# An experimental investigation on Green Building Model using sustainable building materials

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***Abstract—***

*Green building refers to a structure that uses different processes that are environmentally friendly and resource-efficient throughout the building's lifecycle. Constructing a construction with conventional or even modern methods without adapting any green methods produces more wastes in the form of Carbon Dioxide and other harmful gases. Buildings consume nearly 50% of the world's total energy. On the other hand, Green building consumes a minimum amount of energy while bringing in the use of green building materials. In India, there are mainly two rating systems for green building: GRIHA (Green Rating for Integrated Habitat Assessment); LEED (Leadership in Energy and Environmental Design). The LEED Green Rating System was developed and managed by USGBC. It is the most widely used rating system nationally and internationally. Buildings are given ratings of Platinum, Gold or Silver, or Certified, based on the Green Buildings attributes. A Green building when compared to a conventional building seems external and building use differs in the operational savings and operations savings and concerns for human comfort and indoor* *environment. In our proposed model, we are aiming to satisfy the requirements of a Green Building. Our model is included with Solar Panels, natural lighting, and water harvesting.*

## I. Introduction

A green building is constructed with a design and construction process which significantly reduces or eliminates the negative impacts of the building on the environment and occupants. Green building is the practice of creating healthier and more resource-efficient models of construction, renovation, operation, maintenance, and demolition. Green buildings preserve precious natural resources and improve our quality of life.

In other words, a Green building is a structure designed, constructed, operated, and demolished in a healthy and resource-efficient manner. The objectives of Green building is to:

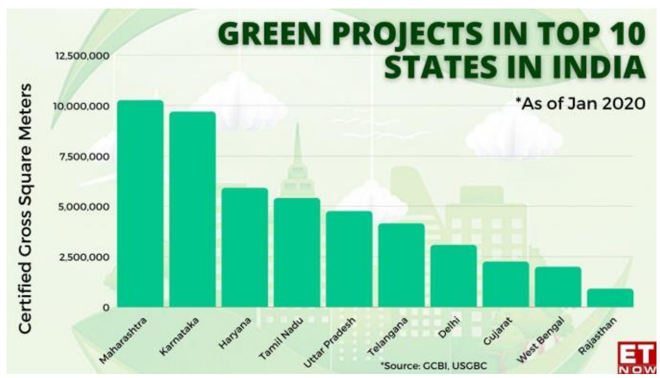
- Minimise the use of non-renewable resources.
- Make use of renewable resources.
- Maximise reuse and recycling of available resources.
- Make use of non-toxic materials.
- Maximise occupant health and productivity.
- Reduce waste and negative environmental impacts.
- Provide a healthy Indoor Environmental Quality (IEQ).
- Decrease life cycle costs.

Resource consumption and energy emissions statistics of buildings:

Statistics of resource consumption:

- 35% of energy resources.
- 40% of natural raw materials.
- 25% of all water supplies.
- 39% of all raw materials.

In India, the Confederation of Indian Industry (CII) adopted the Green Building Movement in 2001. They formed the Indian Green Building Council (IGBC), which promotes the Green Building concept in India. Their vision is, ―To enable a sustainable built environment for all and facilitate India to be one of the global leaders in the sustainable built environment by 2025. The Green Building movement in India started gaining momentum in 2003, from just about 20,000 sq. ft in 2003 to 450 crores sq. ft green footprint in India today.




The area on the project site that has been impacted by any development activity. Access roads, parking lots, nonbuilding facilities, and building structures are all included in the development footprint.

The development footprint is the total land area that is affected by development activities and includes buildings, structures, hardscapes, utilities, roads, and parking areas, as well as any areas that are driven over, trampled, or cleared of natural vegetation and topsoil.

In other words, the development footprint includes any land used for buildings, hard standings, landscaping, site access.

It also includes any area which is used for temporary site storage. The term footprint makes a good metaphor for the human imprint on the natural world. Since few places on the planet remain untouched by man, our collective footprint on the earth is massive. The actions of each individual also have a footprint, or influence on the natural world. In terms of environmental health, it is important to keep the development footprint as small as possible, in terms of both area and degree of impact. By minimising the total amount of space needed for a project, we can conserve more of the site for natural areas.

**GREEN RATING SYSTEM IN INDIA**

Green rating systems for buildings measure and quantify the environmental performance of a given building. India currently has the below green rating systems for buildings.

- Indian Green Building Council (IGBC)
- Leadership in Energy and Environmental Design (LEED)

These green rating systems aim to quantify the environmental, economic, and socio-economic benefits of green building design with an emphasis on sustainable site planning, optimised energy performance, efficient materials, and construction practices.

**Indian Green Building Council (IGBC):**

Indian Green Building Council was formed in the year 2001 as a part of the Confederation of Indian Industry (CII). The vision of the IGBC is, "To enable a sustainable built environment for all and facilitate India to be one of the global leaders in the sustainable built environment by 2025". The council offers an extensive array of services which include:

- Developing new green building rating programs
- Certification services
- Green building training programs

**LEED India:**

Leadership in Energy and Environmental Design (LEED-INDIA) Green Building Rating System is a recognized point of reference both in our country as well as worldwide for the design, construction, and further operation of high-performance green buildings. The organisation supplies building owners, architects, consultants, developers, facility managers, and project managers the paraphernalia that they require to design, construct and operate green buildings.

It was set up in the year 1998 by the United States Green Building Council (USGBC) to evaluate the influence of building design and construction on the environment. LEED-INDIA rating system provides a roadmap for measuring and documenting success for every building type and phase of a building lifecycle.

LEED-INDIA promotes a whole-building approach to sustainability by recognizing performance in the following five key areas:

- Sustainable Site Development.
- Water Savings.
- Energy Efficiency.
- Material Selection.
- Indoor Environmental Air Quality.

**The LEED rating system:**

The LEED rating system has seven areas of concentration:

1. Sustainable Sites.
2. Water Efficiency.
3. Energy and Atmosphere.
4. Materials and Resources.
5. Indoor Environmental Quality.
6. Innovation in Design Process.

7. Regional Priority.


The main aim of reducing site disturbances:

- To conserve the existing natural areas that surround the site.
- To restore the damaged habitats that surround the site.
- To recognize the least costly, least time consuming and most environmentally friendly design for site and stormwater management is often the one in which the design of buildings and site improvements respect the existing natural flows and features of the land, instead of designing the building and site improvements with total disregard for the site, which results in needless, extensive, disruptive, costly and time-consuming excavation and earthmoving.

**DATA COLLECTION:**

A Study on Green rating systems in India:

The pioneer Green rating system in India is LEED-INDIA, formulated, on the international guidelines by Indian Green building Council (IGBC). The study deals in:

Identification of various aspects of development footprint.

Identification of various credit requirements related to development footprint.

Various alternatives of the construction process to minimise development footprint.

Identification of site for the project work:

A site of a Business building, which is under construction in Barawn near Sasaram, Bihar has been identified for the analysis and the corresponding reduction of development footprint.

Site Details:

The terrain is plain with green vegetation around it. The vegetation mainly consists of naturally available trees, grass, and shrubs. In Dinara, the average annual temperature is 25.6 °C | 78.1 °F. The average rainfall here is around 1127 mm | 44.4 inches per year. The average height above MSL is in the range of 200 – 250 metres.

The site layout consists of a plot for 1 building.

**METHODOLOGIES:**

The methodology which is being adopted for the study for reducing development footprint is given as chart below:

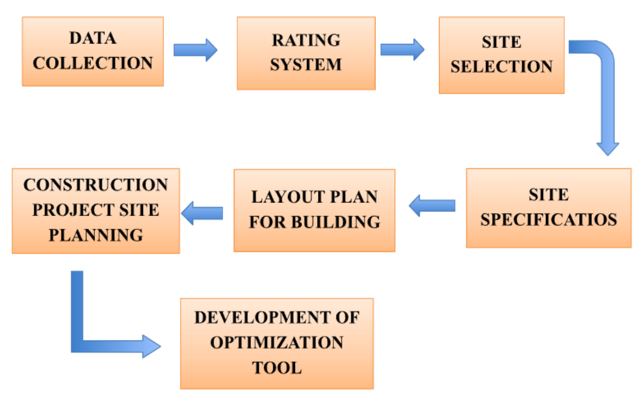



Chart 3.2-1

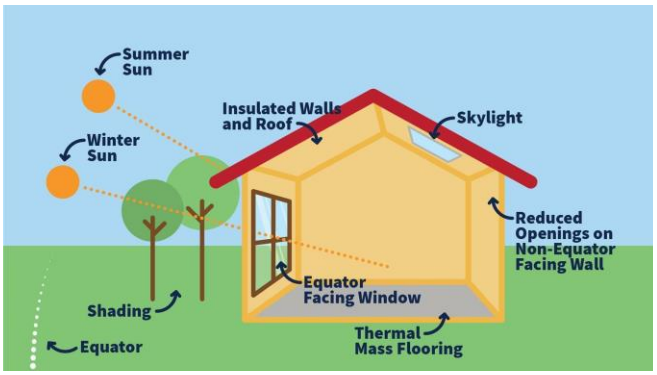
**TECHNOLOGIES TO ACHIEVE ENERGY EFFICIENCY IN BUILDING**

**Passive Solar Building Design**

In passive solar building design, windows, walls, and floors are made to collect, store, reflect, and distribute solar energy, in the form of heat in the winter and reject solar heat in the summer.

This is called passive solar design because, unlike active solar heating systems, it does not involve the use of mechanical and electrical devices.

The key to designing a passive solar building is to best take advantage of the local climate by performing an accurate site analysis. Elements to consider include window placement and size, glazing type, thermal insulation, thermal mass, and shading.[2] Passive solar design techniques can be applied most easily to new buildings, but existing buildings can be adapted or "retrofitted".




## Solar Water Heating

Solar water heating (SWH) is heating water by sunlight, using a solar thermal collector. A variety of configurations is available at varying costs to provide solutions in different climates and latitudes. SWHs are widely used for residential and industrial applications.

A sun-facing collector heats a working fluid that passes into a storage system for later use. SWH is active (pumped) and passive (convection-driven). They use water only, or both water and a working fluid. They are heated directly or via light-concentrating mirrors. They operate independently or as hybrids with electric or gas heaters. In large-scale installations, mirrors may concentrate sunlight into a smaller collector.


## Building Integrated Photovoltaic

Photovoltaic (PV) panels convert solar power into useful electricity. Photovoltaics (PV) is a truly elegant means of producing electricity on-site, directly from the sun, without concern for energy supply or environmental harm. These solid-state devices simply make electricity out of sunlight, silently with no maintenance, no pollution, and no depletion of materials. These PV modules can be installed on the walls and rooftops of buildings. They prove to be economical in the long term.

## Material Efficiency

Using materials that are more "efficient" in the building process today can be less expensive and energy-intensive than using new building materials. An example of this would be using recycled steel to erect the frame of a building instead of using wooden timbers. Using recycled steel saves room in landfills that the steel would otherwise be taking up, saves 75% of the energy required to produce steel in the production process, and saves trees from being cut down to build homes.



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Material efficiency can be achieved by:

- It can be achieved by using eco-friendly materials.
- It can be achieved by construction waste management.
- It can be achieved by using regional and rapidly renewable materials.
- It can be achieved by the use of wastes and debris from demolition works.
- It can be achieved by compressed earth blocks, fly ash blocks. Stabilised mud blocks. HVFC, bamboo, low VOC paints, and other recycled materials.

## ECO-FRIENDLY CONSTRUCTION MATERIALS

### Compressed Earth Blocks

Compressed Earth Blocks (CEBs) are natural masonry blocks produced hydraulically using an Earth Block press. A wide range of soils can be used for the production of these blocks with the key ingredients being clay and sand. These blocks are laid in standard masonry fashion and can be laid in mortar, a clay slurry, or dry stacked.

It is a compressed mix of dirt, non-expansive clay, and aggregate. The slurry used for bonding CEB is also of the same mixture of dirt and clay. Simple in manufacturing, so it can be prepared near the construction site. Economic since it used dirt and clay which is not expensive at all. Fire-resistant, sound-resistant, and non-toxic.


### Fly ash Blocks

Fly ash blocks are a mix of fly ash and lime. Fly ash is a by-product of Thermal power plants. Therefore, fly ash is a waste material that is utilised for construction purposes.

Fly ash is very cheap which proves to be economical for construction. It possesses high strength, good finishing, and is uniformly in size which reduces the quantity of plastering.

### High Volume Fly ash concrete

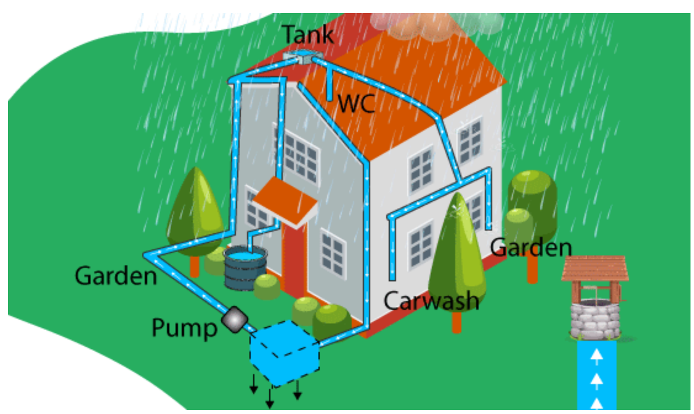
By using fly ash in HVF concrete, about 50% of the cement is replaced with it. Thus reducing the use of cement and utilising waste materials. It is more economical compared to ordinary concrete. Fly ash replacement doesn't alter its strength if the proportion is maintained. It has improved workability, reduced segregation, and bleeding.

### Solar Reflective Glass

It reflects infrared rays of the sun and only permits visible light to pass through it. It also keeps indoors comparatively cooler which helps in achieving energy efficiency. It has high durability and is resistant to surface abrasion, wear and tear.

### Rainwater Harvesting

Rainwater harvesting is the collection and utilisation of stormwater. This system is beneficial individually as well as for society in case of groundwater recharge, reduced runoff, less load on treatment plants, and improvement in the groundwater table.



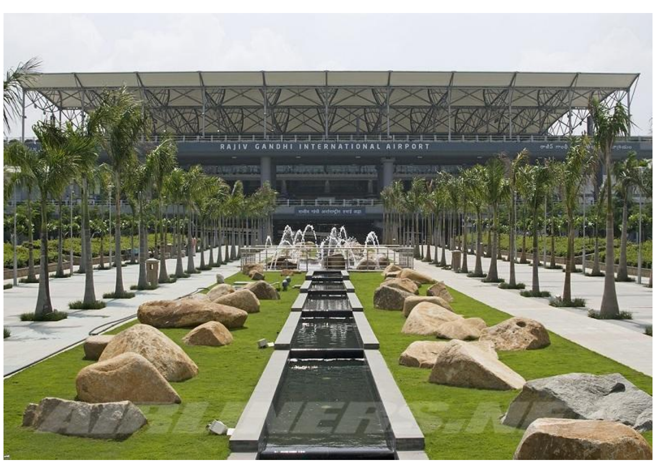

## GREEN BUILDINGS IN INDIA

Some of the Green Buildings in India are:
Suzlon One Earth, Pune:

This significantly unique office is designed by Christopher Charles, a Pune-based architect, and has received LEED Platinum rating in 2010. Spread over 10 acres, this magnificent structure is one of the largest green building projects of the country and is also one of India's first buildings to be LEED (Leadership in Energy and Environmental Design) certified. Suzlon one earth is 100% powered by renewable sources. The campus has 18 hybrid wind turbines that fulfill 7% of the total energy consumption. The structure is designed in a way to ensure maximum daylight exposure thereby reducing artificial lighting consumption.

**Rajiv Gandhi International Airport (RGIA), Hyderabad:**

India's 6th busiest airport, which is situated in Shamshabad of Hyderabad, set a benchmark for the green buildings in India. The structure of the airport is designed in a way to




consume less water, electricity and conserve natural resources. Within the campus of the airport, there is a green belt of 273 hectares with numerous plants. In the last couple of years, RGIA has been successful in saving energy for nearly 3.97 million kWh and has reduced the carbon footprint by 3331 tons.

**SITE LOCATION**


The site location for the project is in Dinara, Bihar. The terrain is plain with green vegetation around it. The vegetation mainly consists of naturally available trees, grass, and shrubs. In Dinara, the average annual temperature is 25.6 °C | 78.1 °F. The average rainfall here is around 1127 mm | 44.4 inches per year.

The average height above MSL is in the range of 200 – 250 metres. The site layout consists of a plot for 1 building.

**DETAILS OF SITE AND DESIGN REQUIREMENTS:**

**Details of the site:**
Address - Dinara, Rohtas NH30, Bihar
Distance from the nearest railway station - 20KM
Plot area - 996.34 sq. m
Floor Area Ratio (FAR) - 1
Possible maximum built-up area - 1315.65 sq. m

**Design requirements:**
This building is going to be designed for a higher middle-class group of people.
According to the available built-up area of the site, we have designed 2 storied buildings.
The plan is designed according to green building principles.

**PLANNING PRINCIPLES ADOPTED IN DESIGN:**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The plan is oriented towards facing east for the maximum utilisation of natural light and ventilation.
The building is provided with larger windows than the normal size windows. This is to make maximum use of natural lights.
Ducts are provided for ventilation of interior parts of the building and to allow cross ventilation.
Balconies connecting dining by French windows to enhance ventilation and interior beauty.
The system of rainwater harvesting is provided for groundwater harvesting and to use later for various household purposes.

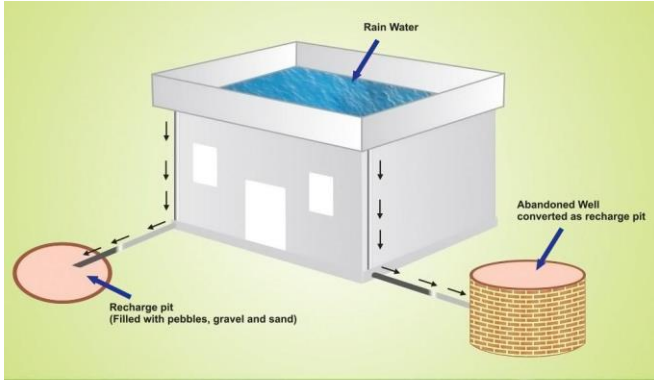
**TECHNOLOGIES ADOPTED**

The technologies adopted in the construction of the building are:

**Solar Photovoltaic Module:**
We are assuming 9556 WHr of power for the entire building per day.

- In KW/Hr = 9.556 KWHr Approx. = 10 KW/Hr
- 2 units of PV modules are installed on the roof and the car shed, each module of 5 KW/Hr.
- Cost of installation of the PV module = Rs 6,00,000/-

Groundwater recharge:
The recharge shaft technique of groundwater recharge is proposed.
The average annual rainfall of the place where the site is located is around 1127 mm




The total catchment area of the building = catchment area of the roof + catchment area of the car shed

- The total catchment area = 559 square metres + 23.22 square metres
- The total catchment area = 582.22 Sq. m
- The average annual water recharged = 954,670 litres

**MATERIALS USED**

**Fly ash blocks**

- Fly ash bricks are eco-friendly, easily available, and economical. Therefore, they are feasible.
- These blocks are hollow and hence reduce the load on the structures and provide insulation to the walls.
- Cost comparison with standard bricks:
- Standard brick of first-class (190×90×90mm) = Rs.10 per brick
- Hollow fly ash block (190×90×390mm) = Rs. 22.5 per brick

**NOTE** - One fly ash block is twice as big as compared to one ordinary brick.

**High volume fly ash concrete:**

- Fly ash concrete is cheap because the main constituent of fly ash concrete is fly ash, which comes cheap and is best suited as a filler material in concrete.
- High-volume fly ash concrete is more economic when compared to ordinary concrete.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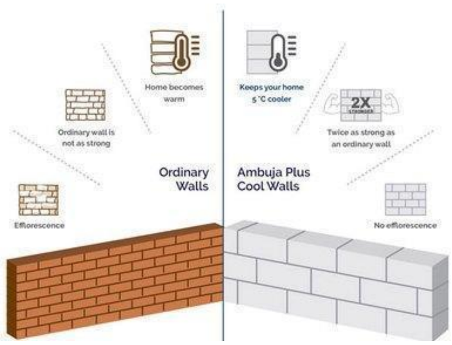
- Concrete created with fly ash tends to be more stable and exhibit a higher grade of overall strength than concrete made with traditional cement products.




**Cost comparison:**

| Grade | Ordinary concrete (Rs.) | HVFC (Rs.) |
|---|---|---|
| M25 | 3750 | 3150 |
| M30 | 4230 | 3750 |

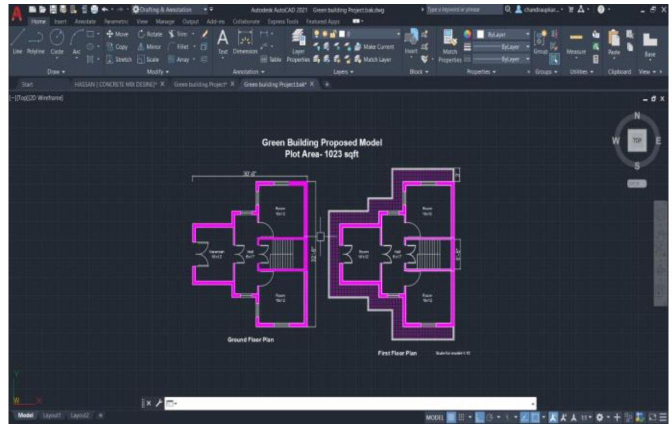
**Solar reflective glass:**

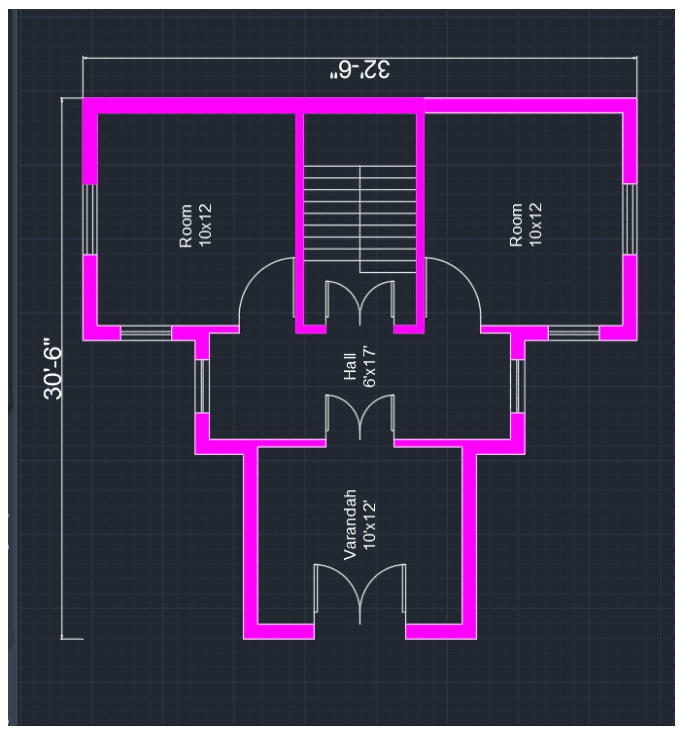
Solar control glass is a hi-tech product developed by the glass industry to allow sunlight to pass through a window or façade while radiating and reflecting away a large degree of the sun's heat. The indoor space stays bright and much cooler than would be the case if normal glass were used. These glasses control the infrared rays of the sun and keep the indoor environment cooler than the outside.

**STRUCTURAL DESIGNS**

The structure of the proposed building is designed using AutoCAD software.
The plan of the structure is generated using the software.

**Images of the structures from AutoCAD**



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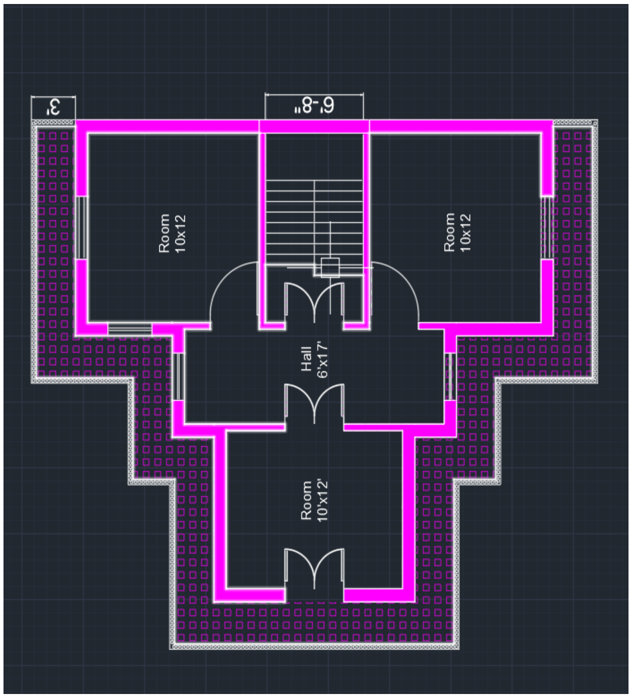


A Green Building may be estimated to be more on the expensive side compared to the conventional building method. But they prove to be more economical, environment friendly in the long run. Green Building will not eliminate the hazardous effects of building construction entirely but will reduce it to some great extent. Through educating, making environmentally friendly products more readily accessible and reliable, and by providing government incentives it is possible to encourage more people to adopt green building and all of the benefits that come along with it.

## CONCLUSION

Green building is conducive to reduce energy consumption, saving land resources and water use, can reduce the construction of soil and water pollution and air pollution, to meet the requirements of the times, to enhance people's quality of life. Many building materials and renewable energy sources exist to lessen one's impact upon the environment.

The objective of the project was to reduce the development footprint in buildings by the development of Green Construction Schemes. Reducing the development footprint will eventually result in more space for vegetation and other purposes combined with less exploitation of the mother Earth. Various methods to reduce the footprint were devised and the development footprint has been reduced to an appreciable extent. The aim of the project was to understand, plan and design a Green Building. This has been achieved by studying various green technologies and methods for buildings. Various green technologies and materials proposed with their feasibility study and cost comparison. The structure of the building is designed by using AutoCAD software. And finally, a self-assessment is done by considering LEED certification standards.

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