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Green Retrofitting of Institutional Building

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Abstract: This paper explores green retrofitting strategies for existing buildings, focusing on energy efficiency, water efficiency and indoor air quality. Through case studies, including commercial, residential buildings, it provides a comprehensive analysis of these strategies. Objectives include demonstrating energy efficiency structure, less consumption of water to improve indoor air quality, benefits, and challenges to enhance sustainability, and overall performance. The methodology involves rigorous case selection, energy modeling, water recycling analysis, indoor air quality assessments, economic analysis, and virtual/physical modeling. Expected outcomes comprise water efficiency assessments, energy efficiency improvements, indoor environmental quality enhancements, and contributions to Sustainable Development Goals. This research contributes valuable insights to sustainable building practices, fostering a more environmentally friendly built environment and addressing resource consumption and environmental impact challenges in the construction sector.

Key words: *energy efficiency, water conservation, indoor air quality, economic analysis,*

I. Introduction

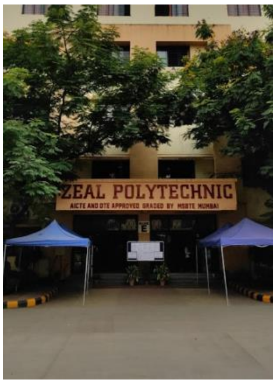
Green retrofitting is a crucial strategy for reducing the resources consumption of institutional buildings. This research explores innovative approaches to enhance the energy efficiency, water efficiency and indoor air quality of such structures. By retrofitting with sustainable technologies, resources consumption can be minimized. Institutional buildings, serving diverse societal functions, face challenges in achieving sustainability goals. Case studies will demonstrate the effectiveness of green retrofitting in improving building performance. The paper aims to inspire stakeholders to adopt sustainable retrofitting practices. Green retrofitting offers economic, environmental, and social benefits for institutional sectors. It fosters resilience against climate change and promotes responsible resource stewardship. Interdisciplinary collaboration and innovative design solutions are key to successful retrofitting projects. Ultimately, green retrofitting can create healthier, resilient, and environmentally conscious institutional environments. The presence study aims to demonstrate an existing building into green building by considering some points like energy efficiency, water efficiency and indoor air quality. These points are considered according to the reference of LEED (Leadership in Energy and Environmental Design), which is the world's most widely used green building rating system. LEED certification provides a framework for healthy, highly efficient, and cost-saving green retrofit buildings, offering environmental, social, and governance benefits.

II. What is green retrofitting

Green retrofitting refers to the process of updating or renovating existing buildings or infrastructure to make them more environmentally friendly, energy-efficient, and sustainable. This typically involves implementing improvements such as installing energy-efficient lighting and appliances, improving insulation, upgrading HVAC systems, using sustainable materials, incorporating renewable energy sources like solar panels, and enhancing water conservation measures. Green retrofitting aims to reduce the environmental impact of buildings, lower energy consumption, decrease operating costs, and create healthier indoor environments for occupants. It is a key strategy for improving the sustainability of existing built environments and mitigating climate change.

III. AREA OF STUDY

IV. Existing institutional building (Zeal Polytechnic, Narhe, Pune).
https://www.google.com/maps/place/Zeal+Polytechnic/@18.448789,73.8229341,17z/data=!3m1!4b1!4m6!3m5!1s0x3bc2953b72319c43:0x549fbdcf78511937!8m2!3d18.448789!4d73.825509!16s%2Fg%2F1tfp0xp0?entry=ttu



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IV. METHODOLOGY

The basic aim and objective of the project is to minimize the energy consumption and make the existing structure more energy efficient and also increase the water efficiency as well as indoor air quality.

1. Case study

The first step includes the case study of any green retrofitting structure

a. Define objective: Clearly outline the process of your case study. Determine what specific aspects of green retrofitting you want to investigate, such as energy efficiency improvements, sustainable material usage, indoor air quality enhancement, etc.
b. Select the building: Choos any building that has undergone green retrofitting. Ideally select a building that closely aligns with your defined objectives.
c. Gather background information: Collect the relevant data about the building this may include original construction data, architectural features, energy consumption patterns, previous retrofitting effort and any available document about the green retrofitting project.
d. Identify green retrofitting measures: Determine the specific green retrofitting measures implemented in building. This may include upgradation of lighting, water fixtures, renewable energy installation and other sustainable features. And select those features which will be useful in project.

2. Green retrofitting measures

After successful completion of case study and selection of specific green retrofitting measure work on the measures. Some of the measures are as following which have been included in our project.

- **Energy efficiency**

It is the most important measure which is included in green retrofitting. It also has more weightage among all green retrofitting measures in certification of green building. The steps which include in energy efficiency measure are as following

a) Gather Information: Collect historical energy bills and any available documentation about the building's construction, equipment, and systems.
b) Site Inspection: Visit the structure and conduct a thorough walkthrou0gh to observe the building ventilation, and air conditioning (HVAC) systems, lighting, appliances, and any other energy-consuming equipment. And also prepare the list of energy consumption equipment in tabular format as given in image 2.

Sr.No	Room No.	No. of lights	No. of fans
1	E4-01	6	5
2	E4-02	4	4
3	E4-03	3	3
4	E4-04	4	4
5	E4-05	5	4
6	E4-06	4	2

Total Lights	26
Total Fans	22

Image – 2

c) Lighting Assessment: Examine the type of lighting fixtures, bulbs, and controls used throughout the structure. Determine if there are opportunities to upgrade to more energy-efficient lighting technologies such as LED bulbs and motion sensors

d) Data Collection: Use energy monitoring tools such as energy meters or data loggers to measure energy consumption patterns over time. This data will help identify peak usage times and potential areas for improvement.

e) Total energy consumption and charges: From light assessment data prepare the report on total energy consumption with total charges per unit.

For example: Energy consumption by LED light/hr (25watt).
Calculating unit/hr. = (watt/hr.)/1000
= 25/1000
0.025 units/hr.

Charges of energy consumption depends upon the use of energy. Also calculate for other energy consumption equipment's as per given image 3

EQUIPMENT	LOCATION	NO.	WATT/Hr	UNIT/Hr	UNIT/D	UNIT/M	CHARGES
FAN	E4 02	4	300W	0.3	2.7	67.5	₹ 675.00
	E4 03	4	300W	0.3	2.7	67.5	₹ 675.00
	E4 04	4	300W	0.3	2.7	67.5	₹ 675.00
	E4 05	4	300W	0.3	2.7	67.5	₹ 675.00
	E4 06	3	225W	0.225	2.025	50.625	₹ 506.25
	E4 07	3	225W	0.225	2.025	50.625	₹ 506.25

Total Unit/Month	1417.5
Cost/Department	₹ 14,175.00
No. of Department	4
Total Cost	₹ 56,700.00

Image – 3

f) Analysis and Recommendations: Analyse the collected data and observations to identify opportunities for energy savings. Prioritize recommendations based on cost-effectiveness and potential energy savings. Some of the recommended material which can be useful for saving energy are following.

i. Super white acrylic paint:

Super white acrylic paint is a high-quality paint designed specifically for use on interior walls. It offers reflectiveness benefits compared to regular acrylic paint. It reflects about 95% of light which is effective in saving energy. Prepare the spread sheet of total material require for project also include charges with tabular format as per given in image 4.

Sr.No	Description	No	L	B	H	Area
1	E4-01					
	W1	2	12.62	_	3.5	88sqm
	W2	2	25.32	_	3.5	177sqm
2	E4-02					
	W1	2	8.1	_	3.5	57sqm
	W2	2	10.88	_	3.5	76sqm

Total Area	2130sqm
Deduction	188sqm
Actual Area	1941sqm
SAC Paint cost/m^2	₹ 7.00
Total Cost	₹ 13,589.10

Image 4

Prepare the analysis report on total energy consumption and energy efficiency material show the cost saving analysis in report. As per given in image 5

Total unit/Month:	Energy Cost/Month:	Energy Cost/Year:
1417.5 Unit	₹ 56,700.00	₹ 6,80,400.00

Cost of Energy/M:	₹ 56,700
Cost of SAC Paint:	₹ 54,356
Project Require/Monthly Cost of Energy:	95.86%
Energy Used/M:	₹ 56,700
Energy Saved/M:	₹ 9,450

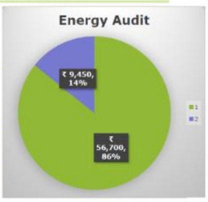

Image - 5

ii. Solar reflective tiles:

Solar reflective tiles are a cutting-edge innovation designed to mitigate the effects of heat absorption in buildings and infrastructure. These tiles utilize advanced materials and coatings to reflect a significant portion of the sunlight that hits them, thereby reducing the amount of heat transferred into the structure. By employing highly reflective surfaces, solar reflective tiles help decrease the demand for air conditioning and lower energy consumption, contributing to both cost savings and environmental sustainability. Additionally, these tiles are engineered to withstand various weather conditions, ensuring long-term durability and performance. Their installation can effectively reduce the urban heat island effect in densely populated areas, leading to a cooler and more comfortable environment. Moreover, solar reflective tiles come in a variety of designs and colors, allowing for aesthetic customization while maintaining their heat-reflective properties. They offer a versatile solution for both new construction projects and retrofitting existing buildings, promoting energy efficiency across diverse architectural settings. As the demand for sustainable building materials continues to rise, solar reflective tiles stand out as a promising solution to combat heat gain and enhance overall building performance. Through their innovative design and practical benefits, these tiles represent a significant advancement in sustainable construction practices.

Image – 6 (solar reflective tiles)

iii. Sola tube:

A Sola tube, also known as a tubular daylighting device (TDD), is a type of skylight that efficiently captures and channels natural sunlight into interior spaces. Consisting of a highly reflective tube, a dome or collector on the roof, and a diffuser in the ceiling, Sola tubes are designed to maximize the amount of daylight entering a room while minimizing heat gain and UV exposure. These devices are particularly popular in spaces where traditional windows or skylights are impractical or insufficient. Sola tubes come in various sizes and configurations to suit different room sizes and lighting needs. They are commonly used in residential homes, commercial buildings, and industrial facilities to enhance natural lighting, reduce reliance on artificial lighting during the day, and create a brighter, more inviting indoor environment. Installation of Sola tubes typically requires minimal structural modifications and can be completed relatively quickly compared to traditional skylights. With advancements in technology, some Sola tubes now feature integrated electric lighting systems for use during nighttime or in low-light conditions, offering a versatile lighting solution for any time of day. Overall, Sola tubes offer an energy-efficient and sustainable way to bring natural daylight into interior spaces, promoting occupant well-being, productivity, and energy savings.

Image – 6 (sola tube sky vault)

- **Water Efficiency**

Water efficiency is a crucial aspect of green retrofitting for institutional buildings, aiming to reduce water consumption and promote sustainability. Implementing water-efficient fixtures such as low-flow toilets, faucets, and showerheads can significantly decrease water usage within these buildings. Additionally, rainwater harvesting systems can be installed to collect and reuse rainwater for non-potable purposes such as irrigation and toilet flushing, further reducing the reliance on municipal water sources.

Advanced technologies like smart irrigation systems and water-efficient landscaping can also contribute to water conservation efforts. These systems use sensors and weather data to optimize irrigation schedules and minimize water wastage. Retrofitting institutional buildings with greywater recycling systems allows for the treatment and reuse of wastewater from sinks, showers, and laundry facilities, thus reducing the demand for fresh water.

Education and awareness campaigns can complement these technological solutions by encouraging building occupants to adopt water-saving behaviors such as turning off taps when not in use and reporting leaks promptly. Monitoring and data analysis tools can track water usage patterns and identify opportunities for further efficiency improvements over time. Overall, integrating water-efficient strategies into the retrofitting process of institutional buildings is essential for promoting environmental sustainability and reducing water consumption in the long run. The following techniques are used in water efficiency process.

a) Water efficient fixtures

Water-efficient fixtures play a pivotal role in the green retrofitting of institutional buildings by significantly reducing water consumption and promoting sustainability. Low-flow toilets are a popular choice, utilizing advanced flushing mechanisms to minimize water usage per flush while maintaining effective waste removal. Similarly, installing low-flow faucets and showerheads can substantially decrease water wastage without compromising on performance. Dual-flush toilets offer users the option to select between a full flush for solid waste and a reduced flush for liquid waste, further optimizing water usage. Sensor-operated faucets and toilets are another innovative solution, ensuring water is only dispensed when needed, thereby preventing unnecessary flow.

Additionally, aerators can be added to faucets to reduce water flow while maintaining adequate pressure, achieving water savings without sacrificing functionality. Retrofitting institutional buildings with water-efficient fixtures not only conserves water but also reduces energy consumption associated with water heating and distribution. These fixtures also contribute to lower utility bills and provide a tangible return on investment over time. Education and training initiatives can complement the installation of water-efficient fixtures by promoting water-saving behaviors among building occupants, fostering a culture of sustainability. Overall, incorporating water-efficient fixtures into the retrofitting process of institutional buildings is essential for achieving meaningful water conservation and advancing environmental stewardship.

Image – 7

b) Rain water harvesting system

Rainwater harvesting is a key strategy in the green retrofitting of institutional buildings, offering a sustainable solution for reducing reliance on municipal water sources. By installing rainwater collection systems, buildings can capture and store rainwater for various non-potable uses such as irrigation, toilet flushing, and landscaping. These systems typically involve the installation of gutters, downspouts, and storage tanks to collect and store rainwater runoff from the building's roof. Implementing rainwater harvesting not only conserves water but also reduces stormwater runoff and alleviates pressure on municipal water infrastructure, contributing to overall environmental sustainability. The which includes in rain water harvesting are following.

c) Assessment:

Evaluate the institutional building's roof area, drainage system, and local climate to determine the feasibility and potential benefits of rainwater harvesting.

i. Design:

Develop a customized rainwater harvesting system based on the building's specific needs, considering factors such as anticipated rainfall, water demand, and available space for storage tanks.

ii. Installation:

Install gutters, downspouts, and filters to collect rainwater from the roof and direct it into storage tanks or cisterns located on-site. Ensure proper sealing and protection against contamination.

iii. Filtration and Treatment:

Incorporate filtration and treatment mechanisms such as mesh screens, sediment filters, and UV sterilization to remove debris, sediment, and pathogens from the collected rainwater, ensuring its quality for non-potable uses.

iv. Storage:

Select and install appropriate storage tanks or cisterns to securely store the harvested rainwater, considering factors such as capacity, durability, and space constraints.

v. Distribution:

Implement a distribution system to transport harvested rainwater to designated usage points within the building, including irrigation systems, toilet flushing mechanisms, and landscaping features.

vi. Maintenance:

Establish a regular maintenance schedule to inspect and clean components of the rainwater harvesting system, such as gutters, filters, and storage tanks, to ensure optimal performance and prevent contamination.

- Indoor air quality

Improving indoor air quality is a fundamental aspect of green retrofitting for institutional buildings, prioritizing the health and well-being of occupants. This involves implementing measures to minimize indoor air pollutants such as volatile organic compounds (VOCs), particulate matter, and allergens. Green retrofitting strategies include upgrading ventilation systems with high-efficiency filters and energy-recovery ventilators to ensure adequate air exchange while filtering out contaminants. Additionally, integrating natural ventilation features such as operable windows and louvers can enhance airflow and reduce reliance on mechanical ventilation, promoting a healthier indoor environment. Selecting low-emission building materials and furnishings, such as paints, carpets, and furniture, further mitigates indoor air pollution by minimizing the release of harmful chemicals into the air. Incorporating indoor plants can also help purify indoor air by absorbing pollutants and releasing oxygen, contributing to improved air quality and occupant comfort. Regular maintenance and cleaning of HVAC systems, ductwork, and air filters are essential to ensure optimal performance and prevent the accumulation of dust and allergens. Monitoring indoor air quality through sensors and periodic testing allows for timely detection of any issues and adjustments to ventilation settings as needed. Education and awareness initiatives can empower building occupants to adopt practices that promote indoor air quality, such as avoiding smoking indoors, reducing clutter, and using environmentally friendly cleaning products. Overall, prioritizing indoor air quality in the green retrofitting of institutional buildings is vital for creating healthier, more comfortable indoor environments conducive to productivity and well-being. The indoor air quality includes some aspects to carry out the process. One of them are in the following.

a) Vertical gardening

Vertical gardening offers a innovative solution for green retrofitting institutional buildings by maximizing green space and enhancing aesthetic appeal. This technique involves growing plants vertically on walls, facades, or other vertical surfaces, utilizing specialized structures such as trellises, modular panels, and living walls. By integrating vertical gardens into building exteriors or interior spaces, institutional buildings can mitigate urban heat island effects, reduce energy consumption, and improve air quality through increased plant coverage and transpiration. Vertical gardens also serve as natural insulation, regulating indoor temperatures and reducing the need for mechanical heating and cooling systems. Additionally, they provide habitat for urban wildlife and contribute to biodiversity conservation in densely populated areas. Low-maintenance plant species and automated irrigation systems can be incorporated into vertical gardens to minimize water consumption and ensure optimal plant health. Furthermore, vertical gardens offer opportunities for educational and recreational activities, fostering a connection to nature and promoting environmental stewardship among building occupants. Incorporating vertical gardening into green retrofitting projects requires careful planning and collaboration between architects, landscape designers, and building owners to achieve successful integration and long-term sustainability. Overall, vertical gardening represents a versatile and effective strategy for enhancing the environmental and aesthetic performance of institutional buildings while promoting urban greening initiatives.

b) Steps includes in vertical gardening

Implementing vertical gardening as part of the green retrofitting process for institutional buildings involves several key steps to ensure successful integration and long-term sustainability:

i. Assessment:

Evaluate the building's structural integrity, sunlight exposure, and available space to determine the feasibility and potential locations for vertical gardens.

ii. Design:

Develop a customized vertical gardening plan based on the building's specific requirements, considering factors such as plant selection, irrigation needs, and aesthetic preferences. Collaborate with architects, landscape designers, and building owners to integrate vertical gardens seamlessly into the building's design.

iii. Structural Preparation:

Prepare the selected vertical surfaces by installing support structures such as trellises, modular panels, or living wall systems. Ensure that these structures are securely attached to the building and capable of supporting the weight of the plants and growing medium.

iv. Plant Selection:

Choose suitable plant species based on factors such as sunlight exposure, climate conditions, and available space. opt for low-maintenance, drought-tolerant plants that thrive in vertical environments and complement the building's aesthetic and functional goals.

v. Growing Medium:

Select a lightweight, well-draining growing medium appropriate for vertical gardening, such as soilless mixes or hydroponic substrates. Ensure proper drainage and aeration to support healthy plant growth and prevent waterlogging.

vi. Irrigation System:

Install an efficient irrigation system tailored to the needs of vertical gardens, such as drip irrigation or misting systems. Incorporate timers or sensors to automate watering schedules and optimize water usage while minimizing runoff and waste.

vii. Plant Installation:

Plant the selected species into the vertical garden structure, taking care to space them appropriately and provide adequate support as needed. Ensure proper root anchorage and irrigation access for each plant to promote establishment and growth.

viii. Maintenance:

Establish a regular maintenance routine to ensure the health and vitality of the vertical garden, including watering, fertilizing, pruning, and pest control. Monitor plant health and growth regularly and address any issues promptly to prevent problems from escalating.

I. Concept virtual model

Virtual models play a crucial role in the planning, design, and implementation phases of vertical gardening projects within institutional buildings. These digital simulations provide architects, researchers, and stakeholders with valuable insights into the performance, feasibility, and environmental impact of proposed green retrofitting initiatives. By leveraging advanced modeling software and techniques, virtual models allow for the visualization of vertical garden designs in a simulated environment, enabling stakeholders to assess various factors, such as sunlight exposure, moisture levels, plant selection, and structural compatibility.

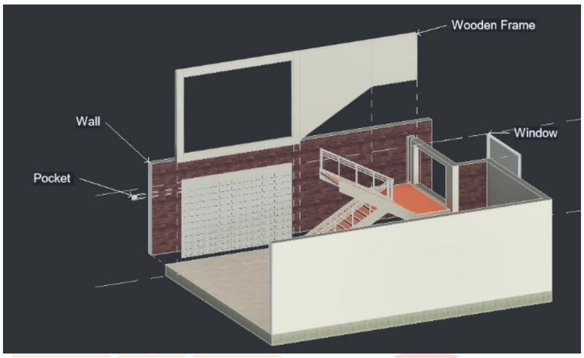

Image – 8

Image – 9

Image – 10

V. CERTIFICATION OF GREEN RETROFITTING

Green retrofitting certification is a process whereby buildings undergo upgrades to improve energy efficiency and sustainability. These upgrades can include installing energy-efficient appliances, improving insulation, and utilizing renewable energy sources. Certification ensures that these retrofits meet specific standards for environmental performance and sustainability. Various organizations offer certification programs, such as LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method). To achieve certification, buildings must undergo an assessment process conducted by accredited professionals. This assessment evaluates factors such as energy usage, water efficiency, indoor air quality, and materials used in the retrofit. Certification provides credibility and recognition for buildings that prioritize sustainability and environmental responsibility. It also demonstrates a commitment to reducing carbon emissions and mitigating the environmental impact of buildings. Additionally, certified green retrofits may qualify for financial incentives, tax credits, or other benefits offered by governments or utility companies. Overall, certification of green retrofitting plays a crucial role in promoting sustainable practices in the construction and real estate industries. One of the organizations which certified the green retrofitting is in the following.

- LEED Certification

The LEED (Leadership in Energy and Environmental Design) certification process begins with project registration with the U.S. Green Building Council (USGBC). Project teams then develop a plan to meet criteria in categories like sustainable site development and energy performance. Points are earned by meeting specific requirements within each category, such as using renewable energy sources or implementing water-saving technologies. After construction, documentation is submitted to the USGBC for review. The review process verifies compliance with LEED requirements. Projects are awarded certification at one of four levels: Certified, Silver, Gold, or Platinum. Certification signifies a commitment to sustainability and environmental responsibility. Buildings must maintain their practices over time to retain certification. Ongoing monitoring and reporting may be required to ensure continued compliance. LEED certification incentivizes and rewards environmentally conscious building practices, contributing to a more sustainable built environment.

- Conclusion:

The green retrofitting of institutional buildings presents a multifaceted approach to enhancing sustainability, energy efficiency, water conservation, and indoor air quality. Through rigorous analysis, innovative strategies, and interdisciplinary collaboration, the project aims to transform the existing Zeal Polytechnic building into a model of environmental responsibility and resource efficiency.

The research underscores the importance of green retrofitting in reducing resource consumption, mitigating climate change impacts, and fostering resilient built environments. By implementing measures such as energy-efficient lighting, water-efficient fixtures, rainwater harvesting systems, and indoor air quality enhancements, significant improvements can be achieved in the building's environmental performance.

The project methodology emphasizes thorough case studies, comprehensive assessments, and practical implementation strategies. By examining real-world examples and leveraging advanced technologies, the project demonstrates the feasibility and effectiveness of green retrofitting initiatives in institutional buildings.

Moreover, the incorporation of LEED certification highlights the commitment to rigorous standards, environmental stewardship, and continuous improvement. LEED certification serves as a benchmark for sustainability and provides credibility and recognition for green retrofitting efforts.

In conclusion, the green retrofitting of institutional buildings offers a pathway to creating healthier, more efficient, and environmentally responsible built environments. By embracing sustainable practices, leveraging innovative technologies, and fostering stakeholder engagement, the project strives to inspire broader adoption of green retrofitting strategies and contribute to a more sustainable future for institutional buildings and beyond.

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