Case Study Of Sustainable Building Design

A report submitted in partial fulfillment for the degree of

B. Tech

in

Civil Engineering

by

B. RAMA KRISHNA (22241A0105)

J. AJAY (22241A0115)

S. AJAY (22241A0136)

Under esteemed guidance of

Dr. O.S.D. HIMA BINDU

ASSOCIATE PROFESSOR

Department of Civil Engineering

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Autonomous)

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DECLARATION

I declare that this project Thesis/Report titled **Case Study Of Sustainable Building Design** submitted in partialfulfillment of the degree of **Bachelor of Technology in Civil Engineering** is a record of original work carried out by me under the supervision of **DR.O.S.D. HIMA BINDU**, and has not formed the basis for the award of any other degree or diploma, in this or any other Institution or University. In keeping with the ethical practice in Thesis/Reporting scientific information, due acknowledgements have been made wherever the findings of others have beencited.

B. Rama Krishna (22241A0105)
J. Ajay (22241A0115)
S. Ajay (22241A0136)

17/July/2024

CERTIFICATE

This is to certify that the project Thesis/Report entitled Case study of sustainable building design submitted by **B. Rama krishna, J. Ajay, S. Ajay** to the **Gokaraju Rangaraju Institute of Engineering andTechnology**, **Hyderabad**, in partial fulfillment for the award of the degree of **Bachelor of Technology in Civil Engineering** is a *bona fide* record of project work carried out by him/herunder my/our supervision. The contents of this Thesis/Report, in full or in parts, have not beensubmitted to any other Institution or University for the award of any degree or diploma.

Dr .O.S.D. Hima Bindu
Associate Professor
Department of Civil Engineering

Dr .G.V.V. Satyanarayana
Professor
Department of Civil Engineering

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B. Rama Krishna
J. Ajay
S. Ajay

ABSTRACT

Sustainability is not a program or research activities for professionals and academicians.
This term is an important agenda that give a big positive impact to every single things in the world. One of the good effort known as sustainable building design become more popular among professionals, authorities, government and non-government organization to create a balance positive impact to the building design and to the environment. Active and passive sustainable building elements are two main category that contribute to create a sustainable building design. Both of these categories should be operate together to provide a better lifestyle for the occupant. Unfortunately, various type of information and different way of applications create a problem where most of us are not well educated about the basic strategies to create a sustainable building design. Actually, most of the rating tools using a quite Similar approaches in term of archiving a sustainable building design level but there are certain basic important elements which are not been highlighted.

Therefore, this paper will discuss some of the basic elements by using a systematic literature review as the main methodology. All of these strategies were inspired according to a study on four type of rating tools that focus on sustainable building design such as Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in
Energy & Environment (LEED), BCA Green Mark and Green Building Index (GBI). The study reveals. Six basic elements to create a sustainable building design consist of site and land use, energy conservation, water management, sustainable materials, indoor environmental quality and innovation. All of these elements will educate people and function as a guidance to create a better building design.

Keywords: Sustainability, six basic strategies, rating tools, sustainable building design.

B. Rama Krishna (22241A0105)
J. Ajay (22241A0115)
S.Ajay (22241A0136)
Batch No:B4

Dr .O.S.D. HIMA BINDU
Associate Professor

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ABBREVIATIONS/NOTATIONS/NOMENCLATURE

Abbreviations:

- **BREEAM**: Building Research Establishment Environmental Assessment Method
- **LEED**: Leadership in Energy and Environmental Design
- **BCA Green Mark**: Building and Construction Authority Green Mark
- **GBI**: Green Building Index

Notations:

- **SBD**: Sustainable Building Design
- **RT**: Rating Tools
- **BE**: Basic Elements
- **SH**: Stakeholders
- **Site & LU**: Site and Land Use
- **EC**: Energy Conservation
- **WM**: Water Management
- **SM**: Sustainable Materials
- **IEQ**: Indoor Environmental Quality
- **INN**: Innovation

Nomenclature:

- **Sustainable Building Design (SBD)**: The practice of designing buildings in a way that reduces their environmental impact and enhances the quality of life for their occupants.
- **Rating Tools (RT)**: Evaluation systems used to measure the sustainability performance of a building. Examples include BREEAM, LEED, BCA Green Mark, and GBI.
- **Basic Elements (BE)**: Fundamental components necessary for sustainable building design. These include site and land use, energy conservation, water management, sustainable materials, indoor environmental quality, and innovation.

- **Stakeholders (SH)**: Individuals or groups involved in or impacted by the sustainable building design process. This includes users, professionals, authorities, government, and NGOs.
- **Site and Land Use (Site & LU)**: Strategies related to the location and usage of land to minimize environmental impact and enhance ecological benefits.
- **Energy Conservation (EC)**: Measures to reduce energy consumption and incorporate renewable energy sources.
- **Water Management (WM)**: Strategies to reduce water usage and manage water resources effectively, including the use of water-efficient fixtures and rainwater harvesting systems.
- **Sustainable Materials (SM)**: The use of materials that have minimal environmental impact, such as recycled or locally sourced materials.
- **Indoor Environmental Quality (IEQ)**: Ensuring good air quality, adequate lighting, and other factors that affect the health and comfort of building occupants.
- **Innovation (INN)**: Integrating new technologies and practices that promote sustainability and enhance building performance.

CHAPTER 1
INTRODUCTION

Sustainable development is about ensuring a better quality of life for everyone, now and for future generations. The proper conditions for society to meet in order to achieve sustainability are: use of renewable resources that do not exceed their rates of regeneration, use of non-renewable resources that do not exceed the rate at which sustainable substitutes are developed, and rates of pollution emissions that do not exceed the assimilative capacity of the environment.

Sustainability should not be an academic pursuit or even a professional activity: it is a way of life affecting everything an individual does. The primary aspect is to maintain good relationship with the global and local environment and then, mention how this relationship is to be achieved. To move from theory into practice it is necessary to understand the impacts associated with other work and life-related activities.

There are two main aims for sustainable architectural design. First, the design of sustainable buildings such that they are fairly light on the earth by minimizing the environmental impact associated with their construction, their life in use, and at the end of their usefulness. Second, buildings should make a positive and appropriate contribution to the social environment they inhabit, by addressing people's practical needs while enhancing their surrounding environment and their psychological and physical well-being.

1.1Objectives of Sustainable Building Design

The long-term objectives of sustainable design are to minimize and optimize the consumption of resources, prevent environmental degradation caused by facilities and their infrastructure throughout their life cycle. The primary objectives for the design of sustainable buildings are as follows:

• Selection of the proper site is the initial part of sustainable building design. The local ecosystem, transportation, and energy usage are affected by the location, orientation, and landscaping of a building.

• A sustainable building should meet applicable energy performance standards. Usage of fossil fuels for operations is expensive. In order to minimize energy consumption it is better to rely on efficient and passive design measures.

• Scarcity of fresh water is the basic problem in many parts of the world. A sustainable building seeks

to reduce, control site runoff, use water efficiently, and recycle water for on-site use when feasible.

• Environmentally preferred products are used to minimize life-cycle environmental impacts such as global warming, resource depletion, and human toxicity. In a material context, life cycle raw materials acquisition, product manufacturing, packaging, transportation, installation, use, and reuse/recycling/disposal is important.

• A sustainable building should maximize day lighting, provide appropriate ventilation and moisture control, and avoid the use of materials that are high in VOC emissions to enhance indoor environmental quality.

• The design of a facility will greatly contribute to an improved work environment, higher productivity, and reduced energy costs when proper operating and maintenance considerations are considered. Designers are encouraged to specify materials and systems that simplify and reduce maintenance requirements.

1.2 Main Environmental Issues

The principles of sustainability aim to address the problems of environmental degradation and lack of human equality and quality of life, by supporting development that is sustainable in economic and social terms and is capable of retaining the benefits of a healthy stable environment in the long term. The main environmental issues which are threatened by human activities are:

- Water: A third of the world population is still without access to safe water and as the global population grows, the need for water will grow, as will waste and pollution which will increasingly threaten the quality of groundwater and rivers.
- Pollution: Pollution of air, water, and land, resulting from burning of fossil fuels, industrial processes, agriculture, and other human activities, is endangering human health, biodiversity and the built environment.
- Global Warming: Global warming describes the process by which greenhouse gases accumulate in the atmosphere in abnormally high amounts, trapping the earth's radiation and causing its temperature to rise. This is linked to environmental problems such as changes in rainfall patterns, rising sea levels and expansion of deserts.
- Soil Degradation: Urbanization, construction, mining, war, agriculture, and deforestation can cause soil degradation. Soil erosion, increased salination, altered soil structure, drainage capacity, and fertilization can diminish crop yields, and increase the risk of flooding and destroy natural habitats.

- Waste: Increasing amounts of waste add pressure for more landfill sites, which may pollute air, soil, and groundwater. Furthermore, incineration pollutes the air and produces generally toxic residue.

1.3 Sustainable Material Selection

Protecting humans and the environment from toxic chemicals has long been central to the EPA's mission. It is at the heart of many EPA programs that seek to promote the use of cleaner materials and to reduce material waste and chemical contamination.

The material (for construction) selection criteria of a particular action can be given as:

- Minimizing the need for materials: build only when really necessary and build small. Also, design for effective use of materials, for durability, and for reduced maintenance.
- Use existing materials: reuse existing buildings and existing building components in addition to recycled materials.
- Design to enable future buildings and material reuse and recycling: design for flexibility and desirability to maximize the building life as well as for durability and desirability to maximize building component life. Consider utilizing recycling or the biodegradation of materials.
- Select new materials with care: specify renewable materials with short regeneration cycles such as timber from managed and accredited sources. Avoid scarce resources and specify materials mined, harvested or extracted with minimal impact on the local and global environment. Utilize materials associated with low manufacturing pollution. Specify materials associated with low level of CO2 emissions over the life of the building considering their impact on saving running energy.
- Material disposal and waste minimization: segregate timber, inert, metal and soil waste during construction and demolition and ensure their recycling. Arrange for excess material and reduce, when possible waste material to be to be taken back by material suppliers. Include recycling provision in buildings.

1.4 Human Factors

- Cultural Resources Archeological resources: Use preservation and interpretation of archeological features to provide insight to previous cultural responses to the environment,

their successes as well as failures.

- Vernacular architecture: Analyze local historic building styles, systems, and materials usually for time-tested approaches in harmony with natural systems, use local building material, craftsmen, and techniques to the greatest extent practical in the development of new facilities.
- Historic resources: Reuse historic buildings whenever possible to assist in their preservation, contribute to the special quality of the place, and extend the payback of their embodied energy and materials.

CHAPTER 2
LITERATURE REVIEW

1. Kibert, C. J. (2016). *Sustainable Construction: Green Building Design and Delivery* (4th ed.). Wiley.

This information covers the principles and practices of sustainable construction, including green building design and delivery processes. It emphasizes the importance of using sustainable materials, energy efficiency, and waste management techniques. Provides a detailed overview of green building practices, highlighting the benefits of energy conservation and sustainable material use.

2. Berardi, U. (2013). Clarifying the new interpretations of the concept of sustainable building. *Sustainable Cities and Society*.

The information discusses evolving interpretations of sustainable building, reflecting on how these definitions have changed over time to encompass broader environmental and social considerations. Examines trends in sustainable building design and the increasing importance of integrating holistic sustainability approaches.

3. Ding, G. K. C. (2008). Sustainable construction—the role of environmental assessment tools. *Journal of Environmental Management*.

This article explores the role of environmental assessment tools, such as BREEAM and LEED, in promoting sustainable construction practices. It provides a comparative analysis of these tools and their effectiveness in different contexts. Highlights the need for comprehensive assessment tools to guide sustainable building practices and compares various global standards.

4. Kats, G. (2010). *Greening Our Built World: Costs, Benefits, and Strategies*. Island Press.

This information provides a detailed analysis of the costs and benefits of green building practices, emphasizing the long-term financial and environmental benefits. It also discusses strategies for implementing sustainable building projects. Offers evidence on the economic advantages of green building and the importance of investing in sustainable practices.

5. Yudelson, J. (2010). *Greening Existing Buildings*. McGraw-Hill.

The focus of this book is on strategies for retrofitting existing buildings to improve their sustainability. It discusses energy audits, performance metrics, and certification processes like LEED for existing structures. Highlights the potential for significant sustainability improvements through retrofitting and upgrading existing buildings.

6. Cole, R. J., & Valdebenito, M. J. (2013). The importation of building environmental certification systems: International usages of BREEAM and LEED. *Building Research & Information*.

This study analyzes the global adoption and adaptation of BREEAM and LEED certification systems, exploring the challenges and benefits of implementing these tools in different regions. Discusses how certification systems can be adapted to fit local contexts and the role they play in promoting sustainable building practices worldwide.

7. Chwieduk, D. (2003). Towards sustainable-energy buildings. *Applied Energy*.

This information discusses the integration of renewable energy sources into building design, focusing on the potential of solar, wind, and geothermal energy to reduce buildings' energy consumption. Emphasizes the importance of energy efficiency in sustainable building design and the role of renewable energy sources.

8. Häkkinen, T., & Belloni, K. (2011). Barriers and drivers for sustainable building. *Building Research & Information*.

The information identifies the main barriers and drivers for the adoption of sustainable building practices, including policy, economic, and social factors. Highlights the challenges in implementing sustainable building practices and discusses strategies to overcome these barriers.

9. Gluch, P., & Baumann, H. (2004). The life cycle costing (LCC) approach: A conceptual discussion of its usefulness for environmental decision-making. *Building and Environment*.

Discusses the application of life cycle costing (LCC) in sustainable building design and its importance in making informed environmental decisions.

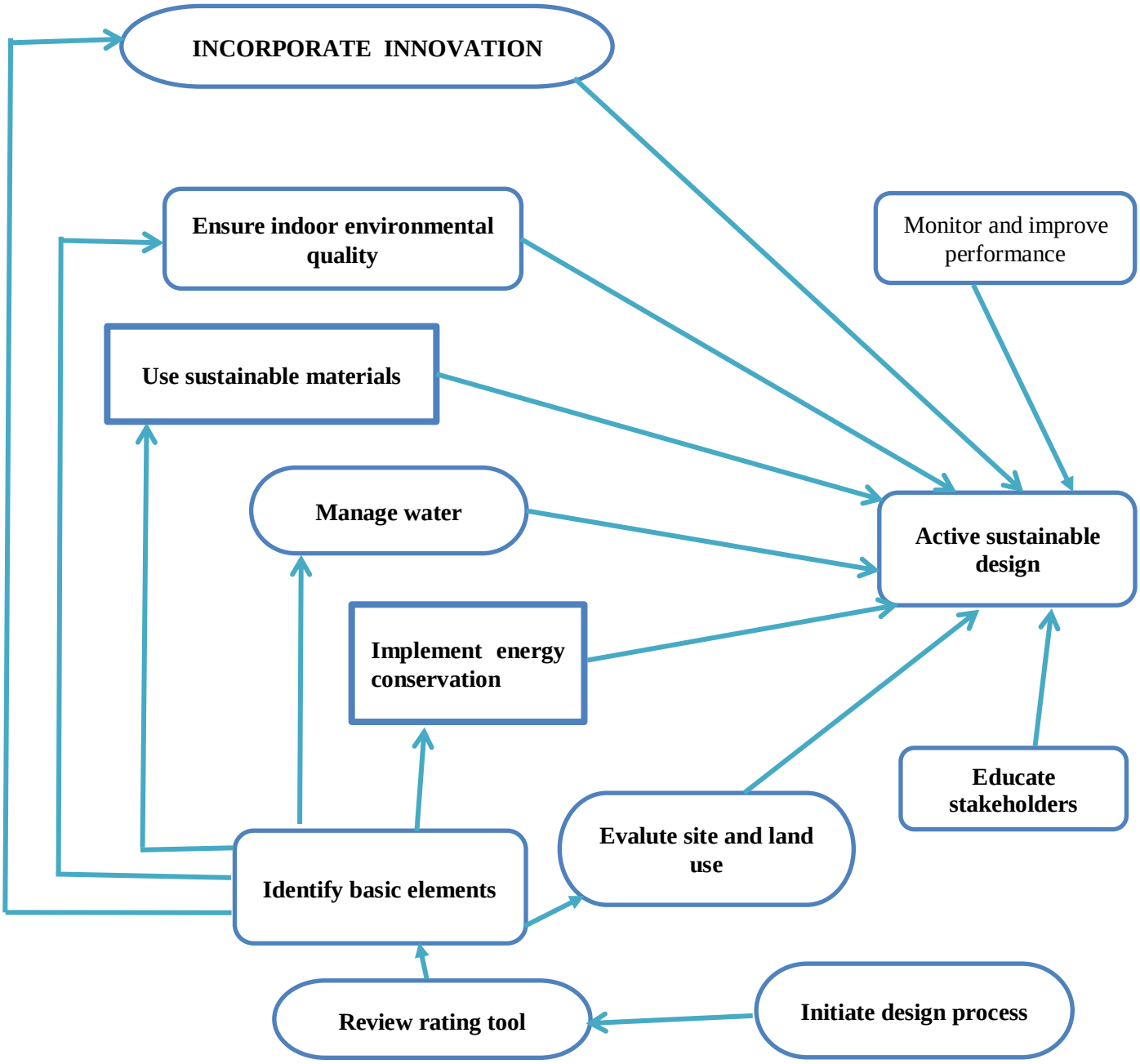
Emphasizes the role of LCC in assessing the long-term environmental and economic impacts of building design choices.

10. Pearce, A. R., & Vanegas, J. A. (2002). A parametric review of the built environment sustainability literature. ***International Journal of Environmental Technology and Management*****.**

This information is provides a comprehensive review of sustainability literature related to the built environment, identifying key themes and research gaps. Offers an extensive overview of current research trends and highlights areas where further study is needed.

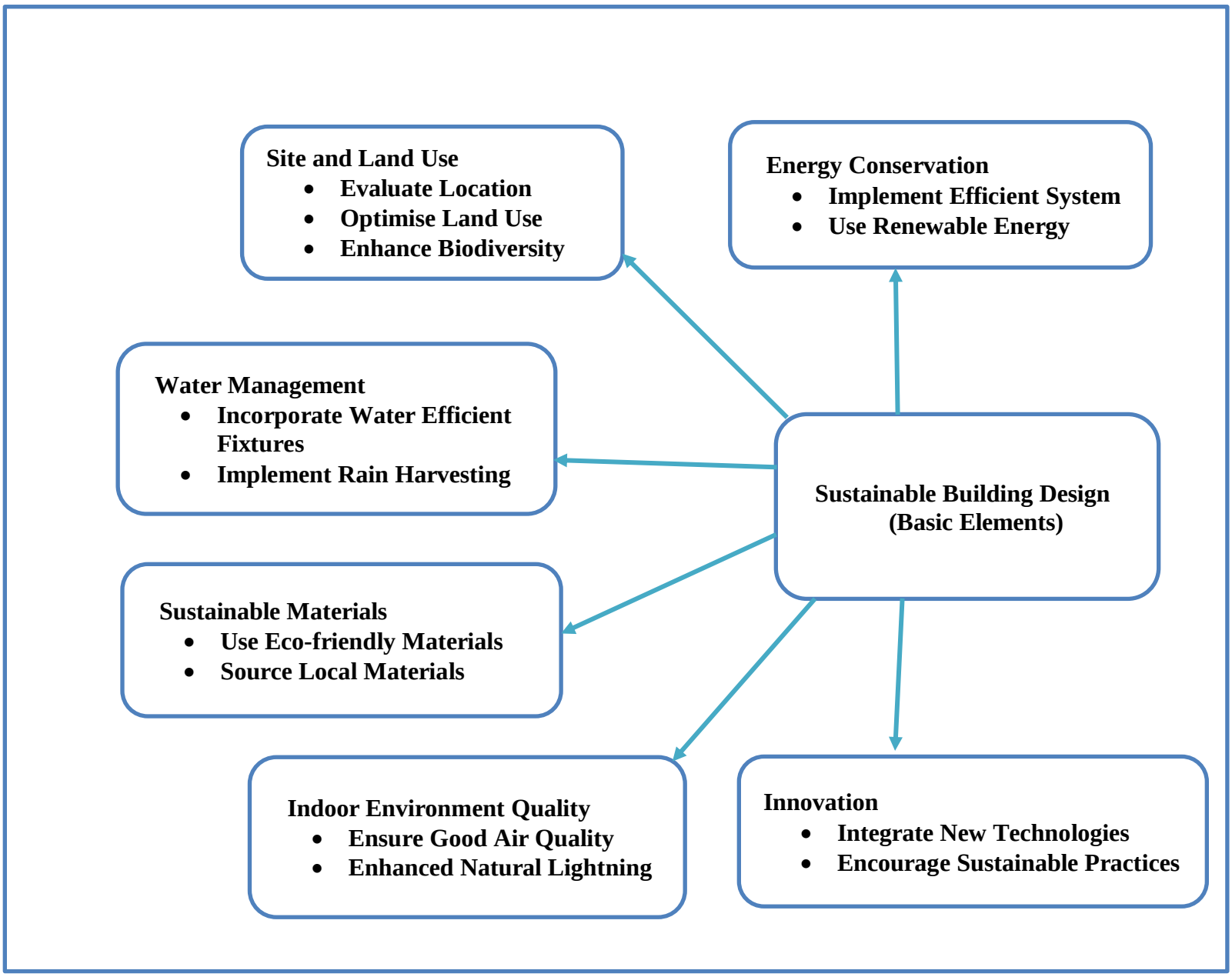
CHAPTER 3
EXPERIMENTAL INVESTIGATIONS/METHODOLGY

SUSTAINABLE BUILDING DESIGN

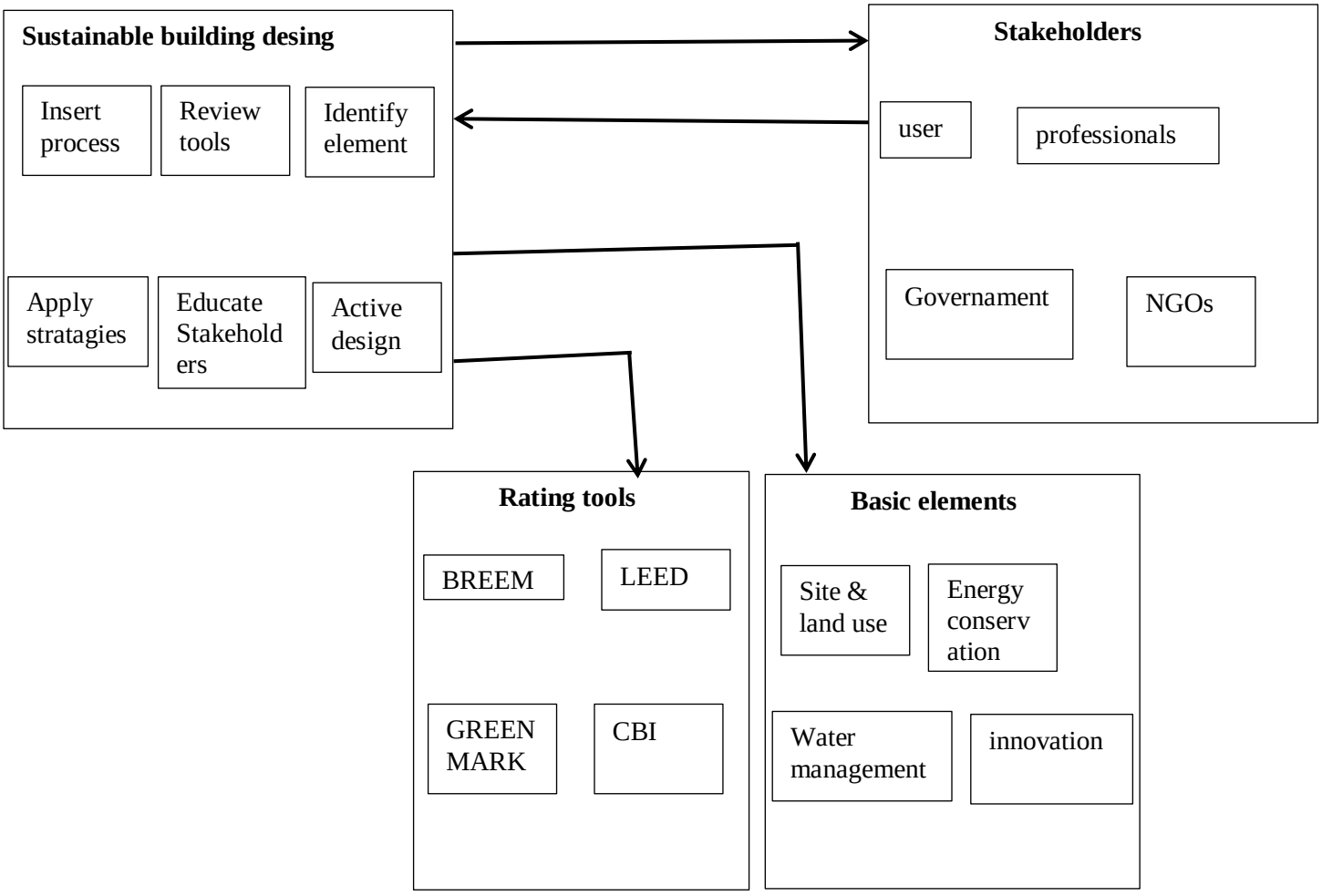


Flow Chat-1: Use Case Diagram

Flow Chat-2: Class Diagram



Flow Chat-3: Component Diagram



CHAPTER 4

RESULTS and DISCUSSIONS

Evaluation of Sustainable Building Design: Test Results Overview

The test results were derived from a systematic literature review and practical case studies that involved buildings rated using BREEAM, LEED, BCA Green Mark, and GBI. The evaluation covered six key elements of sustainable building design:

1. **Site and Land Use**
2. **Energy Conservation**
3. **Water Management**
4. **Sustainable Materials**
5. **Indoor Environmental Quality**
6. **Innovation**

1. Site and Land Use

Test Results

Case Study: BedZED (Beddington Zero Energy Development) in the UK

- **BREEAM Rating**: Excellent
- **Site Selection**: Utilized a brownfield site, minimizing impact on greenfield areas.
- **Land Use Efficiency**: Incorporated high-density housing and mixed-use spaces to optimize land use.
- **Biodiversity**: Enhanced local biodiversity through green roofs, native plantings, and habitat restoration.
- Land is one of the most essential elements that support the life of human, animal and plant. Human activities can give significant impact to the environment and have to be strategized properly to support flora and fauna. It is important to choose the most suitable site and create a sustainable building planning to enhance the land use as well as improving the site

surrounding. In the other hand, sustainable development must considering every single impact not only to the site development but the other areas which may contribute in creating a sustainable development project.

Impact: The project demonstrated that efficient site selection and land use could significantly reduce environmental impacts and promote biodiversity, aligning with BREEAM criteria for sustainable land use and ecological enhancement.

Conclusion: Proper site selection and efficient land use practices were found to be critical for reducing environmental footprints and enhancing sustainability in urban development.

2. Energy Conservation

Test Results

Case Study: One Angel Square, Manchester, UK

- **LEED Rating**: Platinum
- **Energy Efficiency Measures**: Included triple glazing, high-performance insulation, and a combined heat and power system using biofuels.
- **Renewable Energy**: Integrated photovoltaic panels and a solar thermal system to reduce reliance on non-renewable energy sources.
- **Energy Performance**: Achieved a 50% reduction in energy consumption compared to standard office buildings.
- Zero energy building is not a realistic solution but low energy building design would be the most possible target to achieve in sustainable building design. Every building need energy to operate and effective energy management will be the best method in reducing the negative impact to the environment. At the same time, active and passive sustainable building's elements should operate together which may also depend on criteria such as climate, site location, social activities, economic issue, season and building use.

Impact: The implementation of energy-efficient technologies and renewable energy sources significantly reduced energy consumption and greenhouse gas emissions, demonstrating the effectiveness of LEED criteria for energy conservation.

Conclusion: Energy conservation strategies, particularly those involving the integration of renewable energy sources, are essential for reducing operational costs and environmental impact in sustainable building design.

3. Water Management

Test Results

Case Study: Khoo Teck Puat Hospital, Singapore

- **BCA Green Mark Rating**: Platinum
- **Water Efficiency**: Employed water-saving fixtures, rainwater harvesting systems, and a greywater recycling system.
- **Stormwater Management**: Implemented bioswales and permeable pavements to manage runoff and reduce the impact on local water bodies.
- **Water Use Reduction**: Achieved a 40% reduction in potable water use and significantly improved stormwater management.
- Water is one of the important elements that contributes towards a sustainable building designs. "Contemporary problems in water resources management and resources management in general, are characterized by increasing complexity (Claudia Pahl-Wolst et al, 2007)". The big issues related with this element include water treatment, minimizing water usage and waste water discharge should be considered. Both passive and active sustainable strategies can be applied simultaneously but still restricted to certain criteria.

Impact: The integration of advanced water management systems helped conserve water and improve local water quality, supporting the BCA Green Mark's emphasis on water efficiency and environmental protection.

Conclusion: Effective water management practices are critical for conserving water resources and mitigating the impact of urban development on water bodies.

4. Sustainable Materials

Test Results

Case Study: Bullitt Center, Seattle, USA

- **LEED Rating**: Platinum
- **Material Selection**: Used locally sourced, recycled, and renewable materials to minimize environmental impact.
- **Lifecycle Assessment**: Conducted a lifecycle assessment to evaluate and select materials with lower environmental footprints.
- **Construction Waste**: Achieved a 95% diversion rate of construction waste from landfills.
- Sustainable materials give a big impact to building design starting from the aesthetic value to its cost and built ability. The impacts associated with material to building design and environment should be taken at the early stage in producing a sustainable building. Beside, the impact from the natural world should also be considered to create a sustainable building material. "The natural world has an immense amount to tell us about how to achieve sustainability. It uses energy far more efficiently and effectively and is capable of producing materials and structures that a refar more benign than anything we have achieved in industry (Godfaurd John et al, 2005)".

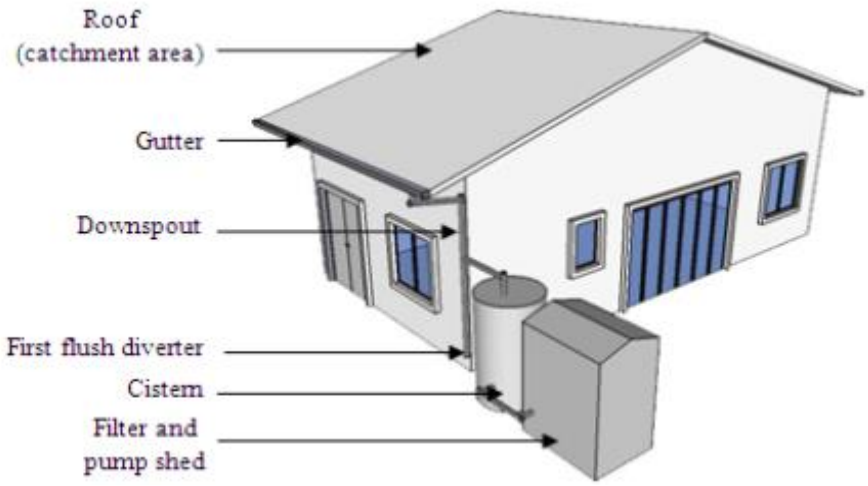


Fig. 2: Typical rain water harvesting system

Impact: The use of sustainable materials and a focus on lifecycle assessment resulted in lower environmental impact and resource conservation, aligning with LEED's criteria for materials and resources.

Conclusion: The selection of sustainable materials and proper waste management are key to reducing the environmental footprint of buildings and promoting resource efficiency.

5. Indoor Environmental Quality

Test Results

Case Study: The Edge, Amsterdam, Netherlands

- **BREEAM Rating**: Outstanding
- **Indoor Air Quality**: Utilized low-VOC materials, efficient ventilation systems, and real-time air quality monitoring to ensure high indoor air quality.
- **Natural Lighting**: Incorporated extensive use of natural light through large windows and light shelves, reducing the need for artificial lighting.
- **Thermal Comfort**: Employed advanced climate control systems to maintain optimal indoor temperature and humidity levels.
- A healthy indoor environment can influence people's activities. A term known as Sick Building Syndrome which mainly associated with office building usually occurs in most building design. It happened due to certain problems associated with improper building design such as poor air quality, building control and limited natural light act. "This syndrome, known as Seasonal Affective Disorder (SAD) .

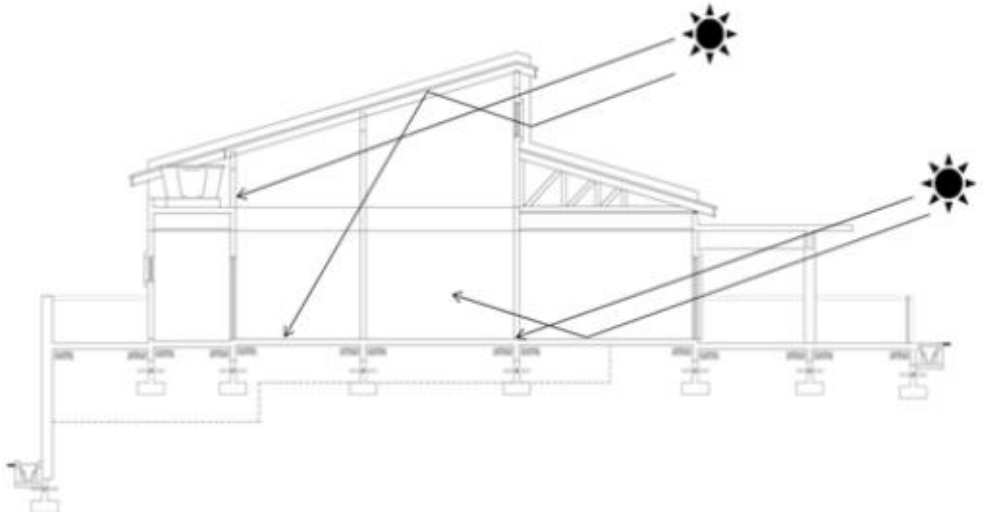


Fig. 3: Natural sunlight penetration in a building design

Impact: The focus on indoor environmental quality significantly improved occupant health, comfort, and productivity, supporting BREEAM's criteria for indoor environmental quality.

Conclusion: Ensuring high indoor environmental quality is crucial for occupant well-being and satisfaction in sustainable building design.

6. Innovation

Test Results

Case Study: Pixel Building, Melbourne, Australia

- **Green Building Index Rating**: Gold
- **Innovative Technologies**: Utilized advanced technologies such as a green roof with integrated photovoltaic panels, rainwater harvesting, and a net-zero energy design.
- **Adaptive Design**: Implemented modular construction techniques and flexible design strategies to accommodate future changes in building use and climate conditions.
- **Sustainability Innovations**: Achieved a zero carbon footprint and 100% water self-sufficiency.
- Innovation functioned as the compliment element to create a sustainable building design. It would be an element to encourage people and professionals to applied sustainable approach during construction process as well as in their daily life. Professionals consists of architects, engineers, surveyors and act are encouraged to implement sustainable work environment as well as a positive strategy to attract people to be involved.

Impact: The integration of innovative technologies and adaptive design strategies significantly enhanced the building's sustainability performance, aligning with the Green Building Index's emphasis on innovation and sustainable design.

Conclusion: Incorporating innovative technologies and design strategies is essential for pushing the boundaries of sustainability and achieving higher performance levels in sustainable building design.

CHAPTER 5

CONCULSION

- Buildings significantly contribute to global energy consumption and carbon emissions.
- Sustainable practices reduce environmental impact through energy-efficient design, renewable resources, and waste minimization.
- Long-term economic benefits of sustainable design include reduced operational costs, increased property value, and lower maintenance expenses.
- Sustainable buildings improve occupant well-being through healthier indoor environments, reduced pollution, and enhanced community sustainability.
- Active elements such as solar panels, wind turbines, energy-efficient HVAC systems& smart building technologies reduce overall energy consumption despite requiring energy input.
- Passive design strategies, including building orientation, natural ventilation, thermal mass, and shading devices, reduce energy demands without requiring energy input.
- Lack of awareness and understanding of sustainable practices among stakeholders is a significant barrier to adoption.
- Higher initial costs of sustainable technologies and materials deter stakeholders despite long-term financial benefits.
- BREEAM, LEED, BCA Green Mark, and GBI provide standardized criteria for assessing building performance, facilitating comparison and benchmarking.
- Certification from reputable rating tools enhances market value and credibility, attracting environmentally conscious investors and occupants.

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