CERTIFICATE

This is to certify that the project entitled **"Green Design for AIKTC"** is a bonafide work of **Ms. Jagtap Disha Vikas (14CE02), Ms. Phalke Shweta Rangnath (14CE04), Ms. Shaikh Aafreen Naaz Nawab Ahmed (14CE05), and Ms. Shegle Ruheen Salauddin (15DCE73)** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of "Undergraduate" in "Civil Engineering"

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APPROVAL SHEET

This dissertation report entitled **"Green Design for AIKTC"** by **Ms. Jagtap Disha Vikas (14CE02), Ms. Phalke Shweta Rangnath (14CE04), Ms. Shaikh Aafreen Naaz Nawab Ahmed (14CE05) and Ms. Shegle Ruheen Salauddin (15DCE73)** is approved for the degree of "Civil Engineering"

Examiners

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Supervisors:

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Date:

Place: Panvel

DECLARATION

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

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ABSTRACT

This study has been highlighted on amalgamation of plants in building plan, which performs a fundamental part for the noise reduction, by the structure as well as refining the breathing condition into these vertical towns. All over the project work, it has been examined to establish the need of planting to merge into building, for the welfare of our economy, society and the environment. The facilities to integrate plants into building include the potential options like green wall, green roof and indoor potting plants that can be fused into the design. This study is mainly focused on the implementation of various types of green walls in the Anjuman-I-Islam's Kalsekar Technical Campus. Existing technologies for green installments like wall- mounted system, freestanding system, cable & wire net system, le-mur vegetal type system, free-falling system for green wall have been focused here.

Our group developed a viability study on the application of 'Green Wall' at the AIKTC Campus. Green walls have the capability to be a fresh sustainable resource for our campus to provide numerous environmental and economic benefits. After carrying out exploration on the different types of green walls and their features, our group selected to focus our report on the construction of a wall mounted system, free-standing system, le mur vegetal type system and cable & wire rope net system at the AIKTC campus. Our purpose was to ascertain the noise reduction effects a green wall could have for our campus and also defining whether it is a commercially practicable plan.

Our objective is to learn the environmental impacts and economic benefits a green wall could have for our campus and also determining whether it is a financially feasible project. To scrutinize the financial practicality of the project, we consulted green wall construction

companies to settle on the total installation, materials and maintenance fees and whether it would make the project self-sufficient.

Our group concluded with the estimation of the total construction cost of different types of green walls to be implemented in the AIKTC campus. Due to the absence of realistic proof from past green wall projects of comparable dimensions and climate, and trusting on imitations, we made a practical estimate of noise reductions. Moreover, green walls can lessen noise levels by 15 db having a sound absorption coefficient of 0.40. The green wall can also boost the concrete appeal of the building while enlightening the psychological fitness of the students and faculty due to the auxiliary greenery.

This topic has been chosen to provide analysis of the keys to one of the greater challenges of noise pollution we confront universally these days, so there must be some serious variations made in our daily life and surroundings.

Keywords— Amalgamation of Plants; Noise Reduction; Green Wall; Wall- Mounted System.

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ABBREVIATION NOTATION AND NOMENCLATURE

VCW	Vertical Vegetated Complex Walls
dB	Decibels
AIKTC	Anjuman- I- Islams' Kalsekar Technical Campus
EU-HEC	Enviro-Con Urban Hydro Environment Centre
WPM	Water Proof membrane

Chapter 1

Introduction

1.1 General

In today's world, many businesses and institutions are making sustainability their main priority. This is because of the adverse effects of environmental degradation, resource depletion, and climate change on our society. Our society is providing new environmentally friendly technologies to reduce carbon emissions, improve air quality and provide health benefits.

There is a new concept that is taking root, especially in urban environments: green walls[1] .Green walls are also known as a 'Vertical Vegetated Complex Walls' (VCW) either free-standing or part of a building, that have a vertical arrangement of living plants naturally removing the toxins and other unhealthy contaminants from the air that we breathe. Better than the old ivy-covered buildings, which can be adversely affected by the vines, these walls are designed to feature a variety of different plants in a vertical environment, and provide all of their needs for moisture and support right on the wall[1].

Green walls are particularly suitable for cities, as they allow good use of available vertical surface areas. They are also suitable in arid areas, as the circulating water on a vertical wall is less likely to evaporate than in horizontal gardens[2][3].

Also, plant selection will impact the design of the supporting system. For example, a denser, faster growing plant will require a greater space between supports than less aggressive species, which allow for smaller intervals between supports. The density of plant life will have further implications for the underlying structure, given that the greater the leaf surface area, the more impact snow and rain will have on the weight of the system[4]

1.2 Classification of Green Walls

Green walls can be classified in many ways. The following figure 1.1 represents the classification of green walls based on their position of implementation and their type of growth.

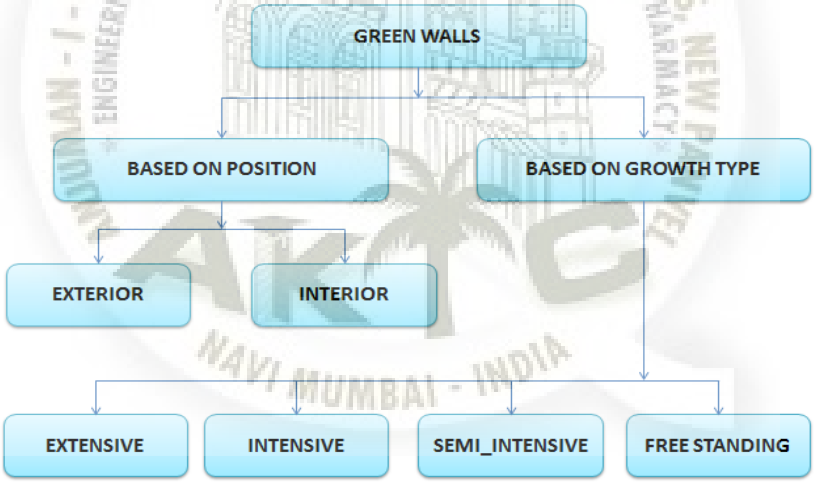

Figure 1.1 Classifications of green walls based on their position of implementation

A green wall can be located on either the interior or exterior of a building as shown in figure 1.2 and figure 1.3 below and they provide advantages in both situations.

Figure 1.2 Interior Green Wall [6]

Figure 1.3 Exterior Green Wall [7]

On the inside, they will filter and oxygenate the air, providing a healthier indoor environment, while also creating the calming effect that natural plant tends to have on most people[1]. On the outside, they will shade the wall from the intensity of the sun, and thus moderate the temperature considerably, as well as provide lovely textural contrast and beauty. Plant surfaces, because of transpiration, do not rise more than 4-5 °C above the ambient and are sometimes even cooler.

There are four general kinds of green walls - Extensive, Free Standing, Semi-intensive and Intensive. Figure 1.4, Figure 1.5, Figure 1.6, and Figure 1.7 shows the different characteristics and appearance of these green walls.

Figure 1.4 Extensive Green Wall [8]

Figure 1.5 Free-Standing Green Wall[8]

Figure 1.6 Semi- Intensive green Wall[8]

Figure1.7 Intensive Green Wall[8]

The following flowchart shows the classification of green walls based on the different types of construction as shown below in figure 1.8.

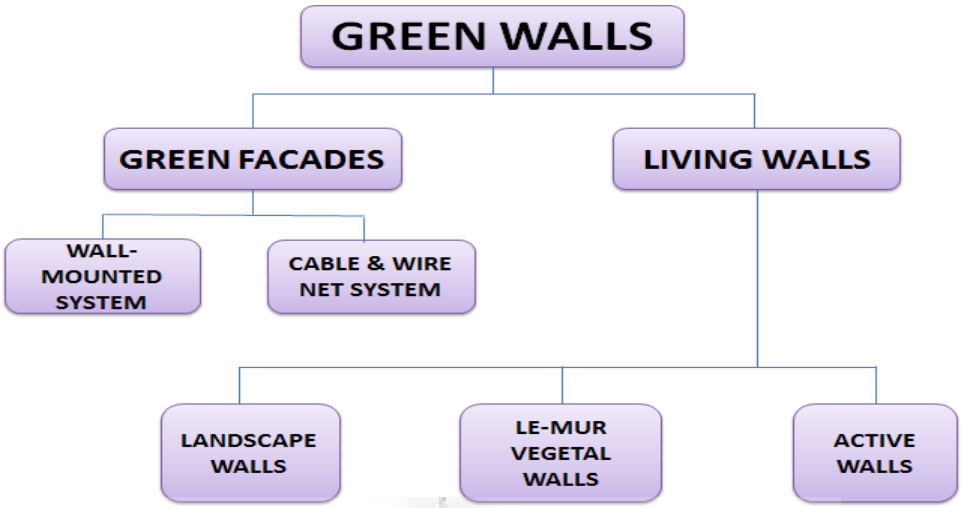

Figure 1.8 Classification of green walls based on type of construction

These systems allow the plants to grow and spread while preventing or minimizing damage to the structure. When grown up the wall of a building or other structure, it is important that there should be an efficient waterproof lining between the planting area and the supporting structure to keep water from seeping into walls [1].

Green façades are wall systems where climbing plants or cascading groundcovers are trained to cover specially designed supporting structures. Plant materials can be rooted at the base of the structures, in intermediate planters, or on rooftops. Rooted at the base of a green facade, climbing plants may take 3-5 years to achieve full coverage. Green façades can be attached to existing walls or built as freestanding structures[4].

The wall- mounted system consists of plants that are grown in containers. Modular panels can be comprised of polypropylene plastic containers, geotextiles, irrigation, and growing medium and vegetation. In this rigid light weight panels are installed vertically as either wall mounted or free-standing system. They can be used on tall buildings in conjunction with intermediate planters or on rooftops. These planters may be required where the growth of climbing plants is physically restricted.[4] Freestanding structures, such as green columns or canopy tree forms made of rigid panels, can be placed on either urban streets or rooftops where space is limited or weight is restricted. Irrigation drip lines are put in place to control the watering and feeding of the plants. Some long vines will grow and root their way up the wall as they climb. Main roots are embedded in the ground and the medium of the wall need only be kept moist to support the climbing roots. [1]

Cable and rope wire systems consist of a kit of parts that includes high-tensile steel cables, wire trellises, anchors, spacers, and supplementary equipment. Vertical and horizontal wires

can be connected through cross clamps to form a flexible trellis system in various sizes and patterns. To cover large areas, stainless steel wire-rope nets can be supported on flexible or rigid frames. [4]

Living walls (also called biowalls, “mur” vegetal, or vertical gardens) are composed of pre-vegetated panels or integrated fabric systems that are affixed to a structural wall or frame. This system supports a great diversity of plant species, including a mixture of groundcovers, ferns, low shrubs, perennial flowers, and edible plants. Living walls perform well in full sun, shade, and interior applications, and can be used in both tropical and temperate locations. Due to the diversity and density of plant life, living walls require more intensive maintenance (regular water, nutrients, fertilizer) than green façades. [4]

Living wall is an interior plants cape that can effectively remove common indoor contaminants and improve the living environment. It represents the hybridization of science and art to deal with real problems of indoor air quality in an aesthetic and sustainable manner. At first glance, the living wall appears as a vertical hydroponic green wall containing a wide range of foliage and flowering plants specifically selected for each site. Living walls may also be a means for water reuse. The plants may purify slightly polluted water by absorbing the dissolved nutrients. Bacteria mineralize the organic components to make them available to the plants. [4]

Some active living walls are integrated into a building's air circulation system so that the air is actually passed through the root system where most of the pollutants are filtered out [1] [5] as shown in figure 1.9.

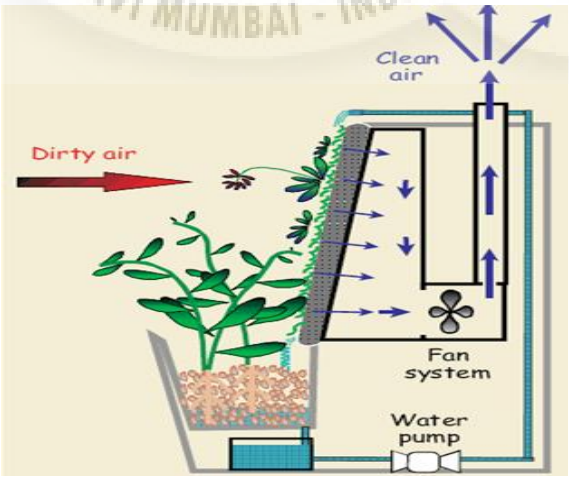

Figure 1.9 Active Living Walls [9]

1.3 Benefits of Green Wall

The integration of plants in structures brings along with a whole lot of benefits. It provides us with purer air supply, reduced noise levels, reduces stress, improves health and provides ecological biodiversity with an aesthetical view too. The concept of introducing plants in buildings becomes important due to the advent of various polluting elements in our environment and due to the reduction in spaces available for planting trees. The benefits of green walls are listed below:

Public Benefits:

- Aesthetic Improvements
- Improved Exterior Air Quality
- Local Job Creation

Private Benefits:

- Improved Energy Efficiency
- Building Structure Protection
- Improved Indoor Air Quality
- Noise Reduction

Design-Specific Benefits:

- Increased Biodiversity
- Improved Health and Well Being
- Urban Agriculture

Human benefits:

- Aesthetics
- Health and Wellbeing
- Dust suppression
- Noise reduction

Environmental Benefits:

- Enhances and protects biodiversity and ecosystems
- Improves air and water quality
- Reduces waste streams.
- Conserves and restores natural resources

Economic Benefits:

- Reduces operating costs

- Creates, expands and shapes markets for green product and services
- Improves occupant productivity
- Optimize life-cycle economic performance

Social Benefits:

- Enhance occupant comfort and health
- Heightens aesthetic qualities
- Minimizes strain on local infrastructure
- Improves overall quality of life

1.4 Background of Study

Humans have developed in amalgamation with nature. Humans depend on plants up to the same extent as plants depend on humans. Therefore, it is important to have a union of plants with human habitats, as they are inter-dependent. Moreover, due to urbanization, where concrete structures dominate, there is an alarm about exposure to nature for humans.

Plants were one of the most under developed resource in terms of utilizing them in building practices. They were mostly utilized for food, building materials, clothes, fuel, pharmaceuticals etc. Over a thousand years, plants have been used as indoor potting materials in houses. With the dawn of contemporary technology, planners and designers are heading on for green structures. Now a day the concept of green infrastructure has taken a boost.

The concept of green walls is as old as the Babylonians, as in the famous Hanging Gardens of Babylon [10] as shown in figure 1.10. Patrick Blanc, the French botanist, popularized the modern concept of green walls. His style of vertical garden is called 'Le Mur Vegetal'. He is known as the 'Father of the Modern Vertical Garden' (Figure 1.11).

Figure 1.10 Hanging Gardens of Babylon[11]

Figure 1.11 Patrick Blanc, the French botanist[12]

He is famous for his modern art, design and urban environmental benefits, which include air filtration and endorses biodiversity. He observed how plants were able to grow vertically

without the need for soil in the wild, and soon developed a way to create artistic vegetation walls that were both lightweight and needed little maintenance. Since these living walls only weigh approximately 30 kg or less per square-meter, he noticed that just about any type of wall would be able to support the weight of a vertical garden. [1] This popular French museum near the Eiffel Tower in Paris as shown in figure is home to one of the best examples of vertical garden work by artist Patrick Blanc. The living wall here is about 200 meters long and 12 meters tall. [13]

The first successful large indoor green wall was built in 1986 at Paris. Hyderabad International Airport was the first green wall project in India, and at that time, it was the first tallest indoor green wall in Asia Pacific Figure 1.12.

Figure 1.12 Hyderabad International Airport [14]

1.5 Problem Identification

Space is a great hindrance in every city. Buildings are going vertical to overcome this limitation and to make the most of the existing space. In the same manner, plants can also grow in the upward direction. It is the most suitable way to go vertical for the ones who love tiny patches of green in their properties. With nationwide prominence on being environment friendly & preserving resources, the green technology have been implemented at many places across India. It is emerging out as an option to reduce the various ill effects of concrete building.

1.6 Aim

The aim of this project is to discover out all the likely means to incorporate plants into buildings and to evaluate how the implementation of plants into the building design in AIKTC

can assist in noise reduction, develop the atmosphere and boost the breathing condition. It includes preparation and installation of the green technologies like the green walls.

1.7 Objectives

- To find out the provisions to integrate plants into the design in AIKTC
- To analyze their impacts on living environment
- To explore the procedures of structuring the different ways of incorporating plants in AIKTC

Chapter 2

Literature Review

2.1 General

2.2 Review of Literature

The demographic trends of India indicate a consistent rise in urbanization. It is estimated that by 2030, over 33% of the total Indian population would be living in urban areas. The rising population and rapid urbanization would push the demand for housing and commercial spaces, providing a further impetus to the growth of the construction sector in the country [15].

Energy is consumed during the construction of a building, during the operation of the building, for maintenance and finally for its demolition. Along with this, the current trend and speed of urbanization makes the situation worrisome. There is a constant demand for new buildings in the residential and commercial sector. It is expected that by 2030, 47.1% of Indian population would be living in urban centres. [16]

Buildings are integrated systems which interact with the environment, rather than being a collection isolated, independent components and an 'integrated approach' to building design and operation is the key to achieve sustainability in future buildings. [17]

Green building is one of measure that has been put forward to mitigate significant impacts of the building stock on the environment, society and economy. However, there is lack of a systematic review of this large number of studies that is critical for the future endeavour. The last decades have witnessed rapid growing number of studies on green building. This paper reports a critical review of the existing body of knowledge of researches related to green building. The common research themes and methodology were identified. [18]

These common themes are the definition and scope of green building; quantification of benefits of green buildings compared to conventional buildings; and various approaches to achieve green buildings. It is found that the existing studies played predominately focus on the environmental aspect of green building. Other dimensions of sustainability of green building, especially the social sustainability is largely overlooked. Future research opportunities were identified such as effects of climatic conditions on the effectiveness of green building assessment tools, validation of real performance of green buildings, unique demands of specific population and future proofing. [18]

Plants are essential for our survival. They provide food, fiber, building material, fuel, and pharmaceuticals. Plants also produce intangible benefits for people, such as improving our health. These benefits occur with plants outdoors and indoors. People have been bringing plants into their homes for thousands of years. We increasingly work indoors, and we are making ample use of plants in these spaces as well. Plants indoors have many benefits. Physically, they contribute to cleaner, healthier air for us to breathe, thus improving our well-being and comfort. They make our surroundings more pleasant, and they make us feel calmer. Interior plants have been associated with reduced stress, increased pain tolerance, and improved productivity in people. [19]

Research studies documenting some of the benefits associated with interior plants are discussed. Of increasing interest to many people is the question of why plants have intangible positive effects on us. If we understand this, then we can make better recommendations regarding the use of plants indoors and out to enhance their effects of people. Studies indicate that people have learned and innate responses to plants. Some of these responses appear to have genetic components. Specific studies are summarized, and potential applications of the results of these studies are presented. [19]

Current systems for greening the buildings envelope are not just surfaces covered with vegetation. Greening systems, as green roofs and green walls, are frequently used as an aesthetical feature in buildings. However, the current technology involved in these systems can maximize the functional benefits of plants to buildings performance and make part of a sustainable strategy of urban rehabilitation and buildings retrofitting. During the last decades, several researches were conducted proving that green walls can contribute to enhance and restore the urban environment and improve buildings performance. Therefore, it is important to understand the main differences between systems in terms of composition and construction methods. [10]

Most recent developments in green walls are mainly focused in systems design in order to achieve more efficient technical solutions and a better performance in all building phases. Yet, green wall systems must evolve to become more sustainable solutions. In fact, continuing to evaluate the contribution of recent green wall systems to improve buildings performance and comparing the environmental impact of these systems with other construction solutions can lead to an increase of their application in buildings and therefore result in a reduction on these systems cost. The decision of which green wall system is more appropriate to a certain project must depend not only on the construction and climatic restrictions but also on the environmental impact of its components and associated costs during its entire lifecycle. [10]

Greenery on buildings is being consolidated as an interesting way to improve the quality of life in urban environments. Among the benefits that are associated with greenery systems for buildings, such as energy savings, biodiversity support, and storm-water control, there is also noise attenuation. Despite the fact that green walls are one of the most promising building greenery systems, few studies of their sound insulation potential have been conducted. In addition, there are different types of green walls; therefore, available data for this purpose are not only sparse but also scattered. To gather knowledge about the contribution of vertical greenery systems to noise reduction, especially a modular-based green wall, two different standardized laboratory tests were conducted. The main results were a weighted sound reduction index (R_w) of 15 dB and a weighted sound absorption coefficient (a) of 0.40. It could be concluded that green walls have significant potential as a sound insulation tool for

buildings but that some design adjustments should be performed, such as improving the efficiency of sealing the joints between the modular pieces. [20]

Chapter 3

Materials and Methodology

3.1 General

The following points will be useful for arrangement of various green technologies to obtain maximum benefit from it:

- Large walls can easily handle plants over three feet in height.
- Each plant covers between ½ to over 3 square feet of wall area.
- According to this assumption, one plant for every 1.3 square feet and 8 plants per square metre.
- Plants with lots of small leaves are useful as they scatter and diffuse sound. [20]
- Experiments have shown that arrangement of different plants in groups appear to work better than one big one.

- Position several arrangements around a space rather than concrete them in one location.
- In this way, the surface area of the plants exposed to noise may be maximized.
- Plants placed at the edges and corners are better than plants in the middle.
- Troughs and barrier planters should be placed a few centimetres away from the walls so that they can absorb reflected sound reaching them directly. [22]
- Avoid large plants that will put a lot of pressure on the angled root area when growing a pocket system vertical garden. Lightweight leaved plants, plants that cascade and plants that grow in mounds close to the root area are the best selections. Succulents, for example, make fine choices as most will hug the wall, are drought tolerant and form decorative and varied foliage that offer interesting shapes, textures and colors in both leaf and flower. [2]
- Angling them slightly away from being parallel with the wall will also help to disperse reflected sound. [13]
- Screen plants should be used instead of office partitions in admins of the respective departments that prove to be cheaper than acoustic panels.
- Plants used in vertical exterior applications are exposed to harsher climatic conditions than those at indoors and as a result, hard species should be selected for projects that intend to reach great heights. Similarly, climbers with a tolerance for wind, frost, and heat should be selected for projects in less hospitable climates. [1]

No two green walls are identical, so the associated costs and benefits have to be calculated separately. Capital and maintenance cost depends on:

- Project size
- System Size
- Support structure requirements
- Complexity of design (use of standard or custom components)

- Cost of installation and labour
- Local availability of materials
- Type of plants used
- Short and long term maintenance

3.2 Tasks

- In order to accomplish our objective of this project by the end of the academic year, we have created three main goals to address the feasibility of a green wall. These goals were further divided into tasks to be completed over the academic year.
- Our first goal is to address the proper type of green wall that should be built and its cost and design. Factors we will address are the location and climate of our campus year round and how a green wall can survive. In order to determine the proper plant selection, we contacted with green wall consultancies viz., ‘’Trees and Trunks’ in Kopar Khairane and ‘Sadabahar Nursery’ located in Panvel, to provide information on local green walls. With this information and other research, we can calculate the total installation and materials cost for a green wall for the campus.
- The next goal is to determine the expected noise reduction due to green walls at the AIKTC campus. In order to reach this goal, we prepared multiple models and obtained research documents on the possible noise reduction due to green walls.
- The last goal was to implement this technology in our campus. We received a sponsorship from Dr. Vinay Nikam (Enviro-Con Urban Hydro Environment Centre (EU-HEC), Thane) regarding the implementation of wall-mounted type green wall in the AIKTC campus.

3.3 Materials

The following are the various materials required for the implementation of green walls in the campus:

Garden Tools:

- Forks & Spades
- Rakes
- Hand Trowel
- Pruners
- Dutch hoe
- Pruning Saw
- Shears
- Hori-Hori-Knife
- Loppers
- Foggers
- Edger

Plants & Shrubs:

The plants used for a living wall vary depending on the amount of sunlight available, the space available, the location on the wall, different exposure to water, and whether your living wall is indoors or outdoors. There are also many vegetables that have been grown successfully in living walls. Species are usually selected based upon their tolerance of growing system, site-specific environmental conditions, color, texture, rates of propagation, and root systems. The panels support groundcovers, ferns, low shrubs, perennial flowers, and edible plants. Pre-vegetated living walls offer an instant green wall for immediate impact. Green façades use climbing plants, which are divided into self-supporting plants (root climbers and adhesive-suckers) and plants that need supporting structure (twining vines, leaf-stem climbers, leaf climbers, and scrambling plants). Climbers vary by hardiness, orientation, and climate. [3] Some of the names [23] are listed below with their images as shown in figure 3.1:

- Philodendron Selloum Golden
- Chlorophytum, Spider Plant (Dark Green)
- Golden Pothos, Money Plant
- Chamaedora Seifrizii, Bamboo Palm Plant
- Shevanti Chrysanthemum (Pink)

- Hedera Helix, English Ivy
- Dracaena Marginata
- Delosperma Congestum Plant
- Rhoeo Spathacea Tricolor, Rhoeo Variegated
- Lantana (Yellow)
- Lantana (White)
- Milky-way Ribbon Grass, Chlorophytum Charlotte
- Portulaca, 9'O Clock (Pink)
- Portulaca, 9'O Clock (Red)
- Portulaca, 9'O Clock (White)
- Portulaca Oleracea, 10'O Clock (Yellow)
- Portulaca Oleracea, 10'O Clock (Pink)
- Portulaca Oleracea, 10'O Clock (White)
- Honeysuckle, Lonicera Periclymenum (Scentsation)
- Ipomea, Morning Glory
- Passiflora Incarnata (Purple), Krishana Kamal
- Madhumati Dwarf, Rangoon Creeper
- Passiflora Sherry (Red)
- Bougainvillea (Pink)
- Curtain Creeper, Vernonia Creeper, Parda Bel
- Schefflera Plant
- Peace Lily, Spahiphyllum
- Pleomele, Song of India (Green)
- Sansevieria Trifasciata Golden Hahnii, Snake Plant
- Scilla Violacea, Ledebouria Pauciflora
- Philodendron Ceylon Golden
- Pleomele, Song of India (Golden)
- Sansevieria Trifasciata Hahnii, Snake Plant
- Money Plant Marble Queen
- Money Plant Marble Prince

Figure 3.1 Plants for Green Walls [23]

Accessories:

- Aluminum Angle Section
- Aluminum Strip (32 x 3) mm
- S.S Hex Bolts 202Q 6 mm dia., length 35 mm
- S.S Hex Bolts 202Q 8 mm dia., length 40 mm
- PVC Trays (241.3 x 88.9 x 76.2) mm
- Water Proof membrane (WPM)
- Vegetative Panels (1 m^2 each)
- Jali Wire Mesh (25 x 25) 11 Guage
- Plastic mesh
- Wooden Strip
- Moss Sheet (242 sq mm each)
- ½ HP pump
- Polyethylene Pipes for Drip Irrigation (Horizontal 16 mm dia, 10 m roll)
- Fertilizer
- Red soil
- Coco-peat (250 g pack each)
- Mounting clips (Stainless steel braided cables)
- Water supply lines (½ inches) / Vertical feeder pipes (19 mm dia)
- Drilling machine
- Water and power supply for drip irrigation

3.4 Methodology

- **Step I:**

The whole campus was surveyed by referring the floor plans of AIKTC College and also by actual measurement to find out the different options to integrate the green wall technologies like wall-mounted system, le- mur vegetal, green screens, free- falling system, free- standing and moss columns in the campus design.

- **Step II:**

The next step was to measure with the help of measuring tapes, the area to be covered under green wall of each different type to integrate the green wall technologies.

- **Step III:**

Further the estimation of cost of construction of one meter square of green wall of each different type was calculated by obtaining information about the different materials required for its construction by consulting various green wall consultancies.

- **Step IV:**

Construction of some models of different types each

- **Step V:**

Effect of green wall on sound absorption was calculated based on the previous research work which was assumed be reduced by 15 decibel.

The following figure 3.2 showns the flowchart of the methodology adopted :

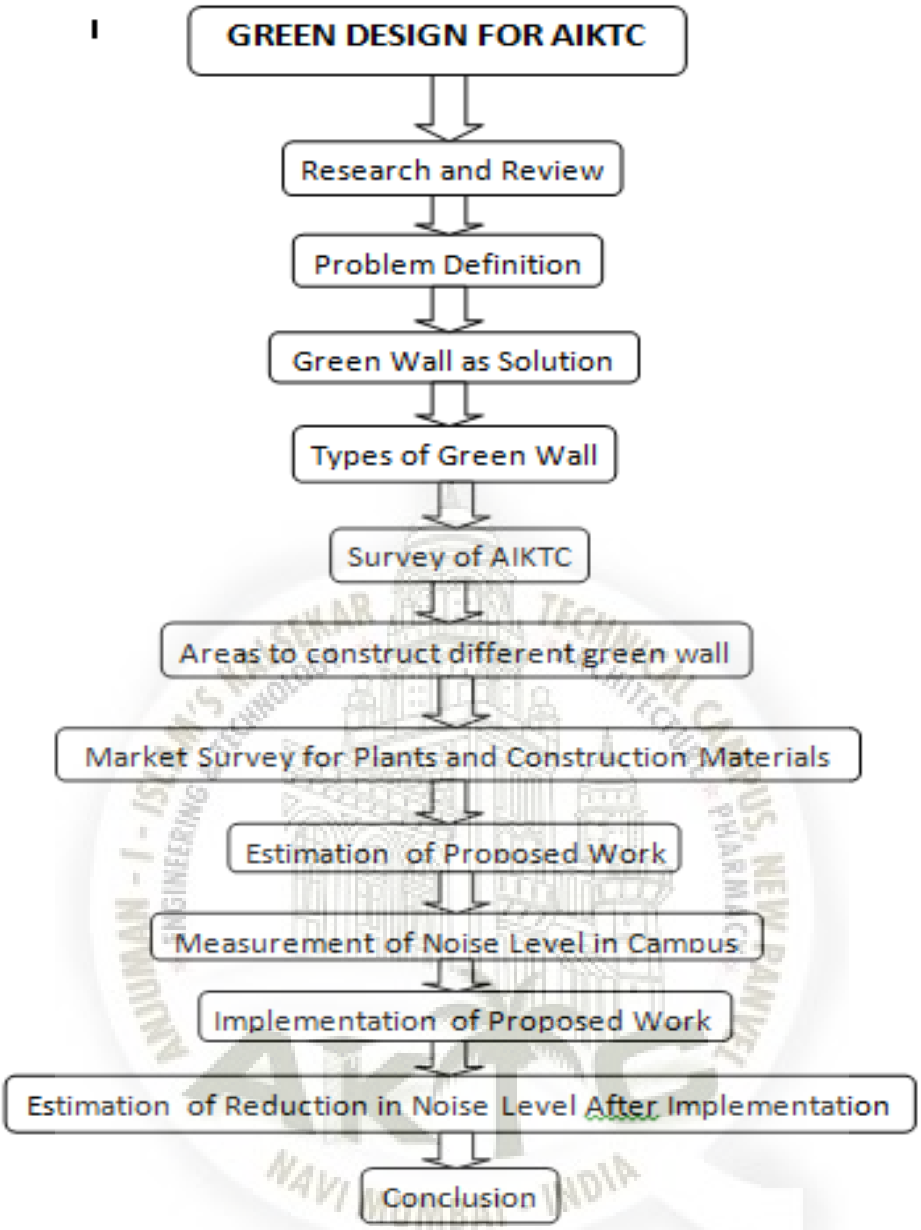

Figure 3.2 Flowsheet for Methodology

Chapter 4

Case Study and Data Collection

4.1 Prepared Models

Some small-sized models were prepared to give an idea about the different types of green walls to be implemented in the AIKTC campus. The different types of models prepared are listed as:

- Free- Standing Model
- Green Screens Model
- Wall- Mounted Model

4.1.1 Free- Standing Model - Preparation

A model has been prepared (Figure 4.1) in the form of a standing frame system on which plants are planted in pots and the frame can be fixed to any wall. We had contacted 'Shree Mahalaksmi Aluminium Electric & Hardware' located in New Panvel for construction of the freestanding frame. It was constructed by placing 3 horizontal aluminium channels between 2

vertical aluminium angles, which were connected to each other by a bolted connection. To this arrangement, a plastic wire mesh of 5 mm spacing was attached with plastic zippers across the vertical inner face of the frame model. Further, the plants like Spider plant (Chlorophytum Comosum Airplane plant), Pothos, Dieffenbachia, Monstera Acacogayensis, Philodendron (Boston Fern) were potted in pots and were placed on the aluminium channels and fixed with jute ropes to the plastic frame. Presently, the plants in the model are kept for their full growth under care and maintenance. This model will form a part of our final implementation of green walls in the AIKTC campus.

Figure 4.1 Free- Standing Model

(Source: AIKTC Garden Engineering Building)

4.1.2 Free- Standing Model – Estimation

Dimensions of model	(0.3048x0.6096) m
Area of model	0.185 m^2

Each panel will be constructed by using four aluminium angle sections. The specifications of the aluminium angle section are as follows:

Dimension of aluminium rectangular section	(0.6096x0.1016x0.0254) m
Rate of an aluminium rectangular section	Rs. 13.716 per m
Number of rectangular sections used	03 Nos.

Cost of rectangular section	Rs.12.54/-
Total length of angle section used	1.83m
Rate of aluminium angle section	Rs.12.192 per m
Cost of angle section	1.83x12.192=Rs.22.3/-
Cost of all aluminium angle sections	**Rs.34.83 /-**

A jali welded mesh is needed as a support system to help the climbers to climb up the surface of wall. Its description is as follows:

Jali welded mesh	25 * 25, 11 guage
Rate of jali welded mesh	Rs. 400 per m^2
Cost of jali welded mesh of given area	**0.185x400 = Rs. 74.322/-**

Now, S.S. Hex Bolts 202Q 8mm dia., length 35 mm will be required to connect the pre-vegetated panels onto the wall. The specifications of the bolt is as follows:

Rate of 8 mm dia. bolt per piece	Rs. 3/-
Total bolts required for model	20 nos.
Total cost of bolts for model	**Rs. 60/-**

Now, finding out the quantity of plants required for the estimated area of green wall:

Number of plants	9 nos.
Approximate rate per plant	Rs. 50/-
Cost of plants for model	50 x 9 = Rs. 450/-
Number of pots used	9 Nos.
Rate per pot	Rs.10/-
Cost of pots	**Rs.90/-**

Now, calculating the quantity of coco peat bag required to fill the trays:

Rate of coco peat per kg	Rs. 10/-
Approximate number required	6 nos.
Cost of coco peat for all pots	**Rs. 60/-**

Thus, the total cost of construction of this type of green wall is as follows:

Cost of all aluminium angle sections	Rs.34.83 /-
Cost of jali welded mesh	Rs. 74.322/-
Total cost of bolts for given area	Rs. 60/-
Cost of plants for model	Rs. 450/-
Cost of pots	Rs.90/-
Cost of coco peat	Rs. 60/-
Total cost of construction of model	**Rs. 769.15/-**

Now, certain additional amount is to be added to the total cost of green wall which is as follows:

Shipping Charges	Rs. 150.0
Labour and construction cost	Rs. 580.84
Total	**Rs. 730.84/-**

Now, the total cost of green wall is calculated as follows:

Cost of construction of green wall	Rs. 769.15/-
Additional cost	Rs. 730.84/-
Total cost of construction of green wall	**Rs. 1,500/-**

4.1.3 Green Screens Model- Preparation

A model has been prepared in the form of mesh type green screens consisting of creepers (figure 4.2). An area was selected for implementation of this type of green wall. Curtain Creeper (Vernonia Creeper, Parda Bel) were potted in trays were placed at the top. A plastic mesh was fixed with the help of bolts on the wall below the trays. Creepers on full growth came down the wall with the support of the mesh.

Figure 4.2 Green Screens Model

(Source: AIKTC Entrance Wall)

4.1.4 Green Screens Model- Estimation

The following information about the wall on which a green screen type of green wall is to be constructed was obtained by actual measurement by using an engineer's tape and with the help of floor plans of AIKTC, which is as follows:

Dimensions of wall	(3 x 1.25) m
Area of wall	3.75 m^2

A plastic mesh is needed as a support system to help the climbers to climb up the surface of wall. Its description is as follows:

Dimension of mesh	(3 x 1.25) m

Rate of plastic mesh	Rs. 48 per m^2
Cost of plastic mesh	**3.75 x 48 = Rs. 180/-**

Now, S.S. Hex Bolts 202Q 8mm dia., length 35 mm will be required to connect the plastic mesh onto the wall. The specifications of the bolt is as follows:

Rate of 8 mm dia. bolt per piece	Rs. 3/-
Total bolts required	4 nos.
Total cost of 8 mm dia. bolts	4 x 3 = **Rs. 12/-**

Now, PVC trays will be required to be placed on the wall. The specifications of the PVC trays is as follows:

Dimensions of PVC tray	(360 x 230 x 230) mm
Number of PVC trays required to cover given area	5 nos.
Rate of PVC tray	Rs. 70 per piece
Total cost of PVC trays to cover all areas	5 x 70 = **Rs. 350/-**

Now, finding out the quantity of plants required for the estimated area of green wall:

Approximate, number of plants to cover one pot	2 nos.
Total number of plants	2 x 5 = 10 nos.
Approximate rate per plant	Rs. 40/-
Total cost of plants for entire area	**40 x 10 = Rs. 400/-**

Now, calculating the quantity soil required to fill the trays:

Rate of one pack of 1 kg of soil	Rs. 30/-
Approximate number of 1 kg of soil bag required	2 nos.
Cost of soil for all pots	**Rs. 60/-**

Thus, the total cost of construction of this type of green wall is as follows:

Cost of plastic mesh of given area	Rs. 180/-
Total cost of bolts for given area	Rs. 12/-
Total cost of PVC trays to cover all the four corners	Rs. 350/-
Cost of plants	Rs. 400/-
Cost of soil	Rs. 60/-
Total cost of construction of green wall	**Rs.1,002 /-**

Now, certain additional amount is to be added to the total cost of green wall which is as follows:

Shipping Charges	Rs. 200.0
Fertilizer Charges	Rs. 200.0
Total	**Rs. 400/-**

Now, the total cost of green wall is calculated as follows:

Cost of construction of green wall	Rs. 1,002/ -
Additional cost	Rs. 400.0
Total cost of construction of green wall	**Rs. 1,402/-**

4.1.5 Wall- Mounted Model- Preparation

A wall-mounted model (figure 4.3) was prepared with the help of ready- to- fix frames on which pots were attached. In these pots asparagus plants were planted. The model was fixed on the wall with the help of bolts.

Figure 4.3 Wall- Mounted Model

(Source: AIKTC)

4.1.6 Wall- Mounted Model- Estimation

Two PVC trays of length 520 mm by width 175 mm consisting of 6 pots were used to prepare this wall mounted model.

Total cost of PVC frame	Rs. 650/-
Cost of plants	6 x 30 = 180/-
Number of bolts	6 nos.
Cost of one bolt	Rs. 3/-
Total cost of bolts	6 x 3 = 12/-
Total cost of model	**Rs. 842/-**

Chapter 5

Results and Discussions

5.1 Proposed Work

The implementation of Green Design for AIKTC was planned to make it a green and clean building. The whole campus was surveyed to find out the different options to integrate this technology in the campus design. All the spots where this green design can be installed were photo-hooted. A few of them are shown below with the before and after images collaged to obtain a clear idea about the same. Figure 5.1 shows the implementation of wall- mounted system on the walls. It will form an exterior green wall system. Figure 5.2 shows the installation of le- mur vegetal type system in a rectangular form. It will form an interior green wall system. Accurate plant spacing is required for the anticipated coverage. Figure 5.3 shows the integration of green screens for the corners of the buildings extending up to the top of the building forming an exterior wall system. Figure 5.4 shows the free- falling type of green wall to be implemented. Figure 5.5 shows the placement of moss media on the columns of the building with a specific pattern to gain an aesthetical view forming an interior wall system. Moss grows in shade and moisture. So it is better to adopt it on the interior walls or columns.

Figure 5.1

Wall- Mounted System (Source: Entrance Wall, Engineering building, AIKTC and [24])

Figure 5.2

Le- Mur Vegetal (Source: Lobby Wall, Engineering building, AIKTC and [25])

Figure 5.3

Green Screens (Source: Entrance Corner, Engineering building, AIKTC and [26])

Figure 5.4

Free- Falling System (Source: First Floor Balcony, Engineering building, AIKTC and [27])

Figure 5.5

Moss Sheet Wall (Source: Entrance Column, Engineering building, AIKTC and [28])

These are some of the proposed work but care is also taken by considering to put a proper waterproof PVC sheet separation between the walls and the green media so that it does not erode the structure. Some of the systems require (3-5) years to become abundantly instituted.

The following types of green walls were proposed to be constructed in the AIKTC:

- Wall- Mounted System
- Le- Mur Vegetal System
- Green Screens
- Free- Falling System
- Moss Sheet Wall

The estimation and costing of eight different types of green walls has been calculated. They are as under.

5.1.1 Wall- Mounted System – Estimation

This type is proposed on the entrance wall of the Engineering building. This type will consist of panels to be constructed and such number of panels will occupy the whole area. The following information about the wall on which a Wall- Mounted System is to be constructed obtained by actual measurement by using an engineer's tape and with the help of floor plans of AIKTC, which is as follows:

Dimension of wall	(3.0 x 2.0) m
Total area of wall	6 m^2

Now, PVC trays will be required to be attached along the aluminium strip. The specifications of the PVC trays are as follows:

Dimensions of PVC tray	180 mm dia. ie., 7 inches
Number of PVC trays required to cover 1-meter length	5 nos.

Rate of PVC tray	Rs. 70 per piece
Number of PVC trays required to cover 1-meter length	5 x 5 = 25 nos.
Cost of 25 PVC trays per panel	25 x 70 = **Rs. 1,750/-**

Now, stainless steel J hooks will be required to fix the trays to the wall. The cost of the hooks is as follows:

Rate of hook per piece	Rs. 18/-
Number of hooks required to fix the trays	25 nos.
Cost of hooks per panel	**Rs. 450/-**

Now, S.S. Hex Bolts 202Q 6mm dia., length 35 mm will be required to connect the hooks onto the wall. The specifications of the bolt are as follows:

Rate of 6 mm dia. bolt per piece	Rs. 2/-
Total bolts required per panel	25 x 2= 50 nos.
Cost of 6 mm dia. bolts per panel	50 x 2 = **Rs. 100/-**

Now, a polypropylene geotextile waterproof membrane will be required to cover the exposed wall area, to protect it from damping. The details are as follows:

Length per roll	100 m
Width of sheet	1 m
Thickness of sheet	0.8 mm
Colour of sheet	Black
Rate of polypropylene sheet	**Rs. 15/ m^2**

Thus, the total cost for **one such panel** will be as follow:

Cost of 25 trays	Rs.1,750.0
Cost of hooks per panel	Rs.450.0

Cost of 20 bolts of 6 mm dia.	Rs.100.0
Cost of plastic WPM	Rs.15.0
Total cost of 1 m^2 i.e., one panel	**Rs.2,315/-**

Now, working out the cost for the whole wall area:

Number of panels of 1 m^2, required to cover the area	6 nos.
Total cost of 6 panels	2,315 x 6 = **Rs. 13,890/-**

Now, finding out the quantity of plants required for the estimated area of green wall:

Approximate, number of plants to cover an area of 1 m^2	25 nos.
Plants required to cover an area of given wall	25 x 6 =150 nos.
Approximate rate per plant	Rs. 50/-
Cost of plants per panel	50 x 25 = Rs. 1,250/-
Total cost of plants for entire area	**1,250 x 6 = Rs. 7,500/-**

Now, calculating the quantity of coco peat packs required to fill the trays:

Rate of one pack of 50 kg of coco peat	Rs. 250/-
Approximate number of 50 kg of coco peat bag required	3 nos.
Cost of coco peat for all panels	**Rs. 750/-**

Now, drip irrigation horizontal and vertical polyethylene pipes of 16 mm dia., are required. The details are as follows:

Rate of polyethylene pipe of 16 mm dia.,	Rs. 250 per 10 m roll
Horizontal length to be covered by drip pipe	3.57 x 10 = 35.7 m
Vertical length to be covered by feeder pipe	2.08 m

Total length of irrigation pipe required	35.7 + 2.08 = 37.78 m ie., 40 m
Number of 10 m rolls of polyethylene pipe required	40/10 = 4 rolls
Total cost of polyethylene irrigation pipes	**4 x 250 = Rs. 1,000**

Thus, the total cost of construction of this type of green wall is as follows:

Cost of all 6 panels	Rs. 13,890.0
Cost of plants for all 6 panels	Rs. 7,500.0
Cost of coco peat for all PVC trays	Rs. 750.0
Cost of polyethylene irrigation pipes	Rs. 1,000.0
Cost of construction of green wall	**Rs. 23,140/-**

Now, certain additional amount is to be added to the total cost of green wall which is as follows:

Shipping Charges	Rs. 1,000.0
Fertilizer Charges	Rs. 1,000.0
Miscellaneous	Rs. 1,000.0
Total	**Rs. 3,000/-**

Now, the total cost of green wall is calculated as follows:

Cost of construction of green wall	Rs. 23,140.0
Additional cost	Rs. 3,000.0
Total cost of construction of green wall	**Rs. 26,140/-**

Now, certain contingencies must be added to the final estimated cost such as follow:

Contingencies	**Percent**	**Cost**

Escalation	3 %	Rs. 784.2
Construction	5 %	Rs. 1,307.0
Labour	5 %	Rs. 1,307.0
Total	-	**Rs. 3,398.2/-**

The amount including the contingencies that will be the grand cost of construction of this type of Wall- Mounted System wall is as follows:

Total cost of construction of green wall	Rs. 26,140/-
Total contingencies	Rs. 3,398.2
Grand Cost of Construction of Wall- Mounted System	**Rs. 29,538.2 ie., 30,000/-**

5.1.2 Patrick Blanc's- Le Mural Vegetal- Estimation

The second type of green wall design proposed is Patrick Blanc's Le Mur vegetal type of green wall. This type of green wall is proposed to be constructed on an ground floor interior wall in the entrance lobby. The following information about the wall on which a Le Mur vegetal type of green wall is to be constructed was obtained by actual measurement by using an engineer's tape and with the help of floor plans of AIKTC, which is as follows:

Dimensions of green wall	(10 x 2) m
Area of green wall	20 m^2

It consists of pre-vegetated panels, which are then fixed on walls. The rate such panels are obtained from dealers, which are Rs. 3,000/- per panel.

Now, S.S. Hex Bolts 202Q 8mm dia., length 35 mm will be required to connect the pre-vegetated panels onto the wall. The specifications of the bolt are as follows:

Rate of 8 mm dia. bolt per piece	Rs. 3/-
Total bolts required per panel	12 nos.
Cost of 8 mm dia. bolts per panel	12 x 3 = **Rs. 36/-**

Now, a plastic waterproof membrane (WPM) will be required to cover the exposed wall area, to protect it from damping.

Cost of plastic WPM	**Rs. 15/ m^2**

Thus, the total cost of such panels will be as follow:

Cost of one pre-vegetated panel	Rs. 3,000.0
Cost of 12 bolts of 8 mm dia.	Rs. 36.0
Cost of plastic WPM	Rs. 15.0
Total cost of 1 m^2 i.e., one panel	**Rs. 3,051.0**
Number of panels of 1 m^2, required to cover the area	20/1 = 20 nos.
Total cost for 20 panels	20 x 3,051 = **Rs. 61,020/-**

In this type, the cost of plants is already included in the pre-vegetated panels used. However, the plants to be used for this type may include:

Schefflera Plant
Peace Lily, Spathiphyllum
Pleomele, Song of India (Green)
Sansevieria Trifasciata Golden Hahnii, Snake Plant

Scilla Violacea, Ledebouria Pauciflora
Philodendron Ceylon (Golden)
Money Plant Marble Queen
Money Plant Marble Prince
Pleomele, Song of India (Golden)
Sansevieria Trifasciata Hahnii, Snake Plant

Now, a wooden strip will be required to border the panels, which is calculated as follows:

Total length of wooden strip	(10 x 2) + (2 x 2) = 24 m
Rate of wooden strip	Rs. 4.92 per m
Cost of wooden strip required	**24 x 4.92 = Rs. 118.08/-**

Now, total cost of this type of green wall is as follows:

Total cost for 20 panels	Rs. 61,020/-
Cost of wooden strip required	Rs. 118.08/-
Cost of Le Mur Vegetal type green wall	**Rs. 61,138.08/-**

Now, certain additional amount is to be added to the total cost of green wall, which is as follows:

Shipping Charges	Rs. 1,000.0
Fertilizer Charges	Rs. 1,000.0
Miscellaneous	Rs. 1,000.0

Total	**Rs. 3,000/-**

Now, the total cost of green wall is calculated as follows:

Cost of construction of green wall	Rs. 61,138.08/-
Additional cost	Rs. 3,000.0
Total cost of construction of green wall	**Rs. 64,138.08/-**

Now, certain contingencies must be added to the final estimated cost such as follow:

Contingencies	**Percent**	**Cost**
Design	10 %	Rs. 6,413.808
Escalation	3 %	Rs. 1,924.14
Construction	5 %	Rs. 3,206.904
Labour	5 %	Rs. 3,206.904
Total	-	**Rs. 14,751.756/-**

In the above contingencies, there is an additional contingency of 10 % of total cost of project as consultant's fees, which is calculated as Rs. 6,413.808/- . Since the project is designed and estimated at students' level, thus there is a saving of Rs. 6,413.808/- , which must had been included in the project otherwise.

The amount including the contingencies that will be the grand cost of construction of this type of le mur vegetal green wall is as follows:

Total cost of construction of green wall	Rs. 64,138.08/-
Total contingencies	Rs. 14,751.756/-
Grand Cost of Construction of Le Mur Vegetal Green Wall	**Rs. 78,889.836/- i.e., Rs. 78,890/ -**

5.1.3 Green Screens- Estimation

The third type of green wall proposed is of a green screen type. This type includes the plantation of plants like creepers at the ground level in trays and they grow up with the support of mesh fixed on walls. This type is to be implemented on the four corners of the Engineering building of AIKTC campus. The following information about the wall on which a green screen type of green wall is to be constructed was obtained by actual measurement by using an engineer's tape and with the help of floor plans of AIKTC, which is as follows:

Dimensions of wall	(2.5 x 17) m and (2 x 17) m
Area of one corner	76.5 m^2
Area of wall	306 m^2

A jali welded mesh is needed as a support system to help the climbers to climb up the surface of wall. Its description is as follows:

Jali welded mesh	25 * 25, 11 guage
Rate of jali welded mesh	Rs. 400 per m^2
Cost per corner	Rs. 30,600/-
Cost of jali welded mesh of given area	**306 x 400 = Rs. 1,22,400/-**

Now, S.S. Hex Bolts 202Q 8mm dia., length 35 mm will be required to connect the pre-vegetated panels onto the wall. The specifications of the bolt is as follows:

Rate of 8 mm dia. bolt per piece	Rs. 3/-
Total bolts required per panel	2 nos.
Cost of 8 mm dia. bolts per panel	2 x 3 = Rs. 6/-
Total bolts required for each corner	153 nos.
Total cost of bolts for each corner	Rs. 459/-
Bolts required for all four corners	153 x 4 = 612 nos.
Total cost of bolts for given area	**612 x 3 = Rs. 1,836/-**

Now, PVC trays will be required is calculated. The specifications of the PVC trays is as follows:

Dimensions of PVC tray	(241.3 x 88.9 x 76.2) mm
Number of PVC trays required to cover 1-meter length	4 nos.
Rate of PVC tray	Rs. 70 per piece
Number of PVC trays required to cover one corner	4 x 4 = 16 nos.
Cost of 16 PVC trays per corner	16 x 70 = Rs. 1,120/-
Total cost of PVC trays to cover all the four corners	**4 x 1120 = Rs. 4,480/-**

Now, a plastic waterproof membrane (WPM) will be required to cover the exposed wall area, to protect it from damping.

Total area to prevent from damping	4 m^2
Rate of plastic WPM	Rs. 15/ m^2

Cost of plastic WPM for one corner	4 x 15 = Rs. 60/-
Total cost of plastic WPM for all the four corners of the building	**4 x 60 = Rs. 240/-**

Now, finding out the quantity of plants required for the estimated area of green wall:

Approximate, number of plants to cover one corner	32 nos.
Plants required to cover all four corners	32 x 4 = 128 nos.
Approximate rate per plant	Rs. 50/-
Cost of plants per corner	50 x 32 = Rs. 1,600/-
Total cost of plants for entire area	**1,600 x 4 = Rs. 6,400/-**

Thus, the total cost for one such corner will be as follow:

Cost per corner	Rs. 30,600/-
Total cost of bolts for each corner	Rs. 459/-
Cost of 16 PVC trays per corner	Rs. 1,120/-
Cost of plastic WPM for one corner	Rs. 60/-
Cost of plants per corner	Rs. 1,600/-
Total cost for one corner	**Rs. 6,839/-**

Now, calculating the quantity of 50 kg coco peat bag required to fill the trays:

Rate of one pack of 50 kg of coco peat	Rs. 250/-
Approximate number of 50 kg of coco peat bag required	3 nos.

Cost of coco peat for all panels	**Rs. 750/-**

Now, drip irrigation horizontal polyethylene pipes of 16 mm dia., are required. The details are as follows:

Rate of polyethylene pipe of 16 mm dia.,	Rs. 250 per 10 m roll
Horizontal length to be covered by drip pipe	(2.5 + 2) x 4 = 18 m
Number of 10 m rolls of polyethylene pipe required	18/10 = 1.8 ie., 2 rolls
Total cost of polyethylene irrigation pipes	**2 x 250 = Rs. 500**

Thus, the total cost of construction of this type of green wall is as follows:

Cost of jali welded mesh of given area	Rs. 1,22,400/-
Total cost of bolts for given area	Rs. 1,836/-
Total cost of PVC trays to cover all the four corners	Rs. 4,480/-
Total cost of plastic WPM for all the four corners	Rs. 240/-
Cost of plants for all four corners	Rs. 6,400/-
Cost of coco peat for all PVC trays	Rs. 750/-
Cost of polyethylene irrigation pipes	Rs. 500
Total cost of construction of green wall	**Rs. 1,36,606/-**

Now, certain additional amount is to be added to the total cost of green wall which is as follows:

Shipping Charges	Rs. 1,000.0
Fertilizer Charges	Rs. 1,000.0
Miscellaneous	Rs. 1,000.0
Total	**Rs. 3,000/-**

Now, the total cost of green wall is calculated as follows:

Cost of construction of green wall	Rs. 1,36,606/ -
Additional cost	Rs. 3,000.0
Total cost of construction of green wall	**Rs. 1,39,606/-**

Now, certain contingencies must be added to the final estimated cost such as follow:

Contingencies	**Percent**	**Cost**
Design	10 %	Rs. 13960.6
Escalation	3 %	Rs. 4188.18
Construction	5 %	Rs.6980.3
Labour	5 %	Rs.6980.3
Total	**-**	**Rs. 32,109.38/ -**

In the above contingencies, there is an additional contingency of 10 % of total cost of project as consultant's fees, which is calculated as Rs. 14578.6. Since the project is designed and estimated at students' level, thus there is a saving of Rs. 14578.6 which must had been included in the project otherwise.

The amount including the contingencies that will be the grand cost of construction of this type of green screen wall is as follows:

Total cost of construction of green wall	Rs. 1,39,606/-
Total contingencies	Rs. 32,109.38/-
Grand Cost of Construction of Green Screen Wall	**Rs. 1,71,715.38 ie., 1,71,750.0**

5.1.4 Free- Falling Green Wall – Estimation

The fifth type is of estimation of creeper gallery wall type. The following information about the wall on which a creeper type of green wall is to be constructed was obtained by actual measurement by using an engineer's tape and with the help of floor plans of AIKTC, which is as follows:

Dimensions of wall	(8.5 x 2.5) m
Area of wall	21.25 m^2

Now, PVC trays will be required to be attached along the aluminium strip. The specifications of the PVC trays is as follows:

Dimensions of PVC tray	180 mm dia. ie., 7 inches
Number of PVC trays required to cover 1-meter length	5 nos.
Rate of PVC tray	Rs. 70 per piece
Number of PVC trays required to cover total length	8.5 x 5 = 42 nos.
Cost of 42 PVC trays	42 x 70 = **Rs. 2,940/-**

Now, stainless steel J hooks will be required to fix the trays to the wall. The cost of the hooks is as follows:

Rate of hook per peice	Rs. 18/-

Number of hooks required to fix the trays	34 nos.
Cost of hooks per panel	**Rs. 612/-**

Now, S.S. Hex Bolts 202Q 8mm dia., length 35 mm will be required to connect the pre-vegetated panels onto the wall. The specifications of the bolt is as follows:

Rate of 8 mm dia. bolt per piece	Rs. 3/-
Total bolts required per hook	2 nos.
Total bolts required	34 x 2 = 68
Cost of 8 mm dia. bolts per m	68 x 3 = **Rs. 204/-**

Now, a plastic waterproof membrane (WPM) will be required to cover the exposed wall area, to protect it from damping.

Total area to prevent from damping	1 x 8.5 = 8.5 m^2
Rate of plastic WPM	Rs. 15/ m^2
Total cost of plastic WPM	8.5 x 15 = **Rs. 127.5/-**

Now, finding out the quantity of plants required for the estimated area of green wall:

Plants required to cover an area of given wall	42 nos.
Approximate rate per plant	Rs. 50/-
Total cost of plants for entire area	**45 x 50 = Rs. 2,100/-**

Now, calculating the quantity of 250 grams coco peat packs required to fill the trays:

Rate of one pack of 50 kg of coco peat	Rs. 250/-
Approximate number of 50 kg of coco peat bag required	1 nos.
Cost of coco peat	**Rs. 250/-**

Now, drip irrigation horizontal polyethylene pipes of 16 mm dia., are required. The details are as follows:

Rate of polyethylene pipe of 16 mm dia.,	Rs. 250 per 10 m roll
Horizontal length to be covered by drip pipe	8.86 m
Number of 10 m rolls of polyethylene pipe required	8.86/10 = 0.886 ie., 1 roll
Total cost of polyethylene irrigation pipes	**1 x 250 = Rs. 250**

Thus, the total cost of construction of this type of green wall is as follows:

Total cost of PVC trays	Rs. 2,940.0
Total cost of bolts	Rs.204.0
Total cost of hooks	Rs. 612.0
Total cost of plastic WPM	Rs. 127.5
Cost of plants	Rs. 2,100.0
Cost of coco peat for all PVC trays	Rs. 250.0
Cost of polyethylene irrigation pipes	Rs. 250.0
Total cost of construction of green wall	**Rs. 6,483.5**

Now, certain additional amount is to be added to the total cost of green wall which is as follows:

Shipping Charges	Rs. 1,000.0
Fertilizer Charges	Rs. 1,000.0
Miscellaneous	Rs. 1,000.0
Total	**Rs. 3,000/-**

Now, the total cost of green wall is calculated as follows:

Cost of construction of green wall	Rs. 6,483.5

Additional cost	Rs. 3,000.0
Total cost of construction of green wall	**Rs. 9,483.5/-**

Now, certain contingencies must be added to the final estimated cost such as follow:

Contingencies	**Percent**	**Cost**
Design	10 %	Rs. 948.35
Escalation	3 %	Rs. 284.505
Construction	5 %	Rs. 474.175
Labour	5 %	Rs. 474.175
Total	-	**Rs. 2,181.205**

In the above contingencies, there is an additional contingency of 10 % of total cost of project as consultant's fees, which is calculated as Rs. 948.35/- . Since the project is designed and estimated at students' level, thus there is a saving of Rs. 948.35/- , which may had been included in the project otherwise.

The amount including the contingencies that will be the grand cost of construction of this type of green screen wall is as follows:

Total cost of construction of green wall	Rs. 9,483.5/-
Total contingencies	Rs. 2,181.205
Grand Cost of Construction of Gallery Wall Creeper	**Rs 11,664.705 ie., Rs. 11,700/-**

5.1.5 Moss Sheet Green Wall - Estimation

This is the fourth type of proposed green wall in which a moss sheet s used to cover a part of the some columns present in the structure. The following information about the wall on which

a green screen type of green wall is to be constructed was obtained by actual measurement by using an engineer's tape and with the help of floor plans of AIKTC, which is as follows:

Dimensions of column	(0.5 x 1) m
Number of columns	80 nos.
Area of one column	0.5 m^2
Total area of column to be converted into moss type green wall	80 x 0.5 = 40 m^2

Now, a wooden strip will be required to border the column areas, which is calculated as follows:

Length of wooden strip for column	(0.5 x 2) + (1 x 2) = 3 m
Total length of wooden strip for all columns	80 x 3 = 24 m
Rate of wooden strip	Rs. 4.92 per m
Cost of wooden strip required	**4.92 x 24 = Rs. 118.08/-**

Now, S.S. Hex Bolts 202Q 6mm dia., length 35 mm will be required to fix the wooden strips and moss sheet onto the wall. The specifications of the bolt is as follows:

Rate of 6 mm dia. bolt per piece	Rs. 2/-
Total bolts required per panel	4 nos.
Cost of 6 mm dia. bolts per panel	4 x 2 = Rs. 8/-
Total cost of bolts for given area	**80 x 8 = Rs. 640/-**

Now, a plastic waterproof membrane (WPM) will be required to cover the exposed wall area, to protect it from damping.

Total area to prevent from damping	40 m^2
Rate of plastic WPM	Rs. 15/ m^2
Cost of plastic WPM for all the columns	**40 x 15 = Rs. 60/-**

Now, a moss sheet is required to cover the specified area. Its description is as follows:

Area to covered under moss sheet	40 m^2
Rate of moss sheet	Rs. 1,500/m^2
Cost of moss sheet	**40 x 1,500 = Rs. 60,000/-**

Thus, the total cost for one such panel will be as follow:

Cost of wooden plank per column	Rs. 14.76
Cost of 6 mm dia. bolts per panel	Rs. 8.0
Cost of plastic WPM	Rs. 15.0
Cost of Moss sheet	Rs. 1,500
Total cost of 1 m^2 i.e., one panel	**Rs. 1537.76/-**

Now, the total cost of this type of green wall is as follows:

Cost of wooden strip required	Rs. 118.08/-
Cost of bolts for given area	Rs. 640/ -
Cost of plastic WPM for all the columns	Rs. 60/-

Cost of moss sheet	Rs. 60,000/-
Total cost of Moss Sheet Green Wall	**Rs. 60,818.08/-**

Now, certain additional amount is to be added to the total cost of green wall which is as follows:

Shipping Charges	Rs. 1,000.0
Fertilizer Charges	Rs. 1,000.0
Miscellaneous	Rs. 1,000.0
Total	**Rs. 3,000/-**

Now, the total cost of green wall is calculated as follows:

Cost of construction of green wall	Rs. 60,818.08
Additional cost	Rs. 3,000.0
Total cost of construction of green wall	**Rs. 63,818.08/-**

Now, certain contingencies must be added to the final estimated cost such as follow:

Contingencies	**Percent**	**Cost**
Design	10 %	Rs. 6,381.808
Escalation	3 %	Rs. 1914.55
Construction	5 %	Rs. 3190.54
Labour	5 %	Rs. 3190.54

Total	**-**	**Rs. 14,677.44/-**

In the above contingencies, there is an additional contingency of 10 % of total cost of project as consultant's fees, which is calculated as Rs. 6,381.808 /- . Since the project is designed and estimated at students' level, thus there is a saving of Rs. 6,381.808/- , which must had been included in the project otherwise.

The amount including the contingencies that will be the grand cost of construction of this type of moss sheet green wall is as follows:

Total cost of construction of green wall	Rs. 63,818.08 /-
Total contingencies	Rs. 14,677.44/-
Grand Cost of Construction of Moss Sheet Green Wall	**Rs. 78,495.52 i.e., Rs. 78,500/-**

5.2 Noise Reduction due to Green Walls

The reduction in noise also occurs due to green walls. From the past similar research work, it is estimated that the noise reduction to be 15 decibels for each green wall. [20] [29] Noise was recorded with the help of a noise meter during morning and afternoon throughout the campus where different green wall types were proposed.

Further the noise reduction levels measured showed the levels of noise before the implementation of the green wall and the levels after the estimated reduction in noise levels after the implementation of the proposed work and its full-fledged growth. The morning readings are as follows (Table 5.1):

Table 5.1 Morning Noise Level Before Implementation of Green Walls

Sr. No.	Time (sec)	Reading (dB)	Wall-Mounted System	Free-standing system	Free-Falling System	Green screens	Le-Mur-Vegetal Wall	Moss Columns	Green Screen Model
1	10	x_1	65.9	56.6	68.5	57.7	56.8	63.7	62.6
2	20	x_2	67.5	57.2	64.9	59.5	56.9	60.2	67.5
3	30	x_3	64.4	57.2	68.2	57.2	70.4	59.8	65.5
4	40	x_4	69.6	57.4	67.6	58.3	64.6	63.3	64.2
5	50	x_5	62.8	56.4	68.4	59.0	58.7	66.8	63.6
6	60	x_6	65.8	62.4	74.7	59.1	64.8	67.8	62.8

Sound Pressure Level $= 10 \log_{10}[(1/6) \times (10^{x_1/10} + 10^{x_2/10} + \ldots\ldots\ldots\ldots\ldots\ldots + 10^{x_{n-1}/10})]$

Wall- Mounted System $= 10 \times \log_{10}[1/6 \times (10^{65.9/10} + 10^{67.5/10} + 10^{64.4/10} + 10^{69.6/10} + 10^{62.8/10} + 10^{65.8/10})]$
$= 10 \times \log_{10}[1/6 \times (3890451.45 + 5623413.252 + 2754228.703 + 9120108.394 + 1905460.718 + 3801893.963)]$
$= 10 \times \log_{10}(4515926.08)$
$= 66.55$ dB

Free-standing system $= 10 \times \log_{10}[1/6 \times (10^{56.6/10} + 10^{57.2/10} + 10^{57.2/10} + 10^{57.4/10} + 10^{56.4/10} + 10^{62.4/10})]$
$= 10 \times \log_{10}[1/6 \times (457088.1896 + 524807.4602 + 524807.4602 + 549540.8739 + 436515.8322 + 1737800.829)]$
$= 10 \times \log_{10}(705093.4408)$
$= 58.48$ dB

Free-Falling System $= 10 \times \log_{10}[1/6 \times (10^{68.5/10} + 10^{64.7/10} + 10^{68.2/10} + 10^{67.6/10} + 10^{68.4/10} + 10^{74.7/10})]$
$= 10 \times \log_{10}[1/6 \times (7079457.844 + 3090295.433 + 6606934.48 + 5754399.373 + 6918309.709 + 29512092.27)]$
$= 10 \times \log_{10}(9826974.851)$
$= 69.92$ dB

Green screens $= 10 \times \log_{10}[1/6 \times (10^{57.7/10} + 10^{59.5/10} + 10^{57.2/10} + 10^{58.3/10} + 10^{59/10} + 10^{59.1/10})]$
$= 10 \times \log_{10}[1/6 \times (588843.66 + 891250.938 + 524807.4602 + 676082.9754 + 794328.2347 + 812830.5162)]$
$= 10 \times \log_{10}(714690.6308)$
$= 58.54$ dB

Le-Mur-Vegetal Wall $= 10 \times \log_{10}[1/6 \times (10^{56.8/10} + 10^{56.9/10} + 10^{70.4/10} + 10^{64.6/10} + 10^{58.7/10} + 10^{64.8/10})]$

$= 10 \text{ x } \log_{10}[\ 1/6 \text{ x } (\ 478630.0923 + 489778.8194 + 10964781.96 + 2884031.503 + 741310.2413 + 3019951.72\ )\ ]$
$= 10 \text{ x } \log_{10}(\ 3096414.056\ )$
$= 64.91 \text{ dB}$

Moss Columns $= 10 \text{ x } \log_{10}[\ 1/6 \text{ x } (\ 10^{63.7/10} + 10^{60.2/10} + 10^{59.8/10} + 10^{63.3/10} + 10^{66.8/10} + 10^{67.8/10}\ )\ ]$
$= 10 \text{ x } \log_{10}[\ 1/6 \text{ x } (\ 2344228.815 + 1047128.548 + 954992.586 + 2137962.09 + 4786300.923 + 6025595.861\ )\ ]$
$= 10 \text{ x } \log_{10}(\ 2882701.471\ )$
$= 64.6 \text{ dB}$

Green Screens Model $= 10 \text{ x } \log_{10}[\ 1/6 \text{ x } (\ 10^{62.6/10} + 10^{67.5/10} + 10^{65.5/10} + 10^{64.2/10} + 10^{63.6/10} + 10^{62.8/10}\ )\ ]$
$= 10 \text{ x } \log_{10}[\ 1/6 \text{ x } (\ 1819700.859 + 5623413.252 + 3548133.892 + 2630267.992 + 2290867.653 + 1905460.718\ )\ ]$
$= 10 \text{ x } \log_{10}(\ 303283.4765\ )$
$= 54.82 \text{ dB}$

The afternoon readings are as follows (Table 5.2):

Table 5.2 Afternoon Noise Level Before Implementation of Green Walls

Sr. No.	Time (sec)	Reading (dB)	Wall-Mounted System	Free-standing system	Free-Falling System	Green screens	Le-Mur-Vegetal Wall	Moss Columns	Green Screen Model
1	10	x_1	74.5	67.6	71.4	60.1	60.3	68.7	71.4
2	20	x_2	77.2	69.4	68.4	63.7	61.4	69.3	69.9
3	30	x_3	73.6	70.0	68.6	64.1	59.2	72.5	71.1
4	40	x_4	75.6	67.9	68.5	60.8	62.5	64.2	70.9
5	50	x_5	73.7	64.5	70.5	63.7	64.1	64.5	68.9
6	60	x_6	75.9	67.3	69.5	62.7	57.7	67.4	68.7

Sound Pressure Level $= 10 \log_{10}[1/6 \text{ x } (10^{x_1/10} + 10^{x_2/10} + \ldots\ldots\ldots\ldots\ldots\ldots + 10^{x_{n-1}/10}\ )\ ]$

Wall- Mounted System $= 10 \text{ x } \log_{10}[\ 1/6 \text{ x } (\ 10^{74.5/10} + 10^{77.2/10} + 10^{73.6/10} + 10^{75.6/10} + 10^{73.7/10} + 10^{75.9/10}\ )\ ]$
$= 10 \text{ x } \log_{10}[\ 1/6 \text{ x } (\ 28183829.31 + 52480746.02 + 22908676.53 + 36307805.48 + 23442288.15 + 38904514.5\ )\ ]$
$= 10 \text{ x } \log_{10}(\ 33704643.33\ )$
$= 75.28 \text{ dB}$

Free-standing system $= 10 \text{ x } \log_{10}[\ 1/6 \text{ x } (\ 10^{67.6/10} + 10^{69.4/10} + 10^{70/10} + 10^{67.9/10} + 10^{64.5/10} + 10^{67.3/10}\ )\ ]$
$= 10 \text{ x } \log_{10}[\ 1/6 \text{ x } (\ 5754399.373 + 8709635.9 + 10000000 + 6165950.019 + 2818382.931 + 5370317.964\ )\ ]$
$= 10 \text{ x } \log_{10}(\ 6469781.031\ )$

= 68.11 dB

Free-Falling System= $10 \times \log_{10}[\ 1/6 \times (10^{71.4/10} + 10^{68.4/10} + 10^{68.6/10} + 10^{68.5/10} + 10^{70.5/10} + 10^{69.5/10})\ ]$
$= 10 \times \log_{10}[\ 1/6 \times (13803842.65 + 6918309.709 + 7244359.601 + 7079457.844 + 11220184.54 + 8912509.381)\ ]$
$= 10 \times \log_{10}(9196443.954)$
= 69.64 dB

Green screens = $10 \times \log_{10}[\ 1/6 \times (10^{60.1/10} + 10^{63.7/10} + 10^{64.1/10} + 10^{60.8/10} + 10^{63.7/10} + 10^{62.7/10})\ ]$
$= 10 \times \log_{10}[\ 1/6 \times (1023292.992 + 2344228.815 + 2570395.783 + 1202264.435 + 2344228.815 + 1862087.137)\ ]$
$= 10 \times \log_{10}(1891082.996)$
= 62.77 dB

Le-Mur-Vegetal Wall = $10 \times \log_{10}[\ 1/6 \times (10^{60.3/10} + 10^{61.4/10} + 10^{59.2/10} + 10^{62.5/10} + 10^{64.1/10} + 10^{57.7/10})\ ]$
$= 10 \times \log_{10}[\ 1/6 \times (107159.305 + 1380384.265 + 831763.7711 + 1778279.41 + 2570395.783 + 588843.6554)\ ]$
$= 10 \times \log_{10}(1370197.698)$
= 61.37 dB

Moss Columns = $10 \times \log_{10}[\ 1/6 \times (10^{68.7/10} + 10^{69.3/10} + 10^{72.5/10} + 10^{64.2/10} + 10^{64.5/10} + 10^{67.4/10})\ ]$
$= 10 \times \log_{10}[\ 1/6 \times (7413102.413 + 8511380.382 + 17782794.1 + 2630267.992 + 2818382.931 + 5495408.739)\ ]$
$= 10 \times \log_{10}(7441889.426)$
= 68.72 dB

Green Screens Model = $10 \times \log_{10}[\ 1/6 \times (10^{71.4/10} + 10^{69.9/10} + 10^{71.1/10} + 10^{70.9/10} + 10^{68.9/10} + 10^{68.7/10})\ ]$
$= 10 \times \log_{10}[\ 1/6 \times (13803842.65 + 9772372.21 + 12882495.52 + 12303687.71 + 7762471.166 + 7413102.413)\ ]$
$= 10 \times \log_{10}(10656161.94)$
= 70.28 dB

The evening readings are as follows (Table 5.3):

Table 5.3 Evening Noise levels Before Implementation of Green Walls

Sr. No.	Time (sec)	Reading (dB)	Wall-Mounted Sys	Free-standing system	Free-Falling System	Green screens	Le-Mur-Vegetal Wall	Moss Column	Green Screen Model
1	10	x_1	60.5	50	61.1	49.7	56.2	58.1	62.2
2	20	x_2	63.8	50.5	63.9	48.3	50.7	55.9	57.3
3	30	x_3	59.3	54	58.5	51.7	52.7	56.3	59.1
4	40	x_4	61.4	51.7	60.1	46.3	52.4	55.7	62.4
5	50	x_5	60.5	53.1	62.1	48.7	60.4	56.4	63
6	60	x_6	58.3	49.1	65.5	45.6	59	57.7	64.4

Sound Pressure Level $= 10 \log_{10}[1/6 \text{ X } (10^{x1/10} + 10^{x2/10} + \ldots\ldots\ldots\ldots\ldots\ldots + 10^{xn-1/10})]$

Wall- Mounted System $= 10 \text{ x } \log_{10}[1/6 \text{ x } (10^{60.5/10} + 10^{63.8/10} + 10^{59.3/10} + 10^{61.4/10} + 10^{60.5/10} + 10^{58.3/10})]$

$= 10 \text{ x } \log_{10}[1/6 \text{ x } (1122018.45 + 2398832.91 + 851138.03 + 1380984.26 + 1122018.45 + 676082.97)]$

$= 10 \text{ x } \log_{10}(1258512.51)$

$= 60.99 \text{ dB}$

Free-standing system $= 10 \text{ x } \log_{10}[1/6 \text{ x } (10^{50/10} + 10^{50.5/10} + 10^{54/10} + 10^{51.7/10} + 10^{53.1/10} + 10^{49.1/10})]$

$= 10 \text{ x } \log_{10}[1/6 \text{ x } (100000 + 112201.84 + 251188.64 + 147910.83 + 204173.79 + 81283.05)]$

$= 10 \text{ x } \log_{10}(149459.69)$

$= 51.74 \text{ dB}$

Free-Falling System $= 10 \text{ x } \log_{10}[1/6 \text{ x } (10^{61.1/10} + 10^{63.9/10} + 10^{58.5/10} + 10^{60.1/10} + 10^{62.1/10} + 10^{65.5/10})]$

$= 10 \text{ x } \log_{10}[1/6 \text{ x } (1288249.55 + 2454708.91 + 707945.78 + 1023292.99 + 1621810.09 + 3548133.89)]$

$= 10 \text{ x } \log_{10}(1774023.53)$

$= 62.48 \text{ dB}$

Green screens $= 10 \text{ x } \log_{10}[1/6 \text{ x } (10^{49.7/10} + 10^{48.3/10} + 10^{51.7/10} + 10^{46.3/10} + 10^{48.7/10} + 10^{45.6/10})]$

$= 10 \text{ x } \log_{10}[1/6 \text{ x } (93325.43 + 67608.29 + 147910.83 + 42657.95 + 74131.02 + 36307.80)]$

$= 10 \text{ X } \log_{10}(76990.22)$

$= 48.86 \text{ dB}$

Le-Mur-Vegetal Wall $= 10 \text{ x } \log_{10}[1/6 \text{ x } (10^{56.2/10} + 10^{50.7/10} + 10^{52.7/10} + 10^{52.4/10} + 10^{60.4/10} + 10^{59/10})]$

$= 10 \text{ x } \log_{10}[1/6 \text{ x } (416869.38 + 117489.75 + 186208.71 + 173780.08 + 1096478.19 + 794328.23)]$

$= 10 \text{ x } \log_{10}(464192.39)$

$= 56.66 \text{ dB}$

Moss Columns = 10 x $\log_{10}$[1/6 x ($10^{62.2/10}$ + $10^{57.3/10}$ + $10^{59.1/10}$ + $10^{62.4/10}$ + $10^{63/10}$ + $10^{64.4/10}$)]

= 10 x $\log_{10}$[1/6 x (1659586.90 + 537031.79 + 812830.51 + 1737800.82 + 1995262.31 + 2754228.70)]

= 10 x $\log_{10}$(1582790.172)

= 61.99 dB

Green Screens Model = 10 x $\log_{10}$[1/6 x ($10^{58.1/10}$ + $10^{55.9/10}$ + $10^{56.3/10}$ + $10^{55.7/10}$ + $10^{56.4/10}$ + $10^{57.7/10}$)]

= 10 x $\log_{10}$[1/6 x (645654.22 + 389045.14 + 426579.51 + 371535.22 + 436515.83 + 588843.65)]

= 10 x $\log_{10}$(476362.26)

= 56.77 dB

The following table 5.4 shows the before and after noise levels:

Table 5.4 Before and After Noise Levels After Reduction

Type	Morning		Afternoon		Evening	
	Before	After	Before	After	Before	After
Wall- Mounted System	66.55	51.55	75.28	60.28	60.99	45.99
Free-standing Model	58.48	43.48	68.11	53.11	51.74	36.74
Free-Falling System	69.92	54.92	69.64	54.64	62.48	47.48
Green screens	58.54	43.54	62.77	47.77	46.86	31.86
Le-Mur-Vegetal Wall	64.91	49.91	61.37	46.37	56.66	41.66
Moss Columns	64.60	49.60	68.72	53.72	61.99	46.99
Green Screens Model	54.82	39.82	70.28	55.28	56.77	41.77

The following bar chart (figure 5.6) shows the noise levels before the implementation of green walls in morning, afternoon and evening sessions:

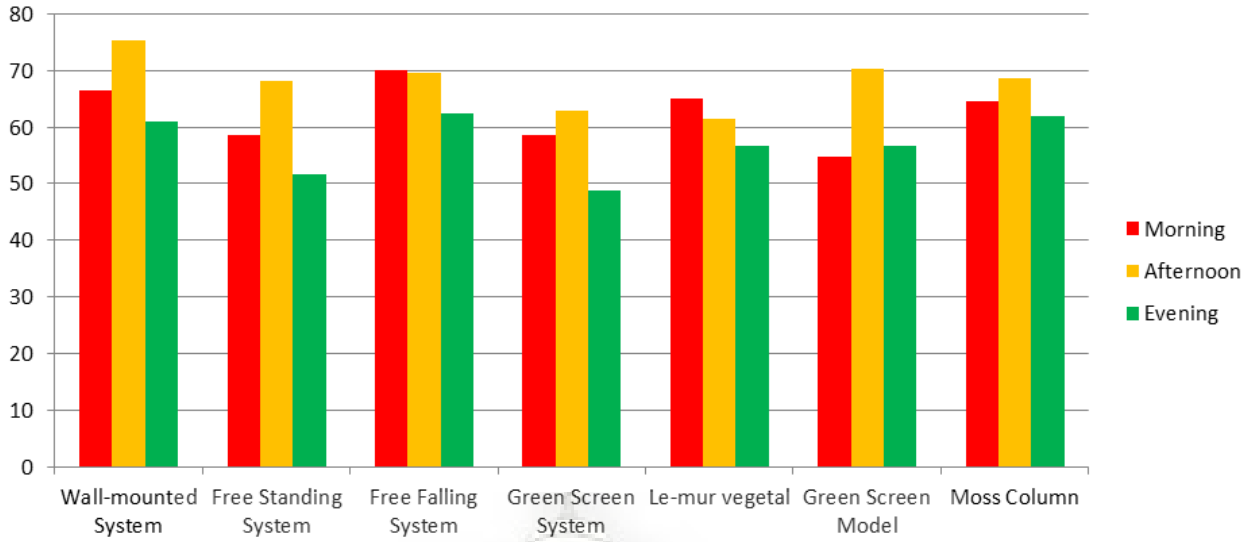

Figure 5.6 Noise Levels Before Implementation of Green Walls

The following bar chart (figure 5.7) shows the noise levels after the implementation of green walls in morning, afternoon and evening sessions:

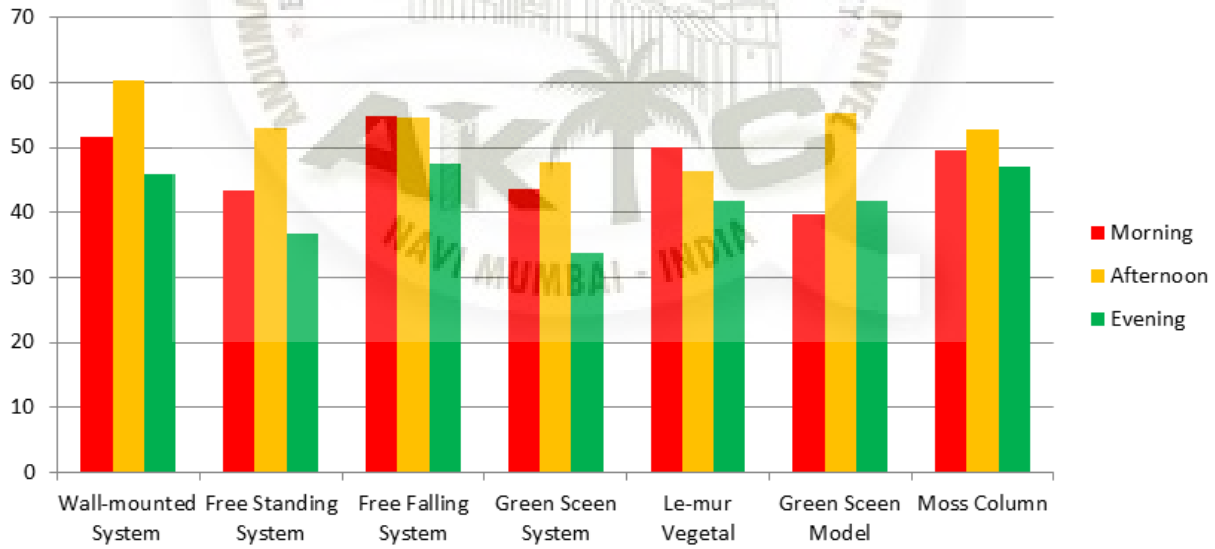

Figure 5.7 Noise Levels After Implementation of Green Walls

Thus it shows that there will be significant reduction in noise level after the full- fledged growth of different types of green walls after implementation.

The work plan for the project was as follows (Table 5.5):

Table 5.5 Work plan for Project

July'17- August'17	• Selection of project • Zero presentation • Acceptance of project
August'17- September'17	• Preparation of small scale model 1 • Quotation letter for construction of green wall in AIKTC • Poster presentation on concept of project
September'17- October'17	• Analysis of model 1 • Presentation phase 1 • Survey of AIKTC for implementation of green wall
October'17- November'17	• Research related to work and more literature review
November'17- December'17	• Preparation of detailed estimate
December'17- January'18	• Calculations and market surveys
January'18- February'18	• Preparation of model 2
February'18- March'18	• Letter work for sponsorship • Estimation and calculation of proposed green wall patch construction • Work started on paper writing for presenting in iCASTe
March'18- April'18	• Letter work for permission of green wall patch in AIKTC • Collection of quotations from different firms for market rates of green wall construction
April'18- May'18	• Implementation of green wall patch • Analysis and results • Black book work

Chapter 6

Summary and Conclusions

6.1 Summary

There is a new concept that is taking root, especially in urban environments: green walls. Green walls are also known as a Vertical Vegetated Complex Walls" (VCW) and they have a vertical arrangement of living plants. Green walls are particularly suitable for cities, as they allow good use of available vertical surface areas. Green walls can be classified in many ways. Based on their position of implementation they can be classified as interior or exterior green wall and based on their type of growth extensive, free standing, semi-intensive and intensive green wall. Classification of green walls based on the type of construction includes the broad classification of green facades consisting of wall- mounted system and cable and wire net system and living walls consisting of landscape, le- mur vegetal and active walls. Space is a great hindrance in every city. Buildings are going vertical to overcome this limitation and to make the most of the existing space. In the same manner, plants can also grow in the upward direction. The aim of this project is to discover out all the likely means to

incorporate plants into buildings and to evaluate how the implementation of plants into the building design in AIKTC can assist in noise reduction, develop the atmosphere and boost the breathing condition. It includes preparation and installation of the green technologies like the green walls. Some small-sized models were prepared to give an idea about the different types of green walls to be implemented in the AIKTC campus namely free- standing model, green screens model and wall- mounted model. In the free- standing model, the plants like Spider plant (Chlorophytum Comosum Airplane plant), Pothos, Dieffenbachia, Monstera Acacogayensis, Philodendron (Boston Fern) were potted in pots and were placed on the aluminium channels and fixed with jute ropes to the plastic frame. The total cost of construction of this free- standing model came out to be Rs. 1,500/- . In the green screens model, Curtain creeper (Vernonia Creeper, Parda Bel) were potted in trays were placed at the top. A plastic mesh was fixed with the help of bolts on the wall below the trays. The total cost of construction of this green screens model came out to be Rs. 1,402/- . A wall-mounted model was prepared with the help of ready- to- fix frames on which pots were attached. In these pots asparagus plants were planted. The model was fixed on the wall with the help of bolts. . The total cost of construction of this free- standing model came out to be Rs. 842/-. The implementation of Green Design for AIKTC was planned to make it a green and clean building. The whole campus was surveyed to find out the different options to integrate this technology in the campus design. All the spots where this green design can be installed were photo-hooted. The types of green walls were proposed to be constructed in the AIKTC were namely wall- mounted system, le- mur vegetal system, green screens, free- falling system and moss sheet wall. The total cost of construction of wall- mounted system came out to be Rs. 30,000/-. The total cost of construction of le- mur vegetal system came out to be Rs. 78,890/-. The total cost of construction of green screens system came out to be Rs. 1,71,750/-. The total cost of construction of green screens system came out to be Rs. 11,700/-. The total cost of construction of moss sheet wall came out to be Rs. 78,500/-. The reduction in noise also occurs due to green walls. From the past similar research work, it is estimated that the noise reduction to be 15 decibels for each green wall. Noise was recorded with the help of a noise meter during morning and afternoon throughout the campus where different green wall types were proposed. Thus it shows that there will be significant reduction in noise level after the full- fledged growth of different types of green walls after implementation.

6.2 Conclusions

From the results obtained the mentioned methodology infers the possible models to be implemented in the A.I. Kalsekar Technical Campus, the financial feasibility of the project and possible noise reduction values after carrying out the proposed work. The proposed work gives us a clear idea about the work planned to be implemented in the campus in the near future. The total area of different types of green walls is measured and noted. Also the rate per meter square of each green wall type is also calculated and listed along with the contingencies and additional cost which then gives the total cost of the project for each type of green wall type. Some models of small scale as a prototype were prepared which give the idea of the proposed green wall structure. Further the noise reduction levels measured showed the levels of noise before the implementation of the green wall and the levels after the estimated reduction in noise levels after the implementation of the proposed work and its full-fledged growth. Thus it can be concluded that it is feasible to construct the mentioned types of green walls as it is economic, viable to construct and has sufficient noise reduction values.

REFERENCES

[1] Green Home Gnome 2013, http://www.greenhomebuilding.com/articles/livingwalls.html, Living walls improve indoor air quality,save energy and add life to your home, viewed 26 September 2017

[2] Kelly Hart 2001, http://www.greenhomebuilding.com/articles/livingwalls.html, Living walls, viewed 26 September 2017

[3] Greg Ggarner , Patrick S. Kelly , Shane Debisingh , Steven Peck , George Irwin , September 2008 , Introduction to Green Walls Technology , Benefits & Design , Developed by Green Roofs for Healthy Cities.

[4] Randy Sharp 2007, https://www.bdcnetwork.com/6-things-you-need-know-about-green-walls, 6 things you need to know about green walls, Building design + construction, viewed 26 September 2017

[5] Shahrina Afrin , 2009, Green Skyscraper : Integration of Plants into Skyscrapers, Department of Urban and Regional Studies.

[6] Mercedes Martty 2015, https://sourceable.net/, The benefits of interior green walls, viewed 26 September 2017

[7] Great green interior wall 2017, http://genericprednisone.us/36115/ideas/great-green-interior-wall-finishes/, viewed 26 September 2017

[8] Green roof technology 2017, http://www.greenrooftechnology.com/green_walls, viewed 26 September 2017,

[9] Vriksha Nursery 2011, http://vrikshanurseries.blogspot.in/, viewed 26 September 2017

[10] Maria Manso, 2015, Green wall systems: A review of their characteristics.

[11] Interesting facts about hanging garden of Babylon 2017, http://www.currentaffairs24x7.com/interesting-facts-about-hanging-garden-of-babylon/, viewed 26 September 2017,

[12] Patrick Blanc at the work project 2017, https://www.pinterest.com/pin/678565868827673118/, viewed 26 September 2017,

[13] Karl Fabricius 2008, http://scribol.com/anthropology-and-history/archaelogy/15-living-walls-vertical-gardens-sky-farms/, Vertical gardens and sky farms, viewed 26 September 2017

[14] Gopanjali Roy 2017, https://mediaindia.eu/aviation/gmr-hyderabad-international-airport-commences-mango-exports-to-south-korea/, GMR Hyderabad International Airport, Media India Group

[15] Kochhar P, 2009, Green rating for integrated habitat assessment, Akshay Urja page 3 (1).

[16] Vij A, 2011. Green buildings, GRIHA and Healthcare. Christian Medical Journal of India, July–September, pp.17–19

[17] Sahoo K and Sastry M, 2010, Thermal comfort through natural ventilation in high-rise buildings in warm-humid climate zone of India. Akshay Urja, volume 4, Issue 5, pp.46–47. Sastry G, 2006.

[18] Jian Zuo, Zhen-Yu Zhao 2014, Green building research-current status and future agenda: A review, Renewable and sustainable energy reviews 30, 271-281

[19] Virginia I. Lohr, 2010, What Are the Benefits of Plants Indoors and Why Do We Respond Positively to Them?

[20] Azkorra, Pérez, Coma, Cabeza, Bures, Applied Acoustics, 2015, Evaluation of green walls as a passive acoustic insulation system for building.

[21] Greenn Tree 2012, http://www.greenntree.com/blog/sound-scrubbing/, accessed on 1-10-2017

[22] Kenneth Freeman 2014, https://www.huffingtonpost.co.uk/kenneth-freeman/how-plants-can-reduce-noi_b_4802876.html, How plants can reduce noise levels indoors, viewed 26 September 2017

[23] Nursery Live 2017, https://nurserylive.com/, Flowering plants and Creepers, accessed on 20- 08- 2017

[24] HCN,2018,http://thearchitectsdiary.com/heart-house-double-height-courtyard-neogenesisstudi0261/, accessed on 11-02-2018

[25] VGPB, 2018, http://www. Vertical garden Patrick blanc. com /patrick-blanc/portraits?page=9, accessed on 12-02-2018

[26] MVG,2018,http://www.jualgeotextile.net/index.php/2015/09/27/membuat-vertical-garden-di-rumah/, accessed on 11-02-2018

[27] MGF,2018,http://greenscreen.com/how-to-prune-a-wall-mounted-green-facadegreen-wall/, accessed on 10-02-18

[28] GPM, 2018, http:// www. Greenplants. Co.uk/moss-walls/, accessed on 15-02-2018

[29] Tautvydas Maslauskas , 19th October 2015 , Green walls the vertical planting systems, VIA University college

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