SUSTAINABLE GREEN BUILDINGS CONSTRUCTION IN URBAN ENVIRONMENTS

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A thesis submitted to the Department of Civil Engineering in partial fulfilment for the degree of Bachelor of Science in Civil Engineering



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Section: (23B+D)
Semester-Spring 2025

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DECLARATION

We hereby declare that this thesis is our own work and, to the best of our knowledge, it contains no material previously published or written by another person, nor has it been submitted for the award of any other degree or diploma at Sonargaon University or any other educational institution, except where due acknowledgment is made.

We also declare that the intellectual content of this thesis is the product of our own work, and any contributions made to the research by others, with whom we have collaborated at Sonargaon University or elsewhere, are explicitly acknowledged.

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ABSTRACT

Human beings have an associate connection with our environment by physical, mental, emotional and spiritual means. This connection can create a vibrant life that people can thrive from in every aspect. This thesis intends to provide a design of a retreat center for meditating with healing spaces. In addition to daily spiritual activities, the reason of such retreat center is for clients to temporarily leave behind the usual diversion they all face for a time – long enough to contemplate relaxation and for an inward change to happen. The built environment implies that physical surroundings have a direct relationship with how a person reacts and behaves. The built environment and the spaces it create should not be seen as only a physical surrounding, but as an interconnection between spirituality, architecture, and sense of place. This study aims to integrate green building materials to the retreat center. Data were gathered through an exploration of the research, supported by documentary analysis from site visits and observation guides. The outcome of the architectural feature and character was identified that would reflect a retreat center. The green building materials are carefully filtered out by identifying which are attainable and which can be integrated. The culmination of all these variables leads to a design of a proposed retreat center integrating green building materials.

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CHAPTER 1

INTRODUCTION

1.1 General

Green buildings are structures having positive impacts on our environment. These buildings are eco-friendly and contain non-toxic materials. Materials used in green buildings are obtained from natural, renewable resources that have been managed and harvested in a sustainable way. Sustainable development is to make the world a better place for everyone without destroying the possibilities for the next generation.

Sustainability and Green Buildings Sustainability of any process can be easily assessed by answering a simple question: Can you keep doing this again and again, forever? The typical construction process requires materials that can only be used once, are not degradable once demolished and usually have negative impacts on the environment. Cement, for example, requires huge amounts of energy to produce and produce toxic gases in the process. But the use of wood or fiber panels that are produced in an environment-friendly way and can be reused or repurposed is eco-friendly. If required, buildings built using these materials can be demolished with little to no impact on the ecology.

Sustainable development ensures that what we are doing now is better for us but should also help our future generations and an endless cycle should exist. Smarter use of natural resources will help our future generations.

Green buildings are one of the examples of sustainable development. In the construction of the green building, we maintain a delicate balance between environmental, social and economic issues.

1.2 History Of Green Buildings

In early days the peoples don't know the importance energy and environment. Underestimate the environmental degradation and vast use of energy was a largest problem in those days. By considering these things the concept of green buildings was upraise in mind and the people thinks about the constructing of green buildings which should be energy efficient and waste reduction building. Green building practices aim to reduce the environmental impact of building. The first rule is that the greenest building is the building that doesn't get built. Since construction almost always degrades a building site, not building at all is preferable to green building, in terms of reducing environmental impact. The second rule is that every building should be as small as possible. The third rule is not to contribute to sprawl, even if the most energy-efficient, environmentally sound methods are used in design and construction. Urban infill sites are preferable to suburban "greenfield" sites.

The Rachel Carson book, "Silent Spring", published in 1962, is considered to be one of the first initial efforts to describe sustainable development as related to green building. The green building movement in the U.S. originated from the need and desire for more energy efficient and environmentally friendly construction practices. There are a number of motives for building green, including environmental, economic, and social benefits. However, modern sustainability initiatives call for an integrated and synergistic design to both new construction and in the retrofitting of existing structures. Also known as sustainable design, this approach integrates the building life-cycle with each green practice employed with a design-purpose to create a synergy among the practices used.

Green building brings together a vast array of practices, techniques, and skills to reduce and ultimately eliminate the impacts of buildings on the environment and human health. It often emphasizes taking advantage of renewable resources, e.g., using sunlight through passive solar, active solar, and photovoltaic equipment, and using plants and trees through green roofs, rain gardens, and for reduction of rainwater run-off. Many other measures are

used, such as using low-impact building materials

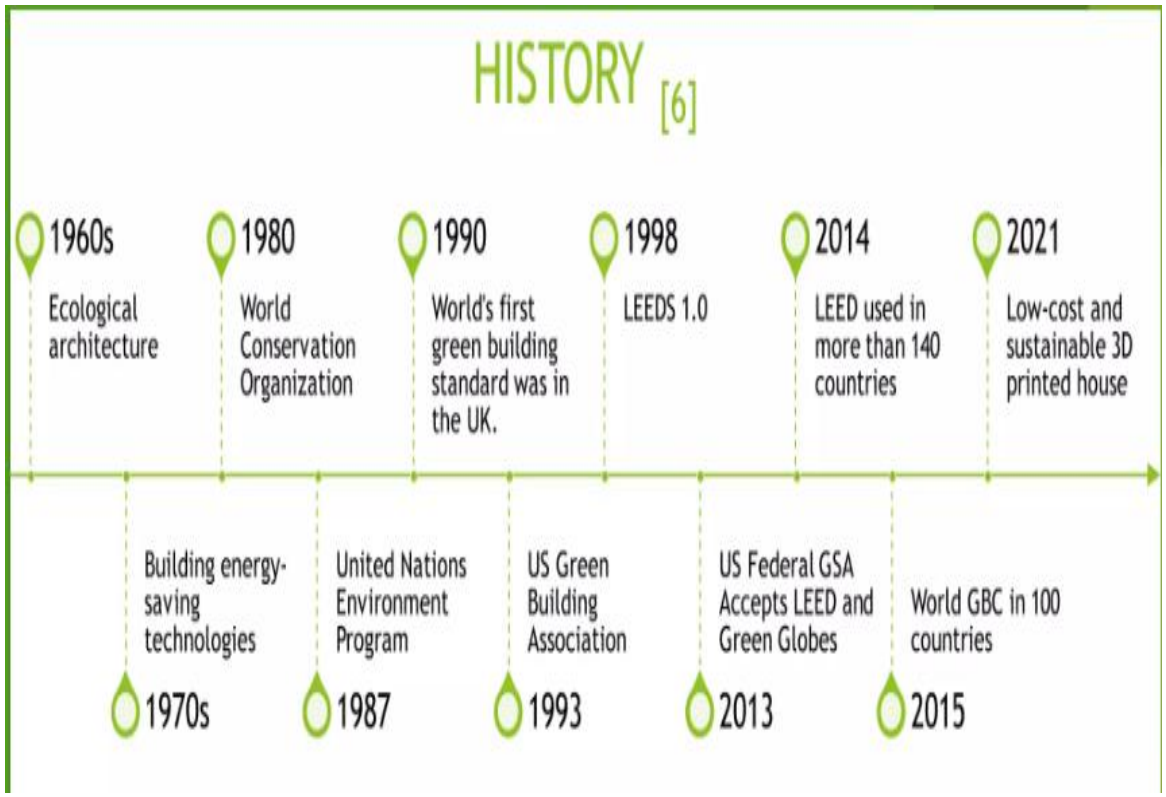


Figure 1.1: Green Building History

Reference: THE GREEN BUILDING | PPT (Visit: 07-09-2024)

1.3 Aims and Scope

The main goal of Green Building is to share new ideas and methods for eco-friendly and sustainable construction. It focuses on reducing the negative impact of buildings on the environment while improving human health and well-being. The journal promotes energy-efficient, affordable, and carbon-neutral designs that align with the United Nations' Sustainable Development Goals (SDGs).

It provides knowledge for architects, engineers, and researchers on creating resilient, climate-friendly buildings in cities, towns, and rural areas. Green Building uses smart

Technologies, energy-efficient materials, and sustainable practices to make buildings more comfortable, cost-effective, and environmentally friendly.

Key ideas include:

- Using renewable energy like solar and wind power.
- Designing with affordable and sustainable materials.
- Creating health-focused spaces with clean air and good thermal comfort.
- Retrofitting older buildings to improve sustainability.
- Developing climate-resilient structures to adapt to environmental changes.

In short, Green Building aims to create better living spaces that are kind to the planet, affordable, and supportive of human well-being.

1.4 Objectives:

Address how green building practices can improve the overall well-being of occupants and set a model for sustainable urban planning in Bangladesh.

1. Understanding the concept of Green Building Design.
2. Designing a residentially viable green building that includes maximum open space while ensuring cost-effective design and materials.
3. Improving indoor air quality by integrating natural ventilation systems through appropriate orientation and layout design.
4. Implementing a rainwater harvesting system with a groundwater recharge mechanism to enhance the regional groundwater table and promote water sustainability.
5. Using eco-friendly and regionally available construction materials to reduce the environmental footprint and support local industries.
6. Installing solar panels for energy generation to lower the power consumption of buildings and promote the use of renewable energy.

1.5. Organization of the report:

The thesis was presented in five (5) chapters as follows:

Chapter one: Gives the introduction which also includes the background of the research, Histrory,outlines the aims and objectives. It also states the benefits, scope, and method of the research briefly.

Chapter two: Gives an overview of literature related to this work.

Chapter three: Methodology. This chapter describes the methodology adopted to carry out the research.

Chapter four: Gives a general overview of the principle of regression analysis. This chapter also shows the research data analysis process, discussion, and findings.

Chapter five: Contains the conclusions drawn from the research, the researcher's contribution to knowledge, and recommendations for further research.

CHAPTER 02

LITERATURE REVIEW

2.1 LEED CERTIFICATION

Leadership in Energy and Environmental Design (LEED) is a green building certification program used worldwide. Developed by the non-profit U.S. Green Building Council (USGBC), it includes a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes, and neighborhoods, which aims to help building owners and operators be environmentally responsible and use resources efficiently.

As of 2024 there were over 195,000 LEED-certified buildings and over 205,000 LEED-accredited professionals in 186 countries worldwide. In the US, the District of Columbia consistently leads in LEED-certified square footage per capita, followed in 2022 by the top-ranking states of Massachusetts, Illinois, New York, California, and Maryland. Outside the United States, the top-ranking countries for 2022 were Mainland China, India, Canada, Brazil, and Sweden. LEED Canada has developed a separate rating system adapted to the Canadian climate and regulations.

Many U.S. federal agencies, state and local governments require or reward LEED certification. As of 2022, based on certified square feet per capita, the leading five states (after the District of Columbia) were Massachusetts, Illinois, New York, California, and Maryland. Incentives can include tax credits, zoning allowances, reduced fees, and expedited permitting. Offices, healthcare-, and education-related buildings are the most frequent LEED-certified buildings in the US (over 60%), followed by warehouses, distribution centers, retail projects and multifamily dwellings (another 20%).Studies have found that for-rent LEED office spaces generally have higher rents and occupancy rates and lower capitalization rates.

2.2 Rating systems

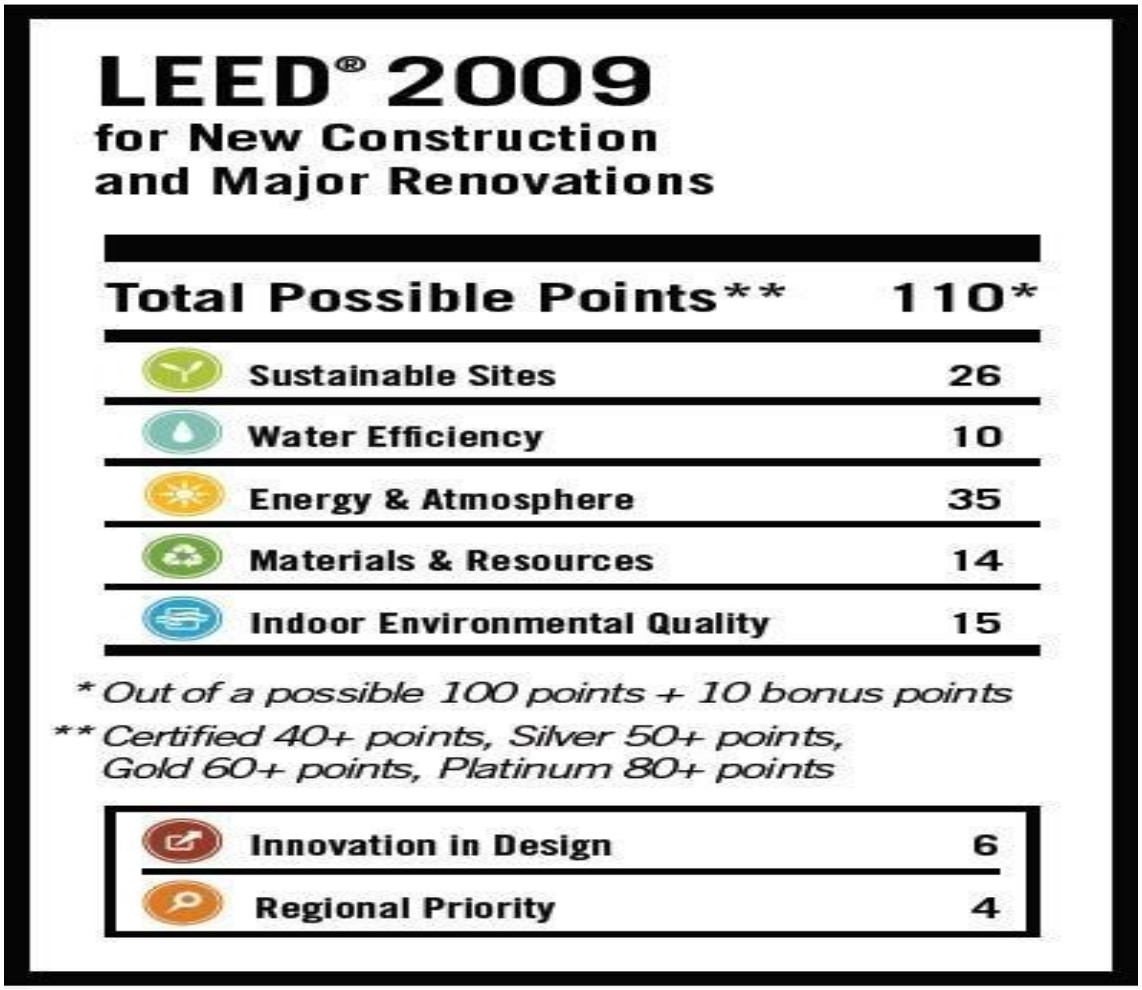


Figure 2.1: LEED Point Marking

Reference: Gallery of Where is LEED Leading Us?...And Should We Follow? - 1

(Visit: 15-09-2024)

LEED is a system for green building certification that has been evolving since 1998 to include new technologies for sustainable building. It offers programs for various types of construction, such as new buildings, homes, schools, healthcare, and more.

The first version, LEED NC v1.0, launched in 1998 and improved through versions like LEED NC v2.0, LEED 2009 (LEED v3), LEED v4, and LEED v4.1. LEED v5 drafts were reviewed in 2024, with the final version expected in 2025. LEED updates are planned every five years.

LEED also influences other systems like Canada's LEED, Australia's Green Star, and the UK's BREEAM. It uses a **point-based rating system** to certify buildings at four levels:

- **Certified**: 40-49 points
- **Silver**: 50-59 points
- **Gold**: 60-79 points
- **Platinum**: 80+ points

Categories for earning points:

1. **Location and Transportation**: Builds in areas with good public transport.
2. **Sustainable Sites**: Reduces environmental harm to surrounding land.
3. **Water Efficiency**: Saves water use.
4. **Energy and Atmosphere**: Lowers energy use and carbon emissions.
5. **Materials and Resources**: Uses eco-friendly materials and minimizes waste.
6. **Indoor Environmental Quality**: Ensures clean air and good lighting for occupants.
7. **Innovation**: Rewards creative sustainability practices.
8. **Regional Priority**: Focuses on solving local environmental problems

2.3 The Complete LEED Certification Checklist

- Location
- Water efficiency and water use reduction
- Energy efficiency and atmosphere
- Material selection and resources used
- Indoor environmental quality
- Integrative process
- Sustainable sites
- Regional priority

You will need to try and meet criteria in each of these areas in order to gain the points needed for the level of certification you are aiming to achieve.

- Energy and Atmosphere: 34%
- Indoor Environmental Quality: 16%
- Location and Transportation: 14%
- Water Efficiency: 11%
- Materials and Resources: 8%
- Sustainable Sites: 6%
- Innovation: 5%
- Regional Priority: 4%
- Integrative Process: 2%

2.4 LEED certified green building in the world



Figure :2.2 Olympic House (IOC headquarter), Lausanne, Switzerland

Year of completion: 2019

Building type: Office

Size: 135,000 sq-ft

Ranking system: LEED V4 Platinum, SNBS Platinum, Cinergy P

Design unit: 3XN Architects

The world-famous green building Olympic House is a building that clearly shows dynamism and flexibility while ensuring sustainability with features such as: using green roofs and 95% of building materials are reused. and recycled from the old administrative building.

Reference: https://3xn.com/project/ioc-headquarters

(Visit: 23-09-2024)



Figure 2.3 : ACROS Fukuoka Prefectural International Hall (Fukuoka, Japan)

The **ACROS Fukuoka Prefectural International Hall** in Fukuoka, Japan, designed by Emilio Ambas and completed in 1995, is a landmark green building. It features a cascading series of green terraces with over 35,000 plants, seamlessly blending with the adjacent Tenjin Central Park. This innovative design mitigates urban land scarcity and improves air quality, reduces the heat island effect, and enhances energy efficiency through natural insulation and light optimization. The building also incorporates rainwater harvesting for plant irrigation and serves as a multi-functional space for cultural, commercial, and governmental activities. Widely regarded as a model of sustainable urban architecture, it emphasizes harmony between nature and modern cityscapes

Ref: https://www.greenroofs.com/projects/acros-fukuoka-prefectural-international-hall/

(Visit: 30-09-2024)

2.5 Green Building in Bangladesh

Bangladesh is one of the most vulnerable nations in the world due to climate change. As the ninth most populous country and twelfth most densely populated countries in the world, its rising population and limited land space have put tremendous strains on the urban ecosystem. The capital of Dhaka itself underwent severe transformations in recent years to catch up the increased rate of urbanization. This change was paralleled by a boom in the real estate, construction and housing industry. According to United Nations Population Fund (UNFPA), Dhaka is one of the most polluted cities in the world. There are six main sectors most likely to be affected by climate change in Bangladesh – water resources and coastal zones, infrastructure and human settlements, agriculture and food security, forestry and biodiversity, fisheries, and human health. Deforestation has resulted in several man made disasters in the country's history. Green buildings assure efficient usage of water and energy and the nation is struggling in the production of electricity and suffering from water. The First Government Green Building Initiative was taken by the Housing and Building Research Institute in 2007.The Eco-Housing Project designed by Ar. Md Nafizur Rahman. With the support of IFC-world bank the HBRI Drafted the Guideline for Green building Code in 2012, in the same year a new chapter on Energy Efficiency and Sustainability was included in BNBC. The Building Energy and Environment Rating System for Bangladesh has been Drafted by Ar. Md. Nafizur Rahman in 2018 for the Sustainable and Renewable Energy Authority (SREDA) The Bangladesh Bank with the support of SREDA also created a point-based rating system for their Refinancing scheme in 2017. In the private sector, the first green building in Bangladesh was by EPIC group in May 2011. Since 2008, Sustainable Built Environment Initiative – Bangladesh (later Bangladesh Green Building

Council) founder, Sanwar Azam had worked to unify the stake holders towards a greener country, saying that with growing population in a diminishing land and rapid urbanization to major cities, 'Going green' had become a marketing ploy for various organizations as there were no quantifiable way to judge a structures sustainability. He offered a centralized board to offer (LEED) certifications to interested projects and firms.

(Reference: https://en.wikipedia.org/wiki/Green_building_in_Bangladesh)

2.6 Example of Green Building in Bangladesh



Figure 2.4: Cityscape Tower LEED Platinum Certification

Cityscape Tower is the first Platinum certified commercial LEED certified building in Dhaka. The building scored 81/110 in the LEED Certification scorecard. The developers of the building, Cityscape International Ltd, have gone leaps and bounds to ensure a LEED Platinum Certification. The building scored highly in each of the seven factors, including 10/10 in Water efficiency. Special features of the building include energy efficient air conditioning, $CO_2$and CO sensors for air quality. On-site water treatment, and rain water harvesting is also present. The roof also contains 18 KVA solar panels. Cityscape Tower is also the first building with full wooden cladding in Bangladesh, making it unique from the glass towers seen in Gulshan Avenue nowadays. Its renewable energy solar system results in the building consuming 44% less energy and 60% water savings compared to buildings situated nearby.

Ref: https://cityscapeintl.com/portfolio/cityscape-tower/ (Visit: 07-10-2024)



Figure 2.5 : Saiham Tower LEED Platinum Certification

Attaining LEED Platinum certification in 2018, Saiham Tower scored 80/110 in the LEED certification scorecard, with Saiham Properties striving for the best in class when it comes to sustainable building. The facility makes use of various optimization methods, resulting in a very high score in each criterion, including 23/37 in Energy & Atmosphere. Saiham Tower's environmentally friendly features include efficient HVAC design for energy efficiency, water use reduction and rain water harvesting facilities. Natural lighting and air, recycled construction materials, and LEED compliant faucets and fixtures are also present. The Curtain Wall glass used in the building's exterior helps with maintaining proper daylight reaching the insides of the building, temperature control, as well as its aesthetics, making the building both functional and aesthetically pleasing.

Ref: https://saihamtower.com/ (Visit: 07-10-2024)



Figure 2.6 : Simpletree Anarkali

The LEED Gold Certified building is the first core and shell constructed LEED certified building in Bangladesh, scoring 71/110 in the LEED certification scorecard. Simple tree Anarkali embodies water conservation, energy efficiency, and sustainable building. It scored well in each of the certification criteria, including 25/28 for Sustainable Sites. The forecourt in the roof consists of 65.3% vegetation. Rain water and recovered water helps with irrigation of the vegetation.The water recovery facilities of Simple tree Anarkali help it achieve 25% reduction in rainwater runoff and 41% decrease in the use of portable water. Furthermore, all the wastewater created on site is subject to Tertiary Treatment. The building also is 12.5% more energy efficient. The western side of the building has double low-e, ceramic fritted glazing panels fitted, helping it keep up with the mandatory SHGC (solar heat gain coefficient) value, while adding to the aesthetics with the display of urban artwork on the west faced.

Reference : HTTPS://WWW.USGBC.ORG/PROJECTS/SIMPLETREE-ANARKALI (Visit: 07-10-2024)



Figure 2.7 : Shahjalal Islami Bank Corporate Headquarters (LEED Gold Certification)

Shahjalal Islami Bank Ltd has set the tone for other banks to follow by making the first-ever LEED Gold Certified bank headquarter in Dhaka. The building scoring 68/110 on the LEED certification score board. Volume zero architects designed the building with the LEED certification in mind. The building had good scores in every criterion, including a score of 9/15 in Indoor Air Quality.

The front of the building faces east, with layers of glasses serving different functions. The first layer consists of horizontal bands containing ceramic fretting, which provides heat resistance. The second layer consists of glass fins with low thermal emissions. These fins run through the length of the building. Horizontal shading covers the southern side of the building, helping further with indoor temperature control. The core of the building acts as a buffer from the heat coming in from the west. This intricate layering of the glass shell also results in an aesthetically pleasing form factor for the building.

Reference: HTTPS://WWW.USGBC.ORG/PROJECTS/SHAHJALAL-ISLAMI-BANK-CORP-HEADQUARTERS (Visit: 07-10-2024)

Green Factory In Bangladesh



Figure: 2.8 Remi Holdings Ltd

LEED for New Construction 2009 Platinum certified on 07/15/2016

Activity Type	LEED
Space Type	Industrial Manufacturing
Project Size	245,947 sq ft

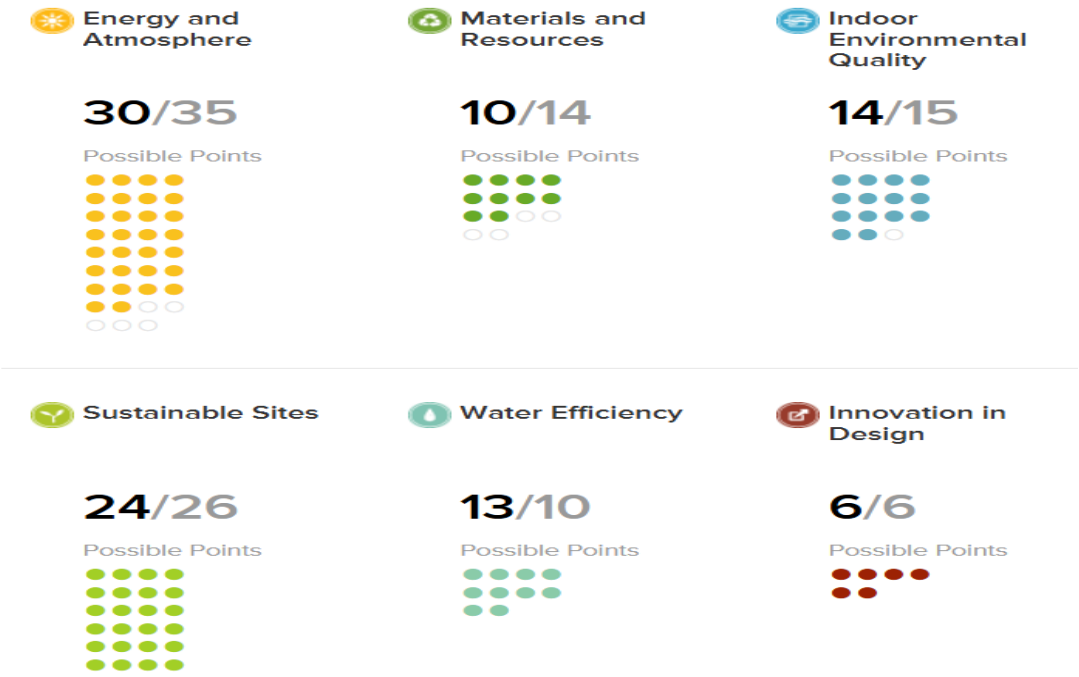


Figure - 2.9 Possible LEED Points

Remi Holdings Limited is the facility that has recently emerged as the greatest in the world for quality. An environmentally friendly clothing manufacturer, Remi Holdings Limited, has established itself in Narayanganj's Adamji Export Processing Zone (EPZ).It belongs to the Bitopi Group's sibling company. This garment's project size is 245,947 square feet. Among all the garment manufacturers in the world, this one has the most. It scored 97 out of a possible 110 points.

The factory's almost 2,500 employees are provided with a comfortable working environment through skylights and helicopter fans. The production floor also features a small garden. This environmentally friendly workplace employs each sewing machine's solar panels, LED lighting, and servo motors to reduce power use.Thermo oil heaters have been installed in place of stream boilers to save production costs. Rainwater can be stored in a facility. The water is frequently used after being cleansed.

Reference : https://www.gbig.org/activities/leed-1000042111

(Visit: 1-11-2024)



Figure 2.10 Tarasima Apparels Ltd.

Tarasima Apparels Ltd., located in Manikganj, Bangladesh, is a prominent ready-made garments manufacturer recognized for its commitment to sustainable practices. In July 2016, the company achieved LEED Platinum certification under the LEED O+M: Existing Buildings v3 - LEED 2009 rating system, earning an impressive score of 93 out of 110 points.

U.S. Green Building Council

This accomplishment positioned Tarasima Apparels Ltd. as the highest-rated LEED-certified green factory in South Asia at the time

Reference: https://dailyasianage.com/news/243629/green-industry-on-rise-in-bangladesh

(Visit: 7-11-2024)

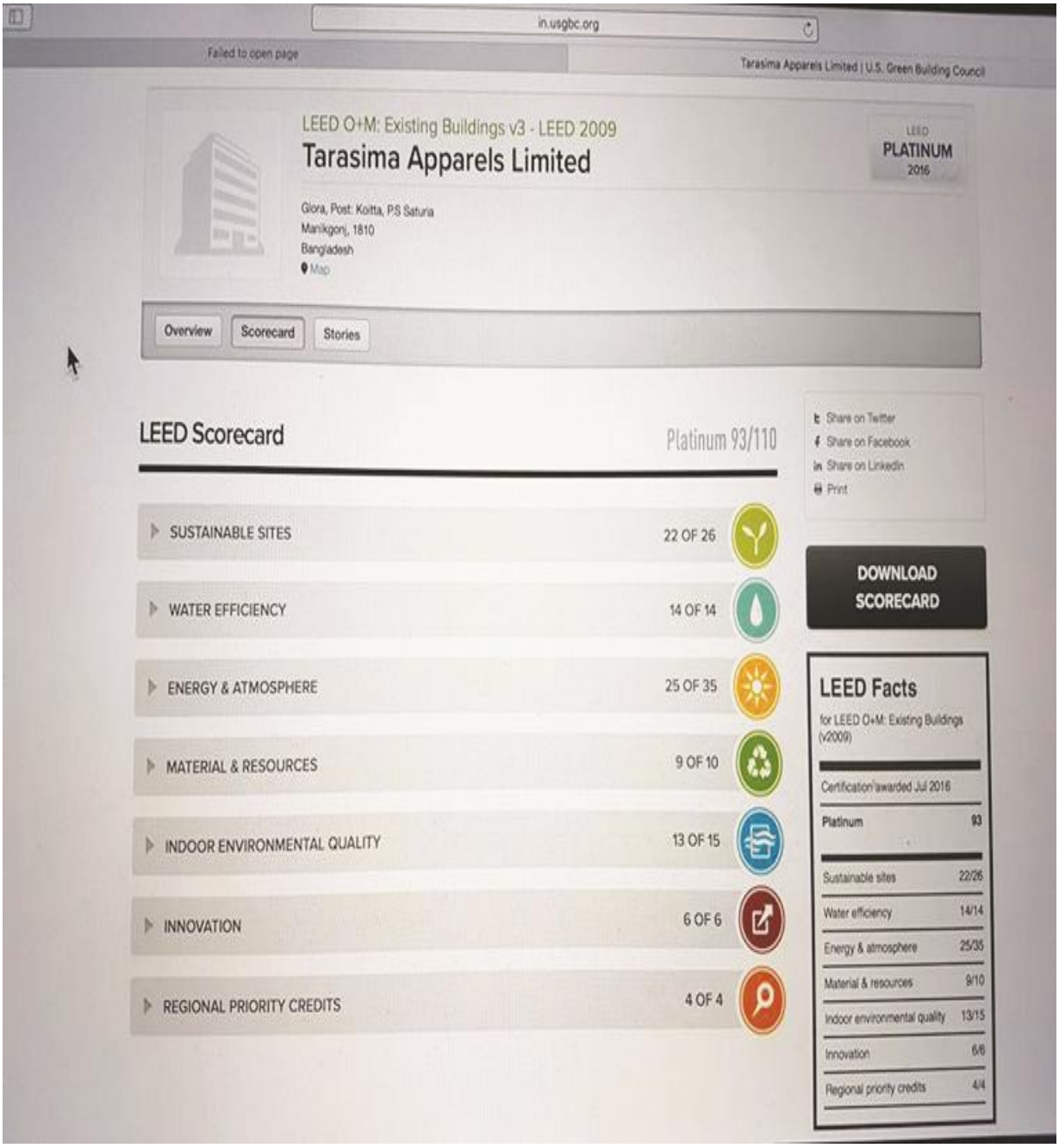


Figure 2.11 Possible LEED Points

Reference: Climatic Design LLC. Design in Concert with Climate » 2235 Shannon Place

(Visit: 18-11-2024)

2.7. Environmental Benefits:

i. Reduce heating (by adding mass and thermal resistance value). A 2005 study by Brad Bass of the University of Toronto showed that green roofs can also reduce heat loss and energy consumption in winter conditions.
ii. Reduce cooling (by evaporative cooling) loads on a building by 50% to 90%.
iii. Act as a terrarium and passive solar heat reservoir—green roofs in urban areas can reduce the city's average temperatures during summer.
iv. Reduce stormwater runoff, Create natural habitats.
v. Filter pollutants and carbon dioxide from the air, helping lower disease rates such as asthma.
vi. Filter pollutants and heavy metals out of rainwater.
vii. Insulate buildings for sound, as soil blocks lower frequencies and plants block higher frequencies.
viii. Contribute to LEED points when properly installed.
ix. Provide agricultural space.

2.8 Financial Benefits:

i. Dramatically increase the roof's lifespan.
ii. Increase real estate value.
iii. **Lower Energy Bills:** Use less electricity and water, saving money.
iv. **Higher Property Value:** Sell or rent for more due to eco-friendly features.
v. **Less Maintenance Cost:** Durable materials and efficient systems mean fewer repairs.
vi. **Tax Savings:** Get rebates or incentives from the government.
vii. **Longer Building Life:** Green buildings last longer, reducing replacement costs.
viii. **Waste Savings:** Recycling and less construction waste save money.
ix. **Cheaper Insurance:** Some insurers charge lower fees for green buildings.
x. **Better Productivity:** Healthier spaces can make workers more efficient

2.8 Limitations Of Green Buildings

The most prevalent limitation for green buildings is their cost. While green buildings can provide significant long-term financial benefits, their initial costs are higher than conventional buildings. The materials and technologies they utilize tend to cost more, the materials may be less readily available, and construction may take longer. Additionally, bank funding for green building projects can be more difficult to secure. Developers and financers must understand the cost savings over the building's entire lifecycle and be willing and able to make a larger upfront investment.

Another challenge is that renewable energy sources, such as wind and solar, rely on varying weather conditions, which could make green buildings susceptible to fluctuations in energy supply. This also underscores that not all locations are equally suitable for green buildings; proper site selection is an important aspect in successful green building projects. Related to fluctuations in renewable energy sources is a lack of full control over indoor conditions, such as building temperatures, when relying on natural resources to assist with heating and cooling. To solve for this may require certain building features, including its positioning on a lot to be handled in a non-preferred way or even in conflict with neighborhood zoning or other building guidance.

2.9 Typical Green Building Characteristics

Energy Efficiency and Renewable Energy

- Building orientation to maximize solar access, shading, and natural lighting.
- Consideration of micro-climate effects on the building.
- Thermal efficiency of building envelope and fenestration.
- Efficient heating, ventilating, and air-conditioning (HVAC) systems.
- Use of alternative energy sources.
- Reduction of electric loads from lighting, appliances, and equipment.
- Utility incentives to reduce costs

Direct and Indirect Environmental Impact

- Protect site integrity and vegetation during construction.
- Integrated pest management.
- Use of native plants for landscaping.
- Minimize watershed disturbance and pollution.
- Choose materials to reduce resource depletion and pollution.
- Use indigenous and energy-efficient materials.

Resource Conservation and Recycling

- Use recyclable or recycled content materials.
- Reuse building components, equipment, and furnishings.
- Minimize construction waste through reuse and recycling.
- Provide easy access to recycling facilities for occupants.

Indoor Environmental Quality

- Use low-volatile organic compound materials.
- Minimize microbial growth opportunities.
- Ensure fresh air supply.
- Use low-chemical and non-volatile cleaning materials.
- Reduce pollution from machines and occupants.
- Provide proper acoustic control.
- Ensure access to daylight and public amenities.

2.10 Green Building Site and Landscape Planning

Site and Landscaping for Green Building:

The purpose of sustainable site planning is to integrate design and construction strategies by modifying both the site and building to achieve greater human comfort and operational efficiency. It ensures:

- Minimum site disruption.
- Maximum usage of microclimate features.
- Appropriate landscaping.

a) Sustainable Site Planning:

- Plan for basic amenities within walking distance of housing. This would reduce the use of private transportation.
- Confirm that the selected site does not fall within the disaster-control zone as specified by the local authority.
- Ensure that basic amenities such as banks, childcare, post offices, parks, libraries, primary schools, clinics, and community halls are near to or within the site premises.

b) Landscaping for Green Building:

Suitably designed landscape is a very effective microclimate modifier. Landscaping plays a very important role in modulating airflows in a building. Moreover, landscape provides the required shading for outdoor areas, which modifies the microclimate. Care needs to be taken to avoid undesirable increases in humidity levels by excessive plantations

2.11 Difference Between Conventional Building and Green Building

Aspect	Conventional Building	Green Building
Definition	Traditional buildings focusing on functionality.	Eco-friendly buildings designed for sustainability.
Energy Use	Consumes more energy, often from non-renewable sources.	Uses renewable energy and reduces energy consumption.
Materials	Uses regular construction materials, not always eco-friendly.	Uses sustainable and recyclable materials.
Environmental Impact	Higher pollution and waste generation.	Minimizes pollution and promotes waste management.
Water Use	Higher water consumption, often inefficient.	Includes systems for water efficiency and recycling.
Cost	Lower initial cost, but higher maintenance expenses.	Higher initial cost, but lower long-term expenses.
Health	May not prioritize indoor air quality.	Promotes better air quality and healthier spaces.

CHAPTER 03
METHODOLOGY

One of the key factors in construction industry is estimating and costing. Accurate estimation is very important as the success and quality of a construction or project depend on it. And cost analysis of a construction is generally developed at all of the stages of the investment process. The loss and profit of a construction or project is strictly dependent on proper estimating and costing. Slight variation of the construction cost can hamper the overall success of a real estate enterprise and it can also hamper the financial stability of the developer. In this paper, a complete guideline for estimating of projects is provided with respect to architectural, structural, electrical and plumbing design. The item wise estimation and costing of a 9 storied residential building in Dhaka city is performed in the spread sheet analysis and the discussion of result and recommendations are provided.

The study has been accomplished based on:

1. General survey: At first we selected a site to make our projects. Then we make a survey and also did the soil test report.

2. Design and drawing collection: We make our projects design though different software like AutoCAD, ETABS etc and made stable our projects.

3. Spread sheet analysis: After doing all process about survey and design and drawing we made a spread sheet about estimation and costing.

4. Cost benefit analysis: Doing all steps 1, 2, 3 we compared the cost benefit between conventional and sustainable green building.

SPECIFICATION OF MATERIALS

The full specifications of the materials for the construction of the building are given below:

Cement

Cement is Ordinary Portland Cement conforming to the requirements of the Standard Specifications for Portland cement Type-I. ASTM C-150 r BDS 232: 1993. BNBC 2.4, 5.2.1 unless otherwise specified. Cement was delivered in bags by the manufacturer with the brand name, type of cement and weight of each bag marked on the bag. Sample

Est of cement was done from the laboratory designated by the Engineer for every consignment of cement. Bulk cement which partially set or which contains lumps of caked cement was rejected. The use of cement reclaimed from discarded or used bags was not permitted.

Water

The water used in mixing and curing concrete was tested by methods described in AASHTO test Method T-26. Water was clean and free from salt, oil, acid, vegetable or other substance injurious to the finished product. Water used in construction work was potable.

Fine Aggregate: Sand

Fine Aggregate was conformed to BDS 243:1963, ASTM C40-92.C87-83 (1990). Fine Aggregate was natural sand, composed of clean, hard, durable uncoated particles resulting from the disintegration of siliceous. Fine Aggregate was free of injurious amounts of organic impurities.

Deleterious substances were not exceeding the following percentages by weight:

1. Clay lumps and friable particles: 3%
2. Coal and Lignite: 0.25%
3. Material passing the 0.075 mm (No 200) sieve: 2%
4. Shale, coal, soft or flaky fragments: 11%
5. Sulfur compounds: 0.3%
6. Organic material content: 5%

Coarse Aggregate: Stone Chips

For all types of concrete with the exception of blinding concrete was consists of hard durable crushed stone boulder and conform to BDS 243:1963 (Coarse and Fine Aggregate for Natural Sources for concrete 1: ASTM C 33: Concrete Aggregates). Coarse aggregate was clean, free from dust and other deleterious materials.

The amount of deleterious substances was not exceeding the following limits:

1. Soft fragments; by 2% by mass , Clay lumps; 0.25% by mass
2. Material passing the 0.075 mm sieve: 0.5% by mass if clay. 1.5% by mass if fracture dust.

Coarse Aggregate: Brick Chips

It was made from brick and conformed to the following requirements:

1. It was made of first class and picked jhama bricks.
2. Nominal size: same as stone aggregate.
3. Appearance was completely non-plastic and free from all organic and other deleterious materials.
4. Unit weight was less than 1100 kg/cum.
5. Water absorption as a percentage of the dry weight did not exceed 14%.
6. Percent wear did not exceed 40% tested by Los Angeles Abrasion Test.

SEQUENCE OF STRUCTURAL WORK

A construction sequence schedule is a specified work schedule that coordinates the timing of land disturbing activities and the installation if erosion-protection and sedimentation-control measures.

1. Site Clearance.
2. Demarcation of Site.
3. Positioning of central coordinate as per grid plan.
4. Surveying and layout.
5. Excavation.
6. Laying binding and placement of foundation steel.
7. Shuttering and scaffolding.
8. Concreting.
9. Electrical and plumbing.
10. DE shutter.
11. Brickwork.
12. Doors and windows frames along with lintels.
13. Wiring for electrical purposes.
14. Plastering.
15. Flooring and tiling work.
16. Painting.
17. Final completion and handing over the Project.

Chapter 04

Result and Discussion

4.1 Findings:

Conventional Building Estimation and Cost:

Drawings

The structural drawings are given below in the following figures.



Figure 4.1: Front Elevation of conventional Building

4.2 Estimation And Costing Of Conventional Building

The total estimation and costing of Slab, Beam, Column, Pile and Pile cap are showing below sequentially.

The total costing of structural works and other are showing below in Table no. 4.6 and 4.7 simultaneously for Conventional Building.

Table no. 4.1: Estimation and costing Floor

SI No.	Name	Unit (BDT)
01	Piling	1,27,840.00
02	Ground Floor	7,74,462.00
03	1st Floor	14,30,305.00
04	2nd Floor	14,30,305.00
05	3rd Floor	14,30,305.00
06	4th Floor	14,30,305.00
07	5th Floor	14,30,305.00
08	6th Floor	14,30,305.00
09	7th Floor	14,30,305.00
10	8th Floor	14,30,305.00
11	Roof Top	7,13,623.88

Table no. 4.2: Total Estimation and costing

SI No	Name	Unit (BDT)
01	Wood, Aluminum, Grill & Railing, Painting	29,86,150.00
02	Sanitary & pluming	22,50,000.00
03	Internal Electrification	25,50,000.00
04	Consumable Materials, Temporary Electrical Gas Bill for Construction Period	3,79,460.25
05	Lift 8-person 1nos	9,37,500.00
06	CCTV, Intercom & Fire Fighting System	93,750.00
07	Project Logo, Apartment No. Car parking No.	56,250.00
08	Consultancy Fee	2,29,294.00

Table no. 4.3: Total Estimation and costing of table 4.1 & 4.2

SI No	Name	Unit (BDT)
01	Table No.5.1: Total Estimation and costing of floor	1,29,30,525.00
02	Table no. 5.2: Total Estimation and costing of Others	94,82,404.00
	Total	**2,24,12,929.00**

Total Cost is about =22412929.00

In Word- **(**Two Core Twenty Four Lac Twelve Thousand Nine Hundred Twenty Nine Taka Only**)** (Approximate)

So, the Cost about square feet is 1590.691 Taka Only (Approximate**).**

N. B: Total amount can be change for the price up down in local market.

Sustainable Green Building Estimation and cost:

Drawings

The structural drawings are given below in the following figures



Figure 4.2: Front Elevation of Sustainable Green Building

Estimation And Costing

The total estimation and costing of Slab, Beam, Column, Pile and Pile cap are showing below sequentially.

The total costing of structural works and other are showing below in Table no. 4.13 and 4.14 simultaneously for Conventional Building.

Table no. 4.4: Estimation and costing Floor

SI No.	Name	Unit (BDT)
01	Piling	14,23,575.00
02	Ground Floor	7,74,462.00
03	1st Floor	14,30,305.00
04	2nd Floor	14,30,305.00
05	3rd Floor	14,30,305.00
06	4th Floor	1430`305.00
07	5th Floor	1430305.00
08	6th Floor	1430305.00
09	7th Floor	1430305.00
10	8th Floor	1430305.00
11	Roof Top	713623.00

Table no. 4.5 Total Estimation and costing of others

SI No	Name	Unit (BDT)
01	Wood, Aluminum, Grill & Rallying, Painting	2986150.00
02	Sanitary & pluming	2250000.00
03	Internal Electrification	2550000.00
04	Consumable Materials, Temporary Electrical Gas Bill for Construction Period	379460.00
05	8Kw Solar Panel Power Plan set	225000.00
06	12 m thick tamped Glass for curtain wall	5043667.00
07	Lift 8 person 1nos	937500.00
08	CCTV, Intercom & Fire Fighting System	93750.00
09	Project Logo, Apartment No. Car parking No.	56250.00
10	Gray Water Reuse Plant	75000.00
11	Consultancy Fee	229294.00

Table no. 4.6: Total Estimation and costing of table 4.4 & 4.5

SI No	Name	Unit (BDT)
01	Table No. 6: Total Estimation and costing of floor	14354100.00
02	Table no. 7: Total Estimation and costing of Others	14826071.00
	Total	**29180171.00**

Total Cost is about = 2,9180171.00

In Word- (Two Core Ninety One Lac Eighty Thousand One Hundred Seventy One Taka Only) (Approximate)

So the Cost about square feet is 1947.293 Taka Only (Approximate)

N.B: Total amount can be change for the price up down in local market.

4.3 Cost Analysis

The analysis shows the difference between the estimation and cost of two same designed building called one is Conventional Building and another is Sustainable green building. From this analysis we are getting an idea about the cost that what if we change a conventional building in a sustainable green building. The difference of the cost of this process is showing below.

Name	Conventional Building	Sustainable Green Building
Window	Normal grill and Thai	Tempered glass 12mm Thickness
Door	Wooden Door	Sliding Door and PVC Door
Wall	10” brick wall	10” Brick Wall with tempered glass wall in master/Child bedroom
Power Supply	No alternate power supply without generator.	8Kw Solar Panel Power Plan sets
Water resources	No alternate water supply without WASA	Rain water Collection and gray water reuse plan
IoT Integrated Automated System	No	Yes
Total Cost(BDT)	**63,564,027.00 Taka** Only(Approximate)	**77,813, 814.00 Taka** Only(Approximate)
Cost Per Sqft	**1590.691 Taka** Only(Approximate)	**1947.293 Taka** Only(Approximate)

4.4 LEED Points:

Our Sustainable building is designed for also thought about the LEED points. We have a goal to achieve a place according to LEED point. For that we tried to design a new, Stylish, and at a time also a environment sustainable building.

We have selected a sustainable site for our projects. We implemented a rainwater harvesting system, gray water use in our projects. We designed all bedrooms near to wall to supply sufficient air and natural sunlight. We also used glass curtain wall for more sunlight.

We used PVC doors which are non-decomposable. We tried to make a best indoor environment by using small plants, plastic paint, and also printed paints. Now if we calculate our achieved points according to LEED those are,

LEED Points For Conventional Building

SI No	Name of points	LEED point	Our Achieved Points	Remarks
01	Sustainable Sites	21	10	Near the main Roads so sound pollution is high but Near a river, Available hospital, bazer, mosque etc.
02	Water Efficiency	11	05	No alternate water source without WASA
03	Energy & Atmosphere	37	11	Using only electricity, Some sun light pass through the window.
04	Materials & Resources	14	07	BSRM rods and normal grill, ralling, and as usual window
05	Indoor Environment Quality	17	02	As usual normal room decoration.

06	Innovation in Design	6	06	For design and structure build(Bonus Point)
07	Regional Priority	4	04	(Bonus Point)
	Total	**110**	**45**	**Only LEED© Certified**

From this chart we have achieved **"45 points out of 110 points"** and we have achieved only **"LEED Certified"** according to "**LEED Points**"

Fig 4.3: Our Achieved **LEED Certified** Logo

LEED Points for Sustainable Green Building

SI No	Name of points	LEED point	Our Achieved Points	Remarks	What we should develop to achieve more points
01	Sustainable Sites	21	14	Far from main road to prevent various kind of sound pollution, Near a river, Available hospital, bazer, mosque etc.	–
02	Water Efficiency	11	08	Rain water harvest, Gray water reuse.	***We can make a submersible pump to backup water***
03	Energy & Atmosphere	37	25	Use Solar Panel, Sufficient air etc.	***We can make a mini wind Turbine on the roof top of the building***
04	Materials & Resources	14	09	Glass Wall instated of Brick wall in bedroom, Veranda	-
05	Indoor Environment Quality	17	07	Small plants, plastic paint, and also printed paints	***We can use artificial grass in drawing & dining for an excellent look*.**
06	Innovation in Design	6	6	Bonus Point For design and structure build	–
07	Regional Priority	4	4	(Bonus Point)	–
	Total	**110**	**73**	**LEED© Gold Certified**	**LEED© Platinum Certified can be achieved**

From this chart we have achieved **"73 points out of 110 points"** and we have achieved **"Gold Certified"** according to "**LEED Points**"



Fig 4.4: Our Achieved **Gold Certified** Logo

LEED Points Graph of Conventional & Sustainable Green Building

This chart is showing the comparison of LEED points between conventional and sustainable building. From this chart its clear that in every steps the sustainable green building are achieving more points then conventional building.

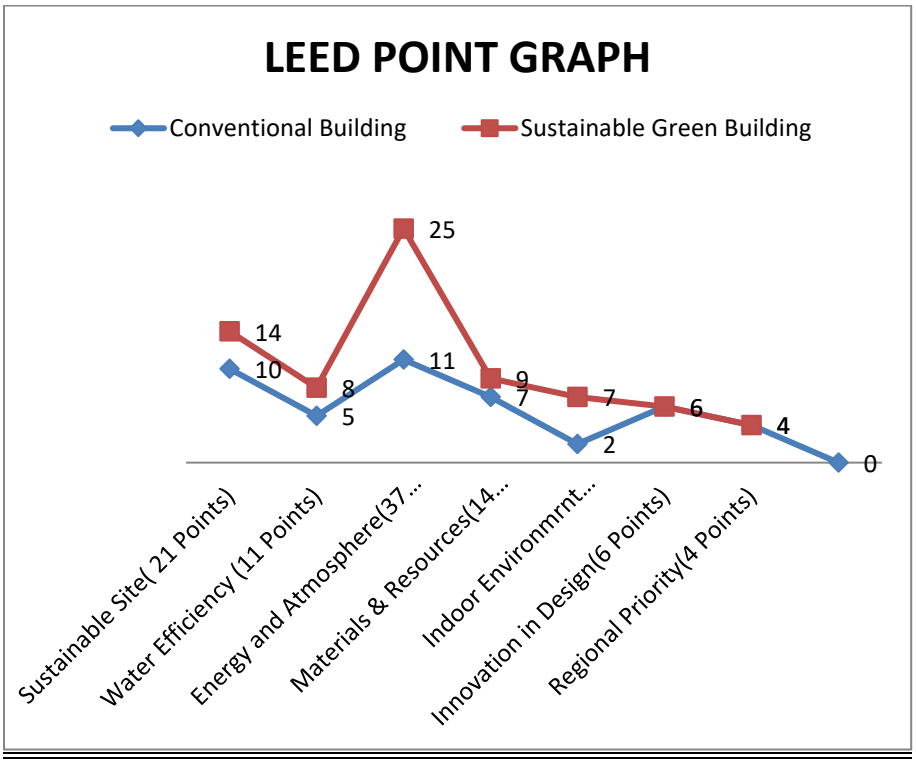


Figure 4.5: LEED Point Graph

4.5 Cost Analysis Dhaka City Green Residential Building

Total Floor Area: 10,000 Sq. Ft.

Estimated Completion Time: 12 months

Table no. 4.7: Total Estimation and costing of Initial Construction

Initial Construction Costs			
Category	**Conventional Cost (BDT)**	**Green Building Cost (BDT)**	**Remarks**
Land Development	500,000	600,000	Earthwork, soil stabilization
Foundation	1,500,000	1,700,000	Recycled materials, fly ash
Structural Materials	6,000,000	7,200,000	Eco-friendly concrete, recycled steel
Walls & Roofing	4,000,000	4,600,000	AAC blocks, bamboo, insulated roofing
Windows & Doors	1,200,000	1,500,000	Double-glazed windows, FSC-certified wood
Plumbing & Water Systems	800,000	1,200,000	Rainwater harvesting, efficient plumbing
Electrical Systems	2,000,000	3,500,000	Solar panels, LED lighting
HVAC Systems	1,500,000	2,000,000	Energy-efficient HVAC systems
Interior Finishes	2,000,000	2,500,000	Low-VOC paints, recycled materials
Landscaping	400,000	800,000	Green roofing, vertical gardens
Certifications	N/A	300,000	LEED/EDGE/GRIHA fees
Miscellaneous	1,000,000	1,200,000	Contingency, taxes, and fees
Total Construction Cost	20,900,000	27,100,000	

Table no. 4.8: Estimation and costing of Operational Cost Savings

Operational Cost Savings				
Category	**Conventional Cost (BDT/year)**	**Green Building Cost (BDT/year)**	**Savings (%)**	**Remarks**
Electricity (Energy)	1,500,000	900,000	40%	Solar, insulation
Water	400,000	200,000	50%	Rainwater harvesting
Maintenance	500,000	300,000	40%	Durable materials
Total Annual Savings	N/A	1,000,000	[~40%]	

Table no. 4.9: Payback Period Analysis Cost

Category	**Amount (BDT)**
Additional Green Building Cost	6,200,000
Annual Operational Savings	1,000,000
Payback Period (Years)	~6.2 years

Environmental Impact	
Category	**Impact**
Energy Reduction (%)	40%
Water Conservation (%)	50%
Carbon Footprint Reduction	~25 tons/year
Waste Reduction (%)	30%

Chapter 05

Conclusions and Recommendation

5.1 Conclusions:

1. Finding from our sensitive analysis is that sustainable building is a big budget project but it saves other external cost like extra electricity bill cause of using electricity in day time

2. It promotes people a healthier living with nature.

3. From this research we able to use reduces wastes. Over the past decades, global warming has remained a steadfast concern due to its increasing evident effects of plants. Construction firms have stared relying resources and methods which are beneficial for us and promote a cleaner environment.

4. From this researches we see that promotes cost efficiency. One of the most sustainable benefits
of sustainable building is their lower maintenance costs with specially engineered design elements that helps reduce water and energy bills. Reduce maintenance and operational costs mean huge saving invested elsewhere such as higher employee wages or product developments.

5. Sustainable building methods utilize eco friendly materials without compressing quality or structural integrity. Many of these materials are recycled and reduced. Among which are bio composites
that are commonly substituted as sustainable building materials have proven to be as reliable and durable as their non renewable counterpart. For green architects, energy efficiency remains their number one priority and goal in building design. Building structure that obtains their energy from nature resources such as wind, sun, and water are exceptionally favorable to our environments.

5.2 Recommendations for Future Work:

This research underscores the importance of integrating green steel structures into sustainable building practices, especially in the context of developing countries like Bangladesh. While significant strides have been made in understanding the potential of green steel as an environmentally friendly construction material, there remains substantial room for further exploration. The study recommends that future researchers focus on addressing the limitations and challenges encountered during this work.

In Bangladesh, the adoption of green steel in construction is still in its infancy. Factors such as cost constraints, lack of awareness, and limited access to advanced technologies have hindered its widespread use. Future studies should emphasize developing cost-effective green steel production methods tailored to Bangladesh's local industries and resources. Investigations into the long-term performance and durability of green steel structures in the country's climate conditions are also essential.

Additionally, further research should explore innovative ways to integrate green steel with other sustainable building materials to enhance overall efficiency. Collaboration between academic institutions, steel manufacturers, and construction companies will be vital in driving progress. Pilot projects demonstrating the feasibility of green steel structures in real-world applications could serve as a practical foundation for scaling up such initiatives.

This research is only a starting point, and we encourage future researchers to build on our findings and push the boundaries of sustainable construction technologies. By doing so, they can contribute to a greener, more sustainable future for Bangladesh and beyond.

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- ✓ This book provides foundational principles and advanced strategies for sustainable construction in urban settings.

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[1] Berardi, U. (2013). Sustainability assessment in the construction sector: Rating systems and rated buildings. *Sustainable Development*, 21(6), 411–424. https://doi.org/10.xxxx

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[3] Zhao, X., & Pan, W. (2015). Delivering sustainability through smart technologies in green buildings. *Energy Procedia*, 88, 201–206. https://doi.org/10.xxxx

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[1] United Nations Environment Programme. (2022). Buildings and climate change: A summary for decision-makers. UNEP. https://www.unep.org/resources/report

- ✓ Discusses global strategies for achieving sustainability in construction.

[2] World Green Building Council. (2023). The business case for green building. https://www.worldgbc.org/

- ✓ Provides an overview of the benefits of green buildings in urban areas.

Reports:

[1] U.S. Green Building Council. (2021). *LEED in Motion: Cities and Communities*. USGBC.

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[2] International Energy Agency (IEA). (2022). *Towards zero-energy buildings: A sustainable solution for urban areas*. https://www.iea.org/reports

Appendix

Appendix A



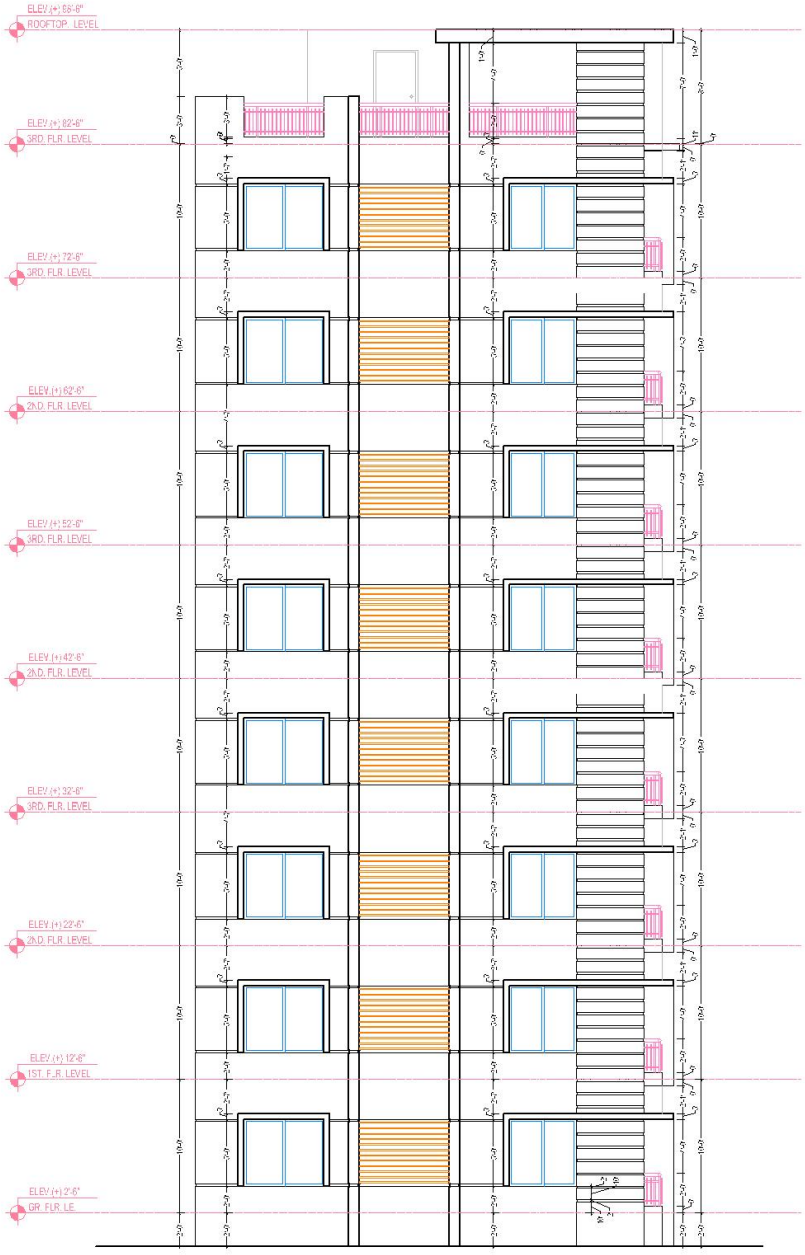
Figure : Side Elevation of Conventional Building



Fig: Front Elevation Of Sustainable Green Building



EAST ELEVATION



SOUTH ELEVATION



WEST ELEVATION



Fig: Back Elevation Of Sustainable Green Building



Fig: Back Elevation Of Conventional Building

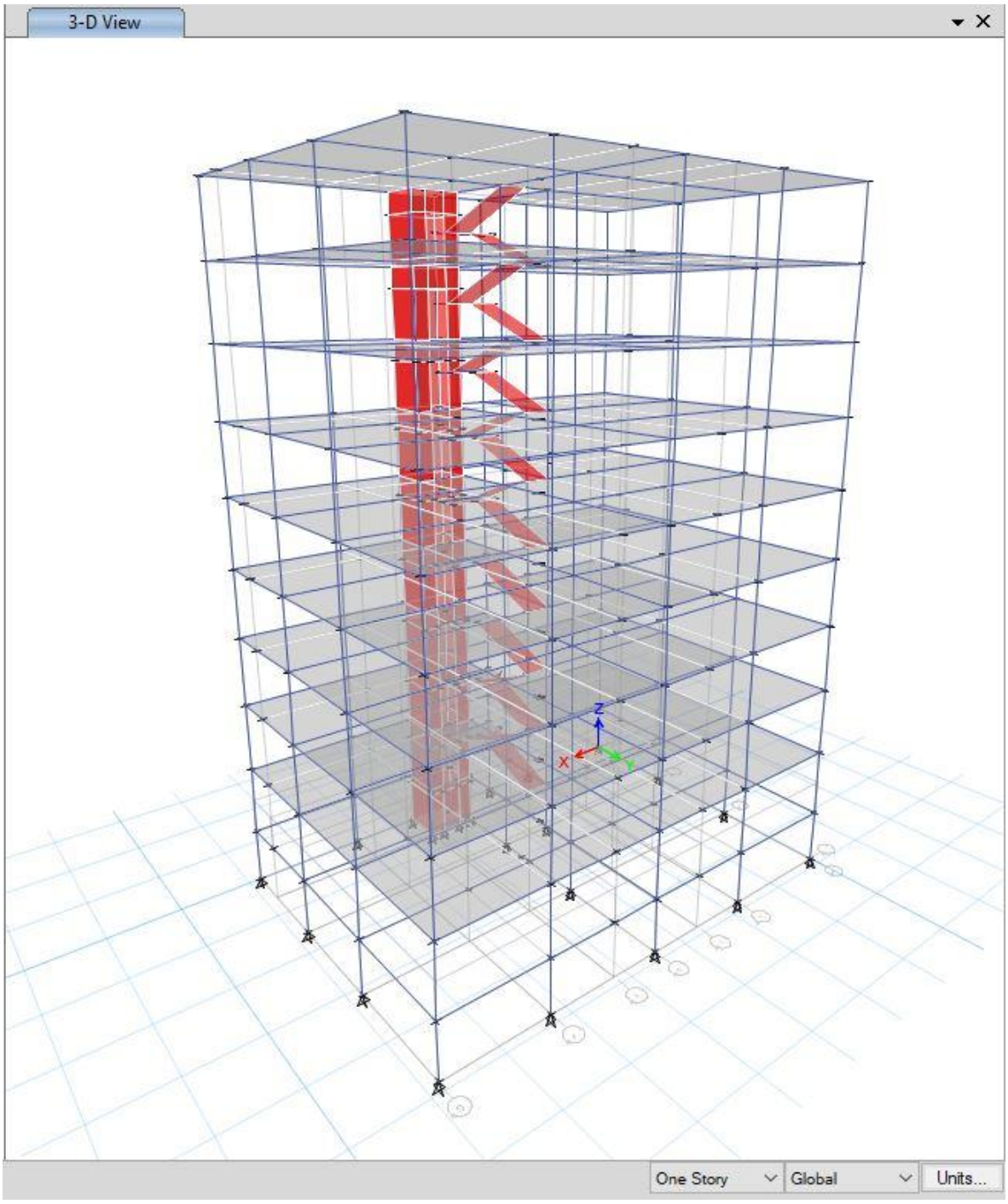
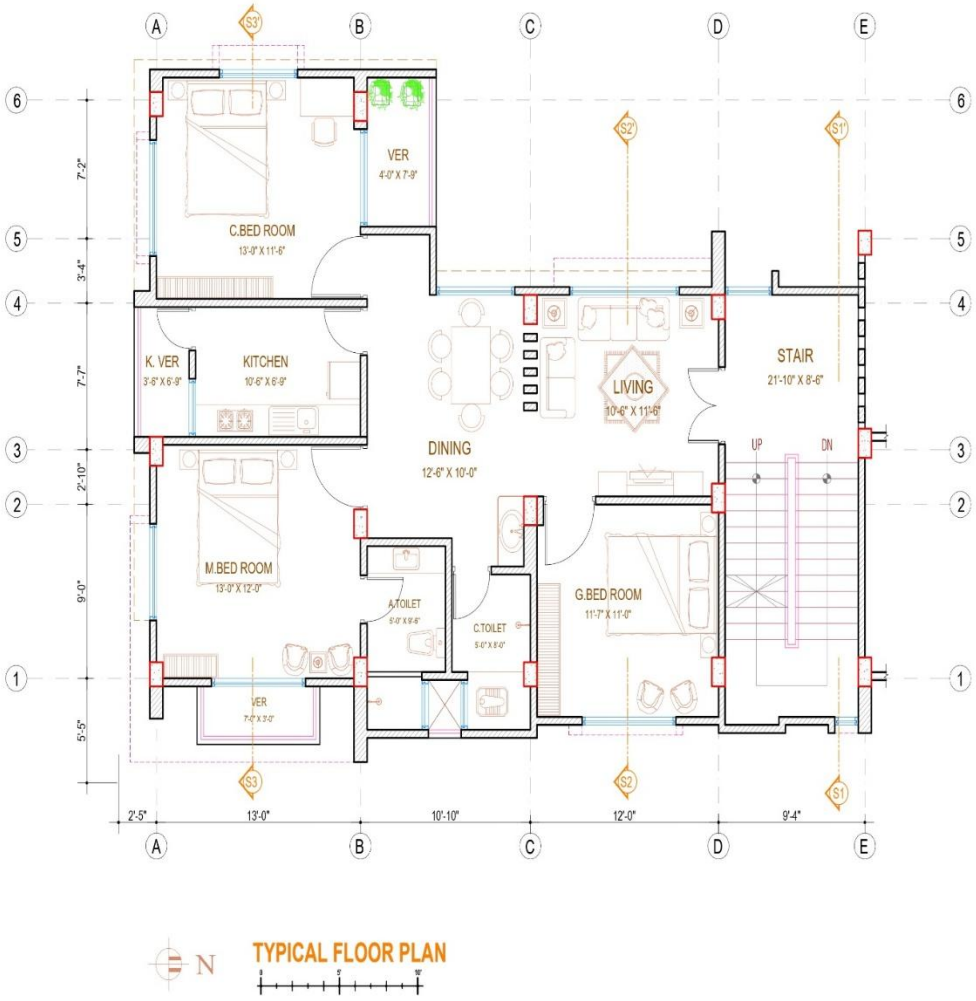


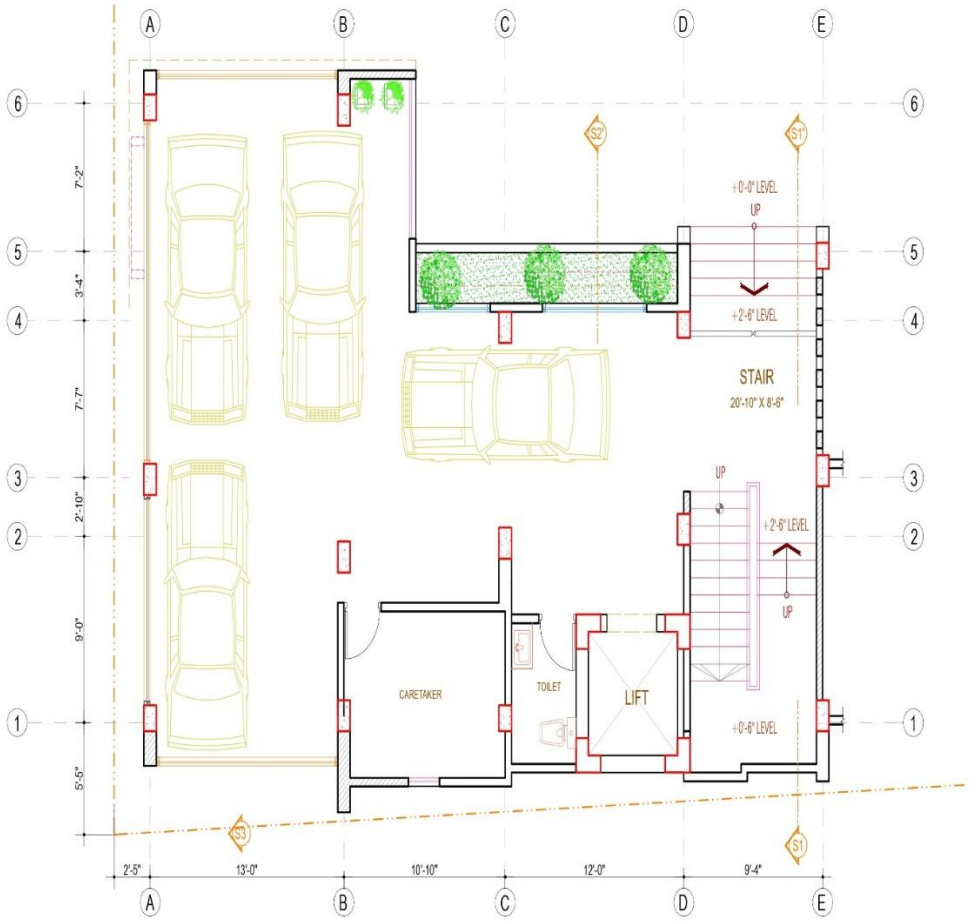
Figure: 3D Elevation of Our Projects Building By ETABS

Appendix C

Projects Related Drawing:

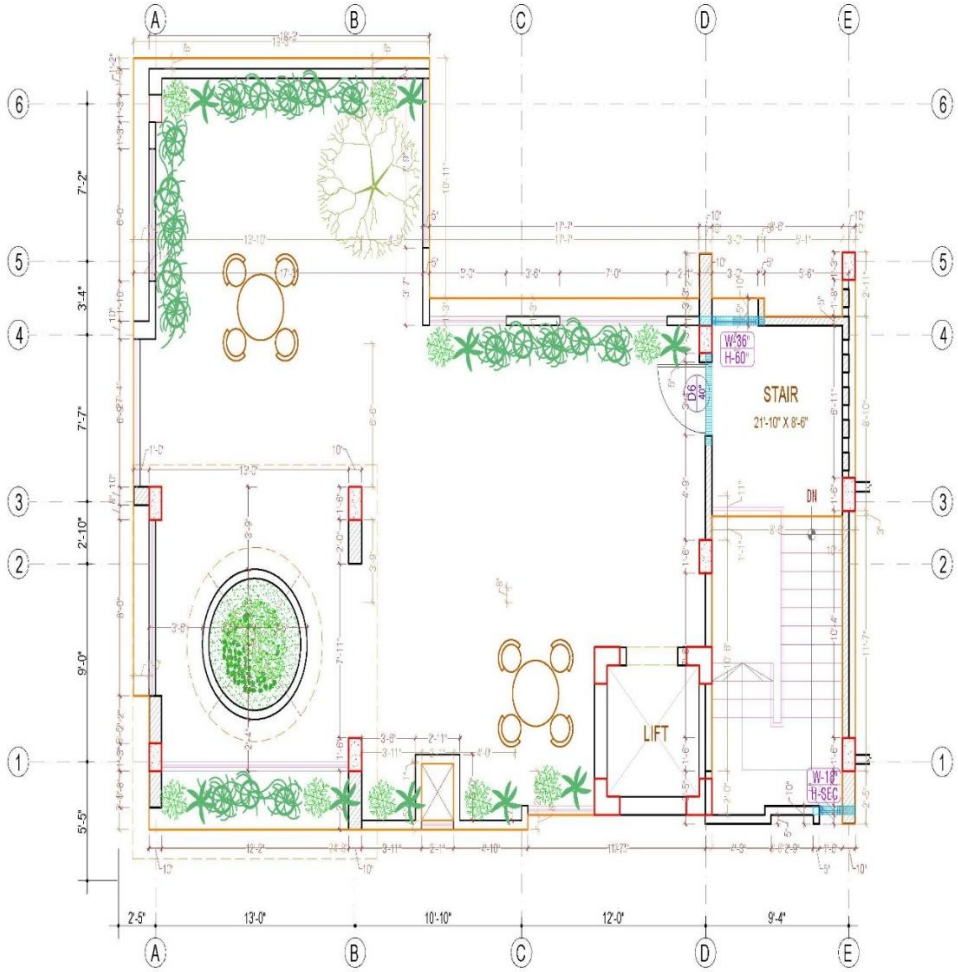


TYPICAL FLOOR PLAN



N

GROUND FLOOR PLAN



N ROOF PLAN

ROOF PLAN

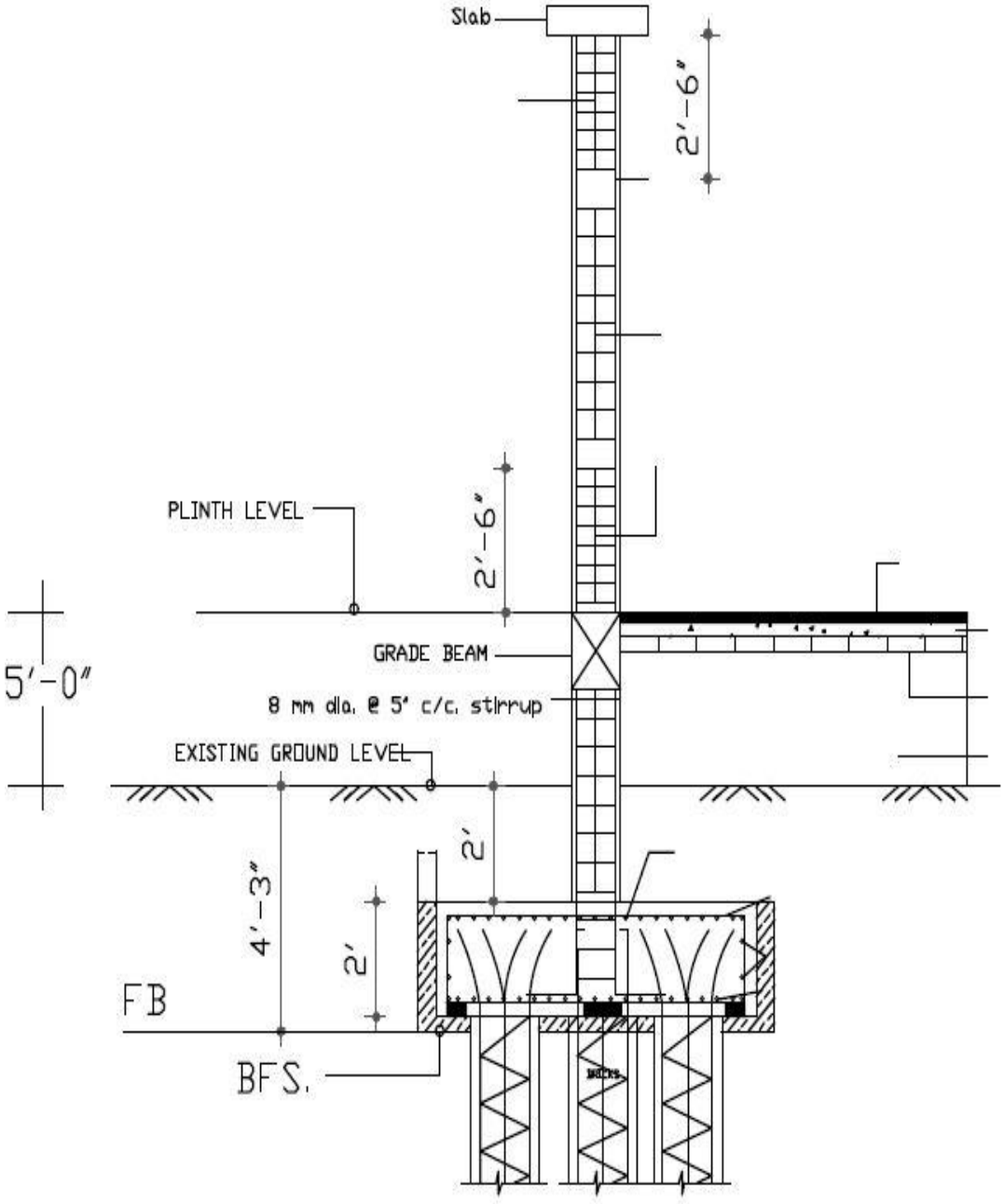
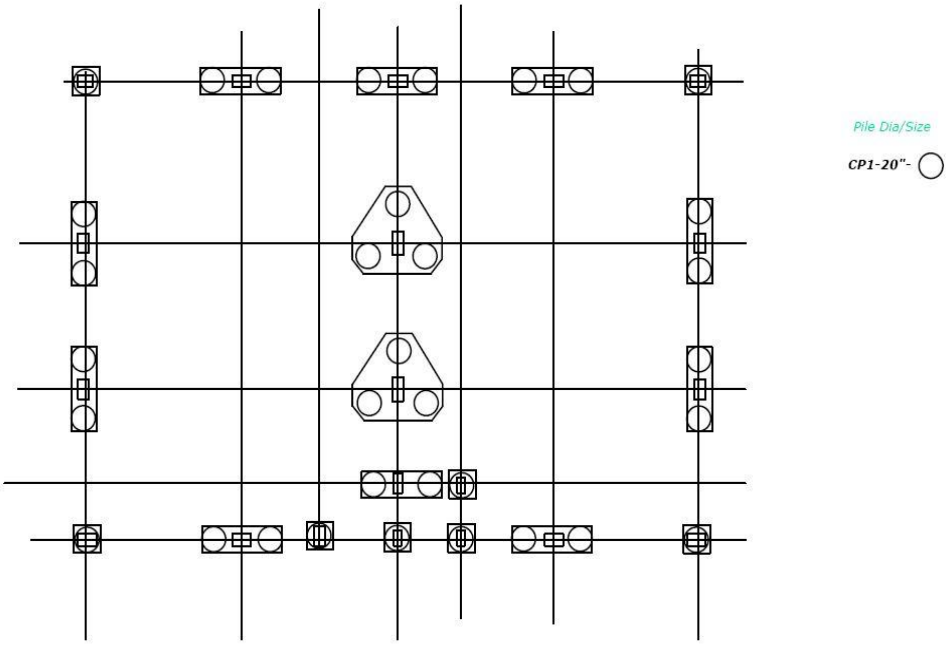
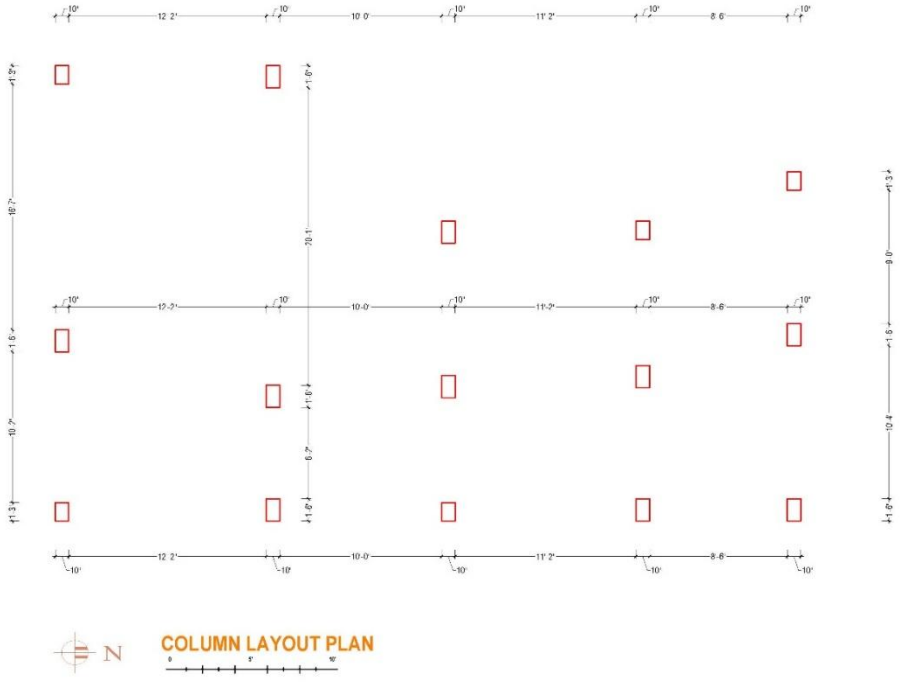


Figure: Pile Design of Our Projects Building



Pile Foundation



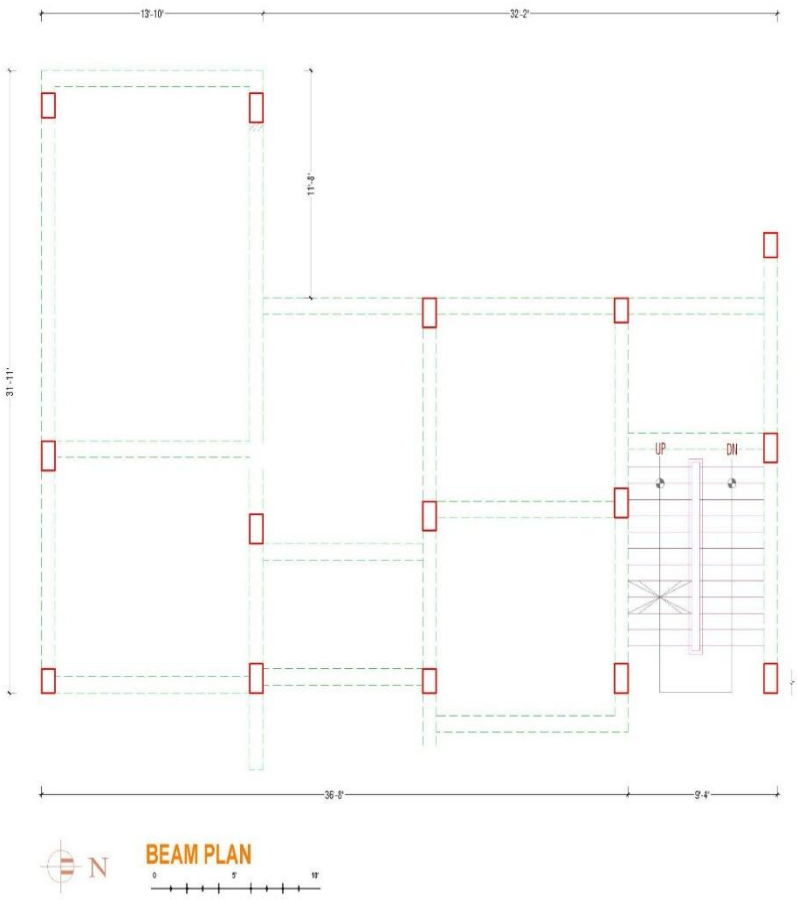
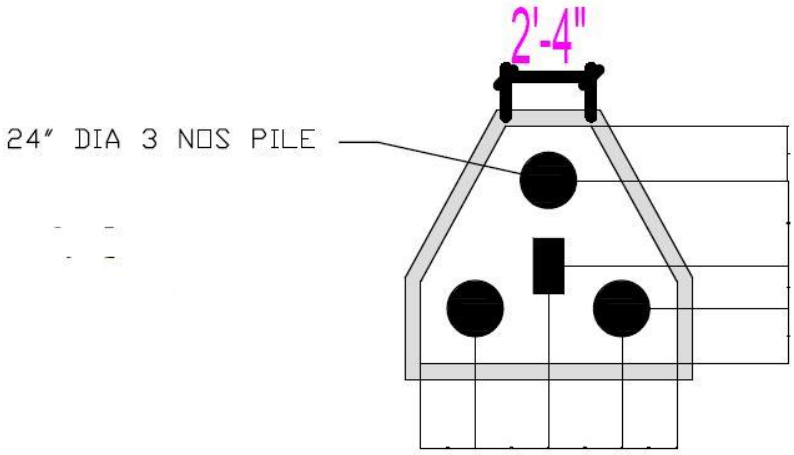
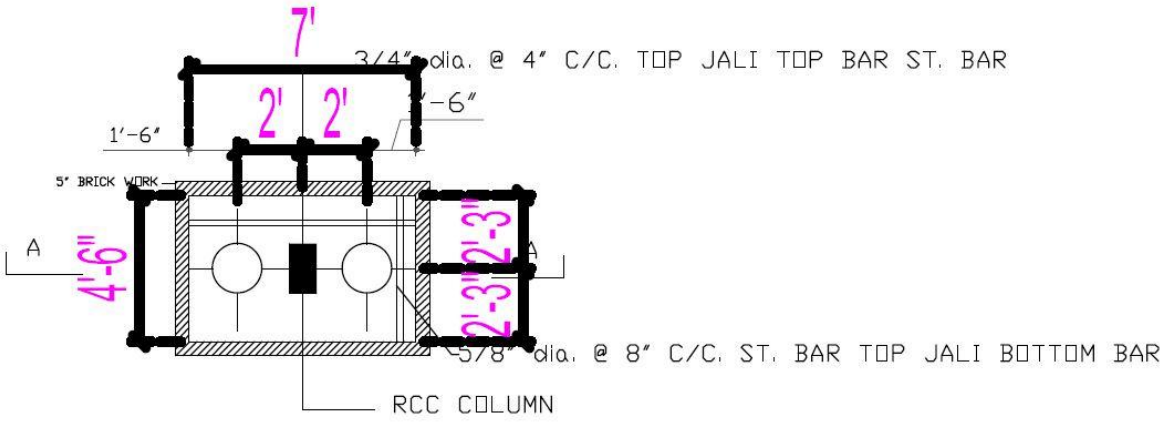


Figure: Beam Layout Plan Our Projects Building



PILE CAP PC-3



PILE CAP PC-2

Appendix C

Load Calculation

According to BNBC-2020

Dead Load:

Floor Finish:

Floor Slab:

1. Clay tiling (0.52" thickness)= 0.268 KN/m^2
2. Cement Plaster/10mm (0.4") thickness= 0.230 KN/m^2
3. Ceiling Cement Plaster 13mm (0.52") thick = 0.287 KN/m^2

Total Floor finish for floor slab= 0.785 KN/m^2

= 0.785*20.89

= 16.4 psf

Roof:

1. Lime plaster/ 0.4" thickness= 0.191 KN/m^2
2. Ceiling Cement Plaster (0.52") thick= 0.287 KN/m^2

Total load of floor finish for roof = 0.478 KN/m^2

= 0.478*20.89

= 9.99 psf

Partition Wall Load:

1. Brick mansonary, excluding plaster burnt clay/ 4" thickness = 1.910 KN/m^2
2. Cement Plaster/0.4" thickness = 0.230 KN/m^2

Total load of partition wall = 2.14 KN/m^2

= 2.14*20.89

= 44.70psf

Brick unit weight= 18.9 KN/m^2

= 121.34 lb/ft^3

Wall Load For Beam:

= Brick unit weight x Brick wall area

= 121.34 x 10'x (5/12)'/1000

= 0.51k/ft.

Live Load:

1. Floor Slab: Residential Building (One & Two Family)

= 2 KN/m^2* 20.89

= 41.78 Psf

2. Roof Slab:

Roof use for gardening, GYM, party and other purpose = 4.80 *20.89

= 100.27psf

3. Stair and exit way (Lending)= 4.80 KN/m^2*20.89

= 100.27 psf

Total Load:

1. Partition Wall= 45 psf
2. SDL= 243 psf
3. Floor Finish= 16.4 psf
4. Live Load= 242.54 psf

Appendix D

Estimation and Costing of Slab

Estimation and costing of slab are shown below in the following Table no. 4.1.

Slab Size (max): 51.42 ft.*32.67 ft. *0.42 ft.

Total Slab: 9 Nos.

Ratio: 1:1.5:3

Admixtures per bag: 250ml

Table no.4 1: Estimation and costing of slab

Name	Admixture /Litter	Volume (Cft)	Volume (cum)	Reinforcement (kg)	Cement (begs)	Sand (cum)	Aggregate (Cum)	Admixture (litter)
Slab	0.25	14406	432	11525	2239	280	559	560

Estimation and Costing of Beam:

Estimation and costing of Beam are shown below in the following Table no. 4.2

Beam Size (max): 1.83 ft.*2 ft. *74 ft.

Total Beam: 7 Nos.

Ratio: 1:1.5:3

Admixtures per bag: 250ml

Table no. 4.2: Estimation and costing of Beam

Name	Admixture/ Litter	Volume (Cft)	Volume (cum)	Reinforcement(kg)	Cement (begs)	Sand (cum)	Aggregate(Cum)	Admixture (litter)
Beam	0.25	9447	283	11336	1468	183	367	367

Estimation and Costing of Column:

Estimation and costing of Column are shown below in the following Table no.4. 3

Column Size (max): 1.5 ft.*2.5 ft. *10 ft.

Total Column: 20 Nos.

Ratio: 1:1.5:3

Admixtures per bag: 250ml

Table no. 4.3 : Estimation and costing of Column

Name	Admixture/ Litter	Volume (Cft)	Volume (cum)	Reinforcement(kg)	Cement (begs)	Sand (cum)	Aggregate(Cum)	Admixture (litter)
Column	0.25	4330	130	6927	673	84	168	168

Estimation and Costing of Pile:

Estimation and costing of Pile are shown below in the following Table no. 4.4

Pile Length:52 ft

Total Pile:36 Nos.

Ratio: 1:1.5:3

Admixtures per bag: 250ml

Table no. 4.4 : Estimation and costing of Pile

Name	Admixture/ Litter	Volume (Cft)	Volume (cum)	Reinforcement(kg)	Cement (begs)	Sand (cum)	Aggregate(Cum)	Admixture (litter)
Pile	0.3	1768	53	2670	275	34	69	82

Estimation and Costing of Pile Cap:

Estimation and costing of Pile Cap are shown below in the following Table no. 4.5

Pile Cap Size (max): 9 ft.*9 ft. *2.16 ft.

Total Pile Cap: 7 Nos.

Ratio: 1:1.5:3

Admixtures per bag: 250ml

Table no.4.5: Estimation and costing of Pile Cap

Name	Admixture/ Litter	Volume (Cft)	Volume (cum)	Reinforcement(kg)	Cement (begs)	Sand (cum)	Aggregate(Cum)	Admixture (litter)
Pile Cap	0.3	2765	83	221	430	54	107	129

Conclusion: Sustainable Green Buildings Construction in Urban Environments

In conclusion, sustainable green buildings are essential for creating healthier and more efficient urban environments. They reduce energy use, save water, and lower harmful emissions, helping to protect the environment. By using eco-friendly materials and renewable energy, green buildings provide long-term benefits for both people and nature.

In urban areas, where space and resources are limited, green buildings offer smart solutions to challenges like overcrowding, pollution, and energy shortages. They improve the quality of life by making cities cleaner, greener, and more sustainable.

To achieve this, collaboration between governments, construction companies, and communities is crucial. With the right policies, technology, and commitment, green building practices can transform our cities into better places to live, now and in the future.