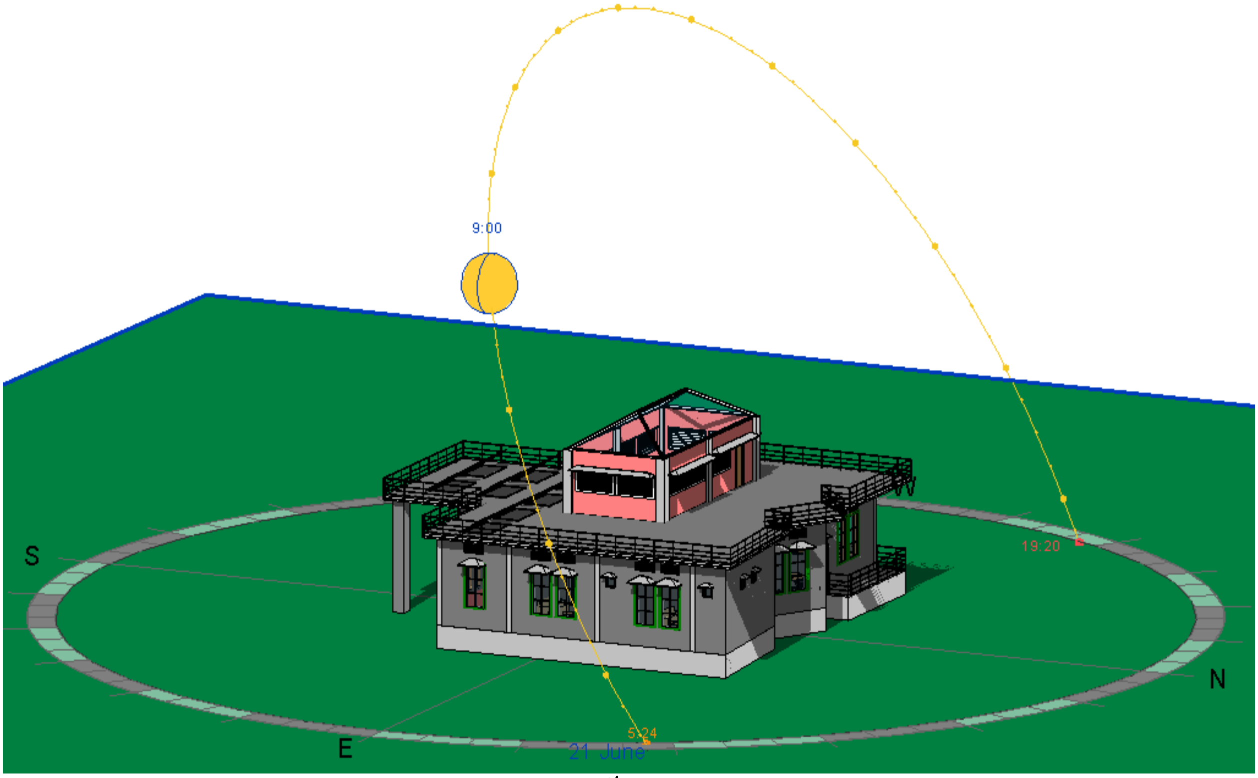

Fig.4.31 at 9:00 pm 21st June North East direction

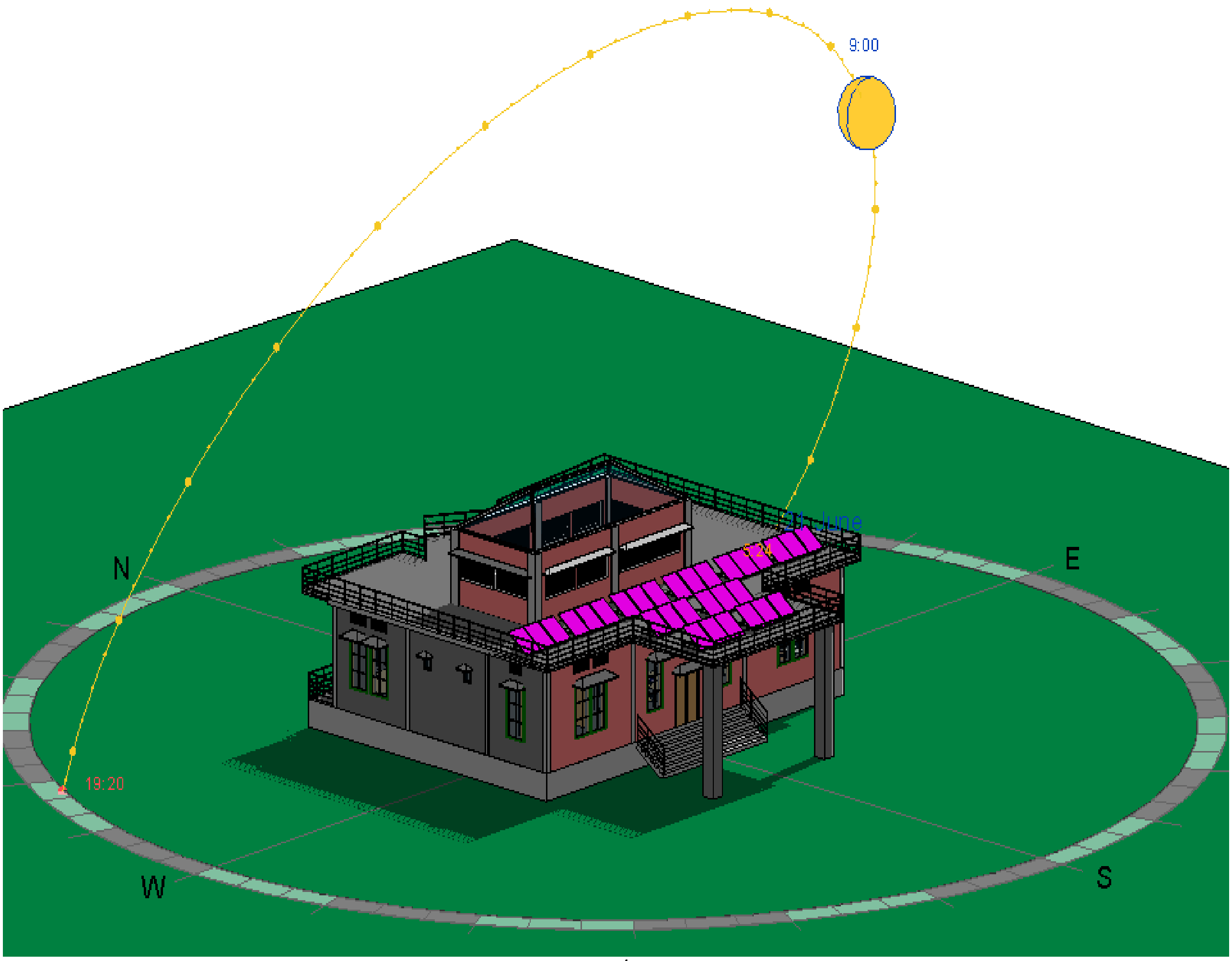

Fig.4.32 At 9:00 am 21st June South West direction

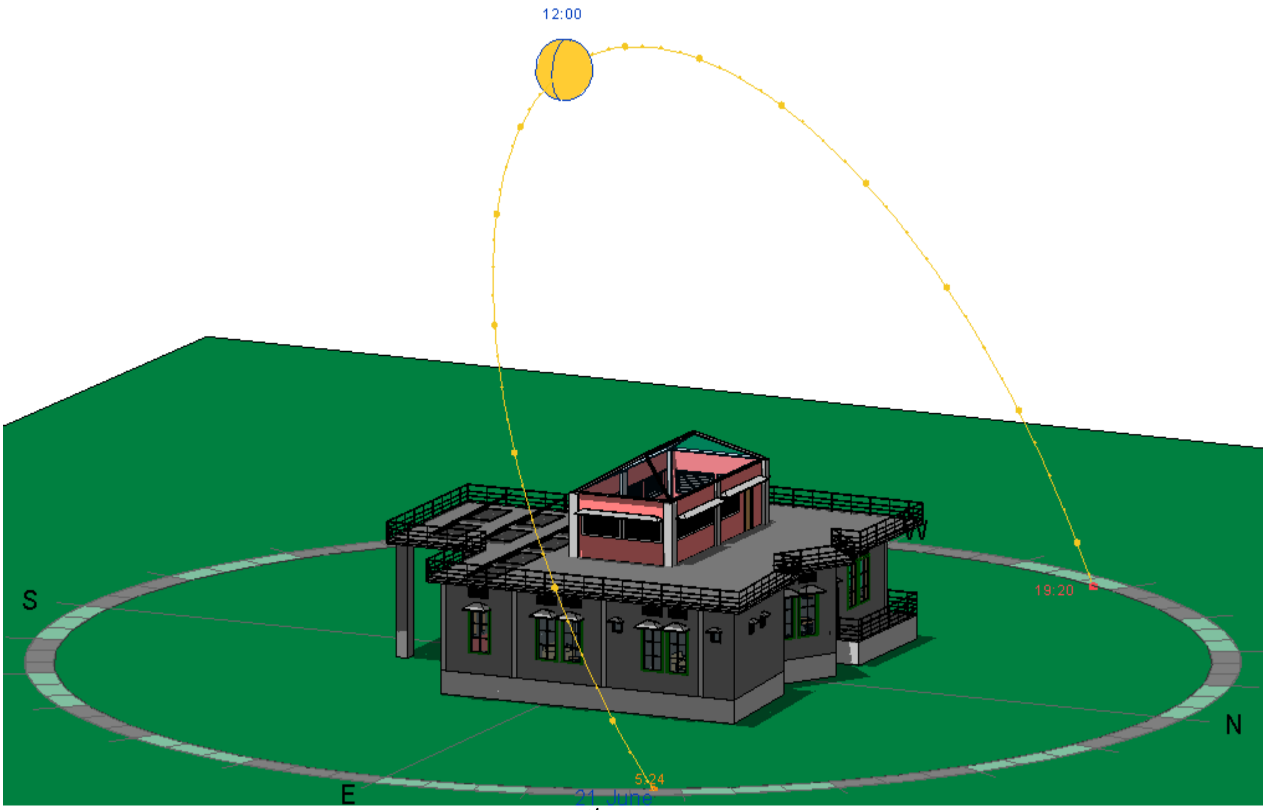

Fig.4.33 At 12:00 pm 21st June North East direction top view

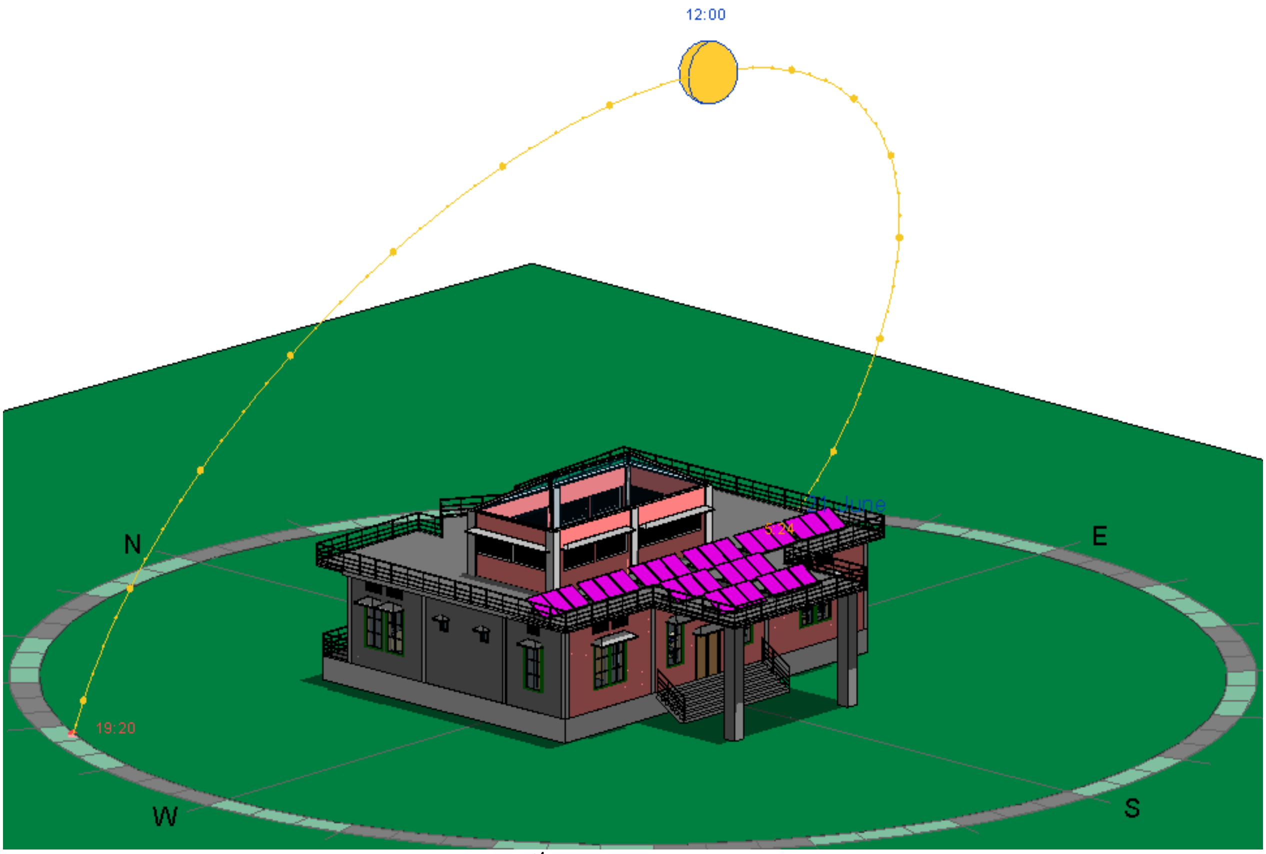

Fig.4.34 at 12:00 pm 21st June West South direction top view

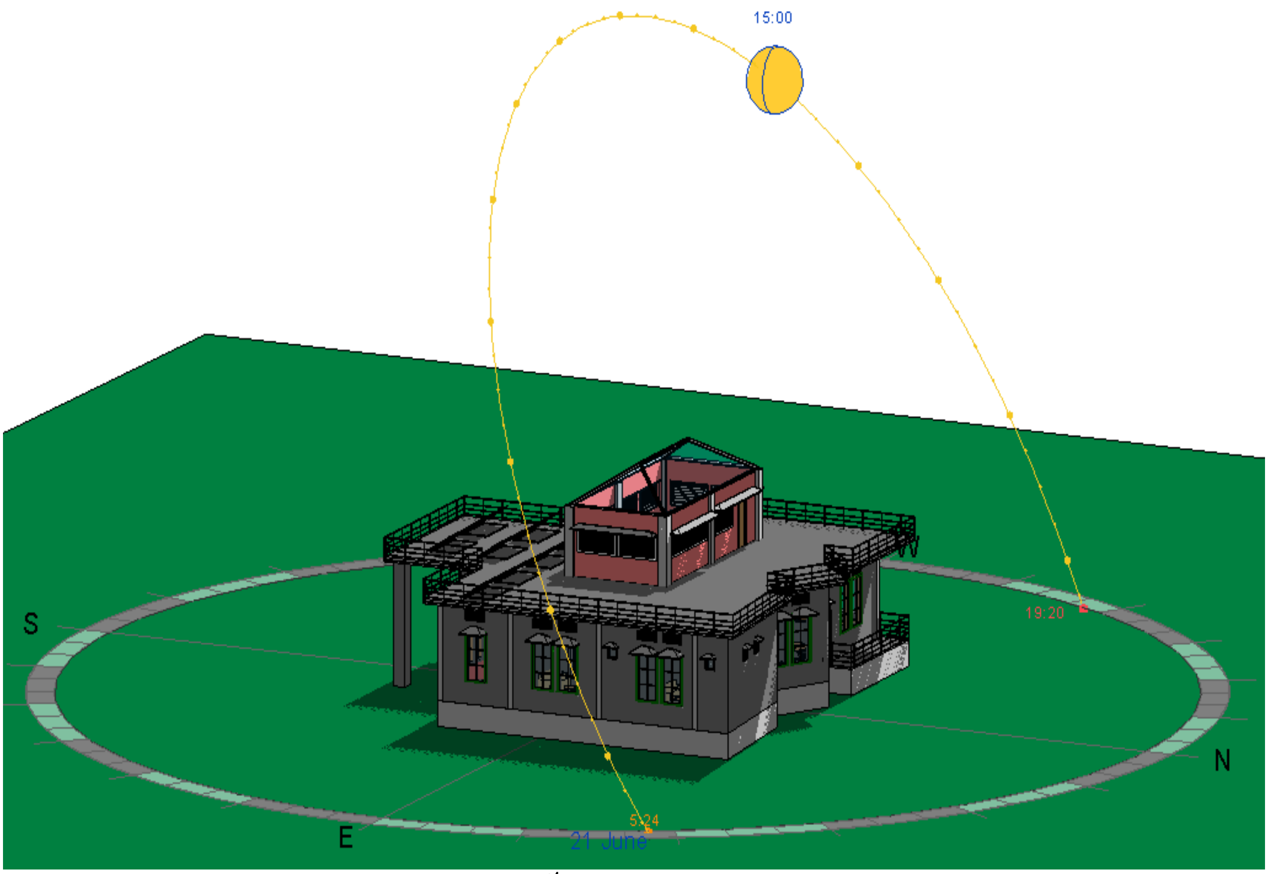

Fig.4.35 at 3:00 pm 21st June East North direction top view

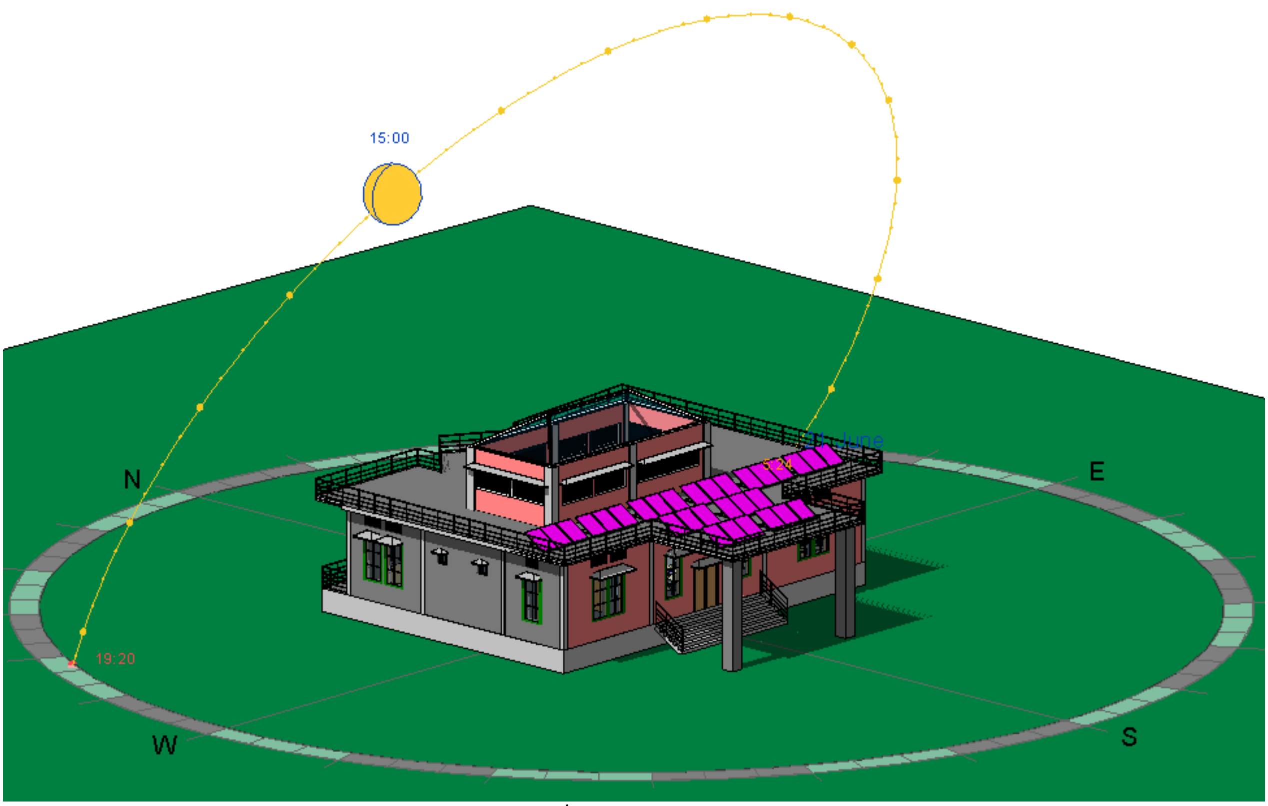

Fig.4.36 at 3:00 pm 21st June West South direction top view

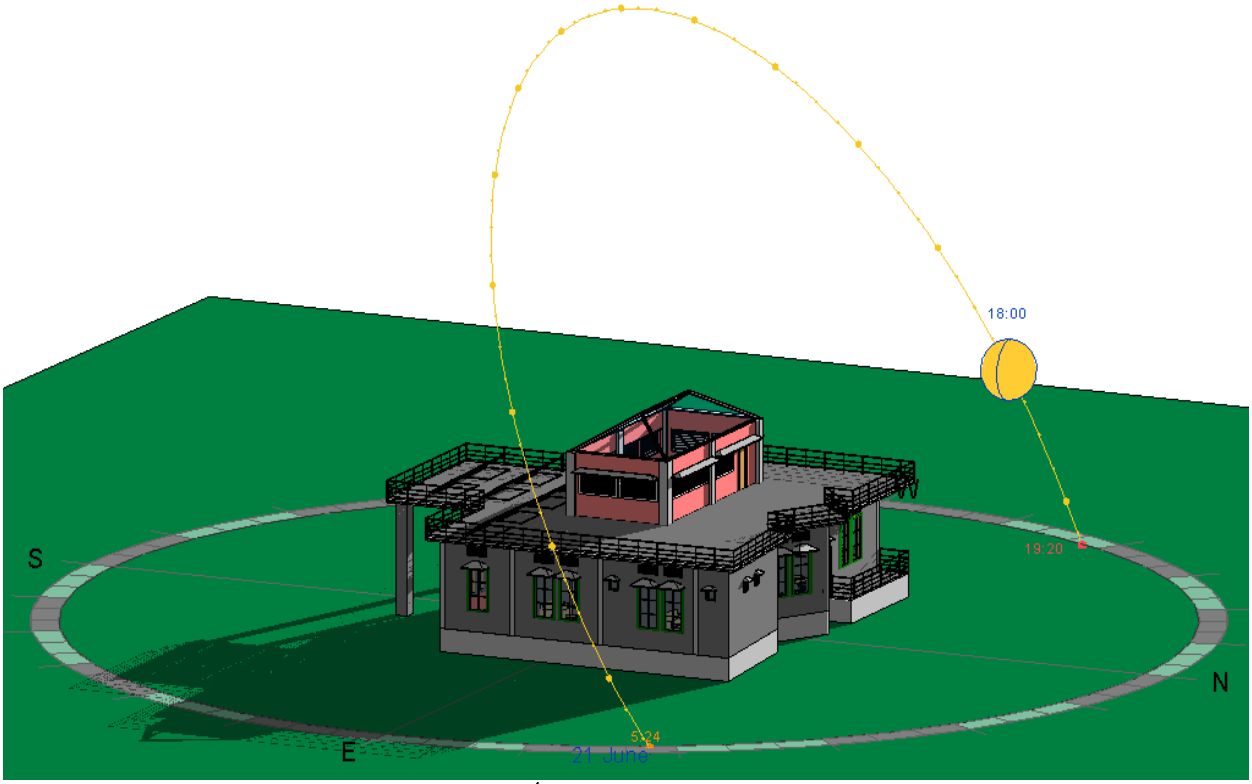

Fig.4.37 at 6:00 pm 21st June East North direction top view

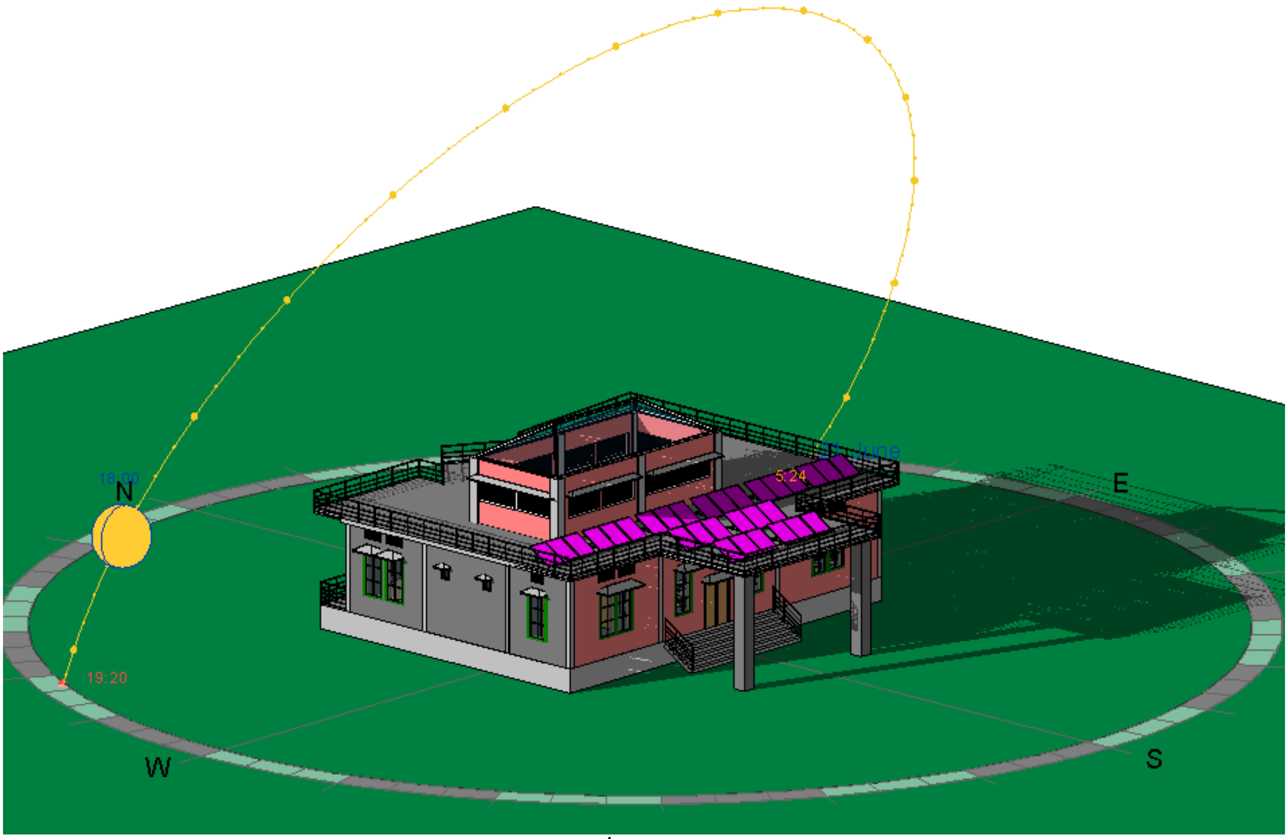

Fig.4.38 at 6:00 pm 21st June West South direction top view

Study of SunPath in 22nd December in Different Time and Orientation in Green Building.

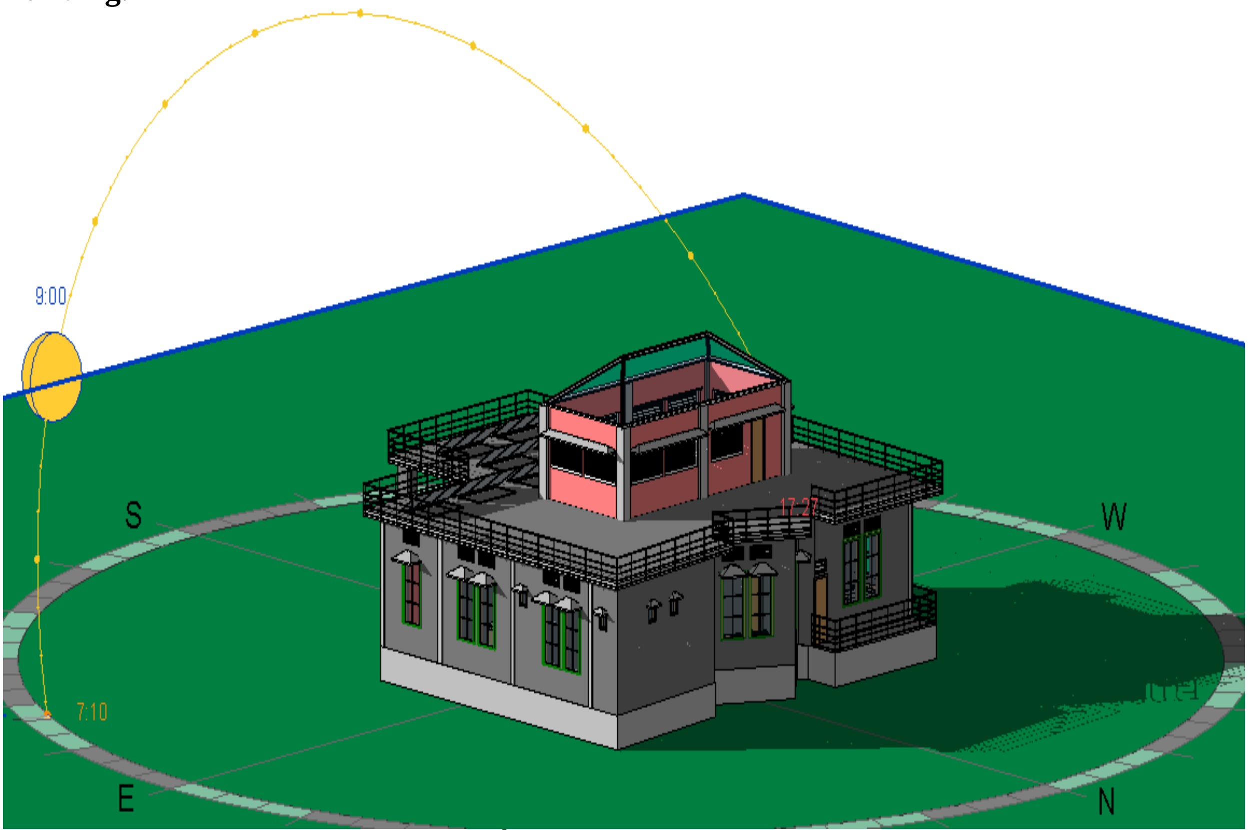

Fig.4.39 At 9:00 am 22nd December East North direction top view

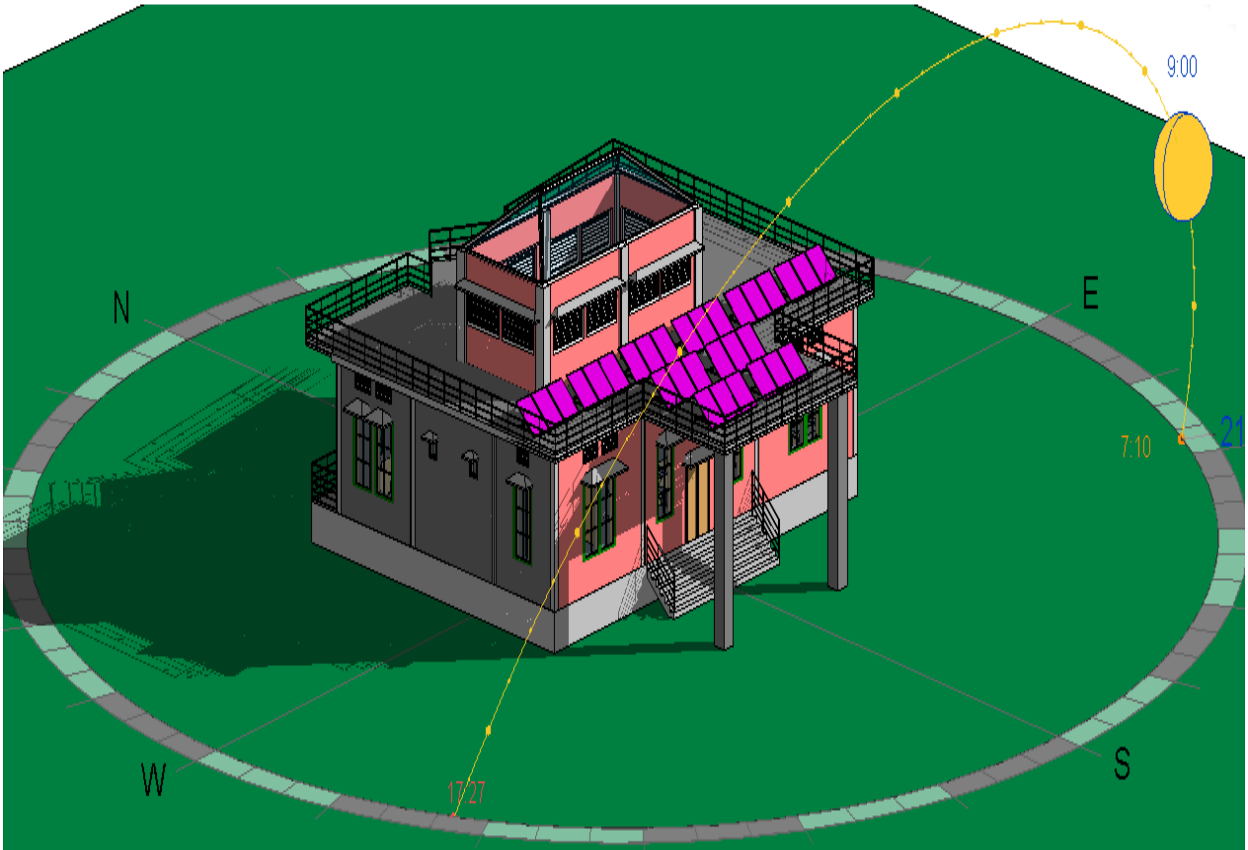

Fig.4.40 at 9:00 am 22nd December West South direction top view

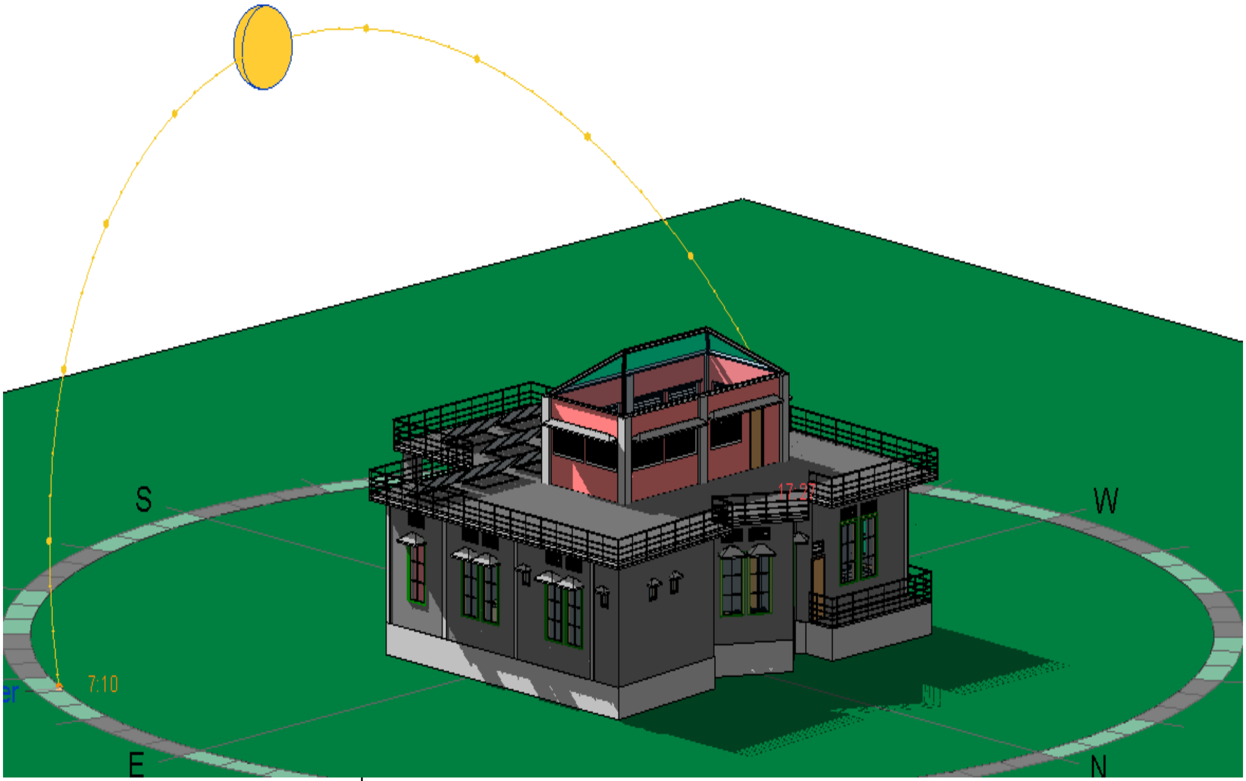

Fig.4.41 At 12:00 noon 22nd December East North direction top view

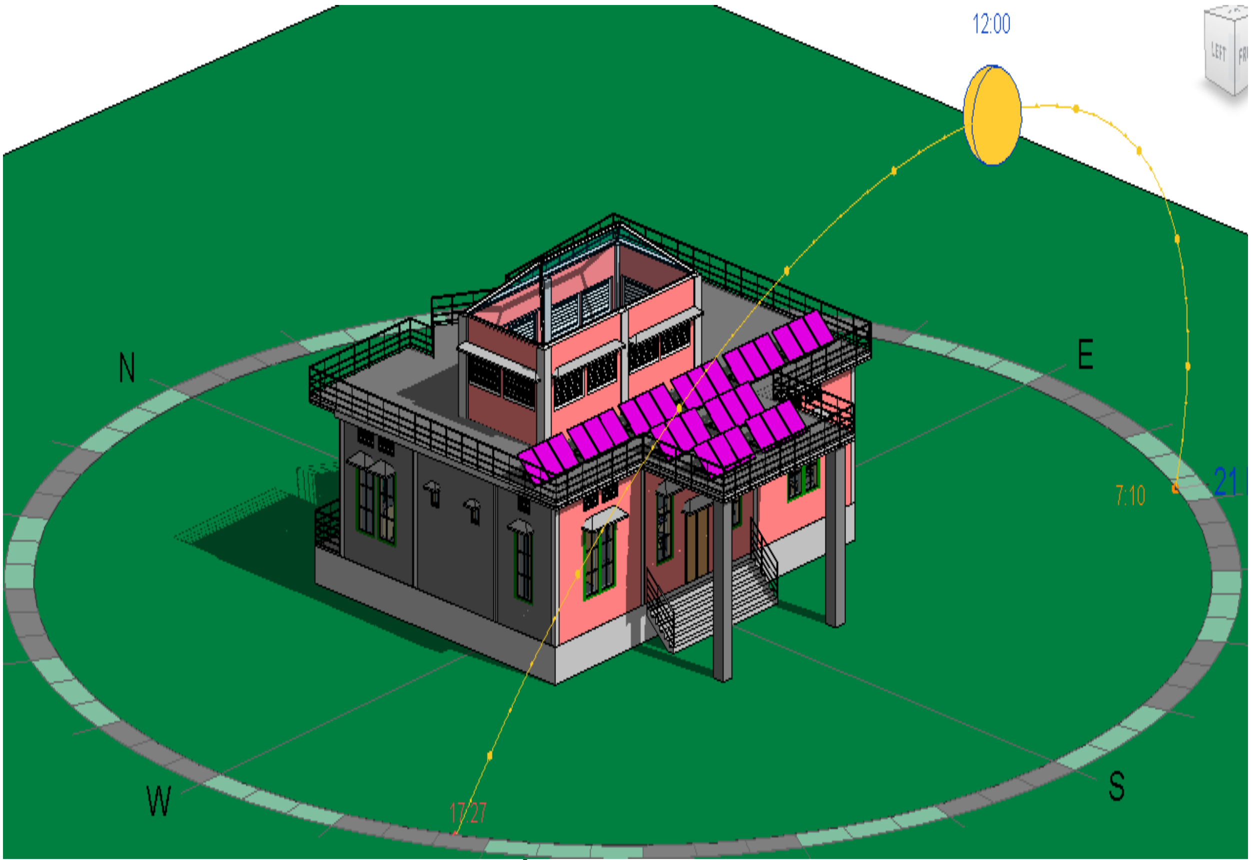

Fig.4.42 at 12:00 noon 22nd December West South direction top view

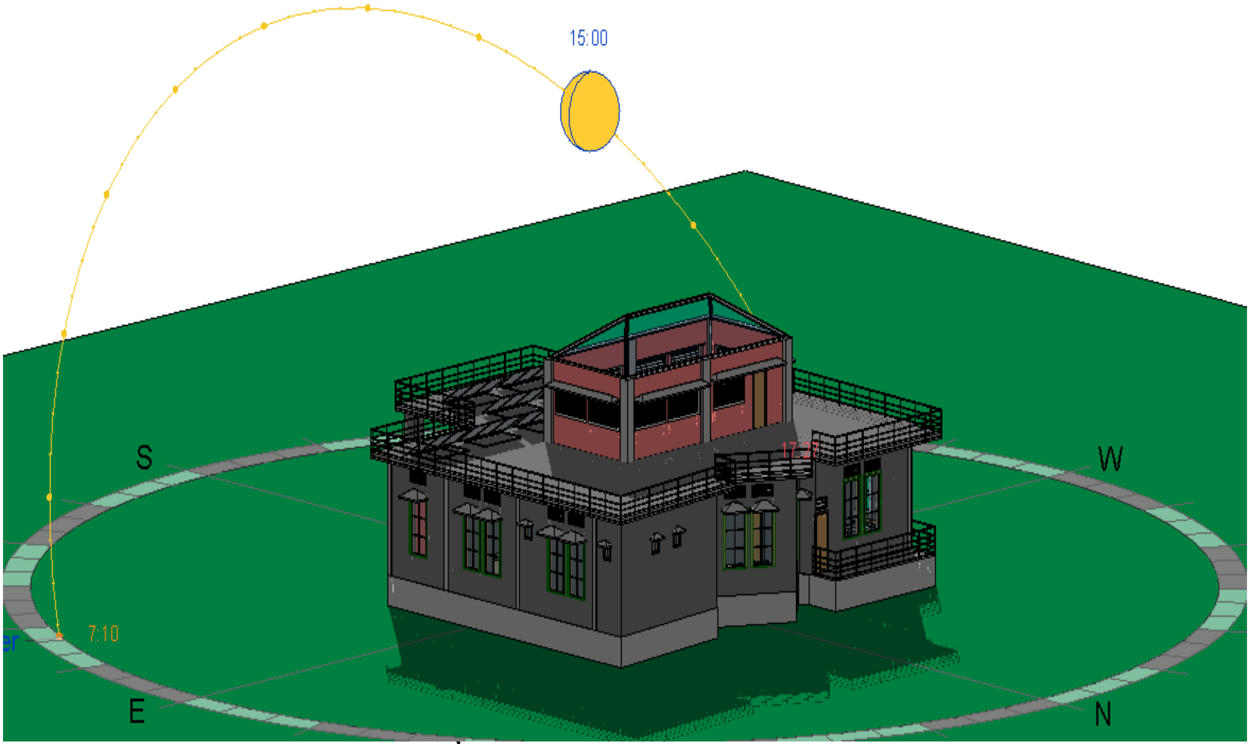

Fig.4.43 at 3:00 pm 22nd December East North direction top view

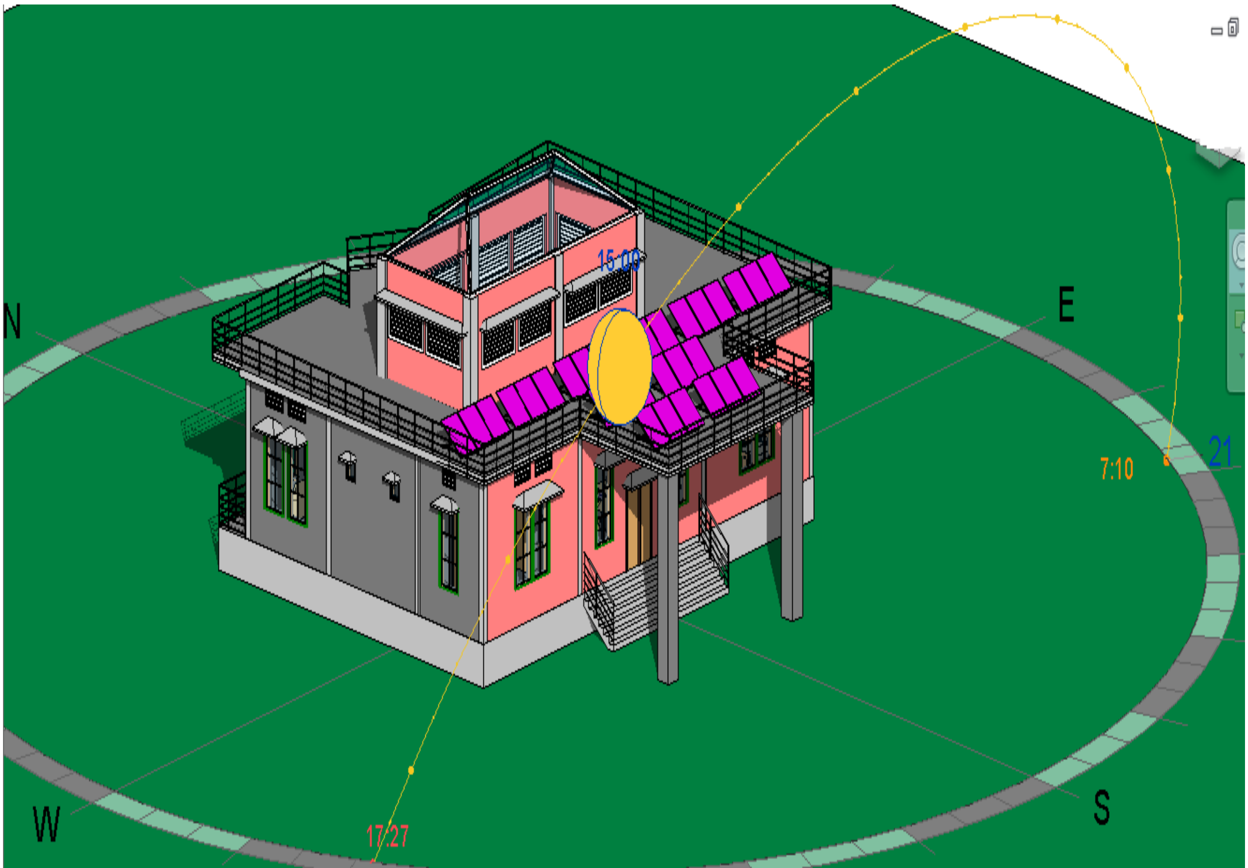

Fig.4.44 at 12:00noon 22nd December West South direction top view

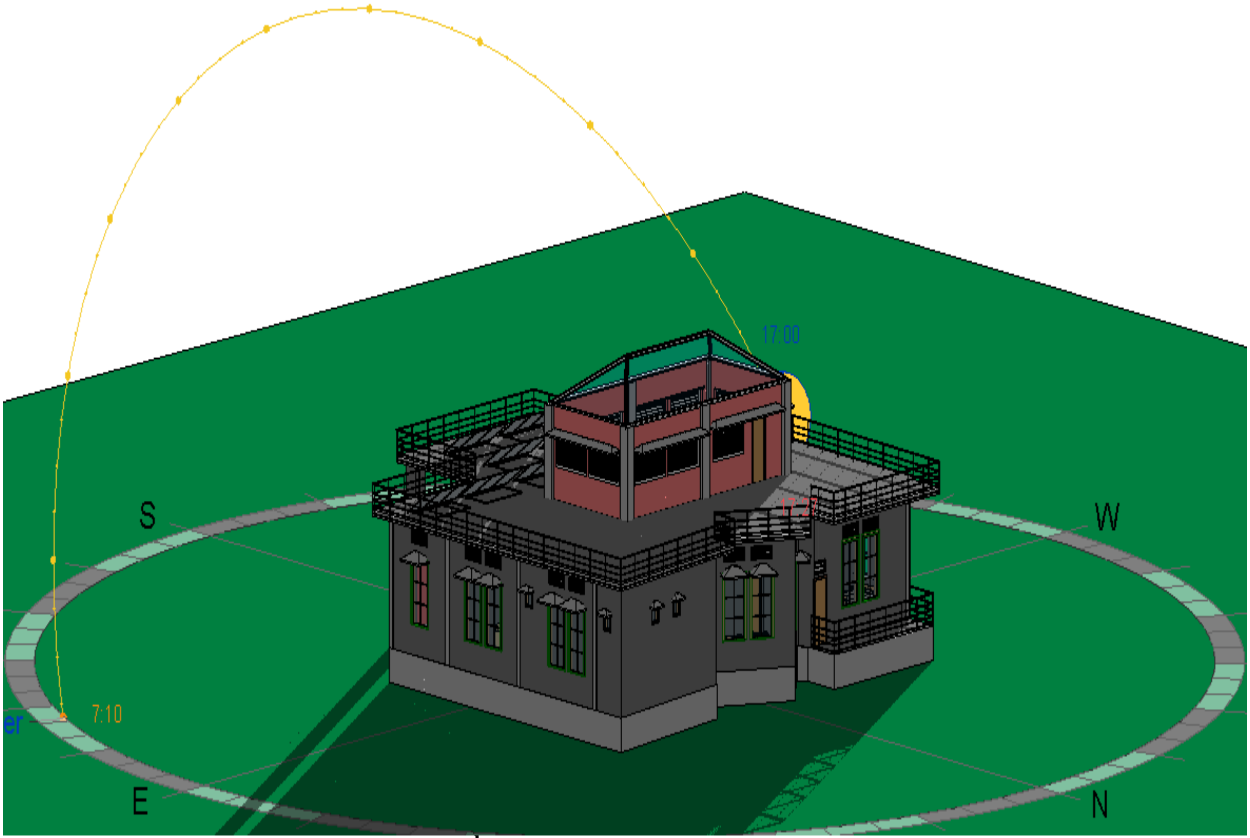

Fig.4.45 at 5:00 pm 22nd December East North direction top view

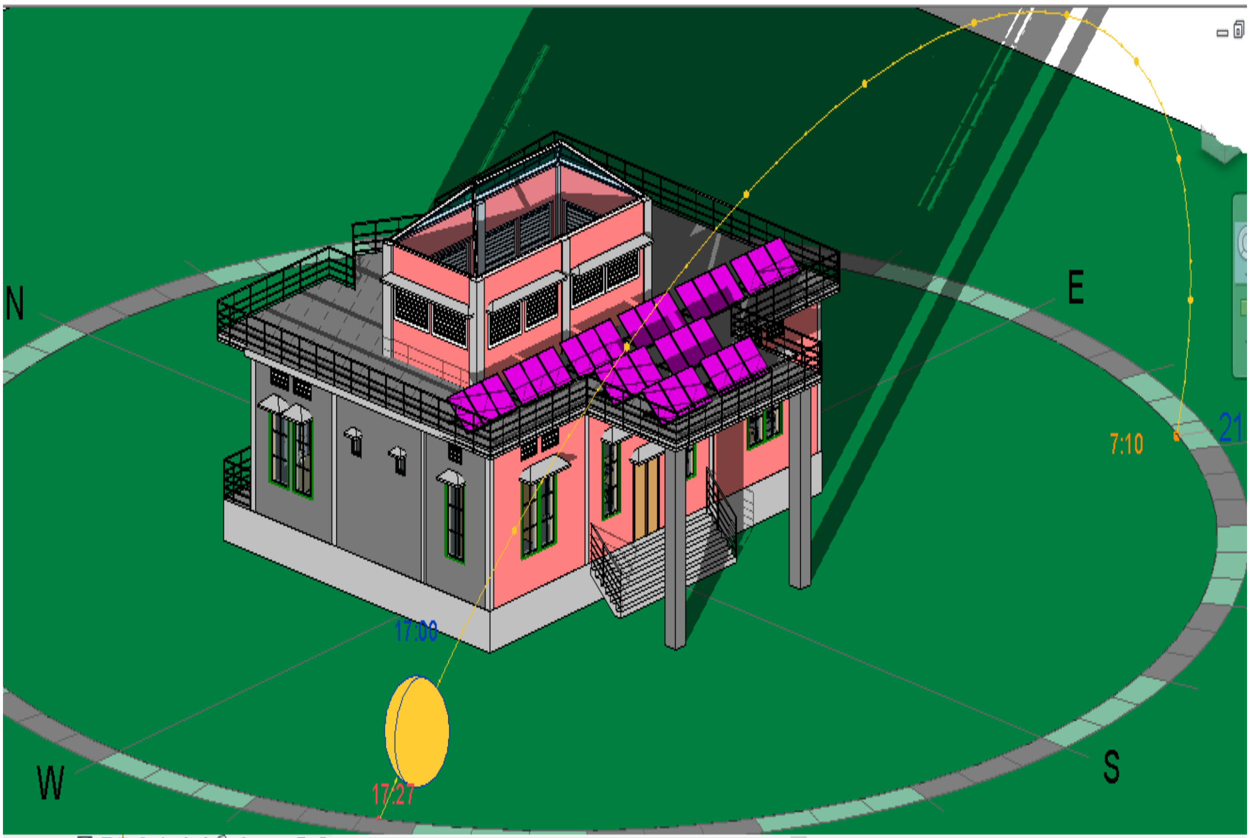

Fig.4.46 at 5:00 pm 22nd December West South direction top view

Chapter 5

COMPARISON OF CONVENTIONAL BUILDING AND GREEN BUILDING

5.1 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. For cost estimating, work breakdown structure (WBS) serves as an important framework for organized collection project cost data and preparing the cost estimates at different levels.

Comparison of Material Cost Analysis of	Conventional Building	Green Building
	Amount(Rs)	Amount(Rs)
Particulars		
External Walls	261922.5	612472
Internal wall	264920	212840
Columns (concrete 1:2:4)	35415.03	31522.7385
Columns Reinforcement	67853.7	75702.52
Concrete Floor	198457.438	160788.9158
Concrete roof	238148.926	175899.7644
Polystyrene roof		28575.7416
Plastering		

External wall	24196.6808	19485.91972
Internal wall	24473.5931	15168.26608
Skylight roof		25562.5
Window fenestration (1:2:4)	7270.179	10636.8
Skylight fenestration		4819.8
Door fenestration	1147.923	1728.48
Stair door Fenestration	573.9615	
Solar control glass		56833.44
Normal window glass	14170	15860
Louvres		33400
Total cost	1138549.931	1481296.886

Table 5.1 Cost Comparison of Conventional vs Green Building

5.2 ENERGY ANALYSIS

5.2.1 REVIT software

Conceptual energy analysis tools help to make every design more sustainable. It can help in presenting analysis results in a highly visual format for easy comparison and interpretation. Also the tools can be used to quickly compare the energy consumption and lifecycle costs of design alternatives right from within Autodesk Revit Architecture software.

Autodesk® Green Building Studio is a flexible cloud-based service that allows to run building performance simulations to optimize energy efficiency and to work toward carbon neutrality earlier in the design process. The Autodesk Green Building Studio web service provides: Annual energy cost • Lifecycle energy costs (30 year) • Annual energy consumption • Lifecycle energy consumption • Carbon emission calculations. Analysis results are presented in a highly-visual, graphical format for easy interpretation.

It can also facilitate collaborative design, allowing to transfer essential information on your building design to the applications used for engineering design or code analysis. The Autodesk Green Building Studio service can help to change the way building energy analysis is used in the building design process.

Below is the comparison in the energy analysis of conventional building and green building.

The building performance factors of both the buildings are :

Location	New Delhi, India
Outdoor Temperature	Max 45°C/ Min 2°C
Average Lighting Power	6.46 W/m^2
People	7 people
Electrical Cost	Rs 5.35/kWh

PARAMETERS	CONVENTIONAL BUILDING	GREEN BUILDING
Life cycle electricity use	388,500 kWh	276,960 kWh
Life cycle energy cost 30 year life and 6.1% discount rate for costs	Rs 20,78,475	Rs 14,81,736

Table 5.2 Electricity Consumption in one Year in Building by Software

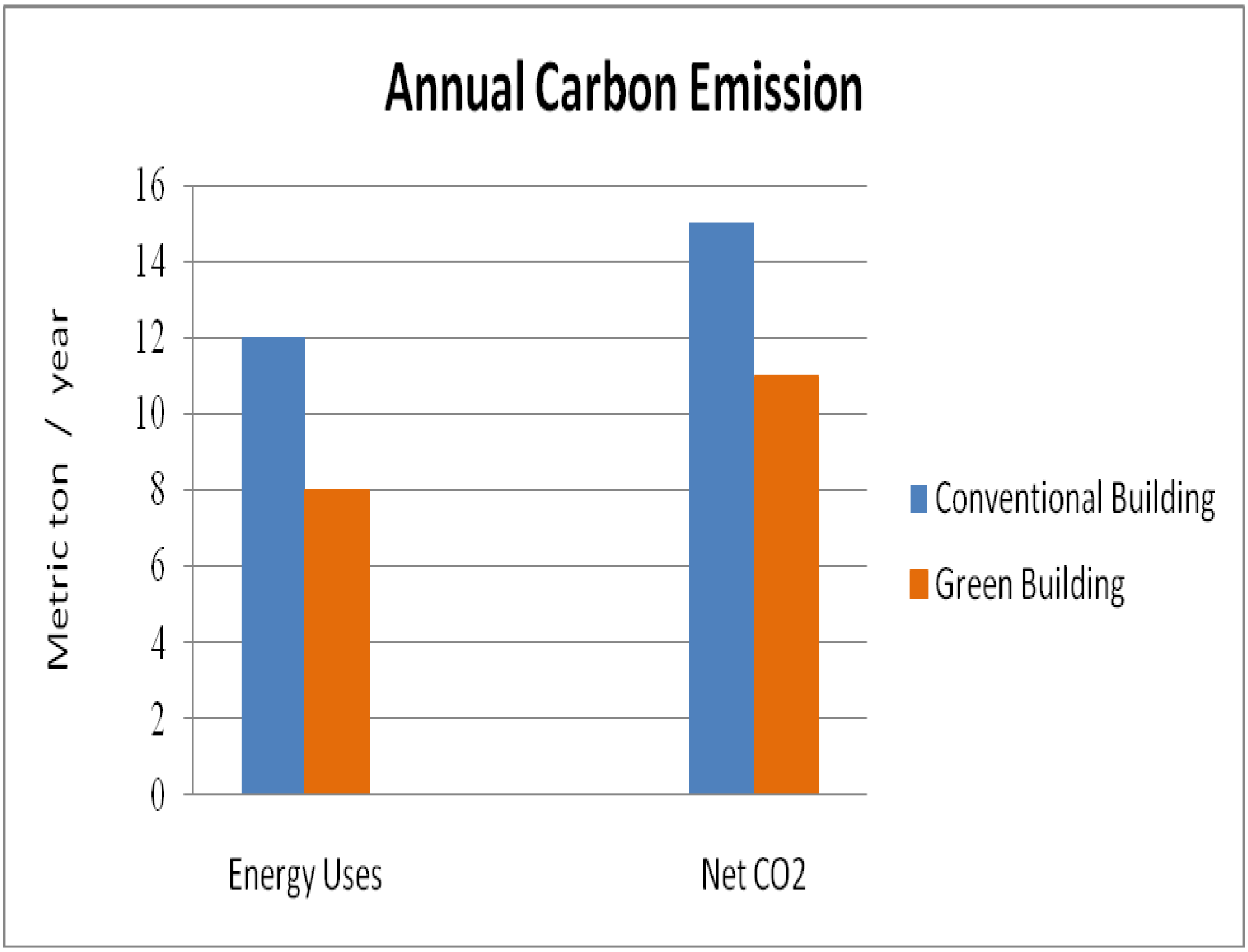

Fig.5.1 Annual Carbon Emission

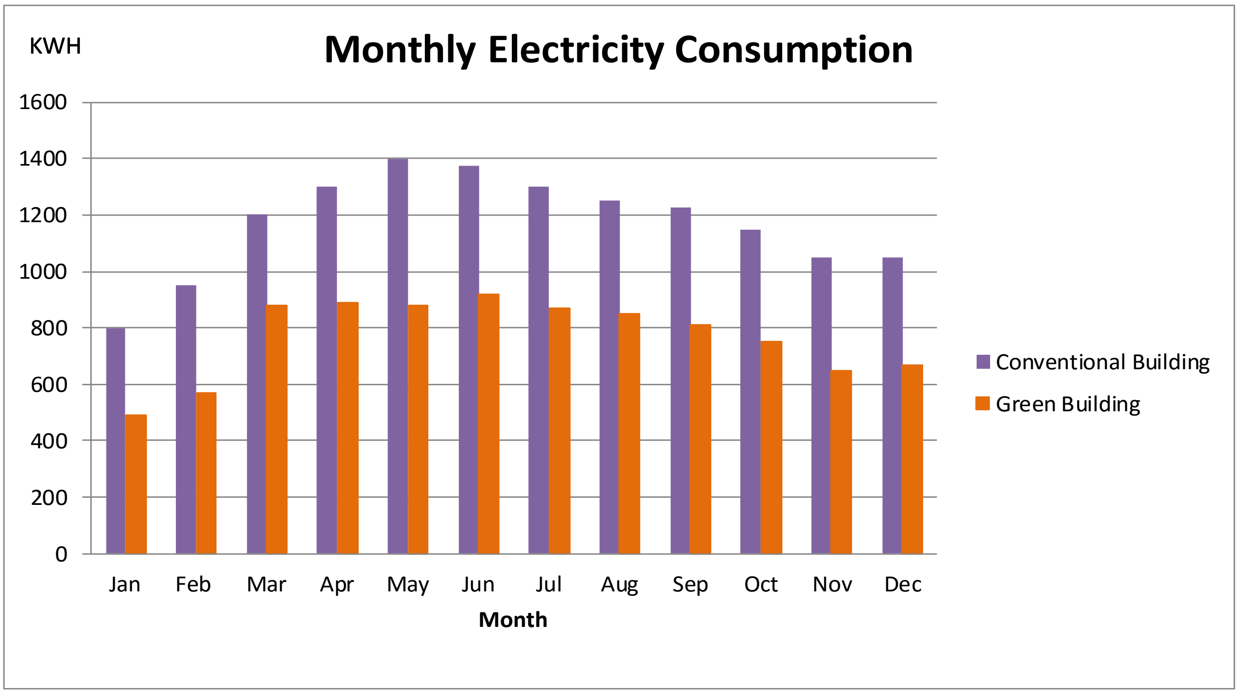

Fig.5.2 Monthly Electricity Consumption

Wind Roses Frequency

The direction of flow of wind during the whole year and also seasonally can be shown in various wind frequency charts

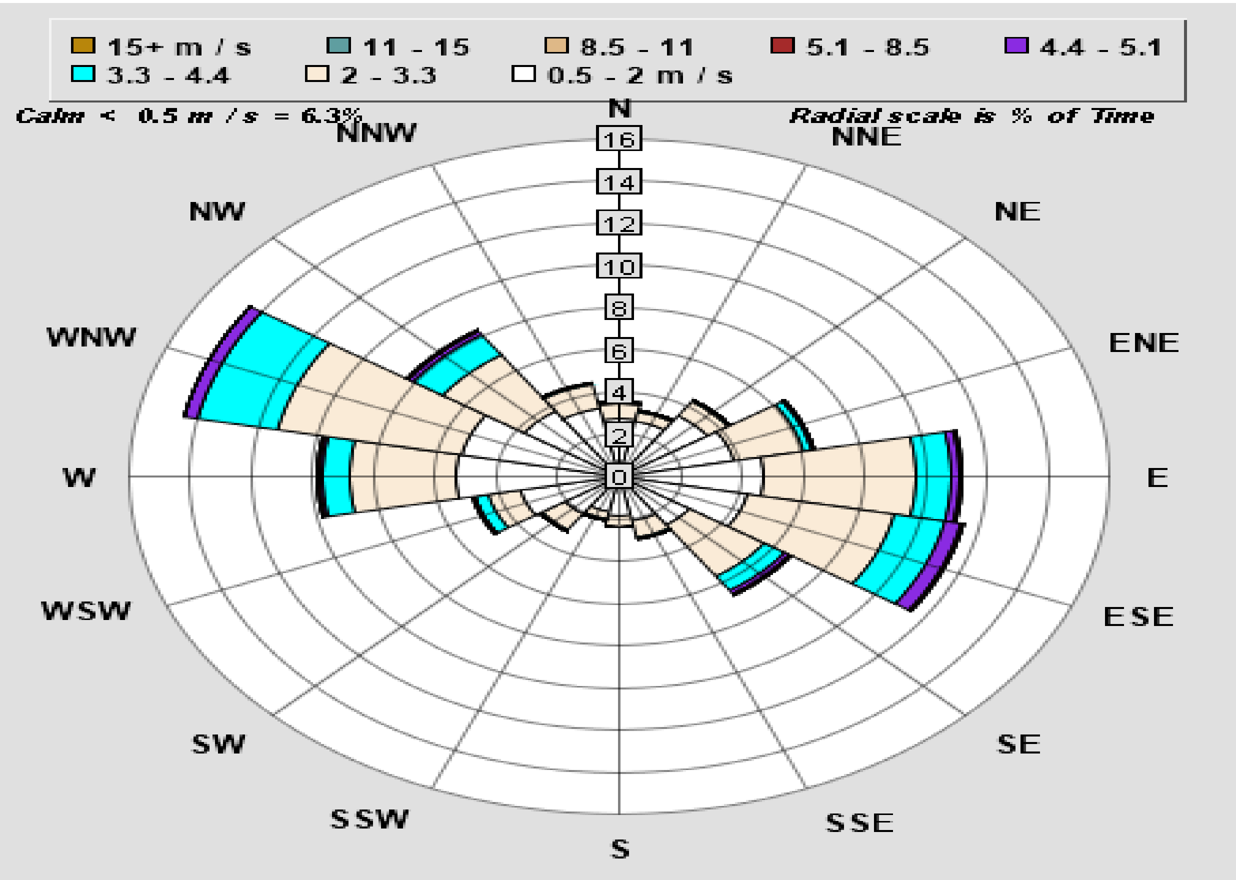

Fig.5.3 Wind frequency throughout the year

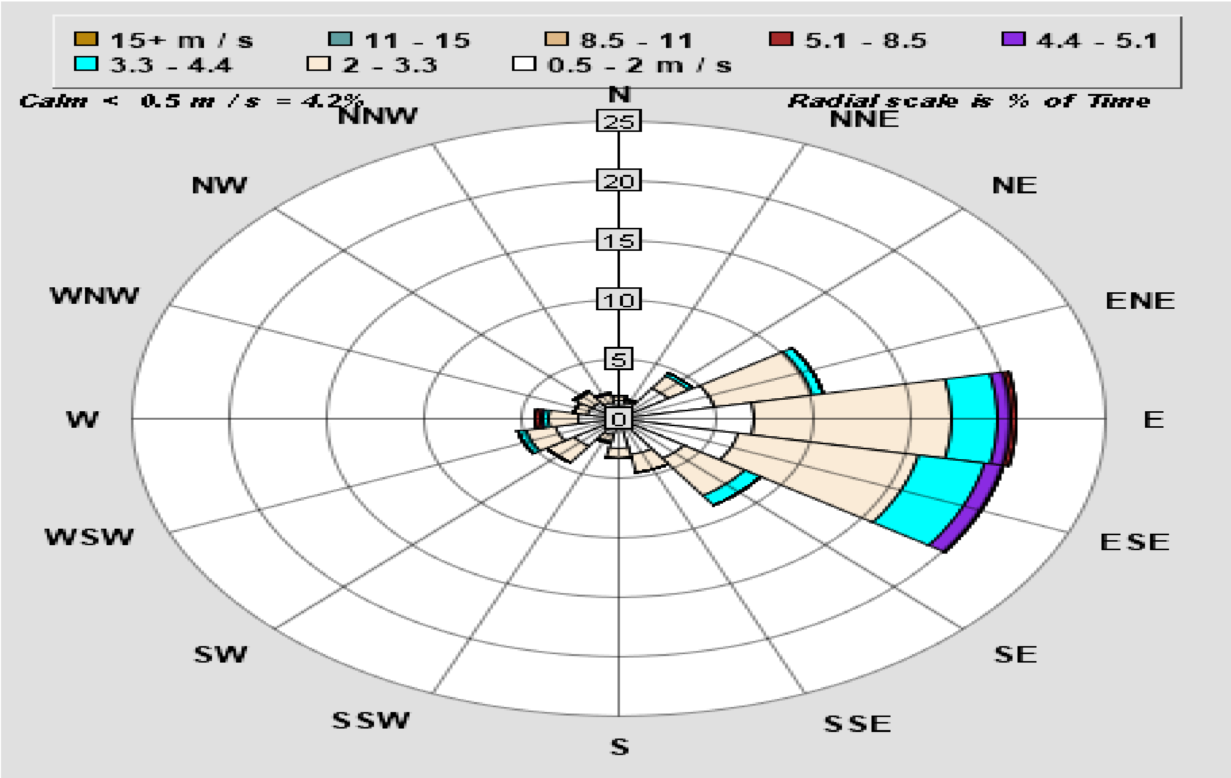

Fig.5.4 Wind frequency during summer

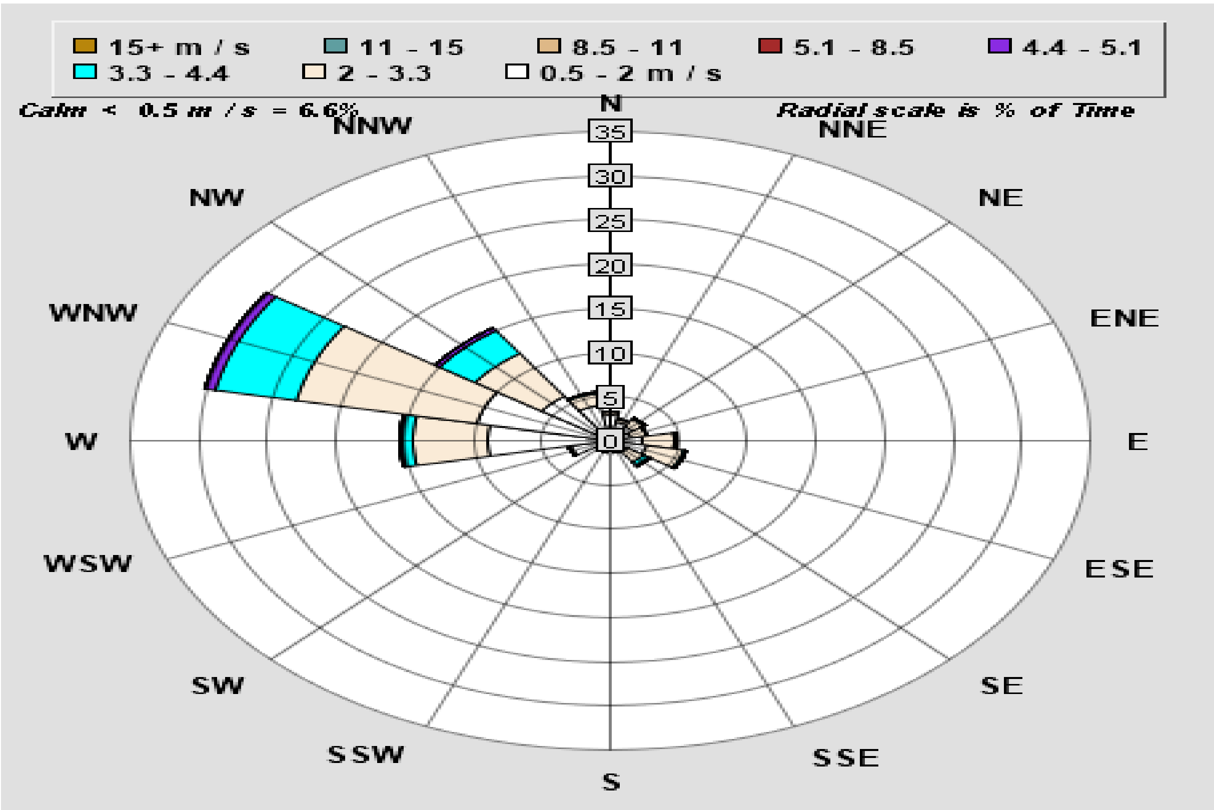

Fig.5.5 Wind frequency during winter

5.2.2 Manual Energy Analysis Calculations

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

Step One: 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 Two: Calculate load for each appliances

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

Step Three: Select HVAC Systems

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

Step Four: 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 Five: Input Electric Utility

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

Step Six: Calculate Energy Costs

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

Table 5.3 Electricity Consumption in one Year in Building of Conventional Building

Month	Appliances	No. of Appliances	No. Days	No. of Hours	Kwh	Kwh Per Month
Jan	Heater	3	31	3	2	558
	Light in Bedroom	7	31	6	0.025	32.55
	Light in Hall	2	31	15	0.025	23.25
					Total	613.8

Month	Appliances	No. of Appliances	No. Days	No. of Hours	Kwh	Kwh Per Month
Feb	Heater	3	28	2	2	336
	Light in Bedroom	7	28	6	0.025	29.4
	Light in Hall	2	28	15	0.025	21
					Total	386.4

Month	Appliances	No. of Appliances	No. Days	No. of Hours	Kwh	Kwh Per Month
Mar	AC	5	20	5	2	
	Compressor			2.5	2	500
	Ac Fan			2.5	0.08	20
	Light in Bedroom	7	31	6	0.025	32.55
	Light in Hall	2	31	15	0.025	23.25
	Fan	8	31	20	0.075	372
					Total	947.8

Month	Appliances	No. of Appliances	No. Days	No. of Hours	Kwh	Kwh Per Month
Apr	AC	5	30	10	2	
	Compressor			5	2	1500
	Ac Fan			5	0.08	60
	Light in Bedroom	7	30	6	0.025	31.5
	Light in Hall	2	30	15	0.025	22.5
	Fan	8	30	20	0.075	360
					Total	1974

Month	Appliances	No. of Appliances	No. Days	No. of Hours	Kwh	Kwh Per Month
May	AC	5	31	10	2	
	Compressor			5	2	1550
	Ac Fan			5	0.08	62
	Light in Bedroom	7	31	6	0.025	32.55
	Light in Hall	2	31	15	0.025	23.25
	Fan	8	31	20	0.075	372
					Total	2039.8

Month	Appliances	No. of Appliances	No. Days	No. of Hours	Kwh	Kwh Per Month
June	AC	5	30	10	2	
	Compressor			5	2	1500
	Ac Fan			5	0.08	60
	Light in Bedroom	7	30	6	0.025	31.5
	Light in Hall	2	30	15	0.025	22.5
	Fan	8	30	20	0.075	360
					Total	1974

Month	Appliances	No. of Appliances	No. Days	No. of Hours	Kwh	Kwh Per Month
July	AC	5	20	10	2	
	Compressor			5	2	1000
	Ac Fan			5	0.08	40
	Light in Bedroom	7	31	6	0.025	32.55
	Light in Hall	2	31	15	0.025	23.25
	Fan	8	31	20	0.075	372
					Total	1467.8

Month	Appliances	No. of Appliances	No. Days	No. of Hours	Kwh	Kwh Per Month
Aug	AC	5	20	7	2	
	Compressor			3	2	600
	Ac Fan			4	0.08	32
	Light in Bedroom	7	31	6	0.025	32.55
	Light in Hall	2	31	15	0.025	23.25
	Fan	8	31	20	0.075	372
					Total	1059.8

Month	Appliances	No. of Appliances	No. Days	No. of Hours	Kwh	Kwh Per Month
Sept	AC	5	20	5	2	
	Compresoor			2.5	2	500
	Ac Fan			2.5	0.08	20
	Light in Bedroom	7	31	6	0.025	32.55
	Light in Hall	2	31	15	0.025	23.25
	Fan	8	31	20	0.075	372
					Total	947.8

Month	Appliances	No. of Appliances	No. Days	No. of Hours	Kwh	Kwh Per Month
Oct	AC	5	20	2.5	2	
	Compressor			1	2	200
	Ac Fan			1.5	0.08	12
	Light in Bedroom	7	31	6	0.025	32.55
	Light in Hall	2	31	15	0.025	23.25
	Fan	8	31	20	0.075	372
					Total	639.8

Month	Appliances	No. of Appliances	No. Days	No. of Hours	Kwh	Kwh Per Month
Nov	Fan	8	30	15	0.06	216
	Light in Bedroom	7	31	6	0.025	32.55
	Light in Hall	2	31	15	0.025	23.25
					Total	271.8

Month	Appliances	No. of Appliances	No. Days	No. of Hours	Kwh	Kwh Per Month
Dec	Heater	3	31	2	2	372
	Light in Bedroom	7	31	6	0.025	32.55
	Light in Hall	2	31	15	0.025	23.25
					Total	427.8

Table 5.4 Electricity Consumption in one Year in Building of Green Building

Month	Appliance	No. of Appliance	No. of Days	No. of Hours	Kwh	Kwh per Month	Energy Reduce by 30 %
Jan	Heater	3	31	3	2	558	390.6
	Light in Bedroom	7	31	6	0.012	15.624	15.624
	Light in Hall	2	31	6	0.012	4.464	4.464
						Total	410.688

Month	Appliance	No. of Appliance	No. of Days	No. of Hours	Kwh	Kwh per Month	Energy Reduce by 30 %
Feb	Heater	3	28	2	2	336	235.2
	Light in Bedroom	7	28	6	0.012	14.112	14.112
	Light in Hall	2	28	6	0.012	4.032	4.032
						Total	253.344

Month	Appliance	No. of Appliance	No. of Days	No. of Hours	Kwh	Kwh per Month	Energy Reduce by 30 %
Mar	AC	5	20	5	2		
	Compressor			2.5	2	500	350
	Ac Fan			2.5	0.08	20	20
	Light in Bedroom	7	31	6	0.012	15.624	15.624
	Light in Hall	2	31	6	0.012	4.464	4.464
	Fan	8	31	20	0.05	248	248
						Total	638.088

Month	Appliance	No. of Appliance	No. of Days	No. of Hours	Kwh	Kwh per Month	Energy Reduce by 30 %
Apr	AC	5	30	10	2		
	Compressor			5	2	1500	1050
	Ac Fan			5	0.08	60	60
	Light in Bedroom	7	30	6	0.012	15.12	15.12
	Light in Hall	2	30	6	0.012	4.32	4.32
	Fan	8	30	20	0.05	240	240
						Total	1369.44

Month	Appliance	No. of Appliance	No. of Days	No. of Hours	Kwh	Kwh per Month	Energy Reduce by 30 %
May	AC	5	31	10	2		
	Compressor			5	2	1550	1085
	Ac Fan			5	0.08	62	62
	Light in Bedroom	7	31	6	0.012	15.624	15.624
	Light in Hall	2	31	6	0.012	4.464	4.464
	Fan	8	31	20	0.05	248	248
						Total	1415.088

Month	Appliance	No. of Appliance	No. of Days	No. of Hours	Kwh	Kwh per Month	Energy Reduce by 30 %
June	AC	5	30	10	2		
	Compressor			5	2	1500	1050
	Ac Fan			5	0.08	60	60
	Light in Bedroom	7	30	6	0.012	15.12	15.12
	Light in Hall	2	30	6	0.012	4.32	4.32
	Fan	8	30	20	0.05	240	240
						Total	1369.44

Month	Appliance	No. of Appliance	No. of Days	No. of Hours	Kwh	Kwh per Month	Energy Reduce by 30 %
July	AC	5	20	10	2		
	Compressor			5	2	1000	700
	Ac Fan			5	0.08	40	40
	Light in Bedroom	7	31	6	0.012	15.624	15.624
	Light in Hall	2	31	6	0.012	4.464	4.464
	Fan	8	31	20	0.05	248	248
						Total	1008.088

Month	Appliance	No. of Appliance	No. of Days	No. of Hours	Kwh	Kwh per Month	Energy Reduce by 30 %
Aug	AC	5	20	7	2		
	Compressor			3	2	600	420
	Ac Fan			4	0.08	32	32
	Light in Bedroom	7	31	6	0.012	15.624	15.624
	Light in Hall	2	31	6	0.012	4.464	4.464
	Fan	8	31	20	0.05	248	248
						Total	720.088

Month	Appliance	No. of Appliance	No. of Days	No. of Hours	Kwh	Kwh per Month	Energy Reduce by 30 %
Sep	AC	5	20	3	2		
	Compressor			1.5	2	300	210
	Ac Fan			1.5	0.08	12	12
	Light in Bedroom	7	30	6	0.012	15.12	15.12
	Light in Hall	2	30	6	0.012	4.32	4.32
	Fan	8	30	20	0.05	240	240
						Total	481.44

Month	Appliance	No. of Appliance	No. of Days	No. of Hours	Kwh	Kwh per Month	Energy Reduce by 30 %
Oct	Light in Bedroom	7	31	6	0.012	15.624	
	Light in Hall	2	31	6	0.012	4.464	
	Fan	8	31	20	0.05	248	
					Total	268.088	

Month	Appliance	No. of Appliance	No. of Days	No. of Hours	Kwh	Kwh per Month	Energy Reduce by 30 %
Nov	Fan	8	30	15	0.06	216	
	Light in Bedroom	7	30	6	0.012	15.12	
	Light in Hall	2	30	6	0.012	4.32	
					Total	235.44	

Month	Appliance	No. of Appliance	No. of Days	No. of Hours	Kwh	Kwh per Month	Energy Reduce by 30 %
Dec	Heater	3	31	2	2	372	260.4
	Light in Bedroom	7	31	6	0.012	15.624	15.624
	Light in Hall	2	31	6	0.012	4.464	4.464
						Total	280.488

Graphical representation of annual electricity consumption per month of Conventional building and Green building

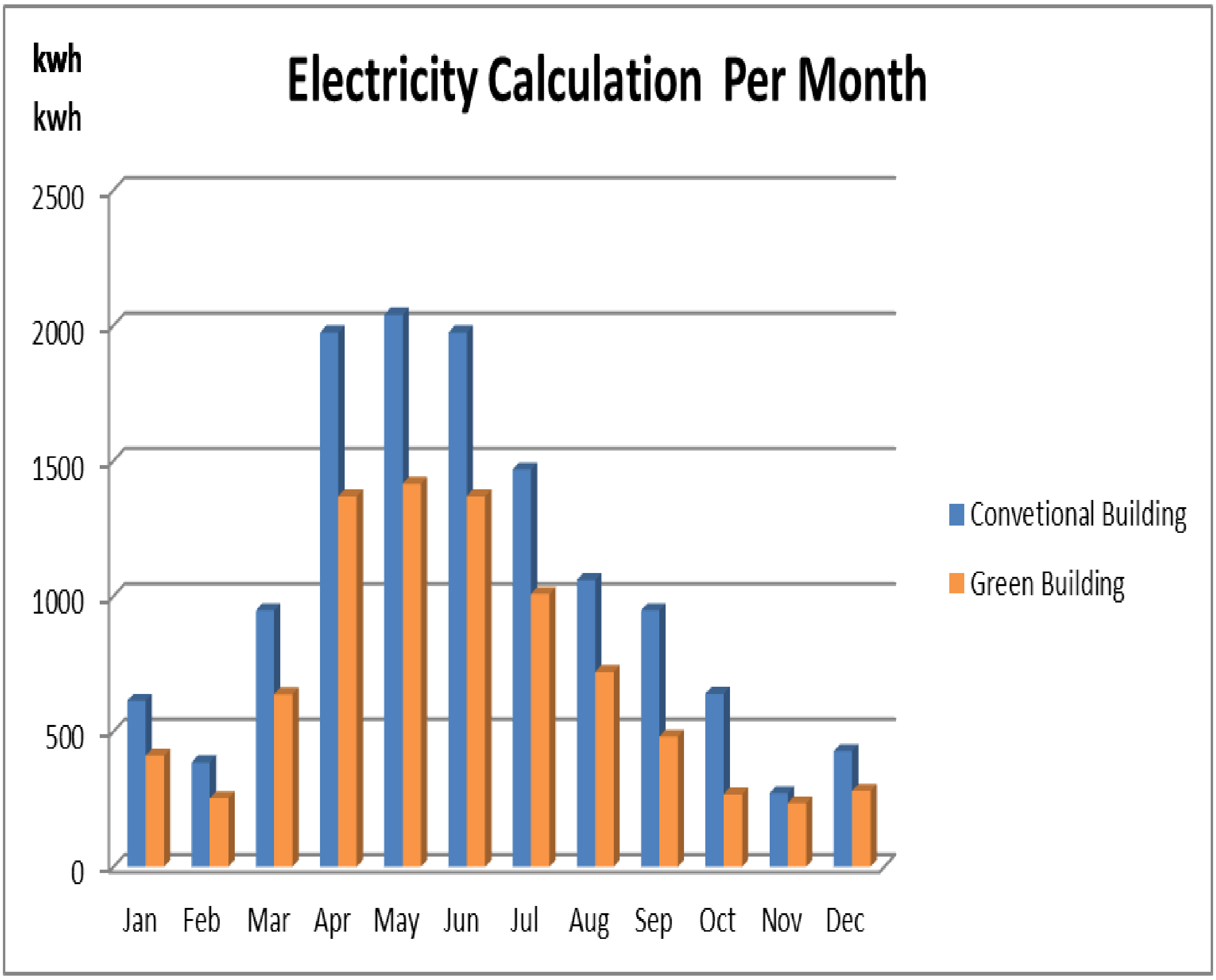

Fig.5.6 Electricity consumption per mon

When solar cells are used in green building, energy consumption is reduced which further decreases the energy cost. The solar panels used are 10 in number each having a capacity of 250Wh. Overall we have got 2.5kWh. Solar panels provide DC voltage and a conversion factor of 0.8 is multiplied to convert it to AC voltage.So we will get a capacity of 2kwh.

Graphical representation of electricity consumption per year of conventional building and green building after using solar energy

Building	Kwh Per Year
Conventional Building	12751
Green Building	8450
Solar Panel	3400
Energy required by in Green Building With Solar Energy Panel	5050

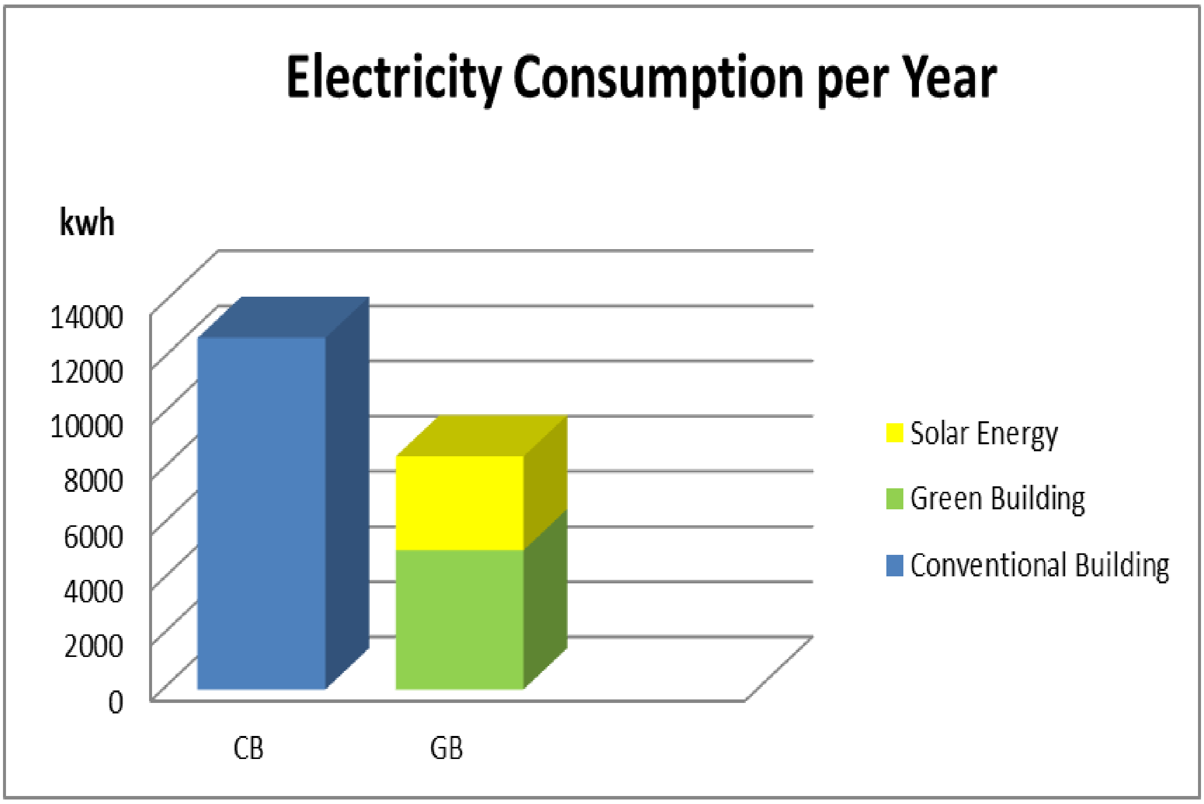

Fig.5.7 Electricity Consumption per year

Graphical representation of electricity consumption for 30 years of conventional building and green building after using solar energy

	Energy Cost for 30 years (Rs) (
Conventional Building	2046471
Green Building	1010480

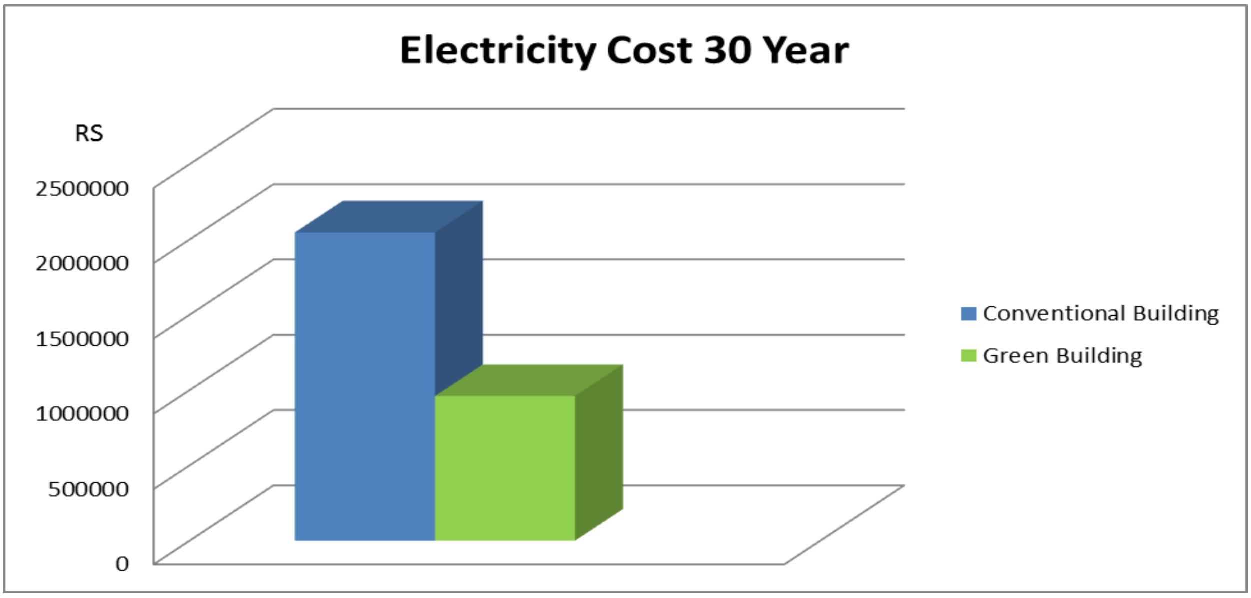

Fig.5.8 Electricity Consumption for 30 years

	(Rs)
Annual cost of conventional building for 30 years	= 12750.6*5.35*30
	= 204647/-
Annual cost of green building for 30 years (without solar panel	= 8449.72*5.35*30
	= 1356180/-
Annual cost benefit for 30 years (without solar panels)	= 2046471-1356180
	= 69029/-
Annual cost of conventional building for 30 years	= 12750.6*5.35*30
	= 2046471/-
Annual cost of green building for 30 years with solar panels	= (8449.72-3400)*5.35*30
	= 810480/-
Cost of installation of solar cells for 30 years period	= 200000/-
Annual cost benefit for 30 years	= 2046471-(810480+200000)
	=1035991/-
Annual cost benefit in green building after installing solar panels	= 1035991-69029
	= 342746.955/-

Chapter 6
CONCLUSION & FUTURE SCOPE

6.1 Conclusion

Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment A green building incorporates environmental considerations into every stage of the building construction and focuses on the design, construction, operation and maintenance phases. In order to maximize daylight penetration into the interior, light shelves was provided above the windows. And also designed for integration of daylighting and to cut off direct radiation, for insulation of walls AAC blocks are used, sunpath for daylight orientation, tropical skylight on the roof was constructed for ventilation and light in the central part of the house. On preparing the 3D model of conventional as well as green building we have compared the material cost of both the buildings. The construction material cost of green building is 23% more than the conventional building which will be covered during its life cycle cost. It is found that though the initial cost of construction of a green building is more than the conventional building but still its life cycle cost is 33.7% lesser than conventional building without using solar panels and 50.6% lesser after using solar panels. This energy analysis comparison is carried out with the help of REVIT which makes it easy to properly study the details and then comparing both at the same time. The structure of the building is prepared keeping in mind the external conditions such as the location, geographical parameters.

6.2 Future Scope

Energy analysis can be done by other softwares as well and one such software is Green building studio. Many others techniques apart from the one used in this project like rain water harvesting technique, green roofing, various other insulaing 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 Construction cost of Conventional Building

	Q O M	Unit	No of bricks	Rate per unit	Amount (Rs)
Exterior walls					
South	64.945	sqm	6494.5	10	64945
East	44.9075	sqm	4490.75	10	44907.5
West	42.745	sqm	4274.5	10	42745
North	76.475	sqm	7647.5	10	76475
Stair room	32.85	sqm	3285	10	32850
Total	261.9225	sqm	26192.25		261922.5
Interior walls	264.92	sqm	26492	10	264920
Columns (concrete 1:2:4)	4.473219	cum		5466.3	24451.9557
	2.005575	cum		5466.3	10963.0746
Column Reinforcement(kg/cum)	1006.47	kg		45	45291.15
	501.39	kg		45	22562.55
Plastering (cement mortar 1:4)					
External wall	6.652832	cum		3637.05	24196.6808
Internal wall	6.728968	cum		3637.05	24473.5931
Concrete floor	36.30563	cum		5466.3	198457.438
Concrete roof	43.56675	cum		5466.3	238148.926
Window fenestration (1:2:4)	1.33	cum		5466.3	7270.179
Main door fenestration	0.21	cum		5466.3	1147.923
Stair door fenestration	0.105	cum		5466.3	573.9615
Window glass	27.25	sqm		520	14170
Total Cost					1138549.93

Annexure 2 Construction Cost of Green Building

	Q O M	Unit		Rate per unit	Amount (Rs)
Exterior walls					
South	57.37	sqm	367.168	350	128508.8
East	41.695	sqm	266.848	350	93396.8
West	41.57	sqm	266.048	350	93116.8
North	78.515	sqm	502.496	350	175873.6
Skylight	54.275	sqm	347.36	350	121576
Total	273.425		1749.92		612472
Interior walls	212.84	sqm	21284	10	212840
Columns (concrete 1:2:4)	3.834188	cum		4432	16993.119
	3.278344	cum		4432	14529.6195
Columns Reinforcement	862.6922	kg		45	38821.14844
	819.5859	kg		45	36881.36719
Concrete Floor	36.27909	cum		4432	160788.9158
Concrete roof	39.68858	cum		4432	175899.7644
Polystyrene roof	264.5902	sqm		108	28575.7416
Plastering (cement mortar 1:6)					
External wall	6.944995	cum		2805.75	19485.91972
Internal wall	5.406136	cum		2805.75	15168.26608
Skylight roof	51.125	sqm		500	25562.5
Window fenestration (1:2:4)	2.4	cum		4432	10636.8
Skylight fenestration	1.0875	cum		4432	4819.8
Door fenestration	0.39	cum		4432	1728.48
Solar control glass	24	sqm		2368.06	56833.44
Normal window glass	30.5	sqm		520	15860
Louvers	33.4	sqm		1000	33400
Total Cost					1481296.882