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ANALYSIS OF PHASE CHANGING MATERIAL TO ENHANCE BUILDING EFFICIENCY

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ABSTRACT
Enhancing building efficiency with Phase Change Materials (PCM) involves leveraging their unique thermal properties to improve energy management and reduce reliance on heating and cooling systems. PCM can absorb, store and release thermal energy during phase transitions, helping to stabilize indoor temperatures. This paper explores the integration of PCM into various building components, including walls, ceilings, floors and windows, as well as their application in HVAC systems and roofing solutions.
This project explores the potential of enhancing building efficiency through the integration of Phase Change Materials (PCM), rainwater harvesting, solar energy, HVAC systems, and Greywater recycling. Key objectives include evaluating the use of PCM in walls, ceilings, floors, windows, HVAC systems and roofing to optimize indoor temperature regulation. The study investigates thermal performance of PCM their ability to absorb, store and release thermal energy and their impact on reducing energy consumption.
Additionally, the integration of rainwater harvesting systems and Greywater recycling is assessed for water conservation and sustainable water management. The role of solar energy in reducing reliance on non-renewable energy sources is also examined. The findings demonstrate that combining these technologies significantly enhances building efficiency, promoting sustainable practices and contributing to energy efficient design and improved environmental performance.

Keywords
Building efficiency, Energy management, Thermal energy storage, Indoor temperature stabilization, Sustainable building practices

1. INTRODUCTION

1.1 General
Solar energy is a renewable resource thus, it will never run out. Because of this, we are free to experiment and determine how to use it most effectively and efficiently. Sunlight and heat are captured and transformed into several types of energy. One of the renewable energies is solar energy, which is the transformation of solar energy. Most of the sunlight is converted to visible light and infrared radiation once it has passed through the atmosphere of the earth. These energies are transformed into electricity using solar cell panels. Due to the limitations and effects of non-renewable energy sources, people must pay attention to renewable energy sources. The increasing need for power in developing nations as a result of global warming, greenhouse gas emissions, shifting oil costs and other factors requires innovative approaches.
Rainwater harvesting is a technology used to collect, convey and store rain water for later use from relatively clean surfaces such as a roof, land surface or rock catchment. RWH is the technique of collecting water from roof, Filtering and storing for uses. Rainwater Harvesting is a simple technique of catching and holding precipitation where its falls. Either, we can store it in tanks for further use or we can use it to recharge groundwater depending

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upon the situation. RWH system provides sources of soft, high-quality water reduces dependence on well and other sources and in many contexts are cost effective. RWH system is economically discounted in construction compared to other sources, i.e., well, canal, dam, diversion, etc.

Rainwater harvesting systems (RWHS) are one of the alternative sources to address the challenge of the water crisis with the least impact on the environment. The notion of RWHS is to collect and store rainwater for use instead of allowing it to run off. The rewards of using RWHS include solving water shortage subjects during droughts or polluted surface water for water intake and reducing the dependency on conventional water supply caused by extra from impervious covers such as roofs.

Developing water reuse or treatment plants is a growing demand due to increasing population, diminishing water resources, changing lifestyle patterns and urbanization together with increasingly stringent wastewater quality discharge regulations and requirement. To curb these water shortages and achieve water sustainability in urban areas, many waters sensitive cities, especially the ones in arid and semiarid regions, have investigated methods for treatment and reuse of water and wastewater. On a small scale, these efforts often involve the collection and conduct of greywater in buildings. Greywater is a broad time for water that was used but does not encompass fecal or biologically degradable waste matter. The percentage of household water that is GW varies locally and among houses, depending on the primary practices of water in a building and how professionally water is used but is normally 50% to 80%

1.2 Problem Statement

Increasing urbanization and population growth, coupled with diminishing water resources and stricter wastewater discharge regulations, highlight the urgent need for sustainable water management strategies. This study aims to investigate the feasibility and effectiveness of rainwater harvesting, greywater treatment and solar energy utilization as alternative solutions to mitigate water scarcity and enhance environmental sustainability in urban settings.

2. OBJECTIVES

The study has following objectives

1. To understand the different types of PCM in Building
2. To analyzed the thermal performance of PCM
3. Explore applications in HVAC systems
4. To study the combined sustainable technologies
5. Promote renewable energy use and review construction techniques.

3. METHODOLOGY

1. Ventilation system

This system to improve the Air Quality by removing indoor pollutants air by fresh air.

Ventilation moves outdoor air into a building or a room and distributes the air within the building or room. To provide healthy air for breathing by both diluting the pollutants originating in the building and removing the pollutants from it. Ventilation refers to process of maintaining clean and fresh air in classrooms to ensure that a healthy and comfortable environment for students and teachers. Improve natural ventilation by fully or partly opening windows, air vents and doors. But do not prop fire doors open.

Ventilation able to open any windows and keep vents or trickle vents open that let in fresh air. If any windows have been painted shut, they should be reopened. If they cannot be opened, ventilation in that area will be less effective. The air can be polluted by many different gases, droplets and particles. The sources of these can be anything from traffic pollution, pollen and building materials, to cleaning products and environmental toxins from the furniture. It's your ventilation system's job to rid the indoor air of these pollutants. This is believed to be the biggest students and teachers of diseases and health problems related to air pollution.

- **Types of Ventilation Systems**

1. Natural ventilation

Probably the most well form of ventilation is natural ventilation. This refers to an ongoing supply of clean air from natural sources which, in most cases, is the most ideal type of ventilation for a building.

2. **Mechanized fan ventilation**

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Mechanism fans are generally installed directly into the windows or air ducts of a building to supply air both to or from an environment. This provides buildings with internal air which is extracted via the fan in a controlled approach.

3. **Smoke ventilation**

In public buildings, it is a legal requirement to provide smoke ventilation in the event of a fire. This helps to alleviate the thick build of condensed smoke if a fire were to break out, which then helps to provide a clearer escape route to anyone trapped in the fire.

4. **Supply ventilation**

Smoke ventilation generally works by pressurizing the building, which forces external oxygen particles inside via a fan. This type of ventilation is especially common within living room and bedroom areas, as this provides the best air quality for homeowners in living spaces.

Fig No. 1 Ventilation System

2.Water harvesting system

The term 'rainwater harvesting' is usually taken to mean the immediate collection of rainwater running off surfaces upon which it has fallen directly.

This definition excludes run off from land watersheds into streams, rivers, lakes, etc. Hence it is the catching of rain water when it falls and storing to use during the non -rainy season.

The saline water from the sea gets evaporated due to the heat from the sun, forms clouds and falls as rain as freshwater. A significant part of this rainwater drains out into oceans and drains. If we are able to harness this effectively, it can be an important source which can be used for various applications.

In short, rainwater harvesting is the process of storing rainwater for reusing rather than allowing it to run off. However, it is vital to understand the steps of rainwater harvesting before that.

The technology of rainwater harvesting can be divided according to the purpose and the source of collecting water methods:

a) Rooftop rainwater harvesting
b) Runoff rainwater harvesting

These methods can be selected considering, the purpose, the type, and quantity of storage, catchment state etc.

- **Rainwater Harvesting**

The use of rainwater is a useful alternative. Rainwater runoff is causing soil erosion, collecting and storing rainwater can provide water for domestic use in periods of water shortage. Rainwater may also provide a solution when the water quality is low or varies during the rainy season in rivers and other surface water resources. Using more of rainwater helps to conserve and augment the storage of ground water. It helps to arrest sea water intrusion in coastal areas. It helps to avoid flood & water stagnation in urban areas Reduces water and electricity bills sources are located at some distance from the community, collecting and storing water close to households improves the accessibility and convenience of water supplies and has a positive impact on health. It costs Less to collect rainwater than to exploit groundwater

- **There are basically two methods of rainwater harvesting**

1) Surface runoff rainwater harvesting
2) Roof top rainwater harvesting

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1. **Surface runoff rainwater harvesting**

Surface runoff water harvesting is the collection, treatment or purification, and storing of storm water for reuse. Surface runoff can be used for irrigation or recharging groundwater. In urban area rainwater flows away as surface runoff. This runoff could be trapped and used for recharging aquifers by adopting appropriate methods.

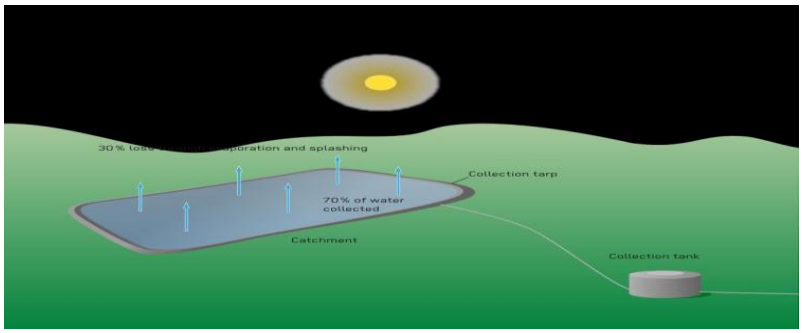

Fig No.2 Surface Rainwater Harvesting

- **Rainwater Harvesting at GHRCEM, Pune**

G H Raisoni College of Engineering And. Management Pune is a widespread educational campus with a vast area of around 10.67 acres. Many Students are studying in the main campus, whose daily requirement has to be served. Due to this fact, there can be a possible water shortage in the future. The nearby water tables are being Exploited daily at a fast pace. With an annual rainfall of around 735 mm in this area of Wagholi Pune. Which provides good opportunities to harvest the rainwater.

The main campus consists of nine buildings namely

- Management Building
- Canteen
- Computer lab
- Survey lab
- Science Block
- Stationery store

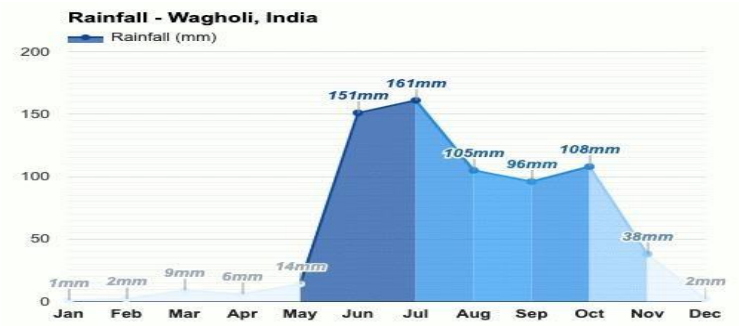

Fig No.3 Rainfall Data of Wagholi.

The orientation of each building is such that it maximizes the chances of collection of water. The open area of main playground will serve as the location for the storage Recharge Well for water collected in buildings mentioned above.

Statement Showing Month Wise Average Rainfall (mm) for the last Years in the Wagholi, Pune.

2.HVAC System

HVAC stands for Heating Ventilation and Air Conditioning.

The term HVAC is used to describe a complete home comfort system that can be used to heat and cool your home, as well as provide improved indoor air quality.

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HVAC can be easily confused with the term AC, but AC simply refers to air conditioning on its own, while HVAC refers to the broader system, which may or may not include an air conditioning unit.

- **Components OF HVAC System**

1. **Air Conditioner**
   An air conditioner cools your home by removing heat and humidity from inside and transferring it outside.
2. **Heat Pump**
   Contrary to their name, a heat pump can both heat and cool your home. They use refrigerant to absorb, transport, and release heat, and they can reverse the flow of that refrigerant depending on if you need heating or cooling. Heat pumps are powered by electricity, not fossil fuels.
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4. **Thermostat**
   The thermostat, located inside your home, allows you to control your indoor temperature. When you change the temperature on your thermostat, it signals to the rest of your HVAC system your home needs to be warmer or cooler

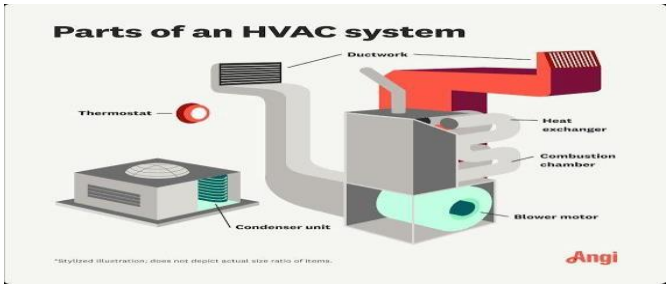

Fig No.4 Parts of HVAC System

1. **Air Heating**
   To heat the air, the HVAC's heating unit must be activated. The HVAC setup uses electronic heating elements to perform the heating operation. Electronic heaters, induction coils, thermostats and so on can be used as heating elements. During suction airflow, the heating element creates a heated zone in the path and as the air flows through it, it warms up. As per result the room is injected with warm air.
2. **2.Air Cooling**
   To cool the air, the cooling unit is activated. An air conditioning unit uses coils as part of a heat exchange to cool the air. Cross flow coils or shell and tube heat exchanges are two types of heat exchanges. Only cooled air is injected into the room through exchange unit, which uses a refrigerant to remove heat from the suction air. The refrigerant is liquefied by a compressor integrated into the cooling units.
   HVAC systems can be classified into four main types.
   Different types of HVAC systems
   Split
   Hybrid
   Duct free
   Packaged forms.

This is the proposed HVAC System Used in **G H Raisoni College of Engineering and Management, Pune.**

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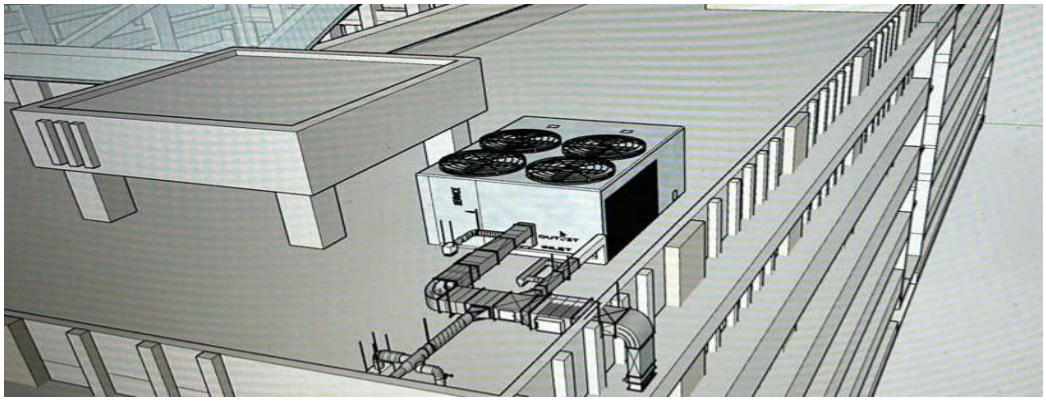

Fig No.5 HVAC System in GHRCEM Pune

- Determine the Number of HVAC System Installed
- Installed HVAC System with generator above the slab
- No. of HVAC Systems - 4
- Total cost – 722500 Rs.

3. GREY WATER SYSTEM.

Greywater systems recycle water by collecting water that has been used for one purpose, and then using it for another. Depending on local regulations, Greywater may be collected from sinks, bathtubs, showers, laundry machines and used for flushing toilets and irrigation.

- **Greywater Process**
  1. The process of using Greywater involves collecting water from sources like showers, sinks and washing machines.
  2. This water is then diverted from the sewer line to be treated and reused. Common steps include filtration to remove impurities and contaminants, and then directing the treated water to non-potable applications like irrigation or toilet flushing.
  3. Greywater systems can vary in complexity, with some using simple filtration methods while others employ more advanced treatment technologies to ensure safety and environmental responsibility.
- **Basic Greywater Guidelines**

Greywater is different from fresh water and requires different guidelines for it to be reused.

- Don’t store Greywater (more than 24 hours). If you store Greywater the nutrients in it will start to break down, creating bad odour.
- Minimize contact with Greywater. Greywater could potentially contain a pathogen if an infected person’s faces got into the water, so your system should be designed for the water to soak into the ground and not be available for people or animals to drink.
  be available for people or animals to drink.
- Keep your system as simple as possible, avoid pumps, and avoid filters that need upkeep. Simple systems last longer, require less maintenance, require less energy and cost less money.
- Install a 3-way valve for easy switching between the Greywater system and the sewer/septic.

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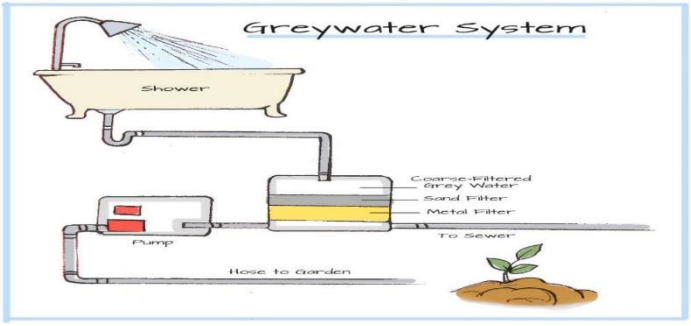

Fig No.6 Greywater System

This is the proposed **Grey Water Tank** used in **G H Raisoni College of Engineering and Management Pune**

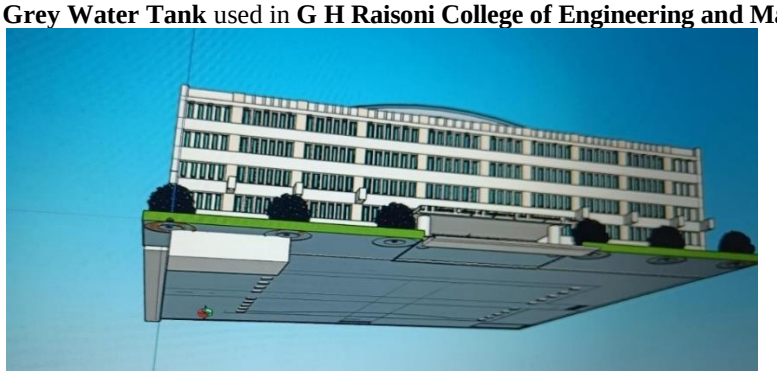

Fig No.7 College Campus Design of Grey Water System

- Determine the Greywater Construction left side of the building
- Excavation till 3.35m by the help of the JCB (26.51x 11.58x3.35) cub. m
- Construction of greywater tank in RCC Roof
- Total cost for greywater Construction – 487944 Rs.

4. CONCLUSION

4.1. The Phase Change Materials (PCM) in building construction and systems offers substantial benefits in enhancing building efficiency and sustainability. By examining various types of PCM and their thermal performance, it is evident that these materials can significantly improve indoor temperature regulation and reduce energy consumption. The application of PCM in HVAC systems further optimizes energy management, contributing to overall building efficiency.

4.2. The exploration of combined sustainable technologies, such as rainwater harvesting, greywater recycling, and solar energy, demonstrates a holistic approach to sustainable building practices. These technologies not only promote renewable energy use but also encourage innovative construction techniques that enhance environmental performance and resource conservation.

4.3. The findings highlight the potential of PCM and other sustainable technologies to advance modern architecture and engineering, paving the way for energy-efficient and environmentally friendly building designs. The integration of these technologies fosters a comprehensive strategy for achieving sustainable development goals in the construction industry.

4.4. Stabilize indoor temperatures, reducing the reliance on traditional heating and cooling systems. Incorporating PCM into walls, ceilings, floors, windows, HVAC systems, and roofing solutions not only improves thermal comfort for occupants but also lowers peak energy demands, contributing to a more efficient and resilient energy infrastructure.

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