DRISHTI
A Revolutionary Concept

Sardar Vallabhbhai National Institute of Technology, Surat

SUSTAINABLE BUILDING

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ABSTRACT

The idea was to make a Building which is made up of eco-friendly material so that the harm to nature can be minimised. Further its objective is to generate its own energy so that the natural resources should be used in very small quantity and it should be also helping to optimize some of the natural resources.

MOTIVATION

The main motivation for taking this project is to know what type of harm environment is getting during the production of the building material and during building the building, and how we could minimize it. We would be getting information of the various technology that can be used to make the building, various eco-friendly material, etc., so that it doesn't harm the environment.

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Chapter 1: Sustainable building: an overview

1.1 Introduction-

Sustainable building (also known as **green building**) refers to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from planning to design, construction, operation, maintenance, renovation, and demolition.

The Green Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Sustainability may be defined as meeting the needs of present generations without compromising the ability of future generations to meet their needs.

Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective of sustainable buildings is 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.

1.2 Need of Sustainable building-

As buildings are responsible for a huge share of energy, electricity, water and materials consumption. The building sector has the greatest potential to deliver significant cuts in emissions at little or no cost. Buildings account for 18% of global emissions today, or the equivalent of 9 billion tonnes of CO2 annually. If new technologies in construction are not adopted during this time of rapid growth, emissions could double by 2050, according to the United Nations Environment Program.

The International Energy Agency released a publication that estimated that existing buildings are responsible for more than 40% of the world's total primary energy consumption and for 24% of global carbon dioxide emissions.

In Rachel Carson book, "Silent Spring" published in 1962, is considered to be one of the first initial efforts to describe sustainable development as related to green building.

Sustainable 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.

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.

1.3 Measure of sustainable building-

Leader in energy and environmental design (**LEED**) is a rating system devised by the United States green building council (USGBC) to evaluate the environmental performance of a building and encourage market transformation towards sustainable design. The system is credit-based, allowing project to earn points for environmentally friendly actions taken during construction and use of a building. Other certificates system that confirms the sustainability of buildings is the British **BREEAM** (Building Research Establishment Environmental Assessment Method) **which recognises and reflects the value in higher performing assets across the built environment lifecycle, from** new construction **to** in-use **and** refurbishment. Currently, World Green Building Council is conducting research on the effects of green buildings on the health and productivity of their users.

In India GRIHA, GRIHA council is an independent platform (registered as a society) for the interaction on scientific and administrative issues related to sustainable habitats in the Indian context. It was founded by The Energy and Resources Institute (TERI), New Delhi with support from Ministry of New.

- LEED certification level-

LEED Rating	Points (out of 110)
Certified	40-49
Silver	50-59
Gold	60-79
Platinum	80-110

- BREEAM rating system-

BREEAM Rating	Score (%)
Outstanding	≥ 85
Excellent	≥ 70
Very Good	≥ 55
Good	≥ 45
Pass	≥ 30
Unclassified	< 30

Chapter 2: Sustainable Site

2.1 Introduction-

A building that has a lot of people traffic going through it on a daily basis, that is sited in a place that can be reached by car is not at all sustainable/green after all. For making them sustainable/ green putting them in places where they enjoy easy convenient access to city (or town), transit system makes a lot of sense.

A sustainable site also prefer brownfield over Greenfield. In other word it is better to rehabilitate a brownfield site with a sustainable building than it is to put that same building on a piece of land that is still in its natural state. Rehabilitating a brownfield site with a green building increases the overall beneficial impact that the green building will have on the larger urban environment.

As Urban areas are full of large areas that have already been degraded by previous use and are also often well connected to the city's existing infrastructure so abandoned lots and decaying structures exist in so many inner city areas as well as in the older inner ring of single family dwellings. These types of sites as well as old factories and industrial areas are urban scar tissues that need healing. Siting a green building in this type of location if this is a possibility can contribute to returning vitality to the urban cores of cities and promote higher density living itself an important green consideration.

A green building site should also be selected based on how easily it can integrate into the existing electric, gas, water, and sewage utilities. Fitting into a city's existing infrastructure so that a project has the smallest impact on the existing energy, water, sewage and road systems. It should organically fit into the surrounding area, making best use of existing roads, sidewalks, alleys, site specific solar resources and so forth.

2.2 Importance-

The location/site of a building is as important as "how it is built". Its connection and linkage to the local bioregion, watershed, and community will help determine how a project can contribute to a sustainable environment. A sustainable project serves more than the immediate function of the building. It must also meet the needs of the local community, support active street life, promote healthy lifestyles, provide ecosystem services, and create a sense of place.

Site selection and design play important roles in both reducing greenhouse gas emissions and helping projects adapt to the effects of climate change. If people can use public transportation, ride bicycles, or walk to the building, the project helps reduce the carbon emissions associated with commuting. A project that is connected to the community by pedestrian paths and bicycle lanes encourages people to walk or bike instead of drive, not only helping to reduce air pollution, but also promoting physical activity.

2.3 Model-

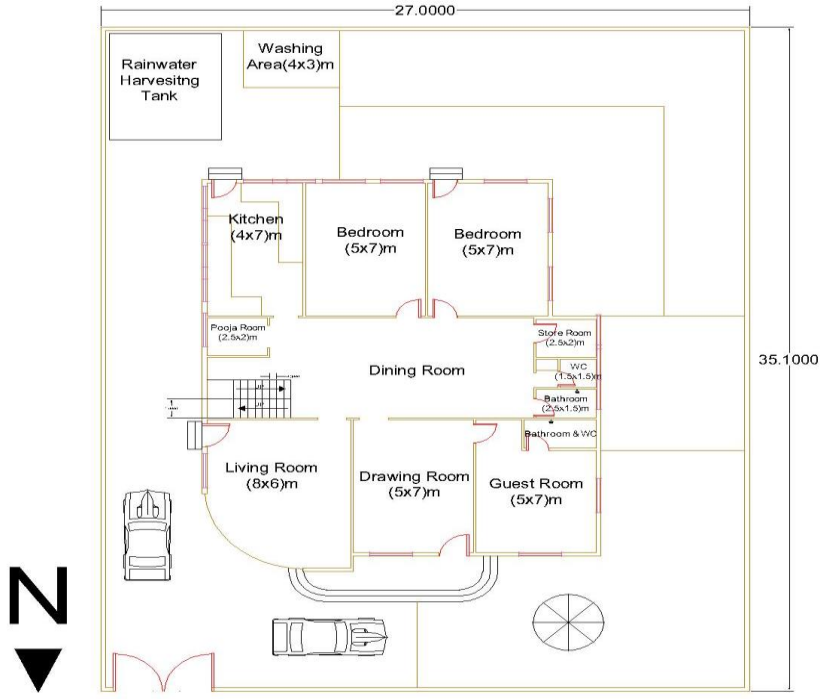
2.3.1 Location-

- The location for our project is Ichchhanath, Surat, India.
- This area is having walk score = 84 out of 100 given by Walk Score advisory Board.
- It is a developed region of Surat city and it is having proper connection to other parts of the city.
- Site is having many nearby facilities like shopping complex, police station, hospital, railway station, airport, restaurants
- Ichchhanath is having different transportation facilities like BRTS (Bus rapid transit system), Auto Stand, easy cab access (Uber, Ola, Zoom car, Jugnoo, etc.)

2.3.2 Plan-

Orientation- Orientation means proper placement of building and its components with respect to the weathering elements as the sun, wind, rain and environmental factors like topography, enhancing view of landscaping. It enables the inmates to enjoy the desirable features of nature & avoid the undesirable ones besides providing convenient access to street and backyards.

A. Plan 1-

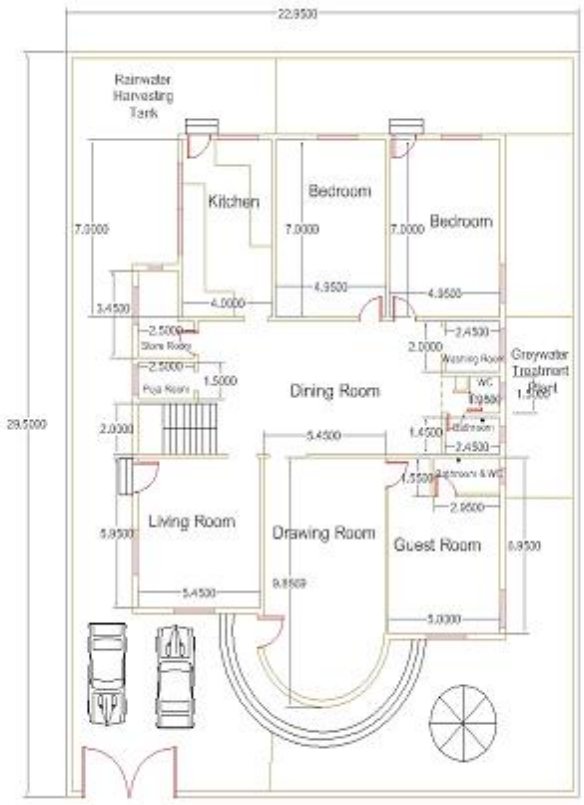


The above given plan is the very first plan of our building. This plan was having all the basic requirements that a building required. But there were some reason because of which it was discarded. The prominent reasons are:-

- The plot area was very large (27m x 35.1m).

- No ventilation for dining room.
- Doors of WC/Bath were opening in dining room as well as in front of puja room.
- Proper space optimization was not there.
- Dimension of rooms were very large.
- Horizontal circulation area =50.4936m^2
- Store room is far away from kitchen.

B. Plan 2-



Pros:-

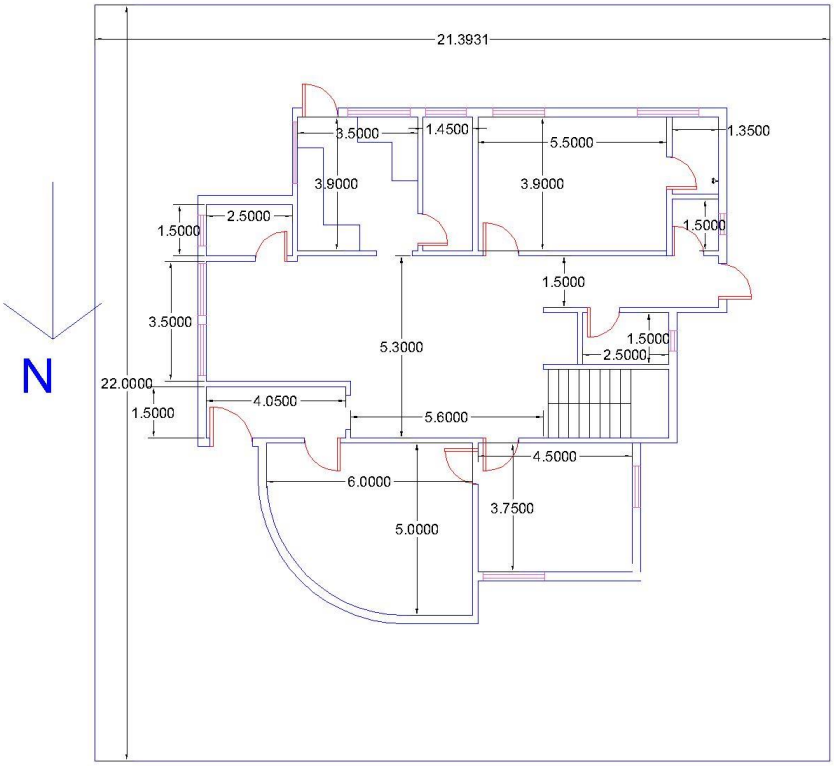
- Store room was near to kitchen.
- Free space was reduced.
- Dimension of rooms were reduced by some extent.
- Facilities like gym room, Study room, theatre room and small office was provided.

Cons:-

- Doors of WC/bath were opening in the dining room as well as in front of the puja room which is not advisable.
- The plan was looking like the rooms were in the single line.
- Ventilation in dining room was not present.

- Circulation area
- Even after deduction of the free space it was quite looking like a spacious home.

C. Plan 3-



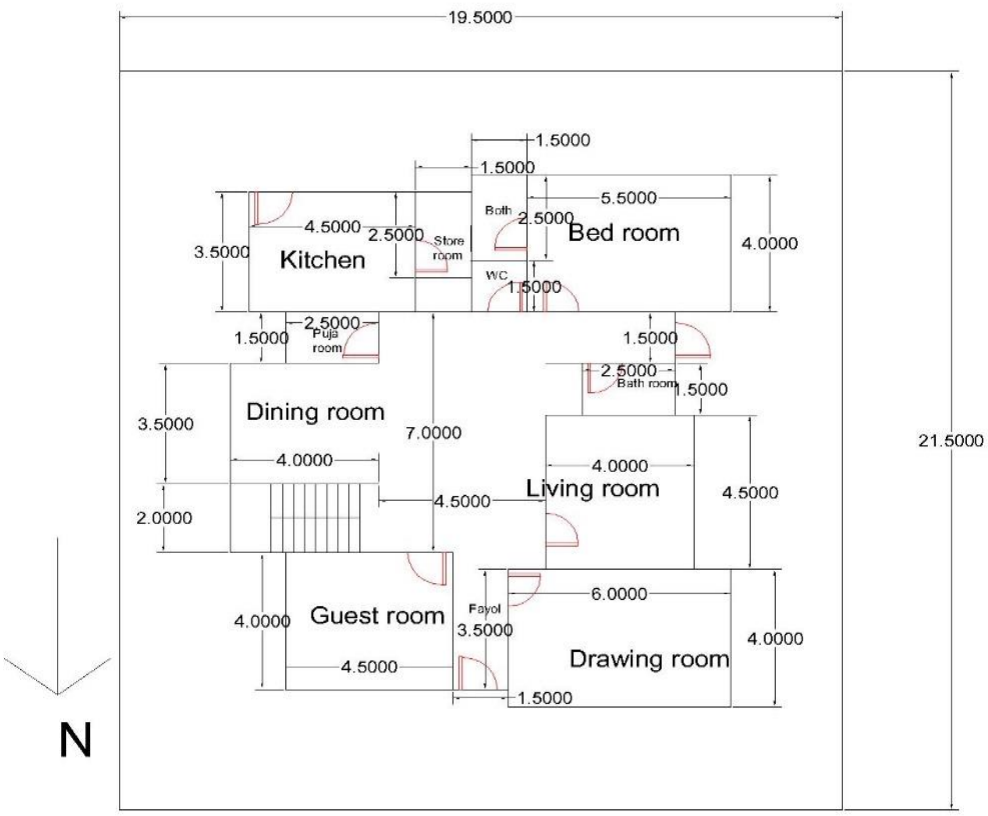
Pros:-

- Fayol (A small lobby inside the home which come just after the entrance of the home) was provided.
- We have given entrance to the drawing room from fayol, while all the other entrance are from the living room. In this way we have kept privacy of the occupants.

Cons:-

- Puja room was not in sandwiched condition.
- Ventilation of living room.
- Roominess factor of store room was not fulfilled.
- Square design of plan rather than rectangular shape.
- Circulation area

D. Plan 4:-



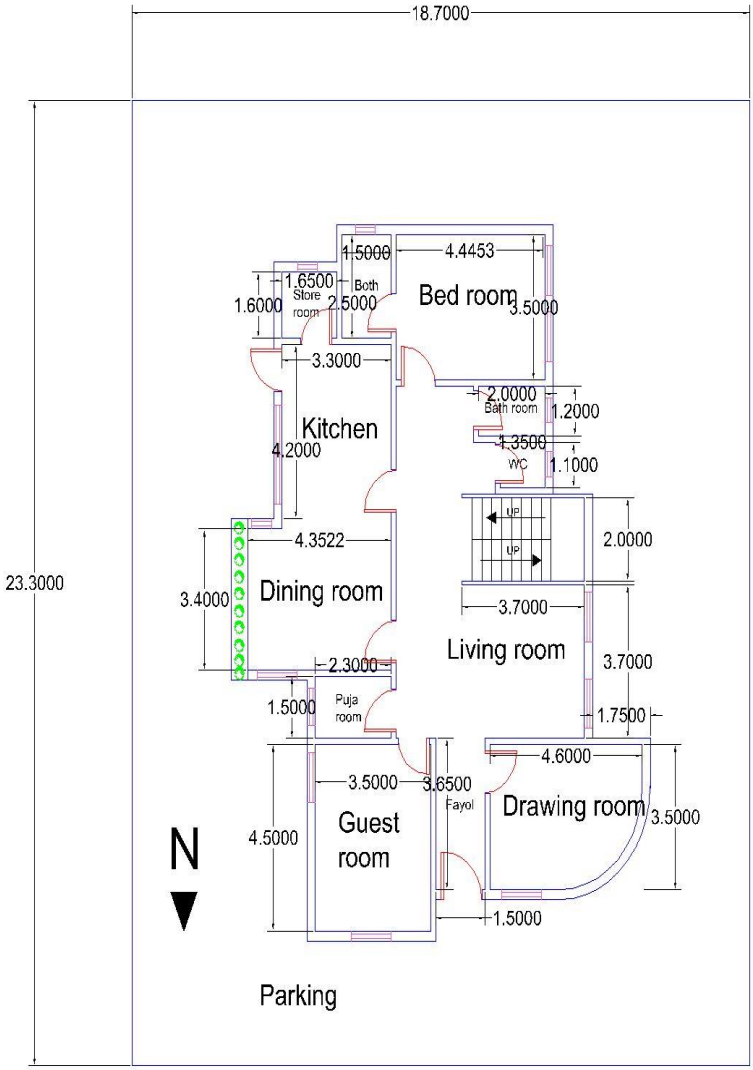
Pros:-

- In this plan Puja room and store room were properly sandwiched.

Cons:-

- Very high horizontal circulation area.
- One WC was not having any ventilation and also proper roominess factor not maintained.
- Square design of plan rather than rectangular shape.

E. Plan 5-



This was our final plan and in this plan our most of the error were rectified.

Pros:-

- Proper ventilation was provided for all rooms and facilities.
- Rectangular plan rather than square one with number of offsets.
- Proper placement of puja room, store room and staircase were achieved.
- Proper Roominess factor of all rooms and facilities were maintained

Circulation area-21.3125m^2

Plot area-389.11m^2

Floor area-157.2375m^2

Parking area-46.9650m^2

Chapter 3: Material Efficiency

3.1 Introduction-

- What is material efficiency?

Material efficiency is part of sustainable development, and taking it into account is now more important than ever due to the growing scarcity of natural resources. Material efficiency covers the minimization of raw materials used in the production process, selection of the most economical raw materials possible, and the reduction and recycling of waste to minimize the amount of unutilized material.

- What is sustainable material?

A sustainable material is one which protects the environment during its entire lifetime. That is from the moment the raw materials are extracted from the source to the time the final product is disposed of there must not be any permanent damage caused to the environment. Not only environment the material should also not have bad impacts on living beings.

Example: we can consider plastic as non-sustainable as it is non- biodegradable so it is not disposed of properly and damages the environment. Bamboo, on the other hand is sustainable.

Therefore sustainable building materials include recycled denim or blown-in fiber glass insulation, sustainably harvested wood, Trass, Linoleum, sheep wool, concrete(high and ultra-high performance roman self-healing concrete), panels made from paper flakes, baked earth, expanded clay grains, coconut, wood fiber plates, calcium sand stone, locally obtained stone and rock, bamboo and non-toxic low-VOC glues and paints. Vegetative cover or shield over building envelopes also helps in the same. Paper, which is fabricated or manufactured out of forest wood, is supposedly hundred percent recyclable .thus it regenerates and saves almost all the forest wood that it takes during its manufacturing process.

3.2 Need of Sustainable Material-

Materials used in traditional buildings causes a lots of problem to environment. Like during their manufacturing a large amount of CO2 is released, they are non-renewable and they don't consider about human health (toxic materials). According to WHO, 4.3 million people a year die from the exposure to household air pollution. So there is need of sustainable materials to tackle these problems-

- Co_2 Emission- sustainable materials are generally by-product of other materials or naturally produces so during their manufacturing very low amount of CO2 is released. Even during after implementation, CO2 emission by them is low.

- Renewable- since materials used in traditional buildings are non-renewable hence they will exhaust. So we need to find alternative for them. Sustainable materials being renewable solves these issue.
- Human comfort- Unlike traditional materials, sustainable materials are non-poisonous. Their thermal mass is also such that they do not get so much heated during summer or cool during winter (means according to human comfort).

3.3 Efficient Materials-

3.3.1 Model -

By our modal we are presenting few materials which are sustainable as they may be less harmful to environment or wastage material. The following materials are as follows

1. **Mosaic Tile**: These tiles are made up of marble scrap. Thus they are a product from waste. Hence it is sustainable as it saves energy, reduces emission CO_2 and transportation cost. Due to light colour it maintains proper temperature. It is used in open balcony and roof.

2. **Bamboo :**

- ❖ It is a natural anti-bacterial that will help buildings where there are children or people who cannot be in contact with bacteria for fear of sickness.
- ❖ Another great feature of bamboo is that it is water resistant, which makes it a better choice than many other hardwood floors that can stain or deteriorate when any kind of moisture gets in contact.
- ❖ It is also an extremely durable piece of material that is easy to move, yet still hard enough to provide you with great flooring.
- ❖ We have used green bamboo in one of the wall of dining room which gives pleasant feeling while having meal.

3. Wooden flooring:-

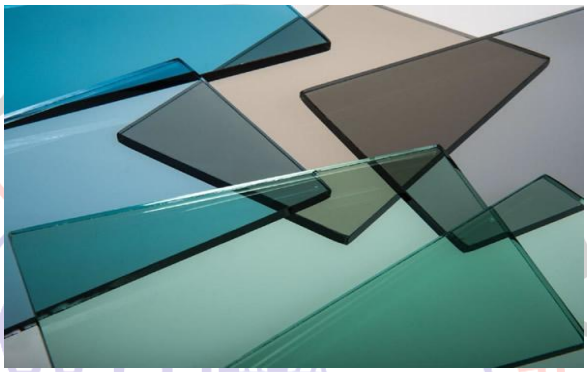
- We have used it in kitchen, rooms, etc.
- Trees absorb carbon during their growing cycle, and this carbon remains stored in products like wood flooring during its service life, thus keeping it out of the atmosphere.
- A life cycle assessment of flooring materials made of solid wood, linoleum and vinyl found the wood flooring had lower energy use and carbon dioxide emissions.
- It is a unique and renewable material.

4. Glass:-

- Architectural glass is glass that is used as a building material.
- When used in buildings, glass is often of a safety type, which include reinforced, toughened and laminated glasses.
- Greenhouse effect: The greenhouse effect refers to circumstances where the short wavelengths of visible light from the sun pass through glass and are absorbed, but the longer infrared re-radiation from the

heated objects are unable to pass through the glass. This trapping leads to more heating and a higher resultant temperature.

- ❖ Recyclable: Glass is 100% recyclable, cullet's (Scraps of broken or waste glass gathered for re-melting) are used as raw materials in glass manufacture, as aggregates in concrete construction etc.
- ❖ We have used it in place of staircase wall and for curved wall so that there should be availability of sunlight during daytime which results in less energy consumption.



5. Stones:-

- ❖ Stone is a great floor finish and is affordable in many countries; Italy and India are both known for the variety and quality of stone they produce.
- ❖ We have used stones instead of concrete for making the compound wall as it is easily available. We have used tiles of stones in kitchen.

Besides these we have used some more material to complete our model:

1. **Teak wood**- We have used teak wood to make columns.
2. **Plywood**- We have used it to make slab, compound wall, parapet wall and ground floor.

3. **Styrofoam**: We have used it to make walls as it was light weight and it remains stiff and does not get bent easily.


3.3.2 Prototype -

Here we are suggesting few materials which can be used in prototype but we are not able to present by our modal –

1. Fly Ash: Fly ash is a by-product form burning coal in electric power generating plants.

Application: The most common use of fly ash is as partial replacement of Portland cement used in producing concrete. Replacement rate normally runs between 20 to 30 percent but can be higher.

Advantages:

- It reduces energy demand of cement plant.
- **Fly ash makes the concrete more workable**. Concrete made with fly ash **requires less mix water**, and **bleeds less than Portland cement concrete**. It also **makes the concrete less permeable**. This means that outside moisture will not penetrate it as easily.
- **Fly ash is less expensive than cement.**

2. Fly ash Brick: Fly Ash can be used for manufacturing Cement Bricks by replacing 10% to 16% Cement with Fly Ash.

Application: Can be used in place of ordinary bricks for construction of walls.

Advantages:

- Saves construction cost – due to uniform shape & size of fly ash brick , it saves labour in laying brick by about 15%. This translates into reduction in laying each brick.
- Less Energy Consumption: huge energy is consumed in heating clay bricks in kilns. By using flyash brick much energy is saved in brick manufacturing.

3. Ashcrete:

Application**:** It can be used as an alternative of concrete. It uses fly ash instead of cement

Advantages**:** Properly cured concrete made with fly ash creates a denser product because the size of the pores are reduced. This increases strength and reduces permeability.

4. Bamboo Fibre:

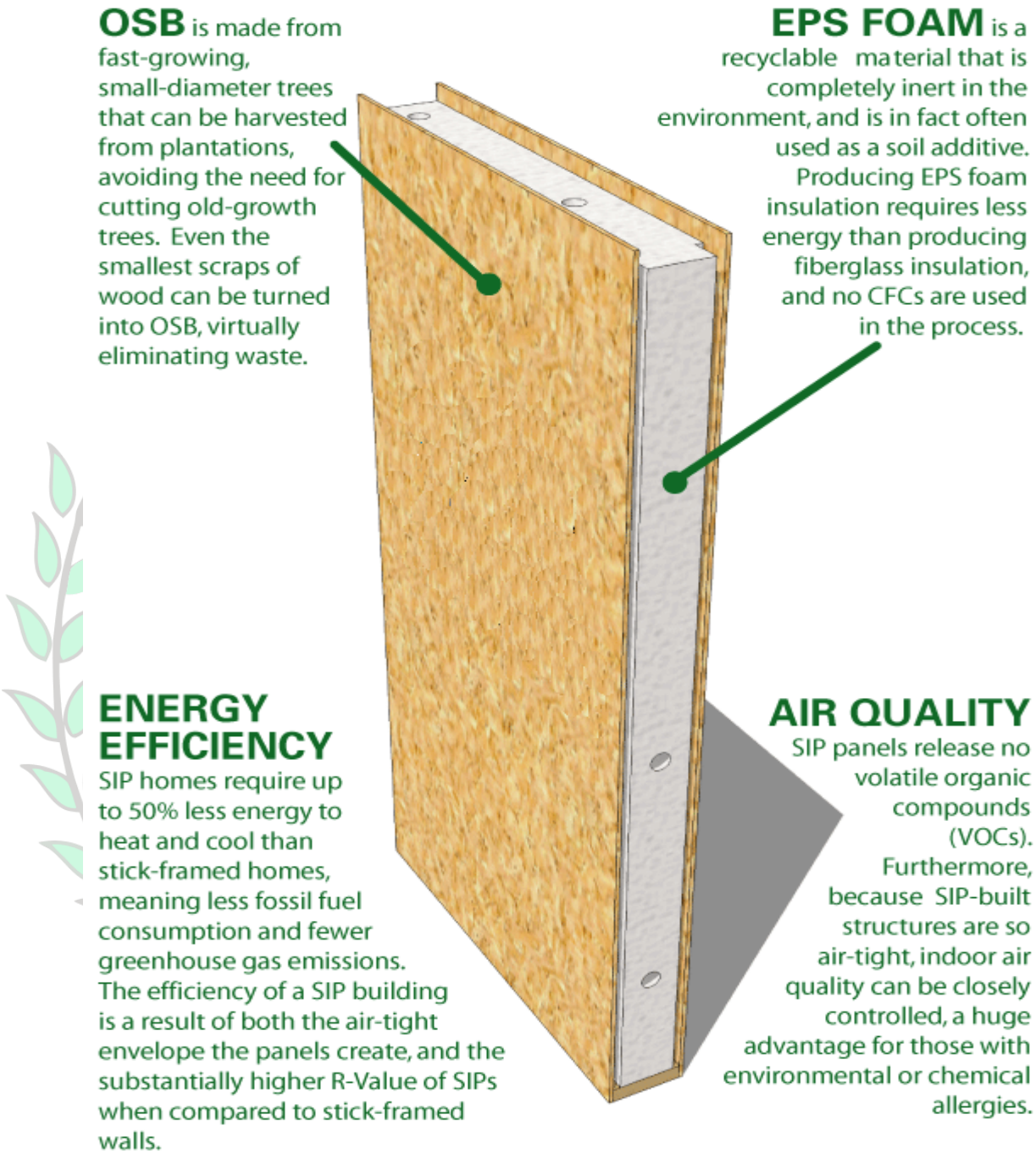
Application**:** It can be used for the reinforcement of concrete beam.

Advantages:

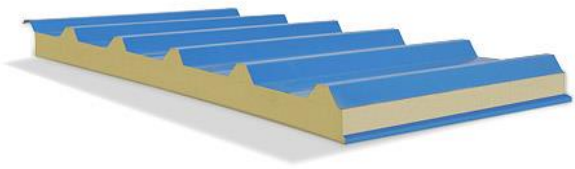
- Tensile strength of bamboo is more than steel.
- This lightweight structure also makes it easy to harvest and transport.
- Due to its incredibly rapid growth cycle and the variety of areas in which it is able to grow, bamboo is also extremely cheap.

5. SIP (Structural insulated panel):-

- Structural insulated panels (SIPs) are one of the most airtight and well insulated building systems available, making them an inherently green product.
- An airtight SIP building will use less energy to heat and cool, allow for better control over indoor environmental conditions, and reduce construction waste.
- The panels consist of an insulating foam core sandwiched between two structural facings, typically oriented strand board (OSB).
- The result is a building system that is extremely strong, energy efficient and cost effective.
- Building with SIPs will save you time, money and labour.



6. Pronto panel:-



- It has High Strength
- It is light weight
- It can be Installed quickly as it is in the form of the walls.
- Thermal insulation
- Environment friendly
- Water and fungi resistant
- Easy to move and shift:- uninstall panels while relocating and reuse; reduce costs in construction.
- Termite retardant
- Decreases energy demands of cooling and heating systems.

7. Permeable Concrete:-

- Permeable concrete is a special type of concrete with a high porosity used for concrete flatwork applications that allows water from precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing groundwater recharge.

Chapter 4: Indoor Environmental Quality Enhancement

4.1 Introduction-

Indoor environmental quality (IEQ) refers to the quality of a building's environment in relation to the health and wellbeing of those who occupy space within it. IEQ is determined by many factors, including lighting, air quality, and damp conditions.

Indoor environments are highly complex and building occupants may be exposed to a variety of contaminants (in the form of gases and particles) from office machines, cleaning products, construction activities, carpets and furnishings, perfumes, cigarette smoke, water-damaged building materials, microbial growth (fungal, mold, and bacterial), insects, and outdoor pollutants. Other factors such as indoor temperatures, relative humidity, and ventilation levels can also affect how individuals respond to the indoor environment.

Strategies for addressing IEQ include those that protect human health, improve quality of life, and reduce stress and potential injuries. Better indoor environmental quality can enhance the lives of building occupants, increase the resale value of the building, and reduce liability for building owners.

4.2 Importance-

Indoor environments having a direct impact on our well-being and our health, it is important to ensure a good indoor environment quality in both our homes and offices. Those most at risk are people with weak immune systems, including children and the elderly. While most will only ever experience medium health effects such as headaches or tiredness, others may suffer more serious health effects due to "sick" buildings. On the other hand, studies also show that an enhanced indoor environment quality in offices can be linked to staff's improved work performance and reduced sick leave. Council's experience shows that good indoor environment quality has become an important criteria for not only those who are developing their own homes but also for savvy developers, who understand today's market demands.

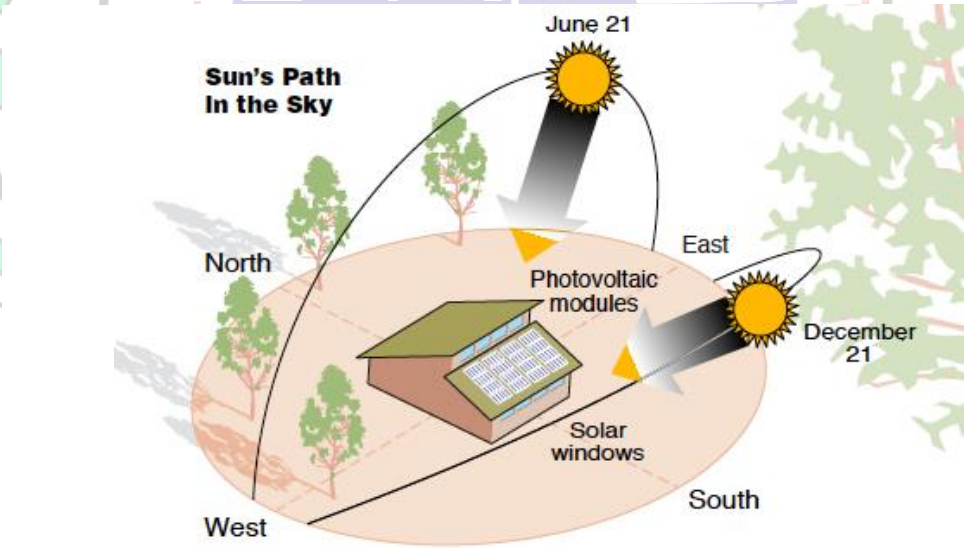
4.3 Factors Influencing Indoor Environmental Quality-

- Airborne contaminants (gases and particles)
- Indoor air quality
- Humidity
- Thermal comfort
- Ventilation
- Daylight, Lighting and Views
- Acoustics conditions.

4.4 Optimal Indoor Environment Quality Design-

In order to optimise **indoor environmental quality,** the design and development process should:

- Ensure good quality design, construction, commissioning, operating and maintenance practices.
- Size of the windows and the ventilator should be such that maximum amount of sunlight can be used keeping in mind the privacy of the occupants.
- Provide thermal comfort controls for occupants where possible.
- Supply adequate levels and quality of ventilation.
- Prevent airborne bacteria, mould and other fungi through a design that manages moisture sources inside and outside the building.
- Use building products that do not emit pollutants.
- Use sound absorbing/insulating materials to help create optimal acoustic levels.
- We can keep chajjas of the windows such that during summer season less amount of sunlight should enter house and during winter season more amount of sunlight should enter.



4.5 Building Management to Improve Indoor Environment Quality-

There are a number of ways that the **indoor environmental quality** of existing buildings can be improved, including:

- Using fragrance-free and low VOC (volatile organic compounds) cleaning products.
- Undertaking audits of cleaning products and devising a cleaning plan to replace products with safer alternatives.

- Vacuuming regularly and using vacuums with HEPA (High-efficiency particulate arrestance) filters.
- Ensuring that HVAC equipment is well maintained and working optimally.
- Creating a door and window opening protocol to maintain sufficient air flow.
- Avoiding dust blowing equipment such as leaf blowers and diesel-powered engine equipment.
- When using pesticides, fertilisers and lime applications, ensuring there is little or no wind.
- Maintaining buildings and furnishings to a high standard reducing the need for renovation and remodelling.
- Ensuring filters in HVAC systems are properly maintained.
- Optimising lighting.

4.6 Solution-

- We have used bamboo wallpaper for absorbing moisture and maintaining air quality inside the house.
- We have used glazed glass so that we can get maximum sunlight.
- We have installed vertical garden inside the dining room so that air quality is improved and humidity can be controlled as due to occupants respiration carbon dioxide levels increases and may introduce germs.
- We have open balcony and extended balcony so that proper use of the natural resources can be done.
- We have used wooden flooring so that moisture content can be minimised.
- Keeping in mind the principle of cross ventilation we have oriented our windows and doors.
- Control disturbing odours through contaminant isolation and removal and by careful selection of cleaning product. Pursue energy efficient strategies to remove harmful odour and recover energy used in conditioning the interior environment.

Chapter 5: Water Efficiency

5.1 Introduction-

Water efficiency is reducing water wastage by measuring the amount of water required for a particular purpose and the amount of water used or delivered. Water efficiency differs from water conservation in that it focuses on reducing waste, not restricting the use. Solutions for water efficiency focus not only on reducing the amount of potable water used, but also on reducing the use of non-potable water where appropriate (i.e. flushing toilet, watering landscape, etc.). It also emphasises the influence consumers can have in water efficiency by making small behavioural changes to reduce water wastage and by choosing more water efficient products.

One of the most important elements of understanding water efficiency is the diversification of water terms in sustainable building practices. Portable water, Grey water, Black water and Process water, all of which provide different utilities in sustainable building water efficiency processes.

5.2 Importance-

According to "The Hindu, Business Line", by 2050 India's total water demand will increase 32 per cent from now. Industrial and domestic sectors will account for 85 per cent of the additional demand. Increasing human demand for water coupled with the effects of climate change mean that the future of our water supply is not secure. As of now, 2.6 billion people do not have safe drinking water. Added to this the changes in climate, population growth and lifestyles and changes in human lifestyle/activities require more water per capita.

Fresh water is scarce in many areas of the developing world because of unplanned withdrawal of waters from rivers and underground aquifers causing severe environmental problems. In many countries, the amount of water being consumed has exceeded the annual amount of renewal creating a non-sustainable situation. In addition to that, rainwater run-off during rainfall from roofs and other sealed surfaces during heavy rain is leading to accumulated flooding in the urban areas of many countries where the drainage system was not designed including the volume of rainwater runoff.

5.3 Things to do to use water more efficiently-

- First- Overall water use can be reduced through the installation of highly efficient fixtures, appliances and systems, throughout our property.
- Second- Rainwater and Grey water should be used in preference to drinking water for purposes such as toilet flushing, laundry and irrigation where appropriate.

5.4 Water efficient fixtures and applications-

Installing water efficient fixtures, appliances and systems in our property is the first step in reducing water consumption. We found these following fixtures are most effective.

1. Water efficient tap: Traditional hand –operated taps have usually flow rate of 10-15 litres per minute. Water efficient taps having low flow rate of 2-5 litres per minutes when operated at full open condition, thus saves up to 70 percent of water.

Examples: auto shutoff taps, sensors taps, etc.

2. Efficient showers in bathroom – One way is to fuse air into the water flow which reduces water consumption by 50 % as some water is replaced by air. Other way is to use showers head with pulsating technology in which instead of a continuous flow water is turned on and off 30 times per second thus saving water. The shower feels normal because the pulsating is fast enough.

3. Efficient washing machine - A full-sized ENERGY STAR certified washing machine uses 50 litres water per load, compared to the 90 litres used by a standard machine. This saves nearly 50 % of water per load.

4. Energy Star Dish Washer: The older non – efficient dishwasher consumes an average of 40-50 litres of water per wash whereas energy star dishwasher consumes about 15 litres per wash.

5. Dual Flush Toilet: A dual flush toilet is a variation of the flush toilet that uses two buttons to flush different amounts of water. One button releases 3 litres for liquid waste and second button releases 6 litres for solid waste. An average of 5 litres for liquid waste and 10 litres of water for solid waste per person per flush is consumed in toilets. Dual flush toilet reduce water usage up to 40%.

6. Waterless Urinals – It look very much like conventional urinals in design and can be used in same manner. However, waterless urinals do not require water for flushing and thus result in saving anything between 155.61 to 465.75 litres of water per urinal per day.

7. Efficient garden irrigation system - A good way to prevent overwatering is to install rain or soil moisture sensors to override your automatic watering system when necessary. A rain sensor simply senses rainfall. Once a designated amount of water has been detected, it shuts down any regularly scheduled irrigation. Rain sensors are small, simple devices and are generally less expensive and easier to install and maintain than soil moisture sensors. Soil moisture sensors are more accurate than rain sensors because they can detect moisture at the level of the root system. They are more exact in measuring how much water your plants are receiving and thus offer greater water savings. However, they are somewhat complicated to install and manage.

Other ways to save water are-

1. Permeable concrete-

2. Car wash- Water can be saved in car washing by using soapy water and bucket instead of washing it directly by water pipe. Soap water spreads easily on car and by applying little amount of additional water we can clean it with a piece of cloth. Now we can collect this water through a small drainage system in a tank and can be used as grey water.

5.5 Rainwater Harvesting-

Rainwater itself is a clean source of water, often better than groundwater or water from rivers or lakes, the process of collection and storage often leaves the water polluted and non-potable.

- Conservation of rainwater is an efficient way to save potable water consumption.
- Rain harvesting is often a good practice to store water. Rain water can be stored up to a year, thus it provides a great source in drinking purpose.
- However sometimes the water gathered on the terrace is dirty and initial rains are acidic so we need to adopt a system to store clean water in the underground tank.
- We use first flush diverter mechanism to flush out unwanted water so that only clean water enters the tank.

5.5.1 First Flush Diverter:

Working-

- A first flush device is designed to prevent dirty water entering the tank from the terrace surface by diverting the water from the storage tank.
- The initial 2-3 rains have acidic content so they need to be flushed out.
- It consists a valve which is kept closed so that dirty water does not enter the tank and it is disposed off to grounds.
- Thus, it ensures only pure water enters the tank.

  Reference: First flush diverter

Challenges:

There is chances that irregularity in rain happens (i.e. a gap of a week or more is there before next rain).so, in this period sand and dust particles get deposited on the terrace. So, a small water diverter will not remove that much impurities.

Solution:

We increase the length of pipe and put valve at some farther distance from diverter so our storage increases and impure water diverts.

Rain water filter:

We can use CALCITE FILTER to filter the rain water.

Calcite Filter:

- Generally, rainwater is acidic, so it is harmful for drinking purpose.
- To neutralise rainwater, we use calcite filter due to its basic property. It contains a layer of calcium carbonate which neutralises acid rainwater.
- It is placed before the inlet of storage tank so the charcoal layer purifies the water and it becomes pure for drinking.

Charcoal Filter:

- It has a layer of micro activated charcoal which is a great purifier of impurities.
- It mostly clears dust particles, pollutants, contaminants, etc.'
- An efficient way to filter rainwater is to place charcoal layer after calcium layer in calcite filter.
- By using this filter system rainwater becomes completely pure for drinking.

5.6 Grey water reuse-

Grey water is the waste water discharged from washing machines, showers and laundry sinks. Grey water is not permitted to be used for drinking purposes however, it can replace mains water for toilet flushing and garden watering. If the untreated grey water is not used within 24 hours it should be discharged to the sewer.

Note- Water discharged from the kitchen and toilets is by law not considered as grey water.

There are a number of grey water systems available on the market that range from manual to mechanical systems.

5.7 Types of water in house pipeline network -

1. Grey Water
2. Black Water
3. Potable Water
4. Rain Water

5.7.1 Grey Water:

- Sources: Showers, Baths, Clothes washing machines or dishwashers.
- Greywater constitutes 60% of total water produced every day.
- Uses of treated greywater: Toilet flushing, irrigation, etc.

Treatment of greywater:

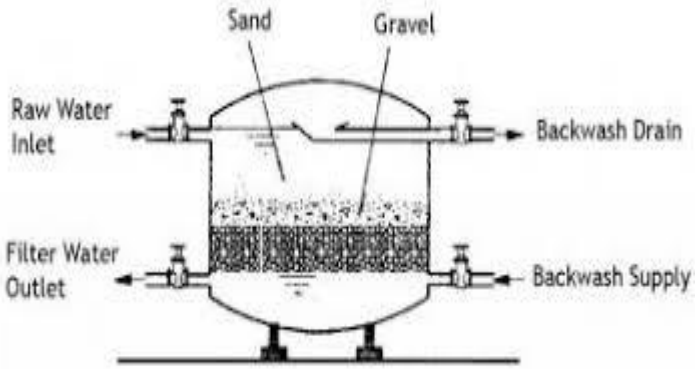
Sand filters are used as a step in the water treatment process of water purification.

There are two main types:

1. Rapid (gravity) sand filters
2. Slow sand filters.

Both filters work differently according to different conditions.

Rapid sand filter:



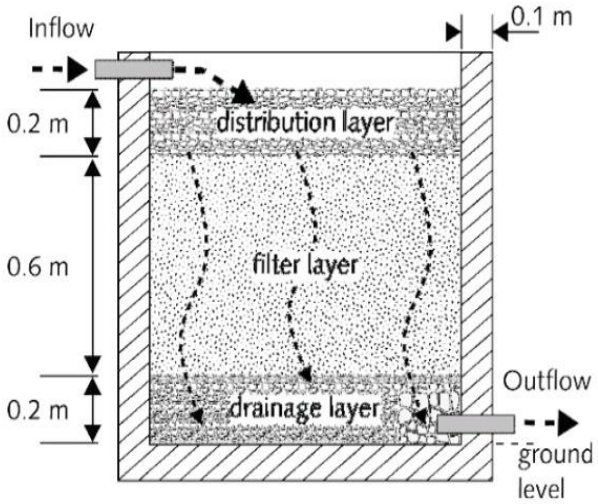
Pros:

- High rate of filtration **3000-6000 litre/hr/m^2.**
- Low installation cost.
- High suitability for towns and cities.

Cons:

- Not effective in removing bacteria.
- High capital and operational costs.
- Frequent cleaning (backwashing) required (every 24-72h).
- High energy input required.

Slow Sand filter design:



- As per the title the speed of filtration is relatively slow in compared to other filters.

- The layers are distributed as follows:
- A 20 cm distribution layer of gravel (grain size 8 - 20mm).
- The filter layer of minimum 60 cm of sand (0-4mm).
- A 20 cm drainage layer of gravel (grain size 8 - 20 mm).
- After 15-20 days, the efficiency of filter increases gradually due to formation of microbial layer.
- Capacity of sand filter:

100 litre/hr/m^2

- Efficiency of sand filter:**70%**

Reference- Slow Sand Filter

WE ARE USING SLOW SAND FILTER AS IT GIVES WATER AT HIGH EFFICIENCY AND AT LOW COST AS COMPARED TO RAPID SAND FILTER.

5.7.2 Potable water:

- Potable water, also known as drinking water is safe to drink and used for cooking preparation. It has PH between 6 to 8.5.
- In our model we have provided two sources for drinking water: Rainwater and Tap water (from corporation).

Consumption of potable water:

Uses	Consumption in litre/day/person
1. Drinking	5 litre
2. Kitchen purpose	5 litre
3. Bathing	55 litre
4. Washing Utensils	10 litre
5. Washing clothes	20 litre
6. Gardening	35 litre
7. Toilet flush	30 litre

5.7.3 Blackwater:

- Sources: Toilets, kitchen sinks.
- Black water contain faeces, urine, water and toilet paper from flush toilets and materials having high pathogen content.
- Difficult to process so directly dispose to main sewer line.

Reference: Types of Water

Analysis of water consumption and calculation for dimension of storage tanks:

- According to survey water consumption for domestic use per person per day is around 150 litres. As there are six members in the house,
- Therefore, total water consumption = **900 litres**
- Grey water production = **900x60%**

= **540 litres**

- Treated grey water production

  540x70%(efficiency) = 350 litres
- Rainwater calculation:

  Area of terrace = **120 m^2**

  Annual rainfall in Surat = **1192 m**
- Run off co-efficient for Mosaic tile = **0.9**
- The amount of rainwater is calculated as: $\frac{120 \times 1.192 \times 1000 \times 0.9}{120 \text{ (days)}}$ **= 1072 litres.**
- Considering losses net amount of water collected in storage tanks becomes **800 litres.**

Calculations for underground rainwater:

- Rainwater can be for drinking purpose and considering around 5 litres of drinking water consumption per person per day
- Total members in house are 6

So,

6×5 litres = 30 litres per day

365 x 30 = 10950 litres.

Calculating for 1 year the water we get approximately is 10,000 litres

- So, we have to build a 10,000 Litre tank to store rainwater.

Rainwater management :

As per calculations during rainy season we are getting approx. 800 litres of rain water daily therefore we decided to build a 10000 litres tank which will store water during rainy season and we can use this water for Drinking nearly for a year.

Dimensions for all tanks:

- Underground rainwater has 10000 litres capacity.

  2.5 x 2 x 2 (in meter).
- Treated grey water has 300 litres capacity

  1 x 0.5 x 0.6 (in meter).
- Underground potable tank will have a capacity of **2300 litres** (**1500 litres from corporation + 800 litres from rainwater**)

  1.8 x 1.3 x 1 (in meter).
- Overhead tank has a capacity of **1000 litres.**

  1 x 1 x 0.5 (in meter).

5.8 Position and number of tanks

1. **Number of tanks:**
   - According to daily needs we need to determine the number of tanks and their respective position.
   - Initial 4 different underground tanks were decided for all types of water and 2 overhead tanks were fixed.

Challenges-

- Four underground tanks are not feasible and suitable for a residential Building, according to our need we should manipulate most effective approach.

Solution-

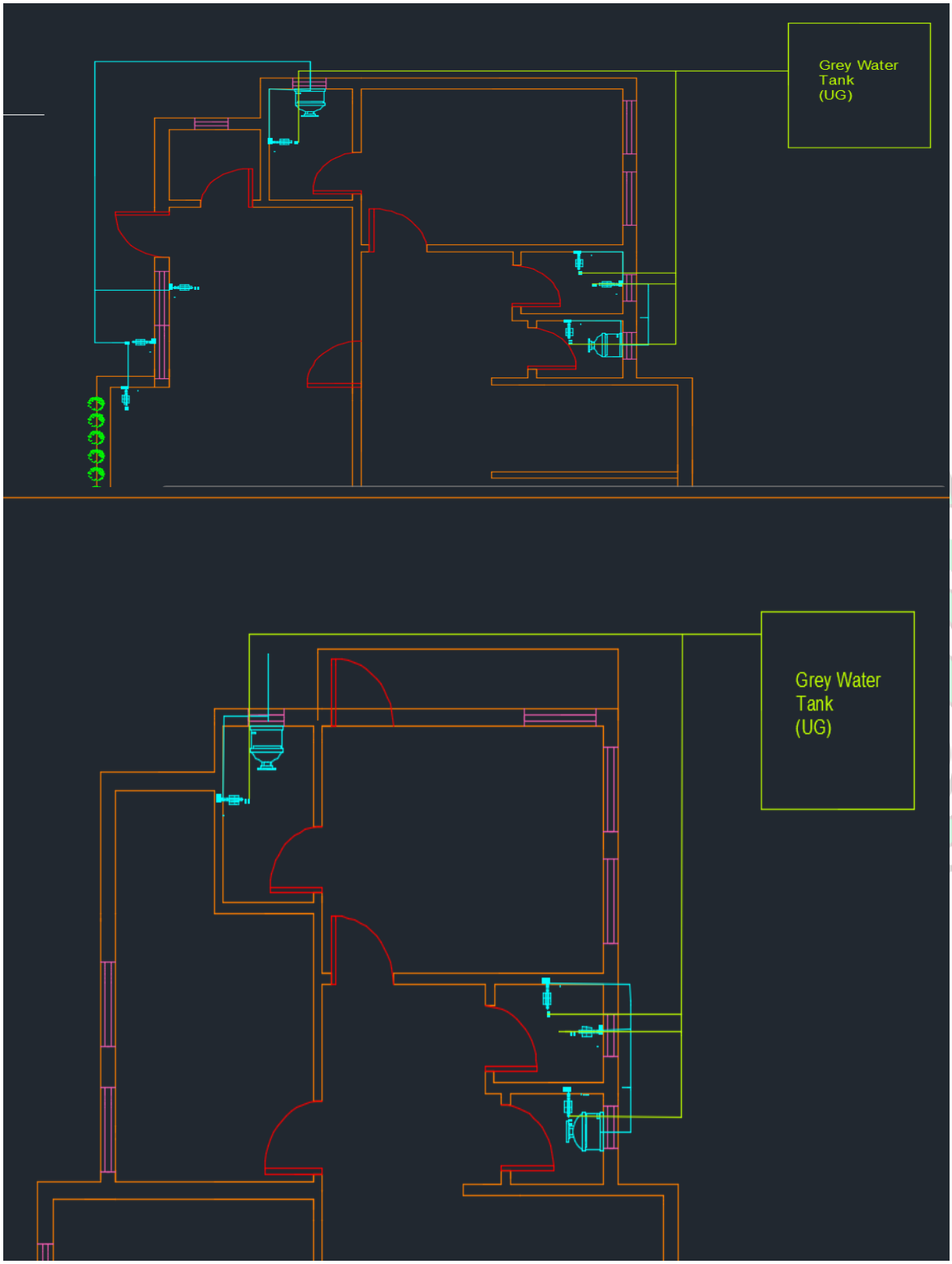
So, we optimised the tanks by reducing excess tanks.

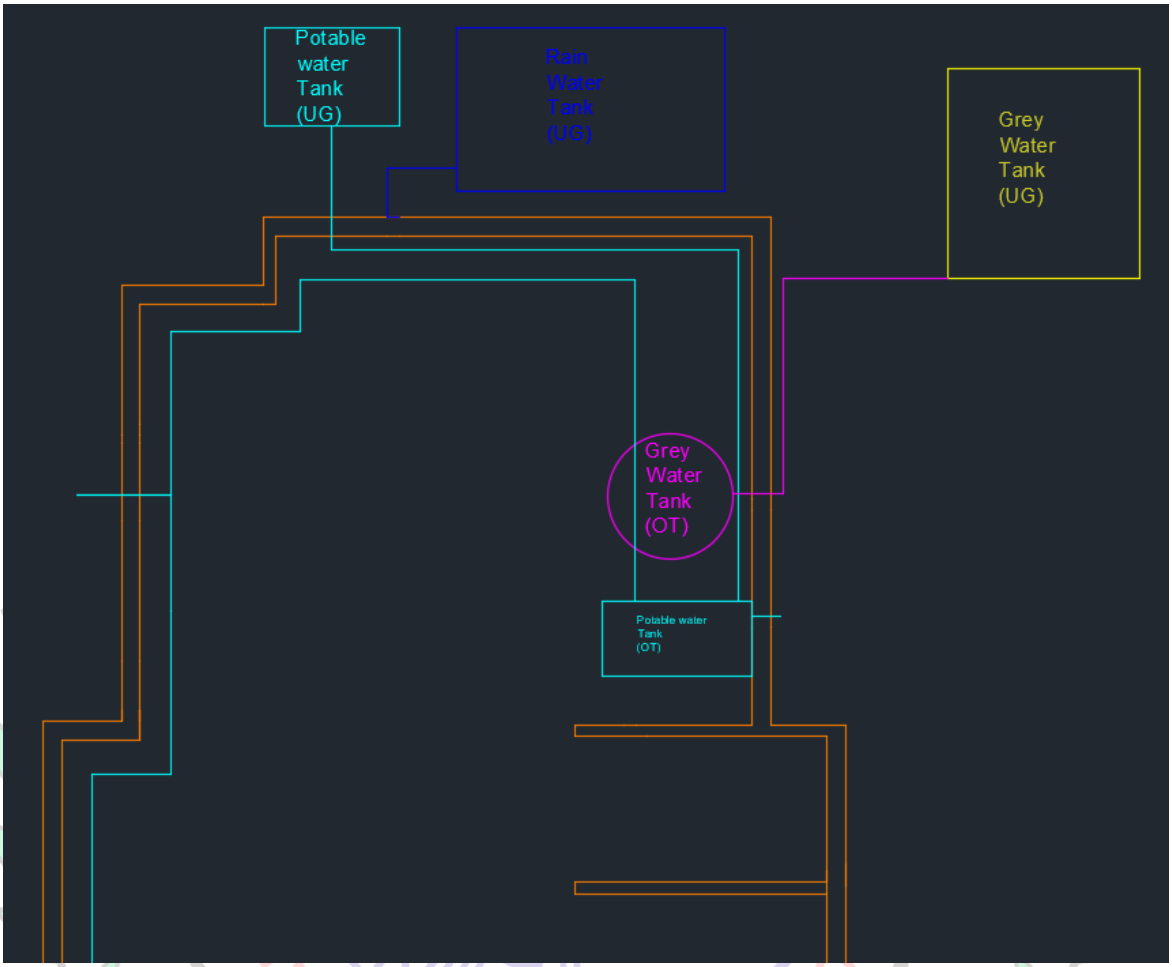
- For freshwater, two tanks are required:
- One tank would be for storage of corporation water and other one is kept for rainwater harvesting.
- A float valve is kept in potable water storage tank which will act when the tank is filled with 1500 litres of water. After filling of 1500 litres of corporation water, ball will block the input from SMC and rain water will be collected in the remaining space.
- For grey water treatment, water is treated by a using a sand filter. After passing through the filter, water is stored in treated grey water tanks.
- So, there will one underground and one overhead tank for treated grey water.

FLOAT VALVE: The valve is connected to the incoming water supply, and is opened and closed by the lever which has the float mounted on the end. When the water level rises, the float rises with it; once it rises to a pre-set level, the mechanism forces the lever to close the valve and shut off the water flow.

2. Position of tanks:

Idea 1:


Grey Water
Tank
(UG)
Grey Water
Tank
(UG)



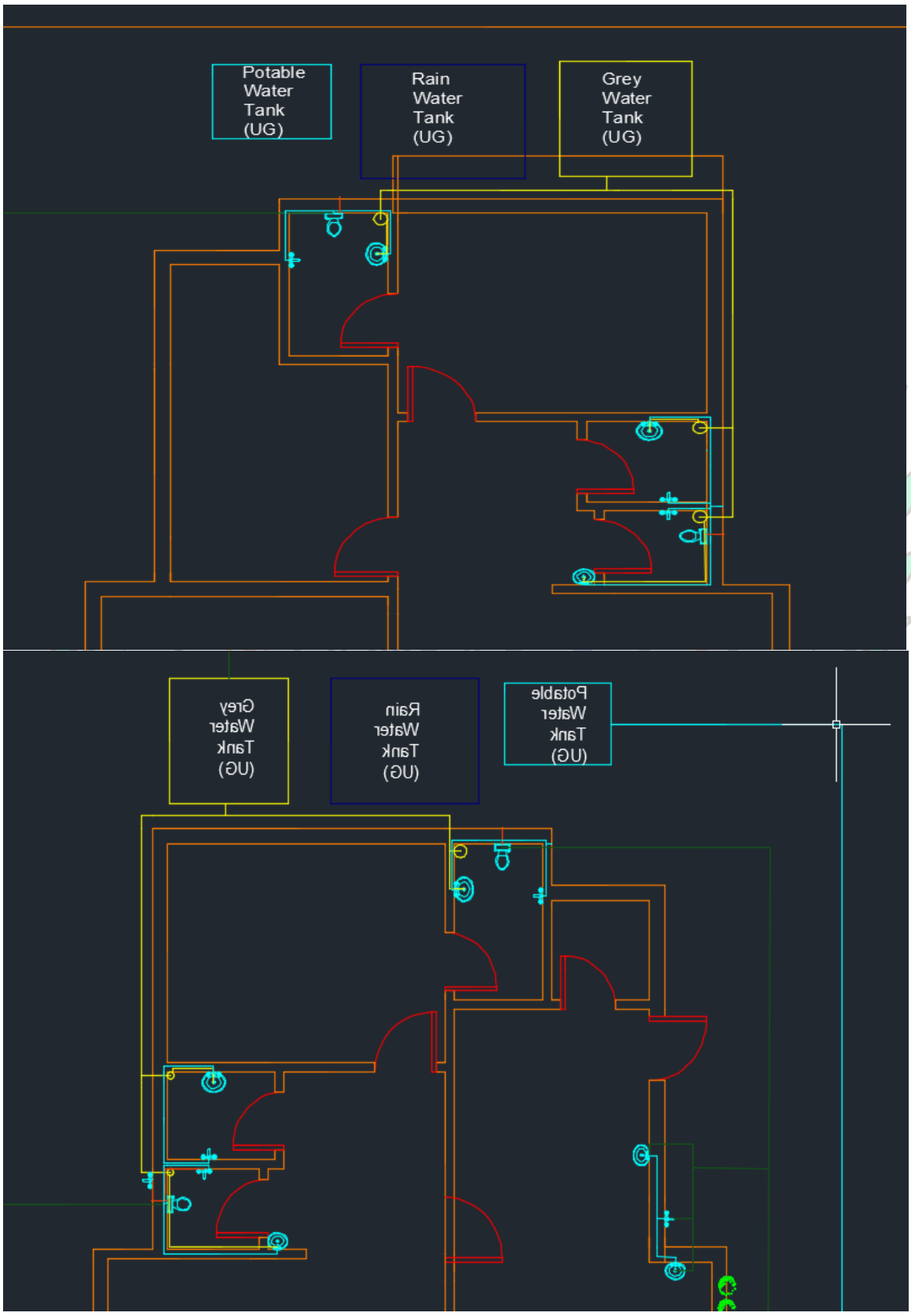
Pros:

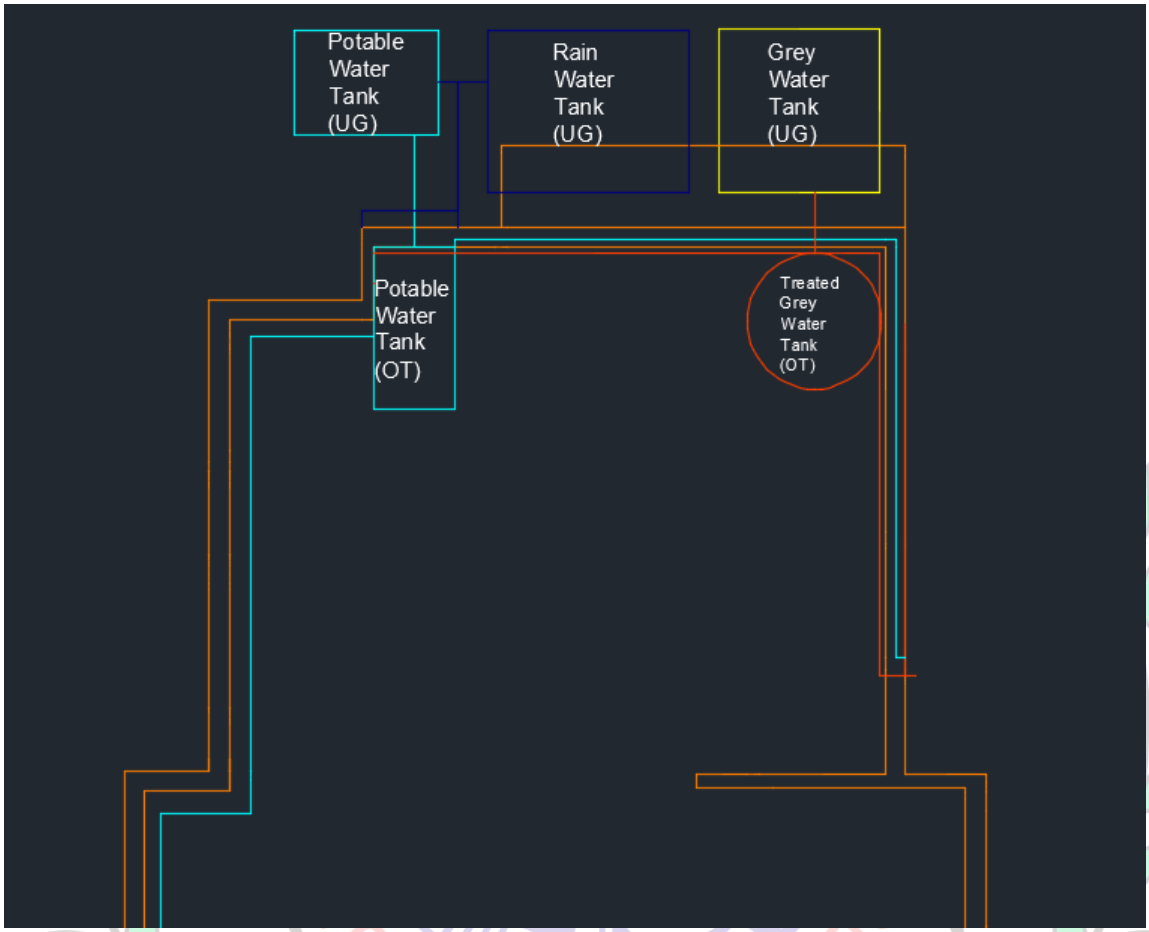
- Less distance between treated greywater tank and bathroom allows us to minimize the number of pipes required for installation.
- Space beside the stairs is utilised by placement of tanks and we can efficiently use terrace area for other purpose.
- Number of underground tanks reduce as rain water and potable water tanks are combined.

Cons:

- Due to this arrangement the distance between kitchen and common bathroom increase.
- As distance increases, number of bends increase and losses occur in transporting water.
- Also, transportation of treated greywater from underground to overhead tank becomes difficult due to more bends and joints.
- The distance between underground potable tank and overhead always increases.
- We cannot store rainwater separately and our purpose of rain water harvesting is not served.

Idea2:





- In this arrangement we shifted the tanks from stairs to the edge of the terrace.
- The problems face in the previous idea were rectified in this plan.
- By this arrangement, the number of bends and joints between underground and overhead greywater tanks reduces and losses are reduced.
- In the case of freshwater tank this arrangement allows us to reduce the loss occurring in transportation of water from underground to overhead tank.
- Also water is easily supplied to all the required destinations.

Finally idea 2 is adopted as it is more efficient in network and losses are reduced.

Chapter 6: Energy Efficiency

6.1 Introduction-

The most important element of green building is energy efficiency. Higher levels of energy efficiency reduce carbon emissions - both from power plants and the home's own energy systems. 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 30% of the overall life cycle energy consumption.

6.2 Importance-

There are solid business reasons why energy efficiency is important for our new building, including:

- Providing energy cost savings incentives to you or your tenants.
- Increasing tenant demand for comfortable and energy-efficient working environments.
- Contributing to the sustainability of your organization.
- Attracting investors wishing to acquire responsible and sustainable investments.
- Future-proofing investments against potential reporting requirements.

By designing a new building holistically, with energy savings goals in mind, we can help to ensure that all systems work together effectively and we can incorporate major energy-efficiency components that would be difficult or impossible to retrofit and will save significant amounts of money over your building's life.

6.3 Solar energy

Solar panel-

Mono-crystalline solar panels have best efficiency up to 18% and It also has better aesthetics, but it also costs higher in comparison to others.

System which we are using is off-grid.

In an off-grid system there is no public electricity grid. Once solar power is used by the appliances in your property, any excess power will be sent to your battery bank. Once the battery bank is full it will stop receiving power from the solar system. When your

solar system is not working (night time or cloudy days), your appliances will draw power from the batteries.

No. of solar panels-4

1 Solar panel generates 1 unit of electricity in 4 peak hours of a day

So 4 solar panels will generate 4 units in peak hours of a day

Installation cost -1,00,000Rs

Usage/day -15units

Solar power generation -5 units

Approximately 30% of electricity of a general household can be produced by a rooftop solar panel system.

Money Saving

Unit cost of electricity in Surat City is App. 6Rs

Usage/Month - 15X30=450 units

Electricity charges/Month - 450X6=2700Rs

Units produced by Solar panels/Month - 5X30=150 units

Maintenance cost of Solar panel annually is 2% of installation cost.

(Ref-https://www.itsmysun.com/faqs/what-would-be-the-annual-maintenance-cost-for-a-solar-pv-system/)

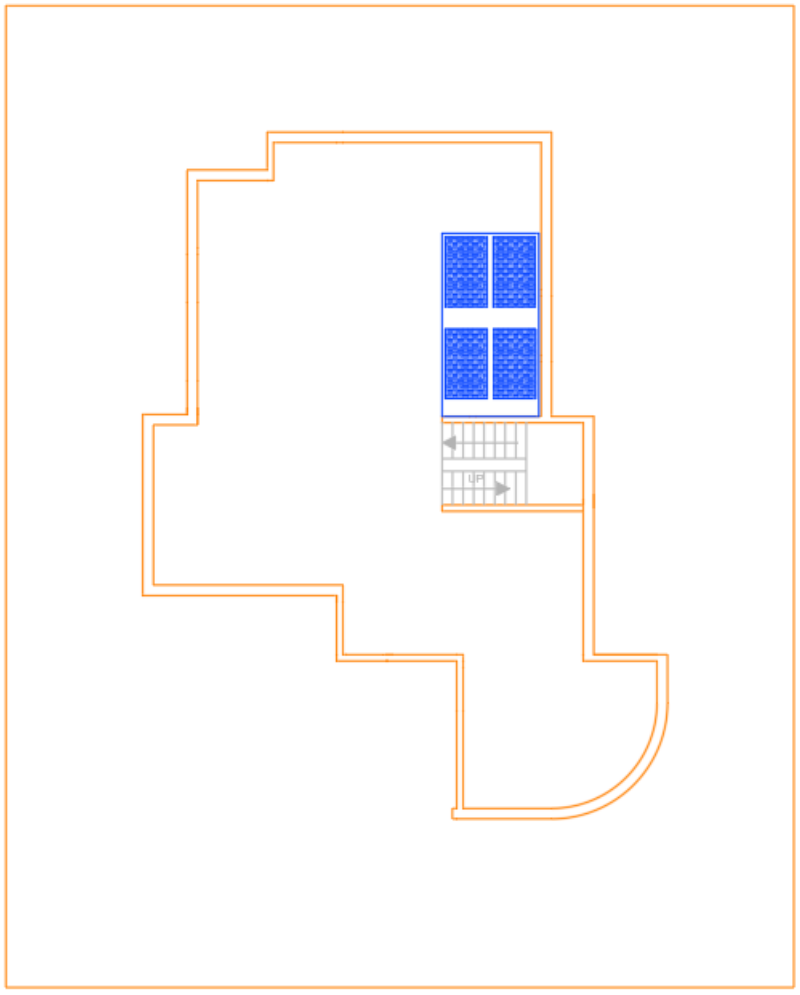
Maintenance cost/Year = 2000 Rs

Maintenance cost/Month = 167 Rs

Money Saving/Month = 900-167=733 Rs

By using Solar panels we can save upto 27% of Money Spent.

Position of solar panel in our plan:



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