PLANNING AND SCHEDULING OF GREEN RESIDENTIAL BUILDING

Submitted in partial fulfillment of the requirements

For the degree of

Bachelor of Engineering

By

SHINDE ADITYA RAMCHANDRA (17CE59)

PUJARI SOURABH VITHAL (17CE42)

RANJITH NEELAN (17CE46)

SIVALINGAM DEVARAJ (17CE60)

Under the guidance of

PROF.GIRISH B. MAHAJAN

Department of Civil Engineering

School of Engineering and Technology

Anjuman-I-Islam's Kalsekar Technical Campus

New Panvel, Navi Mumbai-410206

2020-2021

A Project Report on

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CERTIFICATE

This is to certify that the project entitled "**PLANNING AND SCHEDULING OF GREEN RESIDENTIAL BUILDING**" is a bonafide work of **SHINDE ADITYA RAMCHANDRA (17CE59), PUJARI SOURABH VITHAL (17CE42), RANJITH NEELAN (17CE46) and SIVALINGAM DEVARAJ (17CE60)** submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of "Undergraduate" in "Civil Engineering"

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APPROVAL SHEET

This dissertation report entitled "**PLANNING AND SCHEDULING OF GREEN RESIDENTIAL BUILDING**" by **SHINDE ADITYA RAMCHANDRA (17CE59), PUJARI SOURABH VITHAL (17CE42), RANJITH NEELAN (17CE46), SIVALINGAM DEVARAJ (17CE60)** is approved for the degree of "Civil Engineering"

Examiners

1. ……

2. ……

Supervisors:

1. ……

2. ……

Date:

Place: Panvel

DECLARATION

We declare that this written submission represents my ideas in our own words and where others ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

SHINDE ADITYA RAMCHANDRA (17CE59) ……..

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Date:

ABSTRACT

This project work deals with the planning and scheduling of a (G+4) green residential building which is located in city area. In this project we have tried to provide all basic as well as modern amenities in residential green building which provides comfort and healthy environment. We are aiming to reduce the environmental impact, water consumption, maintenance cost and make the residential building energy efficient. For achieving this we are going to build rain water harvesting tank and provide solar panels. Also we are trying to make this building cost efficient & energy efficient. Realizing the situation about huge energy & water consumption, we need to use energy to its fullest & water sources in premises of building itself so that occupants need not to depend upon external sources which are not affordable.

For achieving more accuracy, we are using Civil engineering software like AutoCAD for planning the green building. We have gone through the core principles of planning and building byelaws which helped us in proper preparations of design of green residential building. Further Scheduling of activities is to be done manually. As we know now a days building sector alone represents 35% energy consumption realizing the situation the need is to adopt a sustainable green building approach, which is the ultimate solution to reduce the energy demand of the building. Over usage of conventional material, not only harms the environment but also affects the natural resources hence we are proposing to use natural cost effective materials and some advanced techniques like rainwater harvesting and solar system to maintain the needs of environment and economy.

Keywords: - PLANNING, ENERGY EFFICIENT, GREEN BUILDING.

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ABBREVIATION NOTATION AND NOMENCLATURE

CAD	COMPUTER AIDED DRAWING
2D	TWO DIMENSIONAL
3D	THREE DIMENSIONAL
PV	PHOTO VOLTAIC
RWH	RAIN WATER HARVESTING
VOC	VOLATILE ORAGANIC COMPOUND
IAQ	INDOOR AIR QUALITY

Chapter 1

Introduction

1.1 General

Planning is the fundamental management function, which involves, what is to be done, when is to be done, how is to be done and who is going to be done at back of the mind. Planning ensures accuracy, economy and quality throughout the project.

A schedule is the timetable for a project activities, programme or portfolio. It shows how the work will progress over a period of time and takes into account factors such as a limited resources and estimating uncertainty.

Implementation of project is nothing but preparing and putting the elements of the strategy into proper place. The benefits of effective planning, scheduling and control of construction projects are: reduced construction time, reduced cost overruns and the minimization of disputes.

A green building is one which uses less water, optimizes energy efficiency, conserves natural resources and provides healthier space for occupants as compared to conventional buildings. Green building expands and complements the building design concerns of economy, utility, durability and comfort. The features of green building include renewable energy, building orientation, solar design, rain water harvesting and the use of natural lighting.

Sustainability concept (economic, social and environment) incorporates and integrates a variety of strategies during the design, construction and operation of building projects. The use of green building materials and products represents one important strategy in the design of a building

For planning purpose, AutoCAD software is used and by referring byelaws of residential building, planning is done. AutoCAD is a commercial software application for 2D and 3D computer- aided design (CAD) and drafting available since 1982 as a desktop application and since 2010 as a mobile, web- and cloud-based app marketed as AutoCAD 360.

GREEN BUILDING RATING SYSTEMS

A green building rating system is basically a reference tool that assesses a building's performance and its impact on the environment. Following are some of the types of green building rating systems.

1) LEED (Leadership in Energy and Environmental Design)

2) IGBC (Indian Green Building Council)

3) GRIHA (Green Rating for Integrated Habitat Assessment)

4) BREEAM (Building Research Establishment Environmental Assessment Method)

ENERGY SAVING CONCEPTS

Solar panel: Nowadays, due to the decreasing amount of renewable energy resources, the last ten years become more important for per watt cost of solar energy device. It is definitely set to become economical in the coming years and growing as better technology in terms of both cost and applications. Everyday earth receives sunlight above (1366W approx.) This is an unlimited source of energy, which is available at no cost. The major benefit of solar energy over other conventional power generators is that the sunlight can be directly converted into solar energy with the use of smallest photovoltaic (PV) solar cells. Moreover, solar energy requires considerably lower manpower.

Rainwater harvesting: Water scarcity is serious problem throughout the world for both urban & rural community. The conventional water sources namely well, river and reservoirs, etc. Are inadequate to fulfill water demand due to unbalanced rainfall. The result analysis shows that the present RWH system is having the storage 53,96,816 liters/year and construction cost of Rs.5 lakhs respectively and is reasonably well in comparison with conventional water sources.

1.2 Problem Statement

As we know the initial cost, energy consumption and water usage of conventional building is more compared to green building construction. Considering the various initiatives taken by government regarding green building design and subsidies still many of the contractors are focusing on conventional building concepts due to ease of availability of raw materials. Our project mainly focuses about proper planning of reducing the environment impact, structure design efficiency, energy efficiency, water efficiency, material efficiency and waste reduction.

1.3 Aim and Objectives

Aim: To propose (G+4) energy efficient Residential green building with all basic & modern amenities using AutoCAD.

To fulfill our aim following are the objectives of project work.

Objectives:

1. To plan green residential building by using AutoCAD software, by keeping in mind the building byelaws and principles of planning.
2. To provide energy efficient system to residential green building by making use of natural resources.
3. To build proper water management system using rain water harvesting techniques.
4. To minimize the waste generated on site.
5. To obtain project duration by manually scheduling all construction activities.

CHAPTER 2
LITERATURE REVIEW

2.1 General

For arriving at exact aim & objectives of our project work, we have referred technical papers and articles published in journals, books relevant to planning & scheduling etc. Also referred research papers for planning energy efficient buildings. Review of literature is mentioned below.

2.2 Review of Literature:

Vipin Kumar, Dr. Shreenivasreddy Shahpur, Maneeth P. D., Brijbhushan S. (2017) had studied "Analysis of Academic Building by Planning, Scheduling & Resource Allocation Using Oracle Primavera P6" and concluded that the construction industry plays an important role in a country's Infrastructure and modern construction. The construction industry is the second biggest industry in India still it's construction has been differential the country over. Numerous Project Managers express that normal cost of the Project goes up by 30% as of the planned cost because of despicable Planning and scheduling. Scheduling effectively helps in scheduling the project by assigning two relationships at a time to each activity and considerably reduces the float. Resources allocated to activities can be visually assessed for each activity & can be managed and reassigned at point of time.

Akshay B. Mokal , Allaudin I. Shaikh , S. Raundal,Sushma J. Prajapati,Uday J. Phatak(2015) have explained about "GREEN BUILDING MATERIALS – A Way towards Sustainable Construction" and concluded that Buildings are actually responsible for maximum resource consumption therefore green building is only solution to the present trend of construction Green building. It creates healthy, comfortable and safe living environment, the building full life cycle process to achieve efficient use of resources (energy, disabilities, the water, materials) with minimum impact on the environment of buildings, also known as sustainable building. Green building minimize the cost efficiency and make use of eco-friendly construction materials and renewable resources. Green construction material reduces side effects on environment to make efficient sustainable structure.

Ashish Kumar Parashar, Rinku Parashar (2012) had conclude the "Construction of an Eco-Friendly Building using Green Building Approach" and stated that the green building approach goes beyond reducing energy use or improving indoor air quality by providing a rat trap bond, cavity wall. The cavity is filled with wooden powder or other insulation materials. This reduces the indoor surface temperature. High quality insulation reduces temperature regulation costs in both summer and winter.

Mr. S Srinivas (2008) have explained about the "Building Insulation" and concluded that the green buildings can save 5-8% energy with a payback of 1-2 years. Building insulation can reduce the interior thermal as well as acoustics. It also reduces the moisture and resistant to air infiltration.

Jigneshkumr R. Chaudhari1, Prof. Keyur D. Tandel, Prof. Vijay K. Patel (2013) had studied about the "Energy saving of Green Building Using Solar Photovoltaic Systems" outline the solution for the energy efficient futuristic building. It includes the calculation for water management and solar panel requirements. Placing windows and skylight can eliminate the need for electrical lighting during the day.

AbhiravMathur, VVSSM.Bharath, N. Leela Prasad (2015) have concluded about the "Design and sizing of a grid connected solar PV system". This paper analysis and designs a photovoltaic (PV) array and defines inverter sizes for a grid-connected PV system. Various inputs like the load, peak power, module voltage, global irradiance and tilt angle are given and a detailed report on the losses of PV array as well as the inverter are obtained.

Dr. K.N. Sheth (2017) have explained about the "Water efficient technologies for green buildings" and concluded that water conservation is the basic principle of green building. The material and system used in reduction of water consumption in building and landscaping the areas. In residential zone potable water can be supplied and in large commercial zone partly potable water and large amount of non- potable water can be supplied. All fixtures, taps, toilets, urinals, etc. should be water efficient. It also states about the reuse of grey water and recycle treated water.

Hayssam Traboulsi, Marwa Traboulsi (2015) had studied about the "Rooftop level rainwater harvesting system". This paper introduces a new technique to rainwater harvesting which can be easily used in both rural and urban areas. It collects and stores rainwater directly in tanks already installed on building roofs and not necessarily in special ground or underground ones. It explains about reducing the rate of surface runoff of rainwater at the coastal zones where rainwater is not captured at all and goes directly to the sea.

Senfuka C., Kirabira J.B., Byauhanga J.K. (2013) had explained about "The Concrete Reinforcing Value of Recycled Steel Bars in Uganda". This research investigates the relationship between the elevated yield values and the residual element content which in turn is a direct result of steel recycling. The steel bars can be reused only when the inner core of the steel bar is stronger. Steel reinforcement of high yield even though they amply meet the standard ductility requirements. This has largely been attributed to their recycled origin.

Kolluru Hemanth Kumar (2014) has explained about "Review paper on permeable pavement systems". This paper was discussed on permeable pavement systems and their current application. It deals with the detailed design of permeable interlocking concrete pavement. Water treatment and recycling pavement system is promising and it is detailed in cut short, research works are outlined.

Mr. Kiran Joseph, Mr. Victor Jose, Mr. Dinesh Kumar, Mrs. Sithara Mary Sunny (2018) have made "A Review on various Green Building Rating Systems in India". It states about the rating systems with regards to their evaluation methods, scopes, performance criteria and energy rating measures. IGBC and GRIHA comparative can make a general checklist study whichcover each and every aspect required for evaluation and certification for any building project.

CHAPTER 3

METHODOLOGY

3.1 GENERAL

We are planning a (G+4) green residential building by referring NBC-2005 which include building byelaws, principles of planning and green building techniques in our proposed work, we will use AutoCAD Software for planning and scheduling will be manual.

3.2 SITE SELECTION

The goal of the site selection process is to evaluate potential sites for the new building and find the best fit for the needs of your project. Site selection is the process of examining multiple options and assessing their relative advantages and disadvantages.

3.2.1 Factors considered for Site Selection

1) **Purpose of building**

   This is the most important factor to consider before purchasing or selecting a site for residential purpose. The site should be selected keeping in view the general scope or the purpose of building and on the basis of extent or privacy required.

2) **Development of surrounding area**

   The site should be situated in locality which is already fully developed or which is fast developing. To secure happy living conditions, generally such neighborhood is preferred where the neighbors belong to an equal status in society and who should be social and friendly.

3) **Available facilities**

   There should be good transport facilities such as railway, bus service, for going to office, college, market, etc.

Civic services such as water supply, drainage sewers, electric lines, telephone lines, etc.
Amenities such as schools, hospitals, libraries
Community services such as police and fire protection, clearing of waste and street cleaning.

4) Nature of soil

The ground soil of the site should be good enough to provide economical foundations for the intended building without causing any problems. Generally, for most satisfactory constructions, the site should have rock, sand or dense soil below 60 to 120 cm layer of light soil or even black cotton soil.

5) Environmental condition

The site should be available in a locality where natural beauty and man-made environment create healthy living and working conditions. Environment also affected by nearest factories, kiln etc: so these thing also need to be considered. The location of the site should be such as to ensure unobstructed natural light and air.

6) Availability of electricity and water supply

7) Availability of drainage and sewage disposal

8) Other factors

A site should be abandoned under adverse circumstances such as unhealthy, noisy or crowded localities; immediate neighborhood or rivers carrying heavy floods, badly maintained drains; reclaimed soils or water logged areas, subject to submergence or settlement and; industrial vicinity having smoke and obnoxious odors.

3.2.2 Selected site

The site selected considering above factors is located in sector-17, Khanda Colony, New Panvel, Navi Mumbai, Maharashtra, India. The surrounding locality is well developed. Facilities like Railway, Bus, public transport, schools, colleges, hospitals and libraries are abundantly available. Civic services such as water supply, drainage sewers, electric lines,

telephone lines, etc. are available. Community services such as police and fire protection, clearing of waste and street cleaning is present.

3.3 PLANNING OF G+4 RESIDENTIAL BUILDING USING AutoCAD

Planning of residential building has been done as per principles of planning and following the guidelines of building bye laws. For accuracy purpose AutoCAD software is used for planning of residential building.

3.3.1 Objectives of Building Bye laws

Bye laws allows disciplined and systematic growth of buildings and towns and prevent haphazard development. Protect safety of public against fire, noise, health hazards and structural failures. Provide proper utilization of space. Hence, maximum efficiency in planning can be derived from these bye laws they give guidelines to the architect or an engineer in effective planning and useful in preplanning the building activates. They provide health, safety and comfort to the people who live in buildings. Due to these by-laws, each building will have proper approaches, light, air and ventilation which are essential for health, safety and comfort.

Some Terminologies:

Amalgamation: Combining two or more plots as a single plot.

Amenities: Means roads, open spaces, parks, recreational grounds, gardens, water supply, electric supply, lighting, sewerage, drainage and conveniences.

Bifurcation: Means bifurcation of a plot into two.

Building line: Means the line up to which the plinth of a building may lawfully extend within the plot on a street or an extension of a street. No overhead projections are allowed beyond the building line.

Building setback: Minimum distance between any building or any structure from the boundary line of the plot.

Frontage: Frontage means the width of the site abutting the access road.

Height of building: Means the vertical distance measured, in the case of flat roofs, from the average level of the ground around and contiguous to the building up to the highest point of the building.

High rise building or Multi-Storey Building: Means a building of a height of 24 meters or more above the average surrounding ground level.

3.3.2 AutoCAD

AutoCAD is a computer-aided software drafting program. It is used for a number of applications like creating blueprints for buildings, bridges and computer chips to name a few. AutoCAD is 2D and 3D computer aided drafting software application. It is commercial software. Since 1982 it was a desktop application.

AutoCAD Features

Storage and accessibility: AutoCAD files can be saved on a computer or archived in any storage media. Software files occupy lesser storage space as compared storage space required for keeping manually drafted paper drawings. Paper drawings also need care and protection from loss or damage due to floods, fires or other calamities and can get damaged over time. The software files can also be stored on any cloud storage, from where they are easily accessible at any time, from anywhere provided there is an internet connection.

3D View: Although it is possible to sketch 3D drawings manually, they are not as effective and realistic as computer aided drawings. AutoCAD help model 3D objects with colours, materials and/or textures applied to various surfaces making them vivid and easier for the user to visualize the end product.

Revisions and Modifications: Any changes in manually drafted paper drawings would require the draftsman to draw the drawing again. Since this involved a lot of effort, the draftsmen just scratched out the older details and drew new details, resulting loss of older details and also not-to-scale drawings. CAD has inbuilt tools that allow any number of revisions and changes easily and quickly. You can edit or delete details easily using simple user-friendly commands. You can also save the previous versions of the file in case you wish to re-use them

Speed: Creating a drawing in AutoCAD is much faster than drawing manually. You can also save time and effort by creating re-usable block library. Easy edits are possible with commands like copy, mirror, stretching, rotate and scale and many more such commands.

Accuracy: AutoCAD enables you to draw with fractional dimensions and also define precision to any number of decimal places, which is not possible to achieve in hand-drafted manual drawings, hence offering accuracy in all dimensions.

3.3.3 Floor plan

The G+4 storied building has four flats on each floor and ground floor is used for parking. Each flat has fundamental amenities such as living room, kitchen, washroom and bedroom. The flat is designed as 3-BHK, having one balcony each for master bedroom and living room.

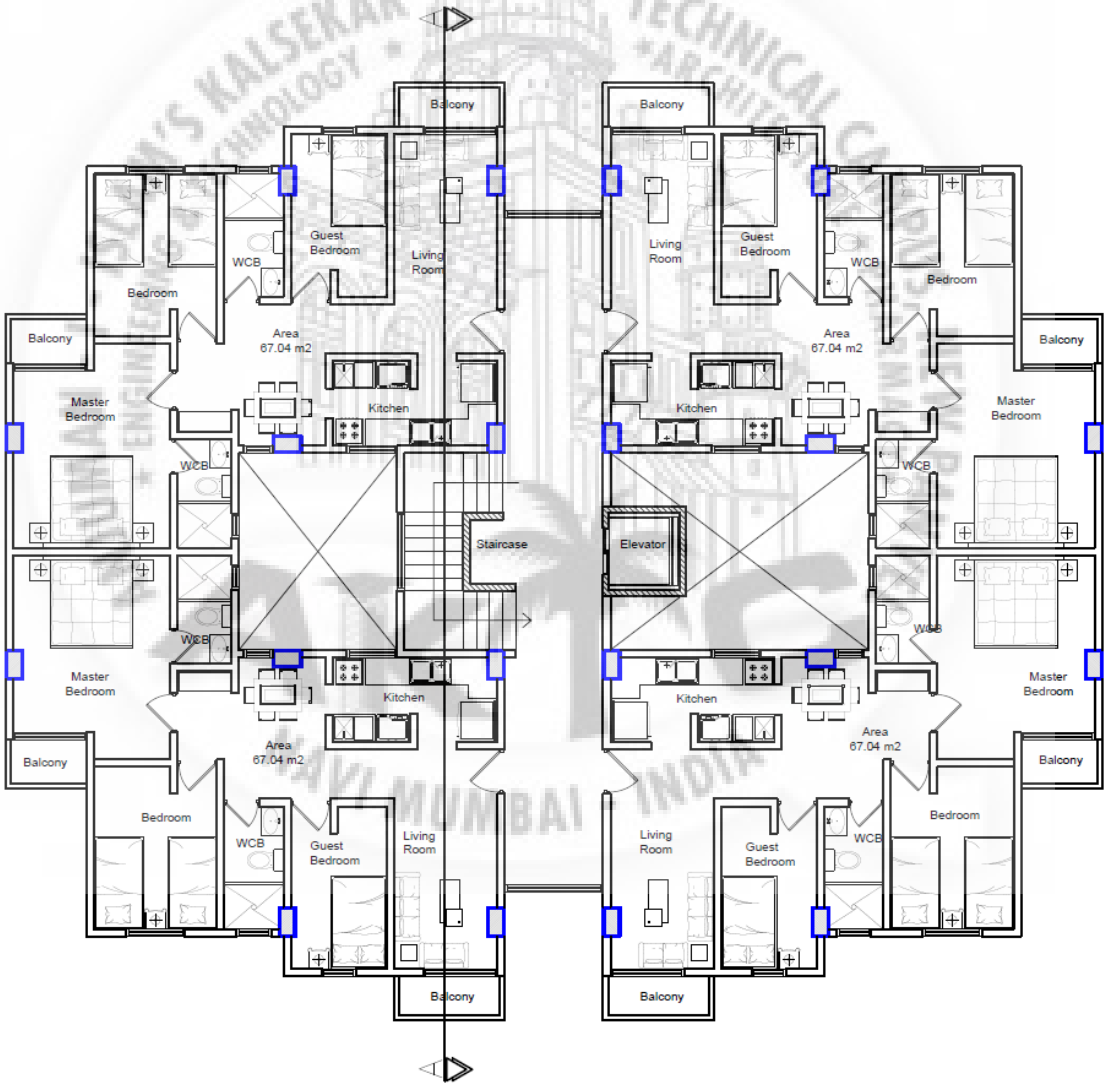


Fig 1: Floor Plan

3.3.4 Sectional elevation

The sectional elevation at section A-A is shown below. The floor to floor height of is 2.9m, which includes 2.6m floor to ceiling height and 0.3m thick slab with tiled flooring. The height of parapet is 1m. The cantilever part of balcony is 0.9m. Open Newel Staircase having two quarter landings is provided. On the opposite side of the staircase Elevator having capacity for 5 persons is provided.

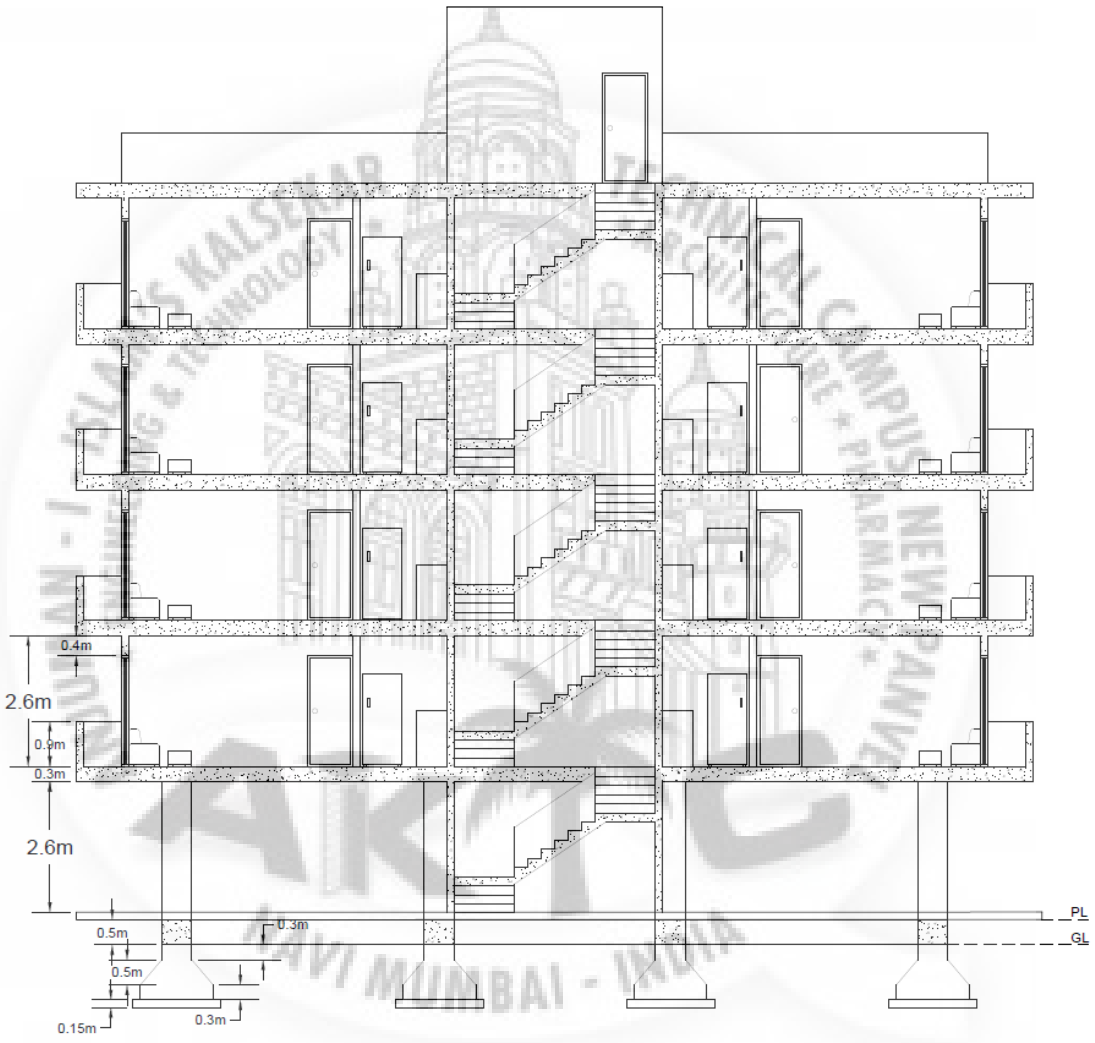


Fig 2: Sectional elevation at section A-A

3.3.5 Foundation Plan

A building foundation actually performs a number of functions. The three most important are to bear the load of the building, anchor it against natural forces such as earthquakes, and to isolate it from ground moisture. The foundation provided is of shallow type. The dimensions of

column is 0.35m x 0.6m. dimensions of plinth beam is 0.6m x 0.5m. 12 isolated footings and 4 combined footings are provided.

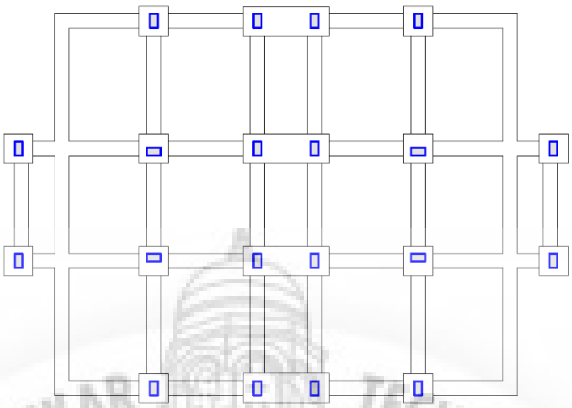


Fig 3: Foundation Plan

3.3.6 Site Plan

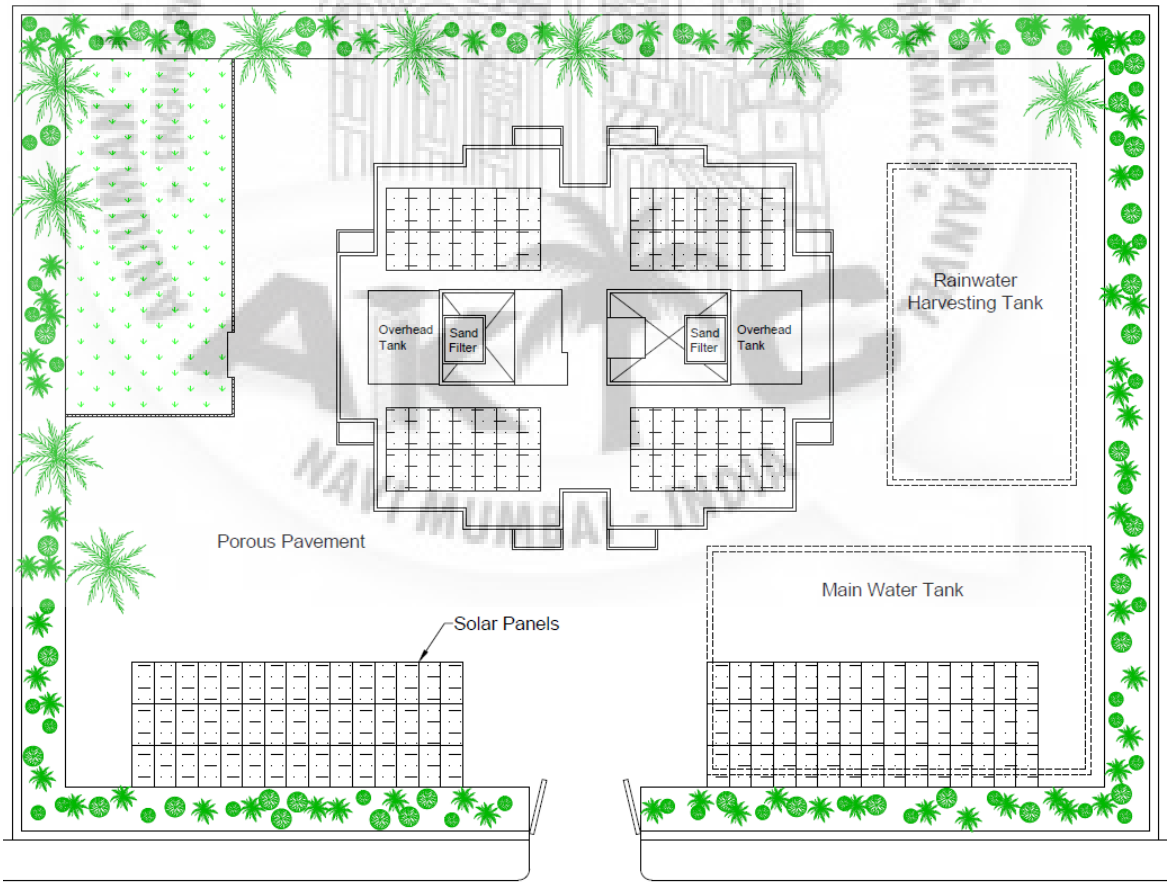


Fig 4: Site Plan

3.4 GREEN BUILDING MATERIALS

In a green building, environmentally-friendly materials (also known as green building materials) are those in which, for their production, placing and maintenance, actions of low environmental impact have been performed. They have to be durable, reusable or recyclable, include recyclable materials in their composition and have to be from resources of the area where the building activity will take place. These materials are preferred to be natural.

3.4.1 Selection criteria for green building material

1**. Resource Efficiency** can be accomplished by utilizing materials that meet the following criteria:

a) Recycled Content: Products with identifiable recycled content, including postindustrial content with a preference for post-consumer content.

b) Natural, plentiful or renewable: Materials harvested from sustainable managed sources and preferably have an independent certification (e.g., certified wood) and are certified by an independent third party.

c) Resource efficient manufacturing process: Products manufactured with resource-efficient processes including reducing energy consumption, minimizing waste (recycled, recyclable and or source reduced product packaging), and reducing greenhouse gases.

d) Locally available: Building materials, components, and systems found locally or regionally saving energy and resources in transportation to the project site.

e) Salvaged, refurbished, or remanufactured: Includes saving a material from disposal and renovating, repairing, restoring, or generally improving the appearance, performance, quality, functionality, or value of a product.

f) Reusable or recyclable: Select materials that can be easily dismantled and reused or recycled at the end of their useful life.

g) Recycled or recyclable product packaging: Products enclosed in recycled content or recyclable packaging.

h) Durable: Materials that are longer lasting or are comparable to conventional products with long life expectancies.

2. Indoor Air Quality (IAQ) is enhanced by utilizing materials that meet the following criteria:

a) Low or non-toxic: Materials that emit few or no carcinogens, reproductive toxicants, or irritants as demonstrated by the manufacturer through appropriate testing.

b) Minimal chemical emissions: Products that have minimal emissions of Volatile Organic Compounds (VOCs). Products that also maximize resource and energy efficiency while reducing chemical emissions.

c) Low-VOC assembly: Materials installed with minimal VOC-producing compounds, or no-VOC mechanical attachment methods and minimal hazards.

d) Moisture resistant: Products and systems that resist moisture or inhibit the growth of biological contaminants in buildings.

e) Healthfully maintained: Materials, components, and systems that require only simple, non-toxic, or low-VOC methods of cleaning.

f) Systems or equipment: Products that promote healthy IAQ by identifying indoor air pollutants or enhancing the air quality.

3. Energy Efficiency can be maximized by utilizing materials and systems that meet the following criteria Materials, components, and systems that help reduce energy consumption in buildings and facilities.

4. Water Conservation can be obtained by utilizing materials and systems that meet the following criteria: Products and systems that help reduce water consumption in buildings and conserve water in landscaped areas.

5. Affordability can be considered when building product life-cycle costs are comparable to conventional materials or as a whole, are within a project-defined percentage of the overall budget

3.4.2 The Green Building Materials

3.4.2.1 Lime

Lime is a calcium product that is composed of calcium oxide and calcium hydroxide.

It is the civil engineering material used for binding two or more mineral materials. It has many qualities like compressive strength, workability, setting time, etc. So, it is used as an alternative to cement. Lime is our chief material which replaces the cement in building construction. It gives the good air quality by absorbing the carbon and emitting oxygen in the atmosphere. By looking at the ancient construction we can make it out the durability of lime in terms of quality and life of it as it strengthens by time to time. The cost comparison of lime and cement is, cost of lime Rs. 7.5/kg. And that of lime is Rs. 6/Kg. Life span of lime building is much more as compared to cement building. Lime is mostly used for preparation of Lime concrete, Lime mortar, and sometimes used as Lime ghola.

Lime is one of the basic building material used mainly as lime mortar in construction. Properties of building lime, advantages, and uses in construction is discussed. The broad category of lime is non-hydraulic and hydraulic lime. The non-hydraulic lime is called as quick lime, fat lime or white lime or as lump lime. Hydraulic lime sets under water and non-hydraulic lime do not set under water. Quick Lime is a form of lime is manufactured by the burning of stone that has calcium carbonate within it. The burning temperature varies, say 900 degree Celsius and above for several hours. This process is called as calcination. The solid product that remain after the removal of carbon dioxide in the calcium carbonate is called as the quicklime.

$CaCO_3$ (Calcium carbonate) → CaO (Calcium Oxide – Quick Lime) + CO_2

The quick lime is used as hydrated lime (quick lime with water). This is because it is unstable and hazardous in nature. There is heat liberated when a small quantity of water is added to the quicklime. After this hydration product, a fine dry white powder is obtained, which is called as calcium hydroxide or slake lime. Now this process is defined as the slaking of lime. The slaking of lime is a process that varies depending upon the extent and type of use. For example, the use of lime in plasters or in mortars, make use of lime in dry or putty form.

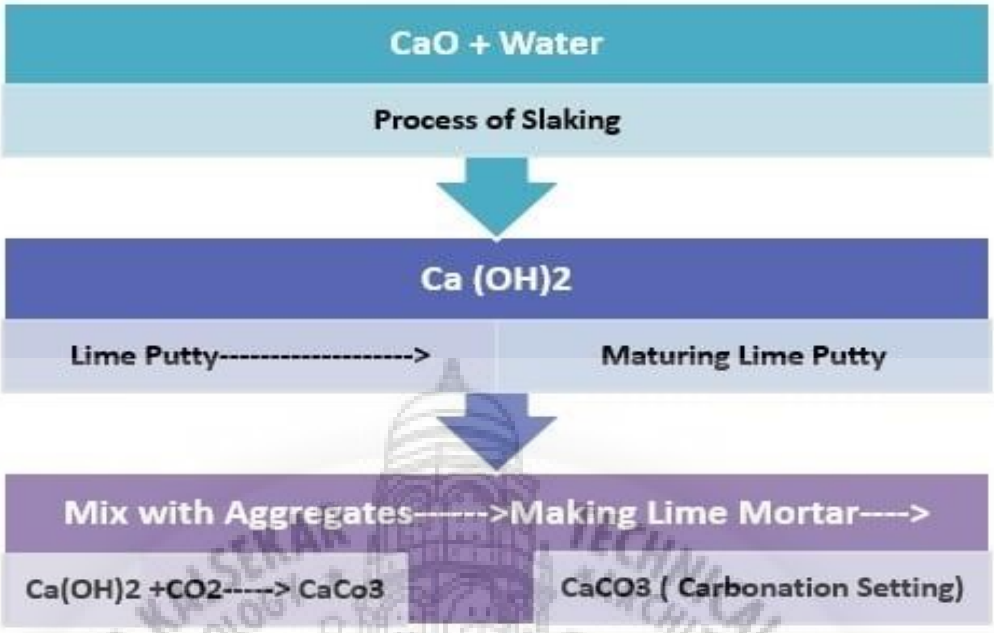


Fig 5: Reaction of lime with water

Putty is formed by the addition of a large quantity of water (two to three times its weight). This process promotes a chemical reaction that makes the whole system to boil. A semi-fluid mass is obtained as a stiffened mass on cooling, which is called as the putty. This material after proper screening is used as the material for construction. Hydraulic lime is a factory based product. These have natural pozzolana or added Pozzolana in it that sets under water. The raw material for hydraulic lime is limestone which is impure, that contains calcium carbonate and impurities of clay. These are also calcinated at 900 to 1000 degree Celsius. The reaction is as follows Calcium carbonate + clay impurities ($Al_2O_3 + Si_2O_3$) → CaO (calcium oxide) + carbon dioxide + Monocalcium silicate (CA), Monocalcium aluminates dicalcium silicate (C2S), dicalcium alumino-ferrite (C2AF)

Properties of Lime for Use in Construction:

The white powdered slaked lime has a wide range of applications in construction. The properties of lime are:

1. **Cementing capability**- This is obtained by their carbonation with carbon dioxide. Lime is used as lime mortar for brick masonry construction.
2. Have a **higher acid resistance**- due to its alkaline nature

3. Gain **Pozzolanic activity**- this gives cementitious products
4. **Sealing of micro cracks**- This is done by the precipitation made by the calcium carbonate when carbon dioxide passes through the lime mortar mix.

Classification of Building Lime:

Fat lime and hydraulic lime are the broad classifications of lime. The process of hardening is the main criteria by which the fat lime differs from the hydraulic lime. The IS 712-1973 have classified the lime into different classes. They are Class A, Class B, Class C, Class D, Class E, and Class F. A lime is considered poor lime if it contains more than 30% of impurities.

Factors affecting Properties of Lime Mortar:

1. The free calcium amount present in the lime mortar
2. The free lime content and porosity are directly proportional
3. The fat lime or non-hydraulic lime does not set under water, it sets with time
4. The hydraulic lime sets after the addition of water. This rate depends on the type as well as the characteristic composition of hydraulic lime.

Advantages of Lime in Construction:

1. **Provides building breathing property**- the lime was regarded as a material by the society for protection against the depletion of ancient buildings. This material let the building to be vapor permeable, thus allowing to breathe. This reduces the chances of trapped moisture and the damage of the building.
2. **Renders Comfortable Environment**- Absorbing moisture by the lime, stabilize internal humidity
3. **Ecological Benefits**- energy conservation than cement, small scale production of lime is possible
4. **Protection of adjacent materials**- Porous texture of lime handle the moisture movement, without affecting the adjacent materials
5. **Provides good workability**
6. **Durability is high**
7. **Beautiful finish for the building**

8. **Self-healing properties**- Any movement of the building made of lime, creates micro-cracks. Presence of moisture make the free lime active to precipitate and heal these micro cracks.

3.4.2.2 Recycled concrete aggregate (RCA)

RCA can be obtained by crushing both reinforced and plain (non-rein- forced) concrete and comprises crushed, graded inorganic particles. It is graded into the same coarse aggregate sizes as natural crushed rock aggregates and used in the same way. The surface texture of RCA particles tend to be slightly rougher than natural aggregates (due to the adhering cement paste) but they are of similar shape.

RCA is of particular benefit where construction is taking place on the site of former construction which comprises a high proportion of concrete (for example, frame, slabs or pavement). Since most RCA will be processed at the construction site and never enter the waste stream, any legal and cost implications of transporting the material and/or classifying the material as a 'waste' is avoided. RCAs have been widely used in road construction for sub-base and concrete pavements over many years. However, there are fewer cases where RCA has been used in concrete structures.

Fig 6: Recycled Concrete Aggregate
(Source: eesc.europa.eu)

Properties of Recycled Concrete Aggregate

1) Particle Size Distribution:

The result of sieve analysis carried out as per IS 2386 for different types of crushed recycled concrete aggregate and natural aggregates. It is found that recycled coarse aggregate are reduced to various sizes during the process of crushing and sieving (by a sieve of 4.75mm), which gives best particle size distribution. The amount of fine particles (<4.75mm) after recycling of demolished were in the order of 5-20% depending upon the original grade of demolished concrete. The best quality natural aggregate can obtained by primary, secondary & tertiary crushing whereas the same can be obtained after primary & secondary crushing incase of recycled aggregate. The single crushing process is also effective in the case of recycled aggregate.

The particle shape analysis of recycled aggregate indicates similar particle shape of natural aggregate obtained from crushed rock. The recycled aggregate generally meets all the standard requirements of aggregate used in concrete.

2) Specific Gravity and Water Absorption:

The specific gravity (saturated surface dry condition) of recycled concrete aggregate was found from 2.35 to 2.58 which are lower as compared to natural aggregates. Since the RCA from demolished concrete consist of crushed stone aggregate with old mortar adhering to it, the water absorption ranges from 3.05% to 7.40%, which is relatively higher than that of the natural aggregates. The Table 4 gives the details of properties of RCA & natural aggregates. In general, as the water absorption characteristics of recycled aggregates are higher, it is advisable to maintain saturated surface dry (SSD) conditions of aggregate before start of the mixing operations.

3) Bulk Density:

The rodded & loose bulk density of recycled aggregate is lower than that of natural aggregate except recycled aggregate-RCA4, which is obtained from demolished newly constructed culvert. Recycled aggregate had passed through the sieve of 4.75mm due to which voids increased in rodded condition. The lower value of loose bulk density of recycled aggregate may be attributed to its higher porosity than that of natural aggregate.

4) Crushing and Impact Values:

The recycled aggregate is relatively weaker than the natural aggregate against mechanical actions. As per IS 2386, the crushing and impact values for concrete wearing surfaces should not exceed 45% and 50% respectively. The crushing & impact values of recycled aggregate satisfy the BIS specifications except RCA2 type of recycled aggregate for impact value as originally it is low grade rubbles.

5) Compressive Strength:

The average compressive strengths cubes cast are determined as per IS 516 using RCA and natural aggregate at the age 1, 3, 7, 14, 28, 56 and 90 days and reported in Table 5. The table 4 shows that the target cube strength was achieved at 28 days for all types of concrete. As expected, the compressive strength of RAC is lower than the conventional concrete made from similar mix proportions. The reduction in strength of RAC as compare to NAC is in order of 2-14% and 7.5 to 16% for M-20 & M-25 concretes respectively. The amount of reduction in strength depends on parameters such as grade of demolished concrete, replacement ratio, w/c ratio, processing of recycled aggregate etc.

6) Splitting Tensile & Flexural Strength:

The average splitting tensile and flexural of recycled aggregate are determined at the age 1, 3, 7, 14, & 28 days varies from 0.30 -3.1 Mpa and 0.95- 7.2 Mpa respectively. The reduction in splitting and flexural strength of RAC as compared to NAC is in order of 5-12% and 4 -15% respectively.

7) Modulus of Elasticity:

The static modulus of elasticity of RAC has been reported in Table 4 and found lower than the AC. The reduction is up to 15% .The reason for the lower static modulus of elasticity of RCA is higher proportion of hardened cement paste. It is well establish that Ec depends on Ec value of coarse aggregate, w/c ratio & cement paste etc. The modulus of elasticity is critical parameter for designing the structures, hence more studies are needed.

8) Durability:

The following parameters were studied to assess the influence of recycled aggregates on durability of concrete.

9) Carbonation:

CO_2 from the air penetrates into the concrete by diffusion process. The pores (pore size>100nm) in the concrete in which this transport process can take place are therefore particularly crucial for the rate of carbonation. The carbonation tests were carried out for 90

days on the specimens (150x150x150mm) of recycled aggregate concrete and natural aggregate concrete in carbonation chamber with relative humidity of 70% and 20% CO2 concentration. The carbonation depths of recycled aggregate concretes for different grade were found from 11.5 to 14mm as compared to 11mm depth for natural aggregate concrete. This increase in the carbonation depth of RAC as compared to NAC, attributed to porous recycled aggregate due to presence of old mortar attached to the crushed stone aggregate.

10) Freeze-Thaw Resistance:

In the freeze-thaw resistance test (cube method), loss of mass of the concrete made with recycled aggregate was found sometimes above and below than that of concrete made with natural aggregate. The results were so close that no difference in freeze thaw resistance (after 100 cycles) could be found. The literature also found that the effect of cement mortar adhering to the original aggregate in RAC may not adversely affect the properties of RAC.

3.4.2.3 Recycled Steel Bars

Strengthening steel bars are usually gathered and sent to scrap sites, where they are melted, and made again into a new reinforcement bar. In Jordan, the demolition of old buildings is creating a growing industry together. The entrepreneurs collect the used steel reinforcement bars (rebars), and manually strain them and then market them at half the price of the new steel bars. If the use of these bars is appropriate, more benefits will be achieved, such as saving energy required to manufacture steel bars, and reducing CO2 emissions. The aim of this paper is to analyze how well the stressed steel bars are appropriate for use with the new concrete in terms of bonding strength.

Steel is 100% recyclable and is highly recycled. In the UK, the overall average end-of-life recovery rate for steel from buildings has been estimated from surveys to be 96% It is important to remember that this is true or closed-loop recycling; every tonne of scrap recovered substitutes one tonne of primary steelmaking and this can happen again and again, with existing technology and without any degradation in terms of properties or performance of the steel.
Steel is produced by two production routes:

- The primary or basic oxygen steelmaking (BOS) route; based primarily on the reduction of iron ore and incorporating typically 10% to 15% of scrap steel
- The secondary or electric arc furnace (EAF) route; 100% scrap based production. In 2019, global production of crude steel was 1.87 billion tonnes and the production split between these two routes was approximately 70:30 (BOS:EAF). Over 600 million tonnes (32%) of this total is estimated to have come from scrap. Although the amount of scrap recycled is generally increasing, scrap supply is constrained by availability and as shown, supply cannot currently meet the global demand for new steel and therefore primary steelmaking from iron ore is still required. It is noted that the greatest demand is in the developing economies where steel is being used to develop infrastructures and buildings. In many developed economies, including the UK, there is a much closer match between steel demand and scrap supply.
- Since steel was first mass produced in the 1880s it has always been highly recycled. Principally because:
- Steel has a relatively high economic value – the price paid for UK scrap structural steel (grade OA) in January 2021 was £230 to £240 per tonne
- The versatility of steel means that it can be easily recycled or remanufactured into new applications as demand dictates
- Steel's magnetic properties mean that it can be efficiently segregated from mixed waste streams.

Steel is available in thousands of different compositions (grades), each tailored to specific applications in sectors as diverse as packaging, engineering, white goods, vehicles and construction. Construction is the largest market sector for steel in the UK accounting for around one third of steel consumption. This versatility promotes recycling since steel scrap can be blended, through the recycling process, to produce different types of steel (different grades and products) as demand dictates. For example, steel from redundant industrial machinery can be recycled into more contemporary products such as cars or white goods which, in turn, can be recycled into new, maybe as yet undiscovered, applications in the future. A case study on this involving the Teesside Meltshop at Lackenby can be accessed here.

Steel products in-use today all contain a proportion of recycled steel from previous incarnations. This can be one or many previous uses. Originally all 'recycled' steel was produced from iron ore and therefore how the initial impacts of primary production, are shared over subsequent uses of the same material is an important question in quantifying its whole life environmental impacts.

As long as recycling continues therefore, the life of a steel product is, in effect, infinite and individual incarnations or uses of a steel product, are merely parts of the larger life cycle of the material. By considering the environmental impact of these intermediate lifecycle stages in isolation, an incomplete, 'snap-shot' of the overall impact is obtained. For example, by only considering the recycling step but excluding the initial, generally larger, impact from the initial primary production.

Steel (as a material) theoretically has an infinite life cycle, through multiple recycling stages, whereas building assessments are generally limited in scope, to the lifetime of the building; typically 60 years. This yields some methodological challenges on which there is a lack of consensus. The longer-term environmental benefits of highly recyclable materials like metals, is increasingly appreciated in the context of the circular economy and the benefits quantified by means of 'whole life carbon assessment.'

This is illustrated in the figure (right) which shows the environmental impact of a hypothetical metal product over five life cycles or five recycling steps. The environmental impact of the first or primary production process is 10 units and the impact of the secondary or subsequent process, i.e. the recycling process, is 3 units. A 100% recycling rate is assumed for simplicity. Note that for structural steel this is a realistic assumption see results from a recent survey.

Steel has a high intrinsic value and promotes an effective scrap collection; however, the focus is often placed on the recyclability of this metal when addressing environmental effects of the steel production cycles. While this is an advantage particularly for saving energy and reducing negative effects on the environment, another reduced impact option exists: material reuse. The loss of steel resources can lead, from an environmental perspective, to the degradation of its climate; hence the use of recycled steel bars can contribute to an atmosphere that is greener.

3.4.2.4 Fly Ash Brick

Fly ash brick (FAB) is a building material, specifically masonry units, containing class C or class F fly ash and water. Compressed at 28 Mpa (272 atm) and cured for 24 hours in a 66 °C steam bath, then toughened with an air entrainment agent, the bricks can last for more than 100 freeze-thaw cycles. Owing to the high concentration of calcium oxide in class C fly ash, the brick is described as "self-cementing". The manufacturing method saves energy, reduces mercury pollution in the environment, and often costs 20% less than traditional clay brick manufacturing.

A possible material mix for the production of fly ash brick:

Material	Mass
Fly ash	60%
Sand/ Stone dust	30 %
Portland Cement or **Lime**	10%

Table 1.Material and Mass proportions

The strength of fly ash brick manufactured with the above compositions is ranges between 7.5 Mpa and 10 Mpa. Fly ash bricks are lighter and stronger than clay bricks.

Main ingredients include fly ash, water, quicklime or lime sludge, cement, aluminum powder and gypsum. Autoclaving increases the hardness of the block by promoting quick curing of the cement. Gypsum acts as a long-term strength gainer. The chemical reaction due to the aluminum paste provides AAC its distinct porous structure, lightness, and insulating properties. The aforementioned properties set it apart from other lightweight concrete materials. The finished product is a lighter block, less than 40% the weight of conventional Bricks, while providing the similar strengths. The specific gravity stays around 0.6 to 0.65. Using these blocks in buildings reduces the dead load, allowing one to save around 30 to 35% of structural steel, and concrete.

Commercial processes fall into two categories; the lime route, and the cement (OPC) route where the latter is used as a source of lime. In the lime route, the composition is fly ash (50%), slaked lime (30%), and anhydrous gypsum (20%), to which 3 to 4 times of stone dust, sand or any inert filler material can be added. In the cement route, the composition is fly ash (76%), OPC (20%), and anhydrite (4%), to which 3 to 4 times of filler material can be added.

The following properties of fly ash affect the strength and look of fly ash bricks.

- Loss on Ignition (LOI): fly ash loses weight when it burns at about 1000 °C due to presence of carbon and water. The weight loss happens due to carbon combustion and moisture evaporation is called "Loss on Ignition (LOI)". This is expressed as percentage. The lower the loss of Ignition, the better will be fly ash. As per BIS it should not be more than 5%.
- Fineness: fine fly ash has more surface area available to react with lime. This increases pozzolanic activity, which contributes to the strength of fly ash bricks. As per BIS it should not be more than 320 m^2/kg.
- Calcium (CaO) content: the pozzolanic reactivity of fly ash is more in high calcium fly ash. The greater the pozzolanic activity leads to higher the strength of fly ash brick. As per ASTM C618 fly ash is classified into two types: Class C contains more than 10% lime and Class F fly ash contains less than 10% lime.

Based on boiler operations, fly ash can be additionally classified as LT (low temperature) and HT (high temperature). LT fly ash containing amorphous phases is generated where boiler temperature is not more than 800 °C, whereas HT fly ash containing glassy reactive phases is generated at more than 1000 °C in super thermal plants. LT fly ash reacts well with lime whereas HT fly ash reacts well with OPC.

Fig 7: Fly Ash Bricks
(Source: i.pinimg.com)

Comparison of Clay Bricks and Fly Ash Bricks:

Properties	**Red Bricks/Clay Bricks**	**Fly Ash Bricks**	**Remarks**
Density	1600-1750 kg/m^3	1700-1850 kg/m^3	Higher load bearing
Compressive strength	30-35 kg/cm^2	90-100 kg/cm^2	Higher load bearing

Absorption	15-25%	10-14%	Less dampness
Dimensional stability	Very low tolerance	High tolerance	Saving in mortar up to 25%
Wastage during transit	Up to 10%	Less than 2%	Saving in cost up to 8%
Plastering	Thickness vary on the both sides of wall	Even on both sides	Saving in plaster up to 15%.

Table 2. Comparison of Clay Bricks and Fly Ash Bricks

Advantages

1. It reduces dead load on structures due to light weight (2.6 kg, dimension: 230 mm X 110 mm X 70 mm.
2. Same number of bricks will cover more area than clay bricks
3. High fire Insulation
4. Due to high strength, practically no breakage during **transport** and use.
5. Due to uniform size of bricks **mortar** required for joints and plaster reduces almost by 50%.
6. Due to lower water penetration **seepage** of water through bricks is considerably reduced.
7. **Gypsum plaster** can be directly applied on these bricks without a backing coat of **lime plaster.**
8. These bricks do not require **soaking** in water for 24 hours. Sprinkling of water before use is enough.

3.4.2.5 Green paint having less VOC

Latex paints are a greener choice than oil-based paints with higher volatile organic content (VOC) emissions. Water-based latex paints are considered greener than oil-based paints. However, manufacturers of oil-based paint claim longer service life and less repainting over the life cycle of the building. The cleanup of oil-based paints is controlled, while latex paint waste is frequently flushed down drains where the algaecides and fungicides in the paint kill the bacteria at the sewage treatment plant.

Zero-VOC and latex formulations have advanced paint technology significantly. Since most commercial repainting is done for new tenants or a new color scheme, longer service life isn't necessarily the determining factor. The choice may be made for us, as state and regional limits on VOCs are established.

VOCs are carbon compounds that evaporate at room temperature and react in sunlight to help form ground-level ozone, an integral component of photochemical smog. VOCs can cause respiratory, skin and eye irritation; headaches; nausea; muscle weakness; and more serious ailments and diseases, according to the EPA. Formaldehyde, a VOC commonly found in paint, is a probable carcinogen. The EPA has found that indoor concentrations of VOCs are regularly up to 10 times as high as outdoor concentrations, and can climb up to a thousand times as high as outdoor concentrations when you are applying paint.

Low- and no-VOC paints may also contain other compounds that affect air quality. While some of these are known and can be avoided, others are not. Manufacturers are not required to disclose all the chemicals used in their products; some ingredients are deemed proprietary information or are used in such small quantities that they do not have to be reported.
Beyond indoor air pollutants, many paints are made with other toxic substances and chemicals that come from non-renewable resources or are energy-intensive or polluting to produce, so even no-VOC paints and stains can affect the environment. Green Seal's paint certification standards prohibit numerous non-VOC compounds, including heavy metals, carcinogens and ozone-depleting compounds.

Latex paints (acrylic or vinyl acetate binders)

Because they use water as the carrier rather than petroleum-based solvents, latex paints have lower VOC levels than oil-based paints. Although they don't cover stains as well as their oil-based counterparts, low- and no-VOC latex paints perform well for most household applications, and high-quality latex paint can be as durable as an oil paint. Latex paint actually contains no latex, so it won't affect people with latex allergies.

Latex paint cleans up easily with water, so you don't need harsh VOC-emitting solvents to work with it. It can also be "recycled" by combining leftovers; oil paints cannot be recycled in this way.

Using recycled latex paint avoids the manufacturing impact, but recycled paint may not be made of low-VOC paint, so it is best suited to well-ventilated areas like the interior of a garage or shed. Green Seal now has a standard for Recycled-Content Latex Paint (GS-43); paints that are certified under this standard cannot contain more than 250 g/L of VOCs.

We recommend using paints that are free of fungicides and biocides like formaldehyde. Although latex paints are biocide-free to begin with, almost all manufacturers add synthetic biocides, or "can preservative," to extend shelf life. Manufacturers are not required to list biocides on a paint's MSDS because they are added in such small amounts, but some paints are labelled biocide- or fungicide-free. If you do not see this on the label and want to avoid biocides, call the manufacturer to determine if biocides are included in the formulation.One hundred percent acrylic paint is more water-resistant than vinyl acetate paint and is good for kitchen, bath and exterior applications. Vinyl acetate paint is adequate for most indoor applications and is less expensive. Look for solids content of over 30 percent to hide stains, cover in fewer coats, and cover more surface area per gallon. This information should appear on the paint's label or technical data sheet (TDS). Almost every major brand of latex paint now has a low-VOC or zero-VOC product line; many of these products are also low-odour.

3.4.2.6 Eco-Friendly Tiles

An Eco-friendly tile replaces the conventional flooring and uses less energy in their production. It is cheap as compare to the conventional tile. They are available as per the client requirement in various patterns and also easy to place. This tile improves performance of indoor environment quality.

Tiles are replaced by the eco-friendly tiles. Eco-friendly tiles are cheap in cost as compared to regular tiles; these tiles are manufactured on the construction site so that its transportation charges are reduced. Cost of regular tiles (Ceramic) is Rs.40 and that of eco-friendly tiles is Rs.35.

Types of eco-friendly tiles are as follows:

Cork Floor Tiles

This eco-friendly flooring is made from the bark of a cork oak tree. The material is fire-resistant and relatively inexpensive which makes it an attractive option.

Pros: The material has small air-filled chambers that work as natural sound insulators. Suberin found in cork is antimicrobial and repels insects. Cork is soft and cushiony under foot. It requires only sweeping or vacuuming to remove small dirt and grime.

Cons: Since the material is soft, it is prone to damage and it can fade with sunlight over time. This isn't ideal for areas that have heavy traffic or bulky furniture as pointy shoes and furniture can sink permanently down into the cork. The material stains easily so it shouldn't be laid out in the kitchen or dining area.

Reclaimed Hardwood Floor Tiles

While wood offers warmth to areas, it does come from the felling of forest trees. An ecologically viable option is reclaimed hardwood—wood that has been processed and retrieved from old, original wood. Hardwood is both sturdy and easy-too –maintain.

Pros: Hardwood flooring has stood the test of time and is durable. It has an undeniable charm and can add style to any interiors. This type of flooring just needs to be vacuumed and occasionally cleaned with a wood floor cleaner.

Cons: To find a good tight wood that is completely dry is a challenge. Also as the wood is old, it is likely to be more prone to pests attack. To avoid that, the wood needs to be sealed every year.

Limestone Floor Tiles

A sedimentary natural rock, limestone is a material that has been used in architecture and is made of calcium carbonate. It is available in a variety of sizes that makes it a popular choice.

Pros: Compared to granite and marble, limestone is cheaper to buy and install. It is available in a variety of shades that can add a rustic feel to the décor. The stone is versatile and can be cut into any size of your choice—large-format, plank or other geometric shapes.

Cons: Limestone is porous and can easily absorb stains and hence needs adequate care. Being a softer stone, it is likely to be damaged if usage is heavy.

Fig 8: Limestone Tiles

3.4.2.7 Solar Reflective Glass

Solar reflective glass gives better indoor quality than the normal clear glass. It keeps the inner temperature cool in hotter summers which reduce the energy consumption. This glass reduces the solar heat gain but allows the optimum lighting through the day which reduce electricity load. It is a good resistant of U.V rays which reduces the cause of skin retention of occupants. It also gives privacy as compare to the normal clear glass.

The regular glass is replaced by the reflective glass and the cost comparison of the glass is, reflective glass is 20% high costs as compared to normal glass. But the advantages of reflective glass are more and its life span is also more.

REFLECTASOL, is a reflective, solar control glass, carefully designed to meet two requirements of architect:

- Heat resistant on the inside.
- Great exterior appearance, for better living and better working.

The process is known as 'on-line pyrolytic coating' (where a silicon based coating is applied to the glass surface by means of pyrolysis) gives the coating a number of properties:

- Total integration into the surface of glass.
- Strength and stability over time.
- Specific solar control properties limiting glare inside the building.

Benefits:

The solar control properties and reflective appearance help the interiors cool and bring the power consumption down. It can be used as well for external or internal use. It's low light transmittance guarantees "visual comfort" against direct sunlight. The combination of high light reflectance and law light transmittance provides internal privacy, even in buildings with large glazed areas.

Handling and processing:

Reflectasol can be used as single glazing or double glazing. To enhance its performances, reflectasol can be combined with other products of Saint-Gobain Glass.

- Acoustics Insulation

  STADIP SILENCE is an acoustic laminated glass which considerably reduces noise level whilst also offering the usual safety and security characteristic of laminated glass.
- Enhanced Thermal Insulation

  Especially the combination of reflectasol with planitherm delivers an energy efficiency that will meet or exceed local energy code requirements. Reflectasol can also be tampered, laminated, screen printed or enameled.

Application:

Reflectasol is suitable for most types of external glazing in commercial buildings:

- Offices.
- Schools.
- Industrial buildings.

- Hotels.It's attractive appearance also enhances the interior of building:
- Reflective quality: creating a one way observation effect in certain lighting conditions, transmitting light whilst screening vision.
- Beveled edges: to create a unique decorative effect (example: traditional internal doors).

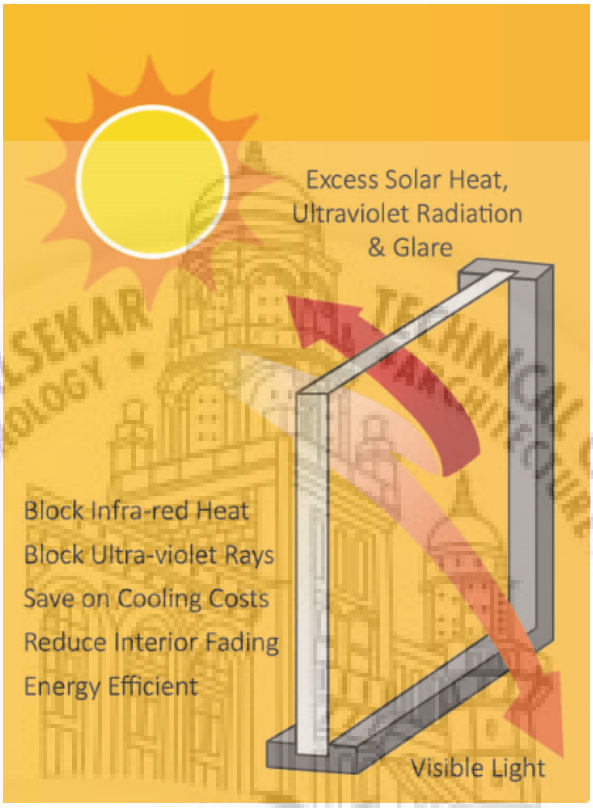


Fig 9: Solar Reflective Glass
(Source: www.xlcoatings.com)

3.4.2.8 Recycled Paver Blocks

Currently about 56 lakh tonnes of plastic waste dumped in India in a year. The dumped waste pollutes the surrounding environment. As the result it affects both human beings and animals in direct and indirect ways. Hence it necessary to dispose the plastic waste properly as per the Regulations provided by our government. The replacement of plastic waste for cement provides potential environmental as well as economic benefits.

Paver block paving is versatile, aesthetically attractive, functional, and cost effective and requires little or no maintenance if correctly manufactured and laid. Most concrete block paving constructed in India also has performed satisfactorily but two main areas of concern are

occasional failure due to excessive surface wear, and variability in the strength of block. Natural resources are depleting worldwide at the same time the generated wastes from the industry and Residential area are increasing substantially. The sustainable development for construction involves the use of Nonconventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways conserving the environment.

Fig 10: Recycled plastic paver blocks
(Source: www.vas-tum.com)

Paver blocks can bear a load of 40 tonnes and is more durable than cement bricks. They can resist temperature up to 120 degree Celsius and can last up to 10 years. They are also much cheaper than other materials.

3.5 SOLAR PHOTOVOLTAIC SYSTEM

3.5.1 Importance of solar energy

All life on earth is supported by the sun. This amazing resource radiates energy and provides us both heat and light by fusing hydrogen into helium at its core. We call this solar radiation. Only about half of this solar radiation makes it to the Earth's surface. The rest is either absorbed or reflected by clouds and the atmosphere. Still, we receive enough power from the sun to meet the power demands of all mankind — millions of times over. Solar energy—power from the sun—is a vast, inexhaustible, and clean resource.

Sunlight, or solar energy, can be used directly for heating and lighting homes and businesses, for generating electricity, and for hot water heating, solar cooling, and a variety of other commercial and industrial uses. Most critical, given the growing concern over climate change, is the fact that solar electricity generation represents a clean alternative to electricity from fossil fuels, with no air and water pollution, no global warming pollution, no risks of electricity price spikes, and no threats to our public health.The solar resource is enormous. According to the US Department of Energy, the amount of sunlight that strikes the earth's surface in an hour and a half is enough to handle the entire world's energy consumption for a full year. Just 18 days of sunshine on Earth contains the same amount of energy as is stored in all of the planet's reserves of coal, oil, and natural gas and, once a system is in place to harness the solar resource and convert into useful energy, then fuel is free.

In relation to the concerns raised over the environmental pollution, many policy makers along with governments and public involvement were continuously striving to promote the clean and pollution free technologies in the electric sector. In meantime a global level awareness on reducing emissions, promoting clean and energy efficient methods were coming into existence with Kyoto Protocol movement under the United Nations Framework Convention on Climate Change (UNFCCC). Considering the electricity sector, most important thing is to promote renewable energy sources such as solar, wind, biomass, fuel cells, geothermal, and hydro power etc. However, among all the renewable energy sources, solar photovoltaic systems have gained much more importance and priority. Energy productions from photovoltaic system can be generated in simple manner when compared to other sources. The number individual

components used in solar PV system are quite low when compared to other system. It does not involve any large size components also. Solar PV systems are classified into two: standalone or off-grid photovoltaic system, and grid connected or on-grid photovoltaic system. In earlier days photovoltaic installations are mostly based on off grid type and works on isolated conditions. But due to advancements in PV technology, and power electronics these systems were started booming as on-grid PV system. At present in most of the nations, the PV installations are working on grid connected mode and still contribute to electricity mix.

On-grid solar photovoltaic system is the one that generates electrical power with the help of solar photovoltaic harvesters and delivers the power to electric utility.
The schematic view and working flow of the system is clearly shown in Fig.11 below

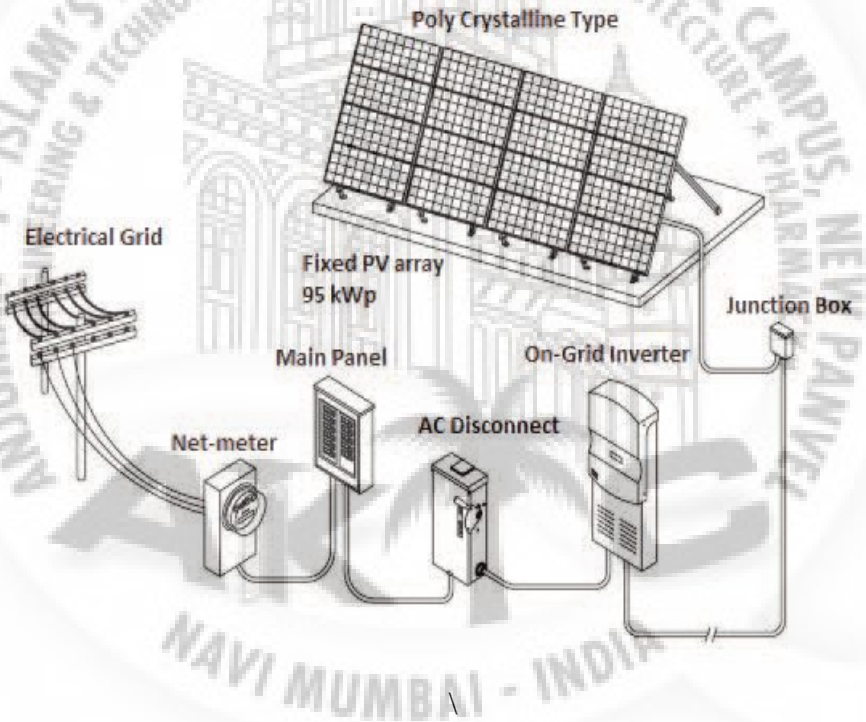


Fig. 11. Schematic view of on-grid photovoltaic system

3.5.2 Solar panel

A solar panel, or photo-voltaic (PV) module, is an assembly of photo-voltaic cells mounted in a framework for installation. Solar panels use sunlight as a source of energy and generate direct

current electricity. A collection of PV modules is called a PV Panel, and a system of Panels is an Array. Arrays of a photovoltaic system supply solar electricity to electrical equipment.

There are many practical applications for the use of solar panels or photovoltaic. It can first be used in agriculture as a power source for irrigation. In health care solar panels can be used to refrigerate medical supplies. It can also be used for infrastructure. PV modules are used in photovoltaic systems and include a large variety of electric devices.

Commercial concentrated solar power plants were first developed in the 1980s. As the cost of solar electricity has fallen, the number of grid-connected solar PV systems has grown into the millions and utility-scale photovoltaic power stations with hundreds of megawatts are being built. Solar PV is rapidly becoming an inexpensive, low-carbon technology to harness renewable energy from the Sun. The current largest photovoltaic power station in the world is the Pavagada Solar Park, Karnataka, India with a generation capacity of 2050 MW.

Solar power in India is a fast developing industry. The countries solar installed capacity reached 37.627 GW as of 31 March 2020. India has established nearly 42 solar parks to make land available to the promoters of solar plants.

3.5.3 COMPONENTS OF ON-GRID SOLAR ARRAY:

The various components involved in the grid connected photovoltaic system are as follows:

1) Photovoltaic Modules*:* Mono crystalline solar cells are simply referred as Si-mono. Si-mono photovoltaic modules or cells are made from a single cylindrical crystal ingot having high purity. From the single crystal, wafer can be sliced and cut in octagonal shapes. At Standard Test Conditions i.e. STC 1000 W/Sq. m, Si-mono cells shows the best performance but the same cell shows poor performance when temperature levels rise.

Poly crystalline solar cells are simply referred as Si-poly. Si-poly modules or cells consist of small crystals which make the cell or module to look as “crystal grain known as crystallites”. Si-poly cells are “produced by sawing a square cast block of silicon first into bars and then into wafers”. These cells perform better at STC and the performance reduces as the temperature rises. Si-poly modules are configured by series and parallel combinations to form Si-poly PV generators as per the requirement. Amorphous silicon solar cells are simply referred as Si-amorph. Si-amorph PV generator is configured with the combinations of the Si-amorph PV modules. These modules are of thin film based and made by sandwiching the Si-amorph

materials of 1 nm thickness between the two panes of glass. Si-amorph PV generators perform better than those of Si-poly crystalline. Also perform better under elevated temperature conditions when compared with crystalline silicon cells.

2) Junction Box: The junction boxes were used majorly in two different places in PV systems i.e. one is at the inter-connection to power converter. Here all the PV strings are joined together. Another place is at solar PV enclose where this junction is used comprises the bypass diodes allowing the power flow only in one direction i.e. from solar panel to the utility system.

3) On-Grid Inverter: On-grid inverter is the one which converts the DC power to AC power. This is one of the essential components of PV system to inter connect with the present day power sector. We have various type of inverter available in the market whose rating is from small kVA to larger kVA. The present available inverter are coming with MPPT enabled and wider input Vdc range.

4) AC disconnect & Main Panel: In photovoltaic systems DC and AC disconnect are the two boxes where AC disconnect role is to separate the on-grid power converter i.e. DC-AC inverter from the electrical utility grid. Output currents of the inverters have to be taken into consideration while sizing the AC disconnect and it simply be circuit breaker. This is generally placed in Main panel. Main panel comes into picture before the electrical system can be integrated to electrical power grid. This generally consists of electro mechanical devices that are used to disconnect the photovoltaic system from the electric grid.

5) Net Meter: Net meter is a device that is used to monitor the inflow and outflow of electricity between the electrical power generating system to electric utility grid. In photovoltaic systems if excess energy is generated that can be sold to the utility by means of this.

6) Electrical Grid: It is an electrical power network interconnecting the load centers and energy providers. It is one of major parts of electrical power system network acting as interface between power generation plant, power transmission line, and distribution lines. It transmits electric power that is generated using any source (renewable or non-renewable) at any place and distributes finally to the consumers as per the requirement.

3.5.4 Operation:

A photovoltaic system operates to generate electricity and the operation is similar for both the off-grid and on-grid photovoltaic systems. Whenever the incident light energy on the photovoltaic module is enough to produce electrons, then DC power is generated at the output terminals of the PV array and then is fed to the power converters which in turn helps in DC to AC conversion. The AC energy can be used directly to electrical loads, or it can be supplied to utility grid by means net metering facility. If the generated is utilized for various load applications at the generation level itself, then it is said to be standalone PV system, if the generated energy continuously fed to the utility grid then it can be termed as on-grid photovoltaic system.

3.4.5 Calculation of Energy Consumption (Table 3).

Equipment/devices	Wattage	Nos.	Working hours per day	Total Energy Consumption (kWh)
LED bulb	15	2 x 16 = 32	1	0.48
Fluorescent tube	30	5 x 16 = 80	10	24
Fan	70	5 x 16 = 80	6	33.6
Computer	200	1 x 16 = 16	2	6.4
T.V	250	1 x 16 = 16	5	20
Refrigerator	350	1 x 16 = 16	8	44.8
Washing machine	700	1 x 16 = 16	1	11.2
Heater/geyser	1000	1 x 16 = 16	1	16
Oven	800	1 x 16 = 16	1.5	19.2
Mixer/blender	250	1 x 16 = 16	0.5	2
Iron	50	1 x 16 = 16	0.5	0.4
Air conditioner	1500	3 x 16 = 48	6	135
Elevator	3750	1	1	3.75

LED tube for building premises	50	24	10	12

Total energy consumption per day = 0.48 + 24 + 33.6 + 6.4 + 20 + 44.8 + 11.2 + 16 + 19.2 + 2 +0.4 + 135 + 3.75 + 12 = **328.83kWh**

3.5.6 Sizing solar array

Efficiency of Inverter = 0.9

The solar array has to generate = 328830 / 0.9

= 365.367 kWh/day

Assuming an average of 8 hours sunshine

The solar array has to generate = 365.367 / 8

= 45.68 kW/day

Capacity of one panel = 380 W

Number of panels = 45680 / 380

= 138.42

= 121 Nos.

Dimension of 1 panel = 1976 mm x 991 mm

Angle of inclination = latitude = 19 degree

Horizontal dimensions = 1.868 m x 0.991 m

Total area required = 1.868 x 0.991 x 121 = 224 sqm.

3.5.7 Return on investment:

Approximate cost of 46 kW Solar system (including batteries, inverter, installation and transportation) = 22,00,000 Rs

Government subsidy = 20% of total cost

= 4,40,000 Rs

Net cost = 17,60,000 Rs

Electricity consumed = 328.83 kWh/day

Cost per unit (1-unit = 1 kWh) = 11.82 Rs

Cost of electricity = 11.82 x 328.83 = 3886.77 Rs/day

Return on investment = Net Cost / Cost of electricity

= 17,60,000 / 3886.77

= 452.81 days

Return on Investment is 1.3 Years.

3.6 RAINWATER HARVESTING

In simple terms, water harvesting means collection and storing of rainwater. Water so collected can be used for irrigation, toilet flushing, washing laundry and for drinking after treatment. Water harvesting in Green Rating is considered important aspect of water efficiency. The Indian Urban Ministry has already issued "Model Building Bye-Laws 2016" the bye law has made provisions mandating rainwater harvesting.

Rainwater harvesting has many benefits but the main one is that it is a sustainable water management practice that can be implemented by anyone on many different levels, from a simple rain barrel to a comprehensive rainwater harvesting system that integrates with an irrigation system or household plumbing.

3.6.1 Benefits of rainwater harvesting

3.6.1.1 Water conservation

The rainwater that falls on your roof and property is essentially free. All it takes is a method to harvest it into a tank or cistern for later use. Rainwater harvesting can be a great educational tool to get people to recognize their individual or household water usage. This can get them to start conserving water in other areas around their home. For communities that rely on imported water to supply their needs, collecting rainwater that falls naturally in the community can reduce the need for imported water. Rainwater harvesting helps utilities reduce peak demands during summer months, saving treated water for more important and appropriate water uses. While

rainwater can be a perfect primary water source for many uses and situations, it is also a great backup water supply for emergency situations.

3.6.1.2 Environmental benefits

Rainwater harvesting can reduce stormwater runoff from a property. The elimination of runoff can reduce contamination of surface water with pesticides, sediment, metals, and fertilizers. By reducing stormwater runoff, rainwater harvesting can reduce a storm's peak flow volume and velocity in local creeks, streams, and rivers, thereby reducing the potential for streambank erosion. Rainwater harvesting systems can be employed as simple and effective methods to meet a municipality's stormwater management program requirements of individual properties. It is an excellent source of water for plants and landscape irrigation since it has no chemicals such as fluoride and chloramines (chlorine).

3.6.1.3 Water energy

While the logical use of rainwater harvesting is for water conservation purposes, it also reduces energy use within a community. Typically, the end use of the rainwater is located on the property where the rainwater is collected. Replacing municipal water use at a home and property with rainwater reduces the amount of water that a municipality has to treat and then pump to your house. The treatment and pumping of municipally provided water require a lot of energy. The implementation of rainwater harvesting can help meet new standards of energy and water efficiency ratings and codes that are being developed in communities.

3.6.1.4 Economic benefits

Collecting and using rainwater to replace municipal water use reduces your water bill Reducing municipal water use for areas such as irrigation reduces the amount of water that a municipality has to treat and pump. This, in turn, reduces water service cost to a municipality. The widespread implementation of rainwater harvesting within a municipality's service area can reduce the long-term water development needs of a city, allowing the city to use their existing water infrastructure investments more efficiently. The cost to the community to supply treated water is becoming more expensive every year. The cost to construct dams, pipes, and treatment

plants, not to mention the cost of maintenance and infrastructure replacement is huge. As water users, the rate-payers in the community ultimately will foot this rising bill. Therefore, the practice of rainwater harvesting can reduce water demand and thus allow municipalities to provide potable water service at a lower cost. Designing and installing rainwater collection systems can provide sustainable jobs for the economy of the future. The rainwater harvesting industry can become a leading employer in the green infrastructure movement. Rainwater stored onsite in a rainwater harvesting system can be available for wildfires and help protect the house and property. Insurance companies can offer discounts for storing water onsite for fire protection. As you can see from the benefits and advantages listed above, the practice of rainwater harvesting is an important and vital part of developing a sustainable water resource path for any community. As local water resources are stretched to provide for population growth and economic development, new water supply strategies and paradigms will be necessary to meet this demand. Rainwater harvesting is an untapped resource that could be developed quickly within communities and that will also have a tremendous impact. Rainwater harvesting is part of a sustainable water supply strategy for local communities.

3.6.2 Components of rainwater harvesting system

A rainwater harvesting system comprises components of various stages – transporting rainwater through pipes or drains, filtration, and storage in tanks for reuse or recharge. The common components of a rainwater harvesting system involved in these stages are illustrated here.

3.6.2.1 Catchments:

The catchment of a water harvesting system is the surface which directly receives the rainfall and provides water to the system. It can be a paved area like a terrace or courtyard of a building, or an unpaved area like a lawn or open ground.

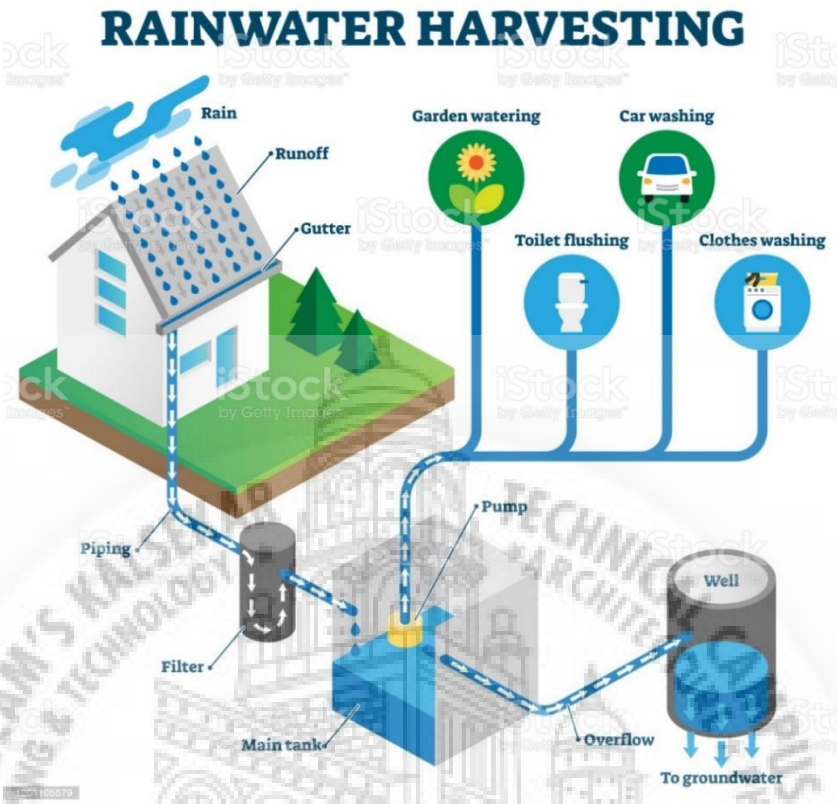


Fig. 12: Rainwater Harvesting System

(Source: istockphoto.com)

3.6.2.2 Coarse mesh:

Coarse mesh is installed at the roof to prevent the passage of debris into the gutter and thereafter into the pipe.

3.6.2.3 Gutters:

Channels all around the edge of a sloping roof to collect and transport rainwater to the storage tank. Gutters can be semi-circular or rectangular and could be made using:

- Locally available material such as plain galvanized iron sheet (20 to 22 gauge), folded to required shapes.
- Semi-circular gutters of PVC material can be readily prepared by cutting those pipes into two equal semi-circular channels.
- Bamboo or betel trunks cut vertically in half.

The size of the gutter should be according to the flow during the highest intensity rain. It is advisable to make them 10 to 15 per cent oversize.

Gutters need to be supported so they do not sag or fall off when loaded with water. The way in which gutters are fixed depends on the construction of the house; it is possible to fix iron or timber brackets into the walls, but for houses having wider eaves, some method of attachment to the rafters is necessary.

3.6.2.4 Conduits:

Conduits are pipelines or drains that carry rainwater from the catchment or rooftop area to the harvesting system. Conduits can be of any material like polyvinyl chloride (PVC) or galvanized iron (GI), materials that are commonly available.

3.6.2.5 First-flushing:

A first flush device is a valve that ensures that runoff from the first spell of rain is flushed out and does not enter the system. This needs to be done since the first spell of rain carries a relatively larger amount of pollutants from the air and catchment surface.

3.6.2.6 Down-take pipe:

Down-take pipes made of PVC or HDPE or even asbestos cement can be used for transporting the rainwater collected from rooftops to filtration system before storing. The diameter of these down-take pipes would vary depending on roof area to be drained.

3.6.3 Design of water tank

Per capita water demand = 150 lpcd

Assume 5 person per residence

Total population = 5 x 16 = 80

Average water demand = 80 x 150

= 12000 liters/day

Maximum daily demand = 1.5 x 12000

= 18000 liters/day

Tank should have capacity for 30 days

Capacity of underground tank = 18000 x 30

= 540000 liters

Required Volume of tank = 540000 liters = 540 m^3

Assume depth of tank = D = 3.5 meters

Volume = 3.5 x L X B

540 = 3.5 x L x B

L x B = 154.3

B = 9.5 m

L = 16.5 m

D = 3.5 + free board = 3.5 + 0.5 = 4 m

Inner dimension of underground tank = 16.5m x 9.5m x 4m

Overhead tank should have capacity for 2 days

Volume = 2 x 18 = 36 m^3

assuming depth = 1.5m

Provide two overhead tanks with inner dimensions – 3m x 4m x 1.7m

3.6.4 Calculation of annual rainwater harvesting

Average annual rainfall in region = I = 1900 mm

Coefficient of rainfall for roof = C_1 = 0.8

Coefficient of rainfall for porous pavement = C_2 = 0.9

Area of roof = A_1 = 318.8 sqm

Area of porous pavement) = A_2 = 1058.8 sqm

Annual Rainwater Harvesting = C x I x A

= [0.8 x 1.9 x 318.8] + [0.9 x 1.9 x 1058.8]

= 2295.124 m^3

= 2295124 liters

Therefore, annually 2295124 liters of water is harvested.

3.6.5 Design of Rainwater harvesting tank

Amount of Water required daily per person for drinking, bath and cooking = 20 liters

The tank capacity has to be designed for dry season between monsoon season of 4 months, the dry period is 245 days.

Tank capacity = 245 x 80 x 20

= 392000 liters

Volume of tank = 392 m^3

Assume depth of tank = 3.5 m

L =1.5B

Volume = 3.5 x L X B

392 = 3.5 x 1.5 x B^2

B = 8 m

L = 14 m

D = 3.5 + free board = 3.5 + 0.5 = 4 m

Inner dimension of underground rainwater harvesting tank = 14m x 8m x 4m

3.6.6 Design of sand filter

The filter is used to remove suspended pollutants from rainwater collected over roof. A filter unit is a chamber filled with filtering media such as fibre, coarse sand and gravel layers to remove debris and dirt from water before it enters the storage tank or recharges structure. Charcoal can be added for additional filtration

Sand filters have commonly available sand as filter media. Sand filters are easy and inexpensive to construct. These filters can be employed for treatment of water to effectively remove turbidity (suspended particles like silt and clay), colour and microorganisms.

In a simple sand filter that can be constructed domestically, the top layer comprises 20cm gravel layer followed by a 30cm sand layer followed by another 20cm layer of gravel and boulders.

Highest daily rainfall in region = 200 mm

Discharge = Q = volume of water collected per day from roof

= area of roof x highest daily rainfall

= 318.8 x 0.2

= 63.76 m^3/day

= 0.738 liters/sec

Assuming Rate of Filtration for slow sand filter = R = 400 liters/hr/m^2 = 0.111 liters/ sec /m^2

Surface area of sand filter = Q/R

= 0.738 / 0.111

= 6.64 m^2

Providing two filters, one on each side. Thus, area of one sand filter = 6.64/2 = 3.32 m^2

Dimensions of sand filter are: - 2m x 1.7m

Provide 100mm diameter pipes from rooftop to the sand filter.

Provide 1 in 200 slope on roof slab.

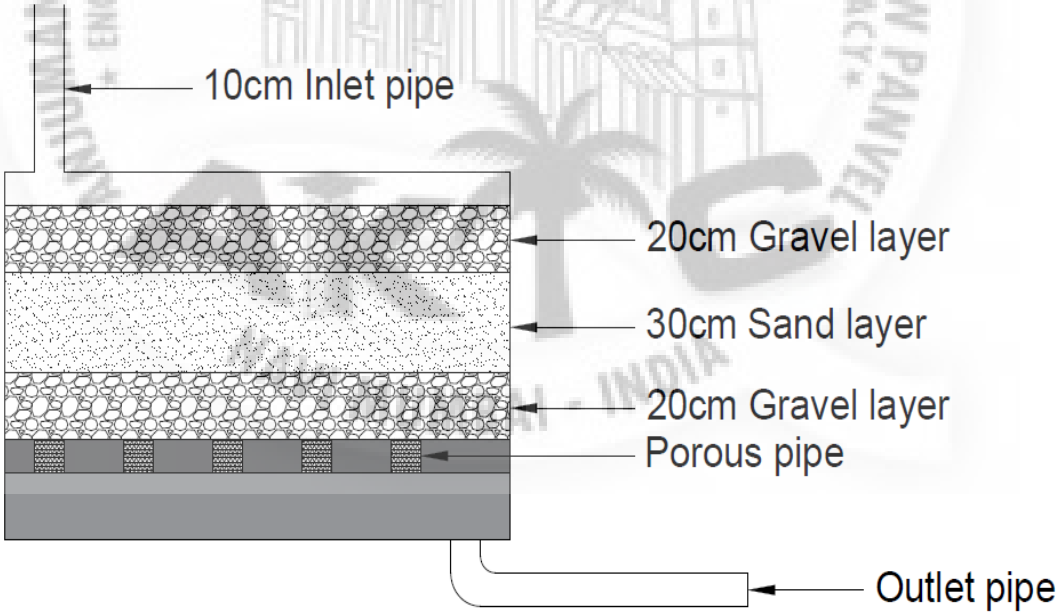


Fig.13: Slow Sand Filter

3.6.7 Porous Pavement

Porous pavement is a water-permeable structural groundcover that infiltrates precipitation, attenuates storm water runoff flows and volumes, and reduces temperatures. Porous pavement provides a stable load-bearing surface without increasing a project's total impervious area. The two main categories of porous pavements are 1) pervious concrete and asphalt, and 2) permeable pavers. Pervious concrete and asphalt are poured in place and resemble their solid counterparts, except the fines (sand and finer material) are removed to create more void space for water to flow through. Permeable pavers are solid, discrete units typically made of pre-cast concrete, brick, stone, or cobbles and set to allow water to flow between them.

3.6.7.1 Components of Porous pavement

1) Pavers: pavers are the top most surface of porous pavement. Paver blocks are placed with a tiny gap between them to allow rainwater to pass through them. Porous pavement is to be protected from fines infiltration during site construction by covering with impervious material.

2) Choker Course: The choker course beneath pervious asphalt or pavers consists of aggregates of size less than 12mm for a minimum of 50mm depth.

3) Aggregate Base: The base course consists of clean, crushed 12mm to 20mm uniformly graded aggregate and below them 20mm to 40mm sized aggregates. The depth of the aggregate base course will vary as per design.

4) Geotextile Fabric: Non-woven geotextile fabric should be placed between the subgrade (native soil) and the aggregate base for proper separation.

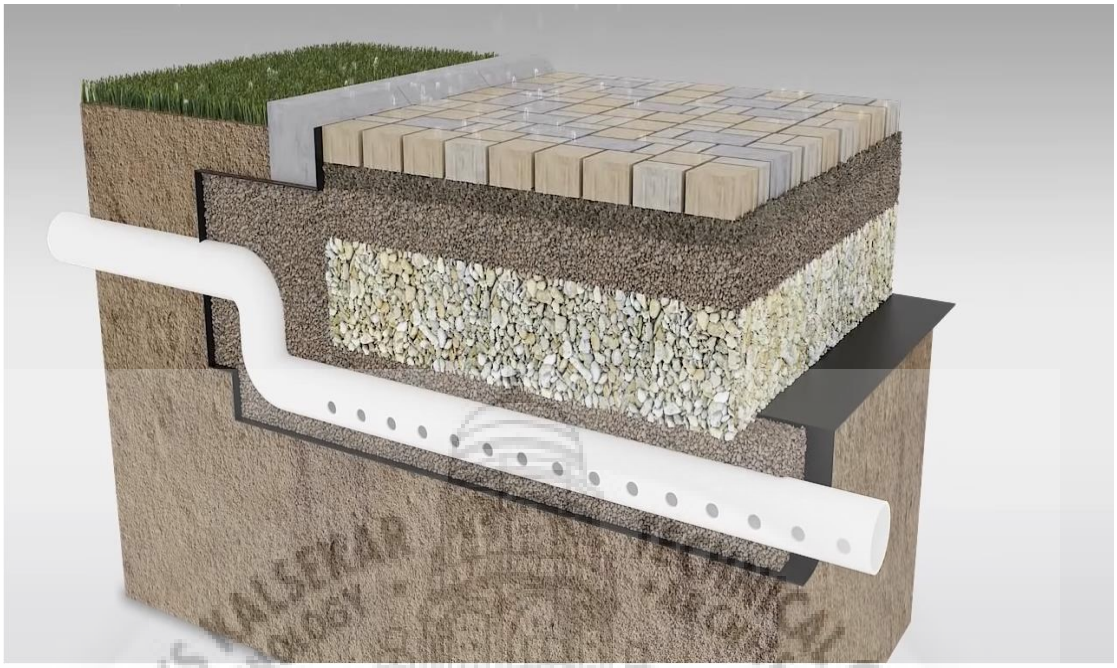


Fig 14: Section of Porous Pavement
(Source: Oaks Pavers)

5) Drainage pipe: Pipes with pores through which water is collected are provided at proper distance from each other. These pipes lead to the drain or storage tank as per requirement.

6) Subgrade: Care should be taken to avoid compaction of the subgrade surface and all construction equipment should be kept off the subgrade. If based on the soil type, the excavation of the surface has been sealed, the surface should be lightly scarified or raked to provide infiltration values consistent with the design.

3.6.7.2 Application & Limitations

Porous pavement is not considered a water quality facility to provide treatment of runoff from other impervious surfaces. However, pollutants captured from direct rainfall on the porous pavement area are treated through filtration, absorption, and other microbial degradation actions in the subgrade. Porous pavement area may be considered 100% pervious in water quality calculations, thus reducing the size of required water quality facilities. Pervious asphalt, pervious concrete, and permeable pavers can be used in most pedestrian areas, residential driveways, public sidewalks, and parking lots. Local jurisdictions may approve pervious asphalt and concrete for private streets and public roadways on a case-by-case basis. Porous pavements

should not be located over cisterns, utility vaults, underground parking or other impervious surfaces and should be applied only where the seasonal high water table is at least 10 feet beneath the facility's bottom or drain rock layer. Porous pavement should not be applied in locations where there is a high risk of chemical spillage.

3.6.8 Limitations of rainwater harvesting

There are several limitations pertaining to rainwater harvesting system:

- The catchment area and storage capacity of a system are relatively small. There is a great variation in weather. During a prolonged drought, the storage tank may dry up.
- Maintenance of rainwater harvesting systems can be difficult for users.
- Extensive development of rainwater harvesting systems may reduce the income of public water systems.
- Rainwater harvesting systems are often not part of the building code and lack clear guidelines for users/developers to follow.
- Rainwater utilization has not been recognized as an alternative of water supply system by the public sector. Governments typically do not include rainwater utilization in their water management policies, and citizens do not demand rainwater utilization in their communities.
- Rainwater storage tanks may take up valuable space.
- Some development costs of larger rainwater catchment system may be too high if the costs are not shared with other systems as part of a multi-purpose network.

3.6.8.1 Advantages

- Improvement in the quality of ground water**.**
- Attainment of drought proofing**.**
- An ideal solution to water problems in areas having.
- Inadequate water resources.
- Reduction in the soil erosion as the surface runoff is reduced.
- Decrease in the choking of storm water drains and flooding of roads.

- Saving of energy, to lift ground water. (One-meter rise in water level saves 0.40kilowatt hour of electricity).
- Makes use of a natural resource and reduces flooding, storm water runoff, erosion, and contamination of surface water with pesticides, sediment, metals, and fertilizers.
- Reduces the need for imported water (the San Diego region imports between 80%-90% of its water from Northern California and Colorado River).
- Excellent source of water for landscape irrigation, with no chemicals such as fluoride and chlorine, and no dissolved salts and minerals from the soil.
- Home systems can be relatively simple to install and operate May reduce your water bill.
- Promotes both water and energy conservation.
- No filtration system required for landscape irrigation.

3.6.8.2 Disadvantages

- Limited and uncertain local rainfall.
- Can be costly to install – rainwater storage and delivery systems can cost between Rs.20,000 to Rs.2,00,000 depending on the size and sophistication of the system.
- Requires some technical skills to install and provide regular maintenance.
- If not installed correctly, may attract mosquitoes (i.e.; West Nile Disease and other waterborne illnesses).
- Certain roof types may seep chemicals, pesticides, and other pollutants into the water that can harm the plants.
- Rainwater collected during the first rain season is generally not needed by plants until the dry season. Once catchment is full, cannot take advantage of future rains.

3.7 SCHEDULE OF PROJECT ACTIVITIES

3.7.1 What is a project schedule?

A project schedule is basically a model or graphical representation of activities. This schedule is developed by analyzing different type of project information like activities to be performed, their estimated duration, relationship between activities, project constraints, lags and leads etc. A project schedule is a key document which is used to plan, monitor and control activities for successful completion of a project.

3.7.2 Project activity

It is a task or work which consumes time & other resources for its completion. In a network, activity is shown by an arrow. An activity is typically one stage of a project management plan. Each activity consists of one or more actions that, upon completion, will lead to the next project stage. Taken together as a series, the activities will result in the final deliverable. Each activity has a defined start and end, as well as a deadline or time period within which it must be completed.

When you are planning a project, one of the key steps is to define the activities required to bring that project to fruition. This generally involves creating an activity list, which is exactly what it sounds like — a list of all the actions required for the project.

Each activity will likely consist of several sub-tasks. Once the activities have been defined, it's up to the project manager and other stakeholders to sequence them — in other words, to place them in the appropriate order, and then track and manage them. Activities are typically tracked with either a **Network Diagram**, representing all the activities for a project in a sequential, workflow format or a **Gantt chart**, which represents tasks via horizontal bars that demonstrate their length and duration.

3.7.2.1 Types of activity

1) Serial activities: serial activities are activities that are performed in series, one after one. If activity B starts after completion of activity A, then it means, A & B are serial activities.

2) Parallel / Simultaneous activities: Activities which are commencing at same point of time. These activities are independent of each other.

3) Dummy activities: Activity which neither consume time nor any other resources. It is not regular activity but sometime it is needed for linking purpose.

3.7.3 Methods of Scheduling

3.7.3.1 Critical Path Method (CPM)

Critical Path Method was introduced by Du Pont & Sprey Rand Corporation in the year 1957. Earlier CPM was used for scheduling various industrial activities but later on it was found to be more suitable for Construction activities.

- CPM is activity oriented network
- CPM is deterministic in nature
- Single time estimate is required for various activities involved in the project.
- CPM is used for scheduling repetitive type projects. i.e. Construction Projects
- Cost is governing factor in CPM.

3.7.3.2 Program Evaluation and Review Technique (PERT)

Program Evaluation and Review Technique was basically developed by U.S Navy while launching Polaris Missile in
the year 1958.
In a project sometimes there are some activities which are uncertain in time.
PERT is useful for scheduling such activities.

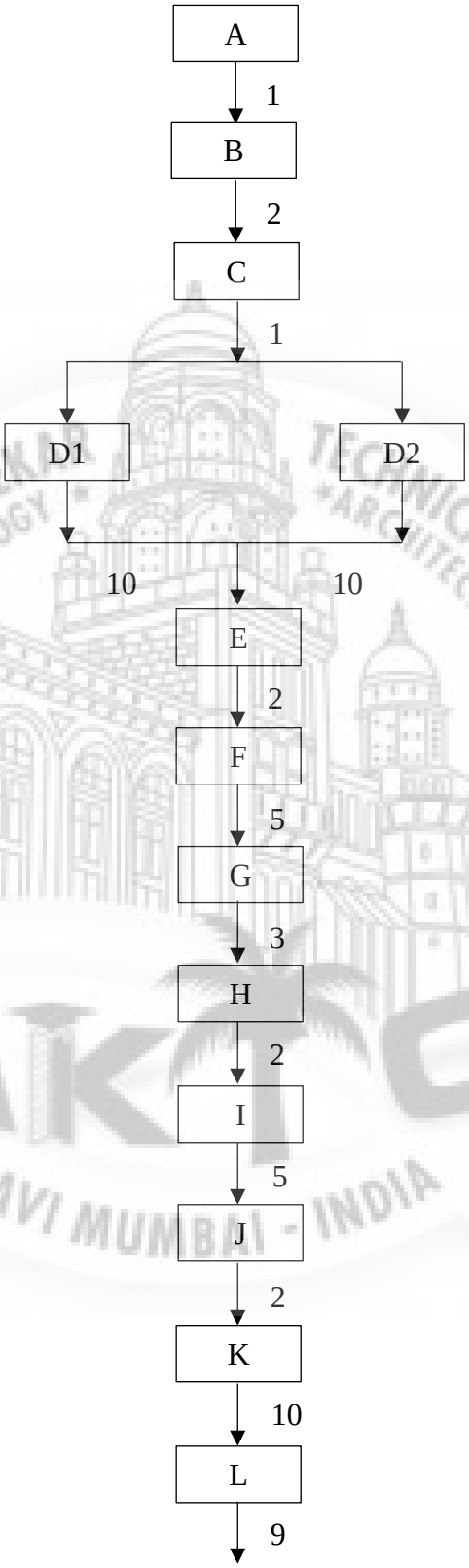
- PERT is event oriented network
- PERT is probabilistic in nature
- Three time estimates are required for various activities involved in the project.
- PERT is used for scheduling non-repetitive & R&D type projects.
- Time is governing factor in PERT.

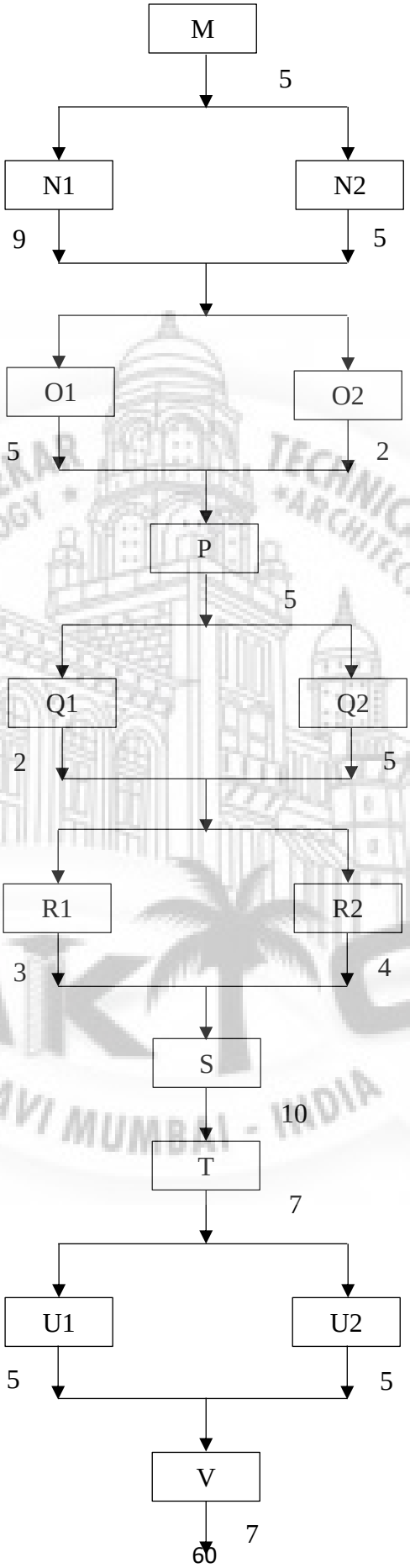
3.7.4 List of activities (Table 4)

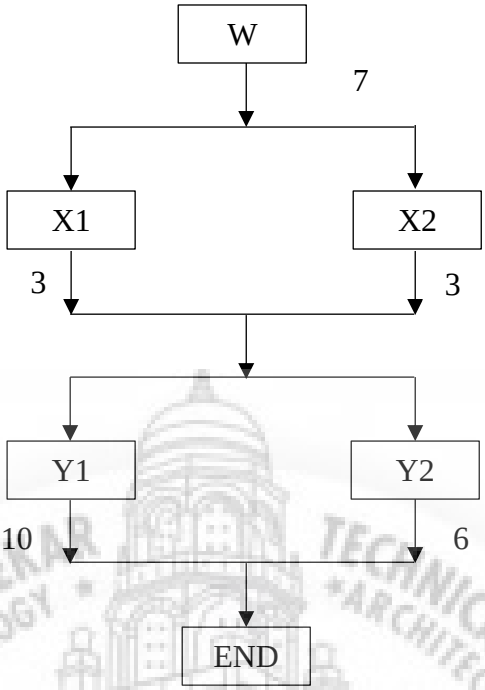
NO.	ACTIVITY	NAME OF ACTIVITY	DURATION
1	PREPARATION OF BUILDING PLAN (DRAWINGS)	A	1
2	SITE CLEARANCE	B	2
3	MARKINGS FOR FOUNDATION	C	1
4	EXCAVATION FOR FOUNDATION	D1	10
5	EXCAVATION FOR WATER TANKS	D2	10
6	PCC FOR FOUNDATION	E	2
7	CASTING OF FOOTING	F	5
8	BACKFILLING AND COMPACTION	G	3
9	PCC FOR PLINTH BEAM	H	2
10	CASTING OF PLINTH BEAM	I	5
11	PLINTH FILLING BY EARTH	J	2
12	CASTING OF COLUMNS	K	10
13	CASTING OF BEAMS	L	9
14	CASTING OF SLAB	M	5
15	BRICKWORK (WALLS)	N1	9
16	CASTING OF STAIRCASE	N2	5
17	CONSTRUCTION OF UNDERGROUND WATER TANKS	O1	5

18	CONSTRUCTION OF OVERHEAD TANKS	O2	2
19	PLUMBING WORK	P	5
20	SAND FILTER SETUP	Q1	2
21	ELECTRICAL WORK	Q2	5
22	INSTALLATION OF ELEVATOR	R1	3
23	SOLAR PANEL WIRING AND INSTALLATION	R2	4
24	INTERNAL PLASTERING	S	10
25	TILE FLOORING	T	7
26	INSTALLATION OF DOORS	U1	5
27	INSTALLATION OF WINDOWS AND GLASS PANELS	U2	5
28	EXTERNAL PLASTERING	V	7
29	CONSTRUCTION OF POROUS PAVEMENT	W	7
30	RECYCLED PAVER BLOCKS	X1	3
31	CONSTRUCTION OF COMPOUND WALL	X2	3
32	INTERNAL PAINTING	Y1	10
33	EXTERNAL PAINTING	Y2	6

3.7.5 Flowchart of Scheduled Activities







3.7.6 Critical path

Critical Path is the path in the network which has longest duration. Critical path is the path in a network which must be completed on time in order to complete the project on time.

Critical path:

A-B-C-D1-E-F-G-H-I-J-K-L-M-N1-O1-P-Q2-R2-S-T-U1-V-W-X1-Y1

3.7.7 Project Duration

Project duration is the total duration of a project. It is the sum of durations of all critical activities.

Project Duration = 134 Days.

CHAPTER 4

RESULTS AND DISCUSSION

1) The Total energy consumption per day of the building is 328.83 Kwh

   As we have provided 121 Solar Panels

   The return on investment is **1.3** years

2) Design of water tank:

a) For underground tank:

   The Underground Tank Storage capacity is of 30 days

   The volume of Underground tank is 540 m^3

   We have designed the inner dimension of underground tank as **16.5 m X 9.5 m X 4 m**

b) For overhead tank:

   The Overhead Tank Capacity is of 2 days

   The volume of Overhead tank is 36 m^3

   We have provided two overhead tanks with inner dimension are **3 m X 4 m X 1.7 m**

3) By using the Rainwater Harvesting Techniques, the annual Rainwater harvested is 2295124 liters

   Design of rain water harvesting tank:

   The tank capacity is of 392000 liters

   The volume of tank is 392 m^3

   The inner dimension of underground rainwater harvesting tank are **14 m X 8 m X 4 m**

4) Design of sand filter:

   The discharge of water is 0.738 liters/sec

   The surface area of sand filter is 6.64 m^2

   The dimension of sand filter are **2 m X 1.7 m**

5) By scheduling the activities in Flowchart we have got the approximate duration of project as 134 days

CHAPTER 5

CONCLUSION

Construction industry is the second largest economic activity in India. Heavy investments are to be made in the civil construction industry for future development. Hence construction project managers with necessary technical knowledge as well as project managing skill are required in large amount to manage the corresponding project efficiently. In this project we have prepared the plan for Residential green building with the help of AutoCAD software. Also keeping in mind about the objectives of our project such as energy efficient system, proper water management, and use of green building materials and reduction of waste.

In this project, we have intentionally used green building materials such as Fly Ash bricks, Recycled Concrete aggregate, Recycled Steel bars, Recycled Paver blocks, Eco-friendly tiles and Paints containing low Volatile Organic Compound to reduce the adverse impact on environment. Also we have successfully designed and provided the Solar Panels to the green residential building through which return on investment is achieved in 1.3 years. Now a days, as we all know the importance and the benefits of Rainwater Harvesting, we have designed and provided separate rainwater harvesting tank which has a storage capacity of 3,92,000 liters using the rain water harvesting techniques. With the help of slow sand filter as we know it removes the suspended matter, floating as well as sinkable particles and produce high-quality water without the use of chemical aids. The harvested rain water can be treated and use efficiently. As a result, water consumption was reduced considerably by making use of recycled rainwater for watering the plants and maintaining lawn and kitchen garden. The greenhouse designed is further low on maintenance as its construction involved extensive use of natural and eco-friendly materials. This work is a step towards making the world green having minimum carbon footprint and to provide a healthy environment to its occupants by taking care of simple needs of providing good ventilation, natural lighting and healthy surroundings.

REFERENCES

1. Vipin Kumar, Dr. Shreenivasreddy Shahpur, Maneeth P. D., Brijbhushan S. (2017) "Analysis of Academic Building by Planning, Scheduling & Resource Allocation Using Oracle Primavera , volume 3 , International journal of scientific research of science and technology.

2. Akshay B. Mokal , Allaudin I. Shaikh , S. Raundal, Sushma J. Prajapati, Uday J. Phatak (2015) "green building materials - A survey toward sustainable construction , Volume 4 , Issue 4 , International journal of application & innovation in engineering and management

3. Ashish Kumar Parashar, Rinku Parashar (2012) "Construction of an Eco-Friendly Building using Green Building Approach", Volume 3, International journal of scientific research in science and technology

4. JigneshKumar R. Chaudhari, Prof. Keyur D. Tandel, Prof. Vijay K. Patel (2013) "Energy saving of Green Building Using Solar Photovoltaic Systems", Volume 2, Issue 5, International journal of innovation research in science engineering and technology.

5. Dr K N Sheth (2017) "water efficient technologies for green buildings", Volume 1, International journal of innovation & scientific research

6. Hayssam Traboulsi, Marwa Traboulsi (2015) "Rooftop level rainwater harvesting system, Volume 1, KACST springer

7. Senfuka C., Kirabira J.B., Byauhanga J.K. (2013) "The Concrete Reinforcing, Volume 2, International journal of engineering & technology

8. Kolluru Hemanth Kumar (2014) "Review paper on permeable pavement, Volume 11, TPMDC

9. Mr. Kiran Joseph, Mr. Victor Jose, Mr. Dinesh Kumar A N, Mrs. Sithara Mary Sunny (2018) "A Review on various Green Building Rating Systems in India", Volume 9, Issue 5, International journal of scientific & engineering research.