SCHOOL OF CIVIL ENGINEERING

A PROJECT REPORT
On

"ECO-MOSS: SUSTAINABLE GREEN WALL SOLUTIONS"

Submitted in fulfilment of the requirements for the award of Degree of

BACHELOR OF TECHNOLOGY
IN
CIVIL ENGINEERING

Submitted by

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CERTIFICATE

Certified that the project work entitled **"ECO-MOSS: SUSTAINABLE GREEN WALL SOLUTIONS"** Carried out by **SNEHA E (R19CV212), LAVANYA KR (R19CV185), PRAMOD S (R19CV197) & HARI MANIKANTA (R19CV177)**bonafide students of REVA University during the academic year **2022-23** have submitted the Project report in partial fulfilment for the award of **Bachelor of Technology in Civil Engineering**during the academic year **2022-23**. The Project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said degree.

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DECLARATION

We, **SNEHA E(R19CV212), LAVNAYA KR(R19CV185), PRAMOD S (R19CV197) and HARI MANIKANTA(R19CV177),** bonafide students of B. Tech in Civil Engineering, REVA University, declare that the Project work entitled **"ECO-MOSS: SUSTAINABLE GREEN WALL SOLUTIONS"** is the result of project work done by us under the supervision of, **Dr. S.VIGNESHWARAN,** Assistant Professor, School of Civil Engineering, REVA University, Bangalore.

We are submitting this project Report in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering by the REVA University, Bangalore during theacademicyear2022-23.
I further declare that this project report or any part of it has not been submitted or forward of any other Degree/Diploma of this University or any other University/Institution.

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Place: Bangalore

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ABSTRACT

The project titled "eco moss - sustainable green wall solutions" aims to explore the use of moss as a sustainable and eco-friendly solution for green walls. Green walls, also known as vertical gardens, provide numerous environmental and aesthetic benefits. However, the challenge lies in maintaining the moisture and aesthetics of moss walls throughout all seasons. To address this challenge, the project focuses on developing innovative strategies to ensure the thriving growth of moss while maintaining its aesthetic appeal. The project encompasses research, experimentation, and implementation of various techniques to create a visually appealing and sustainable moss wall.

The project includes phases such as project initiation, planning, experimentation, data collection, results analysis, and conclusion. Tasks within each phase involve defining project objectives, conducting research, identifying suitable moss attachment methods, preparing moss growth substrates, monitoring growth progress, and gathering qualitative and quantitative data. Through careful analysis and interpretation of the collected data, the project identifies the most effective attachment methods, optimum growing conditions, and maintenance practices for moss walls. The results indicate that moss walls can contribute to improved air quality, reduced noise pollution, and enhanced aesthetics in urban environments.

The discussions highlight the significance of moss as a natural air purifier and its ability to absorb pollutants. Furthermore, the project discusses the challenges of maintaining moisture levels in moss walls and proposes solutions such as automated irrigation systems and microclimate analysis.

Keywords: eco moss, sustainable, green walls, moss attachment methods, moisture maintenance, aesthetics, air quality, urban environment.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TERMS AND ABBREVATIONS

1. ECO - Economical and Ecological
2. MOSS - Microorganisms Oriented Sustainable Solution
3. DIY - Do-It-Yourself
4. CO2 - Carbon Dioxide
5. VOCs - Volatile Organic Compounds
6. IAQ - Indoor Air Quality
7. PM - Particulate Matter
8. HVAC - Heating, Ventilation, and Air Conditioning
9. LED - Light-Emitting Diode
10. CAD - Computer-Aided Design
11. IoT - Internet of Things
12. ROI - Return on Investment
13. GPM - Gallons per Minute
14. UV - Ultraviolet
15. IP Rating - Ingress Protection Rating
16. HVAC - Heating, Ventilation, and Air Conditioning
17. ROI - Return on Investment
18. LCA - Life Cycle Assessment
19. FDI - Foreign Direct Investment
20. LEED –Leadership in Energy and Environmental Design

CHAPTER - 1
INTRODUCTION

1.1 BIOLOGICAL CONCRETE

Thanks to advances in technology there are many innovative construction materials such as biological concrete. This is a revolutionary material, in terms of sustainability and green building practices. In fact, one of its best qualities is that it's self-repairing. Biological concrete is a material that’s at the forefront of construction, one of its best characteristics is that it’s self-repairing. This is a response to the difficulty using vertical gardens on facades. These gardens are an excellent option to improve the energy efficiency of buildings however, they are often expensive and difficult to maintain.“Biological concrete is the result of the search for a better solution to vertical gardens to build “living” façades”. This material, which is also intended for the façades of some constructions, offers environmental, thermal, and decorative advantages. It’s an excellent option for sustainable architecture.Sustainable architecture, with the application of this type of material, also seeks to improve urban environmental parameters. Using biological concrete is a way of thinking about the proper management of resources and energy conservation and biological concrete is a sustainable construction material.The innovation of biological concrete is it works as a natural support for the growth of certain biological organisms. These can be certain types of families of fungi, mosses, and lichens. This type of concrete becomes living concrete by allowing organisms to grow. The material, due to components such as cement, can easily crack, so it’s reinforced with steel. In response to this cracking process, the living organisms that inhabit the biological concrete act on the fracture, occupying the space. Therefore, this type of concrete is self-repairing. Considerable and larger fractures must be repaired with traditional methods. However, the biological concrete system considerably increases the life of buildings by repairing minor cracks.Due to the high pH, it has, higher than 8, bacteria that live in these acidity levels, such as Bacillus often appear. The great innovation of this biological concrete is its ability to grow and develop microalgae, fungi, lichens, and mosses in a natural accelerated way. The bacteria Bacillus repairs concrete when cracks appear. These bacteria can producing limestone, which fills the fractures progressively, sealing the material.

Living organisms can creating spores, and they’re resistant for decades without a problem. Spores are like sleeping bacteria that activate when there’s food and water around. This means they’ll activate and seal a crack if water can get into it. This material isn’t only for new buildings, as it can also enhance restorative rehabilitation work. In addition, the research group points out the use of biological concrete in areas with high seismic activity to help make buildings safer.Biological concrete, in addition to being a material that repairs itself, is an excellent example of a sustainable material. The use of this revolutionary element doesn't only improve the climatic conditions of buildings, but it's also a great contribution to the urban environment.

Concrete is one of the most widely used building materials in the world, used in everything from high-rise buildings to sidewalks. It is durable, relatively cheap, and can be poured into any shape or size. However, concrete also has several downsides. It is a major contributor to greenhouse gas emissions, it requires a lot of energy to produce, and it is prone to cracking and deterioration over time. Recently, a new type of concrete has emerged those addresses many of these issues: biological concrete. Biological concrete, also known as bio cement or biogenic concrete, is a material that incorporates living organisms into the concrete mixture. The organisms, usually bacteria, produce a natural cementing agent that binds the concrete together, resulting in a strong, durable material that is also environmentally friendly. In this essay, we will explore the benefits and drawbacks of biological concrete, as well as its potential applications in the construction industry. One of the main benefits of biological concrete is its environmental sustainability. Unlike traditional concrete, which is produced by heating limestone to high temperatures, biological concrete is produced using natural, non-toxic materials.

The living organisms used in the mixture, typically bacteria, require much less energy to produce than traditional concrete, and they produce fewer greenhouse gas emissions. Additionally, the production of biological concrete does not require any fossil fuels, which further reduces its environmental impact. Another benefit of biological concrete is its durability. Traditional concrete is prone to cracking and deterioration over time, especially in harsh environments. Biological concrete, on the other hand, is able to self-heal. The living organisms in the mixture produce a natural cementing agent that fills in any cracks or fissures in the concrete, making it stronger and more durable. In addition to its environmental sustainability and durability, biological concrete also has several other potential applications. For example, it could be used to create self-repairing roads and bridges, reducing the need for expensive and time-consuming maintenance. It could also be used to create concrete structures that are able to withstand earthquakes and other natural disasters.While biological concrete has many benefits, it is not without its drawbacks. One of the main challenges of using biological concrete is controlling the growth of the living organisms in the mixture. If the organisms grow too quickly or too slowly, it can lead to inconsistent results and weaker concrete. Additionally, the cost of producing biological concrete is currently higher than that of traditional concrete, which may limit its adoption in some markets. Another challenge of biological concrete is ensuring that it is safe for human use. Because the living organisms in the mixture are alive, there is a risk of contamination or infection if they are not properly handled. Additionally, there is a risk that the organisms could mutate or evolve in unexpected ways, potentially leading to unforeseen consequences. Despite these challenges, the potential benefits of biological concrete make it an area of great interest for researchers and engineers.

Biological concrete has a wide range of potential applications in the construction industry. One of the most promising applications is in the creation of self-healing concrete. Self-healing concrete is a type of concrete that is able to repair itself when it cracks or breaks. The living organisms in biological concrete are able to produce a natural cementing agent that fills in any cracks or fissures in the concrete, effectively repairing the damage. Another potential application of biological concrete is in the creation of earthquake-resistant structures. Traditional concrete structures are often brittle and prone to cracking in the event of an earthquake. Biological concrete, with its ability to self-heal and withstand environmental stresses, could be used to create structures that are more resistant to earthquakes and other natural disasters.

The potential benefits of biological concrete extend beyond just temperature and air quality. It is also being explored for its potential to help with water management. In urban areas, the prevalence of impermeable surfaces such as concrete can lead to increased runoff during heavy rainfall, contributing to flooding and strain on existing water infrastructure. Researchers have found that incorporating biological elements into concrete can help to mitigate these issues. For example, the use of certain types of moss can help to absorb water, reducing runoff and promoting infiltration into the ground. There are also potential benefits for biodiversity. Concrete jungles are often criticized for their lack of green spaces, which can have negative effects on local ecosystems. By incorporating biological elements into concrete, such as moss and lichens, it is possible to create new habitats for plant and animal species. In addition, the use of biological concrete can help to promote awareness of the importance of biodiversity and the need for sustainable urban design. However, there are also challenges associated with the use of biological concrete. For example, there is still much research to be done on the long-term durability of these materials.

The growth and survival of biological elements can be affected by a variety of factors, such as temperature, moisture, and pollutants, which can impact the integrity of the concrete. In addition, there are concerns about the potential for biological concrete to contribute to the spread of invasive species, which could have negative effects on local ecosystems. As we continue to grapple with the challenges of urbanization and climate change, innovative solutions like biological concrete will become increasingly important in creating sustainable, liveable-cities.

In conclusion, biological concrete is a promising area of research and development that has the potential to address many of the challenges associated with urbanization and climate change. By incorporating biological elements such as moss and lichens into concrete, it is possible to create materials that are more sustainable, promote better air quality, and provide new habitats for plant and animal species. However, there are also challenges associated with the use of these materials, and further research is needed to understand their long-term durability and potential impact on ecosystems. With continued innovation and collaboration bet ween researchrs,designers, and industry, biological concrete has the potential revolutionizee wa y we build and live in our cities.Bio receptive concrete is a type of material that encourages the growth of plants and microorganisms on its surface, making it a natural and environmentally friendly option for construction projects. The term "bio receptive" refers to the ability of the concrete to attract and support the growth of living organisms. The idea behind bio receptive concrete is to incorporate natural elements into man-made structures, creating a more sustainable and eco-friendlier environment. By encouraging the growth of vegetation on concrete surfaces, bio receptive concrete can help to reduce the urban heat island effect, improve air quality, and reduce the amount of stormwater runoff. One of the key advantages of bio receptive concrete is its ability to support a wide range of plant species. Different types of vegetation can be incorporated into the material, including mosses, grasses, and even trees. The plants can be arranged in various patterns and configurations, creating unique and visually appealing designs. Another benefit of bio receptive concrete is its ability to absorb and retain water. The material is designed to be porous, allowing water to seep through and be stored within the concrete. This feature can help to reduce the amount of stormwater runoff and improve the overall water quality of surrounding areas. There are also several challenges associated with the use of bio receptive concrete.

One of the main issues is the maintenance required to keep the vegetation healthy and thriving. Regular watering, pruning, and fertilization may be necessary to ensure that the plants continue to grow and flourish. In addition, the use of bio receptive concrete may require a different approach to construction and design. The material is typically thicker and heavier than traditional concrete, which can affect the structural integrity of a building. Special considerations may need to be taken to ensure that the concrete is properly supported and reinforced. Despite these challenges, bio receptive concrete offers a unique and innovative approach to sustainable construction. By incorporating natural elements into man-made structures, we can create a more harmonious and environmentally friendly urban environment.

As the demand for green buildings and sustainable design continues to grow, bio receptive concrete is likely to become an increasingly popular choice for architects and engineers alike.

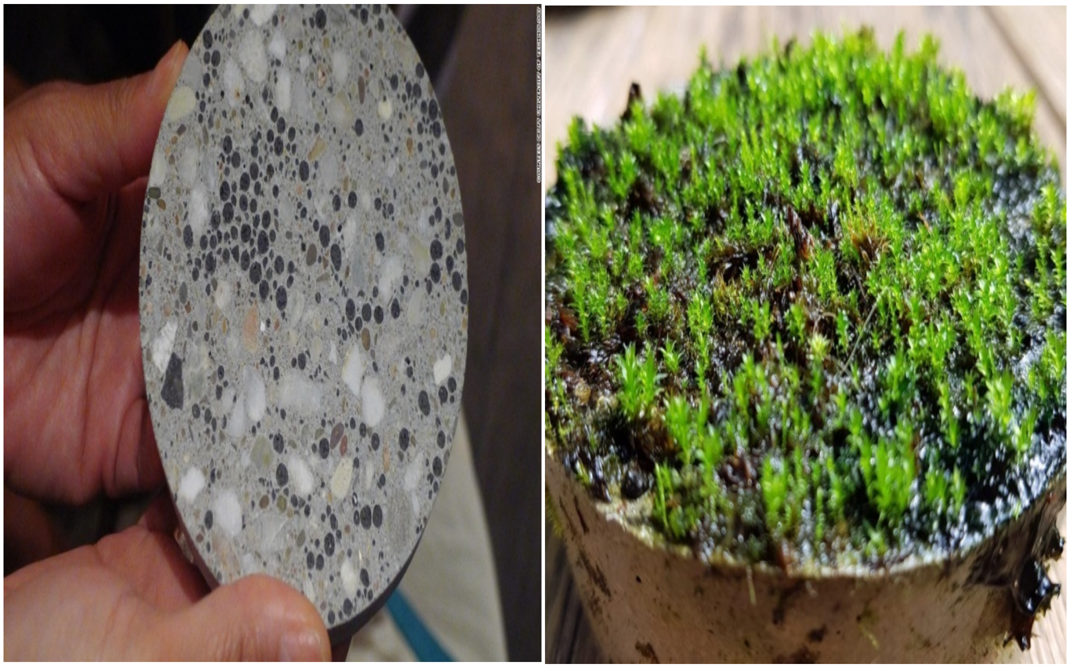


Fig 1.1.(a). Self-healing concrete and moss concrete

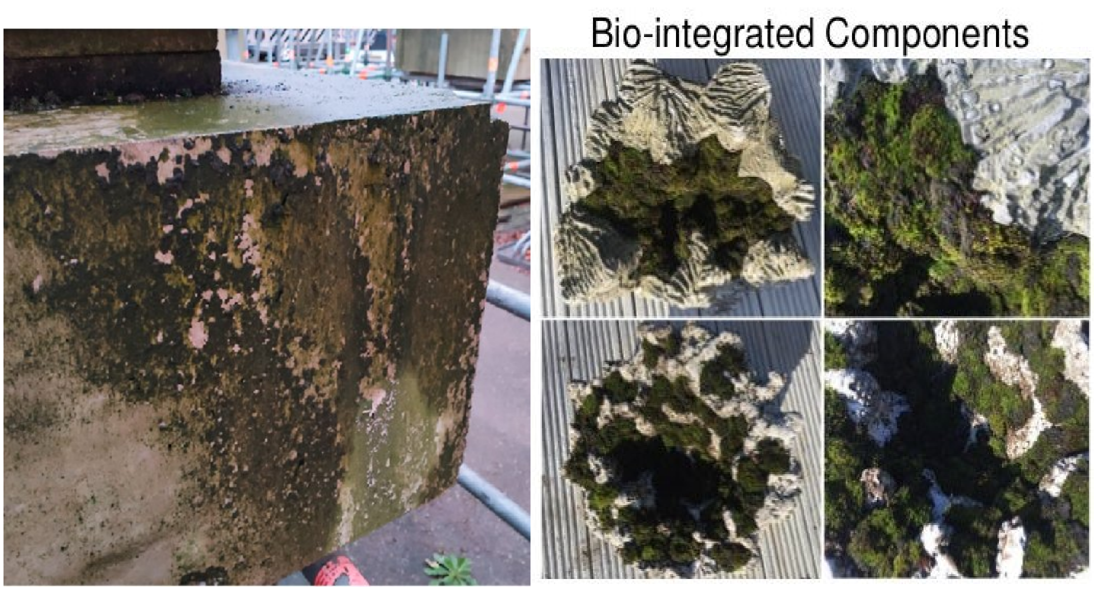


Fig 1.1.(b). Bio Receptive Concrete

1.2 VERTICAL GARDENING

Vertical Gardens: An Innovative Solution for Urban Landscaping

As cities continue to grow, finding green spaces becomes increasingly difficult. Urbanization and limited space have resulted in a lack of greenery, leading to poor air quality, increased pollution, and loss of biodiversity. Vertical gardens have emerged as a creative solution to these problems, providing a unique way to incorporate greenery into urban spaces. In this essay, we will explore the concept of vertical gardens, their benefits, and how they can be implemented in urban settings.

What are Vertical Gardens?

Vertical gardens, also known as living walls or green walls, are a type of garden where plants are grown vertically on a wall or other vertical surface. They can range in size from small wall hangings to large-scale installations covering entire buildings. The plants can be grown in a variety of ways, such as in soil or hydroponically, and can include a range of species from small succulents to larger plants like ferns and ivy.

Benefits of Vertical Gardens

Vertical gardens offer numerous benefits to urban areas. Firstly, they can help to improve air quality by removing pollutants from the air and releasing oxygen. This can have a positive impact on the health of urban residents, reducing respiratory illnesses and other health problems associated with poor air quality. Additionally, vertical gardens can help to regulate temperature, keeping urban areas cooler in the summer and warmer in the winter. This can have a significant impact on energy usage, reducing the need for air conditioning and heating. Vertical gardens also provide habitat for urban wildlife, helping to promote biodiversity. As green spaces become increasingly scarce in cities, providing habitats for birds, insects, and other animals becomes more important. Vertical gardens can provide food and shelter for a range of species, helping to create a more diverse and sustainable urban environment. Finally, vertical gardens can have a positive impact on mental health and wellbeing. Studies have shown that exposure to green spaces can help to reduce stress, anxiety, and depression, promoting a sense of calm and relaxation.

Implementing Vertical Gardens in Urban Areas

Implementing vertical gardens in urban areas requires careful planning and consideration. Firstly, it is important to select the appropriate plants for the location and growing conditions. Factors such as light, temperature, and humidity should all be taken into account when selecting plants for a vertical garden. Additionally, the structure supporting the plants must be carefully designed and engineered to ensure that it can support the weight of the plants and the growing medium.Maintenance is also a critical factor in the success of a vertical garden. Regular watering, fertilization, and pruning are all necessary to ensure that the plants remain healthy and vibrant. Automated irrigation systems can be used to simplify maintenance, ensuring that plants receive the appropriate amount of water and nutrients.

Vertical Gardens: Design Considerations and Maintenance

In addition to the benefits of vertical gardens discussed earlier, these gardens also offer unique design possibilities. A well-designed vertical garden can be a beautiful and striking feature in any space. However, creating a successful vertical garden requires careful consideration of several factors. First, it is important to choose the right plants for the environment in which the vertical garden will be located. Factors to consider include the amount of sunlight, temperature, humidity, and air circulation. Plants that are well-suited to the environment will be more likely to thrive and require less maintenance. It is also important to consider the size and weight of the plants, as larger plants may require additional support. Another important consideration is the structure on which the vertical garden will be mounted. The structure must be able to support the weight of the plants, as well as any irrigation and drainage systems. It is also important to ensure that the structure is stable and secure, as the weight of the plants and water can cause it to become unstable over time. Irrigation is another important consideration for vertical gardens. Because the plants are grown vertically, it can be more challenging to provide them with the water they need. Automated irrigation systems can be a good solution, but they must be carefully designed to ensure that water is distributed evenly throughout the garden. In addition, it is important to consider drainage to prevent excess water from accumulating and damaging the plants or the structure. Finally, it is important to consider the overall aesthetic of the vertical garden. A well-designed vertical garden should be visually appealing and complement the surrounding space. The choice of plants, structure, and irrigation system can all contribute to the overall aesthetic.

Conclusion

Vertical gardens offer numerous benefits and are becoming increasingly popular in both indoor and outdoor spaces. However, creating a successful vertical garden requires careful consideration of several factors, including plant selection, structure design, irrigation, maintenance, and aesthetics. By taking these factors into account, it is possible to create a beautiful and thriving vertical garden that enhances any space. 1) Vertical gardening is a method of gardening that grows upwards instead of horizontally, often using trellises, planters, hanging baskets, or hydroponics. 2) It can provide maximum yield with minimal space and doesn't require soil. 3) Vertical gardening is becoming more popular in urban areas as a way to create green spaces, live a more self-sufficient lifestyle, and for the positive mental impact gardens can have. 4) Vertical gardens can increase productivity per unit area of cultivated land and can be a way of achieving food security and sovereignty. 5) Vertical gardens provide many benefits, including increased production per meter squared, social and societal benefits, utilization of otherwise unused or unusable space, positive impact on climate change, reduced urban heat island effect, mitigation of the impact of pollutants, improvement of overall air quality, improved building energy efficiency, and biodiversity.

Fig 1.2 – Vertical Garden

1.3 GREEN ROOFS

History and Evolution of Green Roofs

The concept of green roofs dates back to ancient times when people in the Middle East and Mediterranean built homes with soil and vegetation on top. In the early 20th century, German architect Le Corbusier included green roofs in his designs as a way to combat urban heat and provide green space in cities. However, it wasn't until the 1960s that green roofs became more popular in Europe, and it took until the 1990s for them to gain traction in North America. Today, green roofs are found all over the world, from Scandinavia to Singapore.
A green roof, also known as a living roof, is a roof that is partially or completely covered with vegetation. Green roofs have been gaining popularity in recent years due to their numerous benefits. They not only provide insulation and reduce the urban heat island effect, but they also absorb rainwater and provide habitats for birds and insects. In this report, we will discuss the benefits, types, and challenges of green roofs. Green roofs, also known as vegetated roofs, eco-roofs, or living roofs, are roofs that are partially or completely covered with vegetation, planted over a waterproofing membrane. They are designed to absorb and retain rainfall, improve air quality, reduce the urban heat island effect, and provide habitat for wildlife. Green roofs have been around for centuries, but their popularity has increased in recent years due to their numerous benefits. In this essay, we will explore the history, benefits, types, and challenges of green roofs. Green roofs are an emerging technology that has become increasingly popular in urban areas in recent years. A green roof is a roof that is covered in vegetation, which serves a number of purposes including reducing the heat island effect, mitigating stormwater runoff, improving air quality, providing habitat for wildlife, and even reducing energy consumption in buildings. In this essay, we will explore the benefits of green roofs, the different types of green roofs, and the challenges associated with their installation and maintenance.

Benefits of Green Roofs

Green roofs offer a number of benefits to both the environment and the people who live and work in buildings with green roofs. One of the most significant benefits of green roofs is their ability to reduce the heat island effect in urban areas. The heat island effect is a phenomenon in which urban areas are significantly warmer than surrounding rural areas due to the absorption and retention of heat by buildings, roads, and other infrastructure. Green roofs can help to reduce the heat island effect by absorbing and dissipating heat through evaporations.
In addition to reducing the heat island effect, green roofs also help to mitigate stormwater runoff. This is particularly important in urban areas where impervious surfaces such as roads and buildings prevent rainwater from being absorbed into the ground. Instead, rainwater runs off these surfaces and

into storm drains, which can cause flooding and erosion. Green roofs absorb rainwater, which reduces the amount of stormwater runoff and helps to recharge groundwater supplies. Green roofs also have the potential to improve air quality in urban areas. Plants absorb carbon dioxide and other pollutants from the air and release oxygen, which can help to improve air quality. In addition, green roofs can provide habitat for wildlife, including birds, insects, and small mammals. This can help to increase biodiversity in urban areas and provide a source of food and shelter for wildlife.Finally, green roofs can also help to reduce energy consumption in buildings. The layer of vegetation on a green roof acts as an insulating layer, which can help to regulate the temperature inside buildings. This can reduce the need for air conditioning in the summer and heating in the winter, which can help to lower energy bills and reduce greenhouse gas emissions.

Types of Green Roofs

There are several different types of green roofs, each with its own unique set of characteristics and benefits. The most common types of green roofs include intensive, extensive, and semi-intensive.
Intensive green roofs are characterized by their depth and complexity. These types of green roofs are often used for recreational purposes and can include features such as trees, shrubs, and even small ponds. Intensive green roofs require a significant amount of maintenance, including regular watering, fertilization, and pruning.Extensive green roofs are much simpler than intensive green roofs and are often used for their environmental benefits rather than their aesthetic appeal. These types of green roofs typically consist of a thin layer of soil and vegetation, such as sedums or grasses. Extensive green roofs require very little maintenance and are often installed on flat roofs.Semi-intensive green roofs are a combination of intensive and extensive green roofs. These types of green roofs are often used for their aesthetic appeal and may include a variety of vegetation types, including flowers, shrubs, and even small trees. Semi-intensive green roofs require more maintenance than extensive green roofs but less than intensive green roofs.

Challenges Associated with Green Roofs

While green roofs offer many benefits, there are also several challenges associated with their installation and maintenance. One of the biggest challenges is the cost of installing a green roof. Green roofs require a significant amount of structural support, waterproofing, and insulation, which can make them more expensive than traditional roofs.Another challenge is the maintenance required to keep a green roof healthy and functioning properly.

Conclusion

Green roofs are an innovative solution to many of the environmental and social challenges faced by urban areas. They offer numerous benefits, including storm water management, air and water quality improvement, and urban heat.

Fig 1.3 (a) – Green Roofs

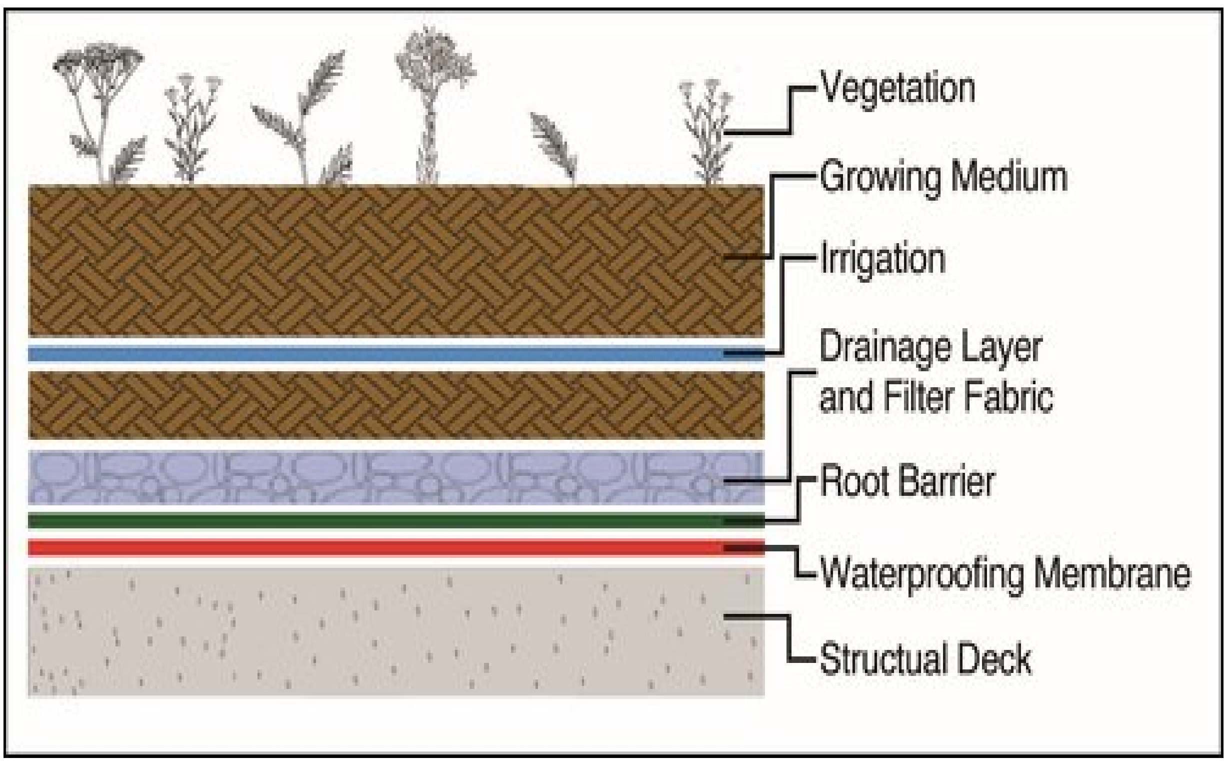


Fig 1.3 (b) - A green roof section, showing the layers of a green roof. This section shows an optional irrigation system

1.4 ADVANTAGES OF MOSS CONCRETE

Moss is a type of plant that is typically found in damp and shaded areas. It is a non-vascular plant, meaning that it lacks the specialized tissue for transporting water and nutrients that is found in most other plants. Despite this, moss is a highly adaptable and resilient plant, and it is often used in landscaping and horticulture projects for its unique aesthetic and ecological benefits.

In this project, moss plays a key role in creating a green roof system that is both aesthetically pleasing and ecologically sustainable. Green roofs are becoming increasingly popular in urban environments as a way to combat the negative effects of urbanization, such as heat island effects, air pollution, and stormwater runoff. Moss, in particular, is well-suited for green roof systems due to its ability to absorb and retain water, filter pollutants from the air, and provide a natural cooling effect.There are several different types of moss that are commonly used in green roof systems, each with its own unique characteristics and benefits. Some of the most common types of moss used in green roofs include:

1. Hypnum moss - Hypnum moss is a fast-growing and highly adaptable moss that is well-suited for use in green roofs. It is capable of absorbing large amounts of water and retaining it for long periods of time, which makes it an excellent choice for reducing stormwater runoff.

2. Polytrichum moss - Polytrichum moss is a hardy and drought-tolerant moss that is often used in green roofs due to its ability to withstand dry conditions. It is also a good choice for filtering pollutants from the air, as it has a large surface area and can trap particles as they pass through.

3. Haircap moss - Haircap moss is a dense and compact moss that is well-suited for use in green roofs. It is able to absorb and retain large amounts of water, which makes it an excellent choice for reducing stormwater runoff. It also provides a natural cooling effect, which can help to reduce the heat island effect in urban areas.When incorporating moss into your green roof system, there are several key factors to consider. First and foremost, it is important to choose the right type of moss for your particular environment and climate. Different types of moss have different requirements in terms of light, moisture, and temperature, so it is important to do your research and choose a moss species that will thrive in your particular location. Once you have selected your moss, it is important to ensure that it is properly installed and maintained. Moss can be attached to your green roof substrate in several different ways, including using adhesive, wire mesh, or other types of support structures. It is important to choose a method that will provide adequate support for your moss and allow it to grow and spread over time. In terms of maintenance, moss requires relatively little upkeep compared to other types of plants. It is important to keep the moss moist, but not waterlogged, and to ensure that it receives adequate sunlight and nutrients. Regular pruning and weeding may also be necessary to keep your moss looking neat and tidy. In addition to its aesthetic and ecological benefits, moss has also been found to have several other potential uses and benefits. For example, recent research has suggested that moss may be a valuable source of biofuel due to its high oil content. Additionally, moss has been used for centuries in traditional medicine to treat a variety of ailments, including respiratory issues, digestive problems, and skin conditions.Overall, moss is a highly versatile and valuable plant that can be used in a wide variety of applications, from green roofs and landscaping to medicine and biofuels. By incorporating moss into your green roof system, you can create a beautiful and sustainable environment that one potential application of moss is in air purification. Moss has been shown to absorb air pollutants such as carbon dioxide, volatile organic compounds (VOCs), and particulate matter. In fact, moss is believed to be even more effective at absorbing these pollutants than traditional houseplants. This makes moss a promising option for indoor air purification, particularly in areas with high levels of air pollution.In addition to its air-purifying properties, moss also has potential as a bioindicator. Bioindicators are organisms that can be used to monitor the health of an ecosystem. Moss is particularly useful as a bioindicator because it is sensitive to changes in its environment, such as changes in air quality or water availability. By monitoring the growth and health of moss in a particular area, researchers can gain insights into the overall health of the ecosystem.Another potential use of moss is in green roofs. Green roofs are roof systems that are covered with vegetation. They are becoming increasingly popular in urban areas as a way to mitigate the urban heat island effect and improve air quality. Moss is an excellent option for green roofs because it is low-maintenance and can thrive in a variety of growing conditions. Additionally, moss is able to absorb and retain water, which can help to prevent stormwater runoff and reduce the strain on urban drainage systems.Moss is also a promising material for use in biomimicry. Biomimicry is the practice of using natural systems and processes as inspiration for technological innovation. Moss has a number of unique characteristics that make it an attractive option for biomimetic applications. For example, moss is able to absorb and retain large amounts of water, making it an effective water-harvesting material. Additionally, moss is able to adhere to surfaces without the need for adhesives, making it a potentially useful material for a range of industrial and consumer applications.Despite its many potential uses, moss is still an underutilized resource. This is partly due to the fact that mosses are often difficult to propagate and cultivate in large quantities. However, recent advances in biotechnology have made it easier to cultivate moss in controlled environments, which could help to increase its availability for use in a range of applications.In conclusion, moss is a versatile and valuable resource that has a wide range of potential applications. From air purification to biomimicry, moss has a lot to offer in terms of environmental and technological innovation. As we continue to explore the potential uses of moss, it is important to remember the importance of sustainable harvesting and cultivation practices to ensure that this valuable resource is preserved for future generations.Moss is perfect for green facades as it has rhizoids instead of roots. As opposed to roots, Rhizoids are non-destructive, leaving the façade in perfect condition with very little maintenance. It creates a space for insects stimulating biodiversity in cities. The moss also helps solve air- and noise pollution, contributing to the well-being of an urban environment and its inhabitants. Moss is perfect for green facades as it creates a space for insects stimulating biodiversity in cities. The moss also helps solve air- and noise pollution, contributing to the well-being of an urban environment and its inhabitants. Characteristics of moss make it incredibly suited for green façades. With rhizoids instead of roots, moss is non-invasive to the façade, and with its dense leaf system, it provides many wonderful benefits to the urban environment.Firstly, moss converts CO_2 to oxygen and absorbs and removes other pollutants such as PM_{10}, VOCs, NO_x, and NH_3, from water and air, thereby reducing contamination. Secondly, moss can absorb and retain large amounts of water in its leaf system, contributing to water retention. Thirdly, through evapotranspiration and shielding of the surface from sunlight, moss attributes to cooling of the structure, which is beneficial for urban environments. Fourthly, moss increases local biodiversity by providing habitat for vital fauna on otherwise bare concrete surfaces. Fifthly, with its dense leaf system, moss captures sound and reduces noise pollution. Sixthly, coordinated moss growth turns bare concrete structures into beautiful sights, which is aesthetically pleasing. Finally, moss produces biomass, which is a suitable renewable resource for other products. The main reason why certain types of concrete support spontaneous and abundant growth of moss is that they are relatively porous, resulting in a high moisture-retaining capacity that improves their bio-receptivity towards moss growth. Moss can grow on concrete, especially in those portions that are moist, hidden from the sun, and have no ventilation. Although moss has no roots, it has threads that can hold onto the concrete surface, allowing it to stay alive. Meanwhile, concrete has a porous surface that can absorb water, which is what mosses need to survive.

Advantages of using moss

1. Environmental Benefits: Mosses can absorb air pollutants such as carbon dioxide, sulfur dioxide, and nitrogen oxides. They also help to mitigate the effects of climate change by capturing and storing carbon in their tissues.

2. Low Maintenance: Mosses are low-maintenance plants and do not require frequent watering or fertilization. Once established, they can thrive on rainfall and minimal sunlight.

3. Aesthetic Appeal: Mosses can provide a unique and attractive addition to any project. They come in a variety of colors and textures and can be arranged in different patterns to create visually appealing designs.

4. Cost-Effective: Mosses are relatively inexpensive and can be easily obtained in many areas. They are also easy to propagate and can be grown in a variety of substrates, including soil, rocks, and even concrete.

5. Sound Insulation: Mosses can provide sound insulation and absorb unwanted noise. They are commonly used in acoustic panels and soundproofing materials.

6. Ecological Restoration: Mosses are often used in ecological restoration projects due to their ability to grow in harsh environments and their ability to help stabilize soil and prevent erosion.

Overall, the use of moss can provide a range of benefits, including environmental, aesthetic, and economic advantages. As the importance of environmental sustainability continues to grow, the use of moss in urban design is likely to become more widespread. By incorporating moss into our cities and buildings, we can create more livable and sustainable spaces for both humans and wildlife.

Fig 1.4 - Moss cultivated on a concrete building

CHAPTER 2
LITERATURE REVIEW

Bio-receptive façade panels that support the natural growth of mosses, micro-organisms, and small plant species are potential alternatives than traditional green walls. Supporting the moss's development naturally could offer great potential for achieving ecologically richer, healthier, and zero-carbon cities. In particular, a limited amount of hydration is required for mosses to grow on these bio-receptive surfaces, which is ideal for the hot, humid environment of north Egypt. This review paper is aimed at identifying the feasibility and influencing factors of implementing such a façade innovation in a hot, humid climate as north Egypt. To investigate this feasibility, first, it is essential to compare the critical factors for moss growth with the target environmental conditions. These key feasibility factors for the approach were classified as environmental and physical growth factors. Second, a field study was undertaken to confirm the availability of such moss resources in north Egypt since the climatic conditions correspond to the acceptable range necessary for its application of the approach. This study resulted in promising families of mosses being available, in which great potential for the use of bio-receptive concrete with a cover of moss to expand the green areas vertically is expected. Especially, this green expansion will be with moss, which blooms randomly in the natural environment. This technique may bring additional advantages by generating new sustainable materials from low-cost and readily available resources. It is considered to be an approach to enhance greening and reduce urban environment's susceptibility to climate change without requiring extensive irrigation and maintenance. **(R. Mahrous et al.2022).** The building envelop is generally considered as our third skin. Moss growth and mold growth are constrains which reduce the strength of the third skin. This study is aimed to analyze the effect of the mold growth and moss growth on different walling materials such as Brick, cement blocks, cement stabilized earth block, Cabook, Mud concrete blocks, Geo polymerized earth blocks walls and plastered walls with cement plaster and rough finish plaster in a tropical climate. Organic matter, surface roughness, water absorption capacity, sorptivity and the capillary action of those walling materials were studied first. After which mold growth and moss growth were conducted in the real world controlled environment to accelerate the mold growth and moss growth. The growth rate and the strength reduction due to the effect of mold growth and moss growth were studied. The results demonstrate that walling materials with high porous spaces have the high potential to grow moss and mold. The walling materials with the high organic matter also encourage moss and mold growth. Interestingly it was found that even though materials like mud concrete block and geo polymerized earth blocks have high organic matter, their less surface roughness helped to reduce the moss growth and mold growth. And also, plastering can emphatically reduce the speed of mold growth and moss growth**. C. Udawattha et al., (2018).** Increased urbanisation will put an increasing strain on our green spaces, which is expected to have a significant effect on our physical and mental health, as well as the health of our ecosystems. As such it is important to integrate more green spaces in our urban fabric. One way of doing this is by making use of so-called bioreceptive concrete on our façades and other structures, which allows for biological growth to take place on the concrete substrate itself, without requiring any additional systems or maintenance. However, the challenge is to create an affordable concrete mixture that is sufficiently bioreceptive for biological growth to take place. As such, in our research we test four possible measures to make concrete more bioreceptive: changing the aggregate to CEC (crushed expanded clay), adding bone ash to the mixture, increasing the wcf (water cement factor) and using a surface retarder on the concrete. Of these measures, changing the aggregate to CEC ($p = 0.024$), the addition of bone ash ($p = 0.022$) and the use of a surface retarder ($p < 0.001$) were found to significantly increase bioreceptivity. Increasing the wcf factor, however, was not found to significantly increase bioreceptivity ($p = 0.429$). It was also found that whereas it was previously though a pH below 10 is necessary for biological growth to take place, this does not appear to be the case. Although further research under natural conditions is necessary, the creation of an inexpensive bioreceptive concrete looks to be feasible.**M. Veeger,(2021).** Vertical greening systems and green roofs provide ecosystem services in the urban context. Despite the important benefits they provide, economic (initial and maintenance costs) and environmental issues may limit the widespread diffusion of these greening systems. Mosses can be a low-cost and low-maintenance alternative green envelope for large-scale application on existing urban and industrial buildings thanks to their low requirements in terms of growing substrates, low amount of water and nutrients needed, and high desiccation tolerance. The study assesses the' growing ability of mosses on building materials and low-cost materials, by means of growing tests performed under controlled environmental conditions on horizontal and vertical surfaces. Moss growth depends mainly on the physical characteristics of the materials, although an acidic moss mixture improves species richness. Results show different surface coverage: capillary matting > cement plaster > lime plaster > terracotta brick > slate > quartzite. The water retention capacity and its homogeneous distribution on the growing surface are the limiting factors for moss growth. **K. Perini et al. (2020).** The increasing construction of tall buildings in Indonesia has led to the reduction of green areas and the increase use of building materials such as concrete panels. This research sees the potential of building façades created by using concrete panels as media for growing plants to replace those green areas that have decreased. The plants that are used in this research are selected based on the climatic conditions of tropical countries in Indonesia. The plants that are chosen are fast growing, require less maintenance, and are considered to be suitable for cementitious materials. A previous study has found that bryophyte moss meets those criteria. This research compares the performance of pre-vegetated and non-pre-vegetated concrete panels by investigating compressive strength through laboratory experiments. Three mixes of concrete, three moss species, and three concrete surfaces were examined with 9 panels, 27 cube samples, and 9 cube controls. The study contributes to a growing body of research on the sustainability of building façades in which further investigation is needed. **Chairunnisa& Susanto (2018).** A low cost and lightweight moss envelope system for buildings has been developed to address the problem of the lack of greening in densely urbanized areas. Several moss species have been sampled in the wild, selected, based on their ability to tolerate the abiotic stresses of urban environments, cultivated in controlled conditions and tested for their growth capacity on different (building) materials. Five of these showed the most promising results in terms of growth speed and coverage, proving the most suitable for the development of the greening system: Homalotheciumsericeum, Barbula unguiculata, Pseudoleskeaincurvata, Grimmiapulvinata and Hypnum cupressiforme. An in vitro growing method was also set up for large scale moss cultivation and application. A modular multi-layer panel, with a built-in irrigation system, has been developed, designed and tested. MosSkin is a low-cost low maintenance, versatile and lightweight system, with interesting performances in terms of water management and surface temperature reduction (up to 14 ◦C). **K. Perini et al. (2022).**Rapid urbanization and the lack of green infrastructure threaten the health of urban dwellers. Green façades have been proposed as a green infrastructure solution to compensate for the loss of green spaces in dense city areas; however, as far as we know, there is inadequate evidence for associations between views of green façades and relaxation. This study aims to clarify the physiological and psychological relaxation effects of viewing a green façade landscape. Twenty-five Chinese females (23 ± 1.5 years) viewed a green façade landscape or a building-wall for 5 min. Data were generated using electroencephalographic, heart rate variability, and skin conductance physiological measures and psychological measures using a semantic differential questionnaire and a Profile of Mood State. Findings suggest that, compared to the viewing of the building wall, the viewing of the green façade resulted in a significant increase in alpha relative waves in the frontal and occipital lobes, a significant increase in parasympathetic activity, and a significant decrease in the skin conductance as well as a substantial increase in comfortable, relaxed, and natural feelings, and a significant improvement in mood state. The green façade appears to enhance human physiological and psychological relaxation compared to the building-wall.**Mohamed Elsadek(2019).** While the market for "green" building materials has been expanding rapidly, the susceptibility of these materials to fungal growth is not well understood. The relative fungal resistance of four pairs of green building materials and their conventional analogs was assessed. An artificial inoculation protocol was used to investigate the effects of external nutrient levels, host material, and spore levels on the susceptibility of building materials to *Aspergillus niger*. Also, a natural inoculation protocol was utilized to evaluate the resistance of the building materials to colonization by common indoor fungi. Increasing spore levels and the presence of external nutrients promoted the growth of *A. niger* on the surface of drywall, conventional ceiling tile, and gypsum wallboard. Following natural inoculation, a strong correlation was found to exist between the equilibrium moisture content (EMC) of organic-based materials and the time until 50% of the total surface area of a material specimen was covered by fungi ($T_{50\%}$). Fungal growth rates on the top, back, and side surfaces of coated or composite building materials were quite different. The results suggest that the presence of organic matter in a given building material and its EMC are more important predictors of fungal susceptibility than is the label of "green" or "non-green".**Chi P. Hoang (2010).** Living walls can help bring nature to urban canyons. However, contemporary living walls are cost prohibitive and made of materials with shorter life spans than their buildings. High cost often restricts their use to luxury applications promoting ecological symbolism rather than impactful propagation of urban nature. This study shows an approach to lowering living wall costs and increasing their use by integrating them into the building's structure.Existing living wall systems are hung like curtains from a building's façade; they are made as light as possible to reduce the weight they superimpose. Their lighter materials, e.g., felts and plastics, limit their life cycle. Conversely, combining the living function with the exterior envelope will match a living wall's life cycle to its building, and cost diminishes by eliminating a living wall's secondary support structure. This study focuses on concrete construction, a typology needing ecological evolution. Chosen for its ubiquity, durability, affordability, and plasticity, concrete was tested as a potential growing medium for plants.The result of the study is a new living concrete material and system aimed at advancing biophilic design in cities facing shifting climates and population densification. Presented are a new cast-in-place living wall system, a new concrete and its mechanical properties, verification of constructability, identification of plants suitable to cementitious environments, indoor germination and growth, full-scale tests of a new construction methodology, how concrete's chemical composition affects irrigation water, outdoor germination and perenniality, and a cost analysis showing a 50% reduction to the installed cost of living walls. Cost savings include plants grown from seed-in-situ (eliminating raising plants in a nursery and transplantation), and not using fertilizer (eliminating chemicals and a fertigation system). This study shows how rethinking the current living wall paradigm could shift the industry toward solutions to democratize living walls via lower cost and permanence.**Benjamin Riley (2019).** This paper explores the potential of mosses as biomonitors of heavy metal deposition in urban areas. The authors conducted a study in Mexico City, where they collected samples of moss from various locations and analyzed them for heavy metals. They found that mosses can effectively absorb and accumulate heavy metals, making them a useful biomonitor of heavy metal deposition in urban areas. They also found that mosses can be used as a cost-effective and non-invasive alternative to traditional biomonitors**. M. Martínez-Zavala, E. Cuevas-Díaz, and A. Pérez-Vargas. (2019).** This paper explores the use of mosses as an indicator of urban pollution. The authors conducted a study in the city of Houston, Texas, where they collected samples of moss from various locations and analyzed them for heavy metals and other pollutants. They found that mosses can effectively absorb and accumulate heavy metals and other pollutants, making them a useful indicator of environmental pollution in urban areas.**D. E. Rowe and R. D. Venable. (2017).** This research paper investigates the use of mosses as bioindicators of atmospheric heavy metal pollution. The researchers analyzed moss samples from various locations in Spain and found that mosses can effectively accumulate heavy metals, making them valuable tools for monitoring air pollution. The paper also discusses the potential implications of these findings for public health and environmental policy.**Carballeira et al. (2017).**

CHAPTER - 3

MATERIALS AND METHODS

The preparation of a moss grass mat for concrete walls involves various materials and methodologies. The objective of this project is to create a green and sustainable solution to enhance the aesthetic value of concrete walls and reduce environmental pollutants such as carbon dioxide. In this chapter, we will describe the materials and methods used to achieve this objective. This includes the selection of appropriate moss species, preparation of concrete walls for moss growth, and maintenance of the moss grass mat.

The materials has been used are Concrete cubes, Moss (Java moss or similar fast-growing moss), Buttermilk, Water, Blender or food processor, Paintbrush, Spray bottle, Greenhouse jar or plastic bag, Watering can or spray bottle, Fertilizer (optional).Fresh moss samples were collected from natural habitats, including trees, rocks, and soil, in the local area. The collected samples were identified and classified based on their species. After collection, the moss was washed thoroughly with distilled water to remove any contaminants and soil particles. The moss was then air-dried to remove excess water before use.To prepare moss paste, take a handful of moss and put it in a blender or food processor. Add buttermilk and water in the ratio of 1:1:1, and blend the mixture until it becomes a paste. Once the moss paste is ready, the next step is to apply it to concrete cubes. First, prepare concrete cubes of size 6 x 6 inches and allow them to dry for at least 24 hours before applying moss. Then, use a paintbrush to apply the moss paste evenly on the surface of the concrete cubes, making sure to cover the entire surface area with a thin layer of moss paste. Place the cubes in a greenhouse jar or plastic bag to keep them moist and prevent the moss from drying out, and keep them in a shaded area with indirect sunlight for the first few weeks.To care for the moss grass mat, water the cubes regularly, either with a watering can or spray bottle, and add fertilizer to the water to help the moss grow faster. Mist the cubes regularly to maintain the moisture levels, and keep them in a shaded area with indirect sunlight. After 4-6 weeks, the moss will start to grow on the concrete surface. Once the moss has fully grown, carefully remove the cubes and attach them to the desired wall using a suitable adhesive. This process of preparing and applying moss paste on concrete cubes can be an innovative and sustainable way to improve the urban environment. The use of moss on green facades contributes to the well-being of an urban environment and its inhabitants by converting CO_2 to oxygen and absorbing and removing other pollutants such as PM10, VOCs, NO_x, and NH_3 from water and air. Moss can also absorb and retain large amounts of water in its leaf system, contributing to water retention. Through evapotranspiration and shielding of the surface from sunlight, moss attributes to cooling of the structure, which is beneficial for urban environments.

Additionally, moss increases local biodiversity by providing habitat for vital fauna on otherwise bare concrete surfaces, captures sound and reduces noise pollution, and produces biomass, which is a suitable renewable resource for other products. Overall, this innovative and sustainable use of moss on green facades can be an effective way to enhance the urban environment.The moss growth was monitored regularly for a period of four weeks. The growth of moss was assessed based on visual inspection, thickness of the moss layer, and its greenness. The pH level of the substrates was also measured regularly to ensure that they remained within the neutral range.The propagated moss samples were attached to concrete surfaces using an appropriate adhesive. The attachment process was monitored to assess the strength and durability of the attachment over time.

Fig 3 (a) – Flow chart of Moss grass method


MOSS PASTE PREPARTION


APPLICATION OF MOSS PASTE


A WEEK AFTER APPLICATION


GREEN-HOUSE ENVIRONMENT

PATCHES OF GREEN GROWTH

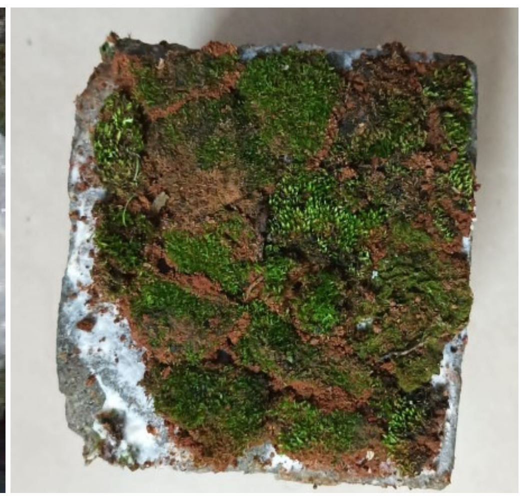

MOSS COMPLETLY ATTACHED

SPREADING OF GREEN GROWTH

MOSS PROGRATION ON CUBE

Fig 3(b)- Growth images of moss by method one.

BUTTERMILK PASTE



PINCUSHION MOSS PLACED

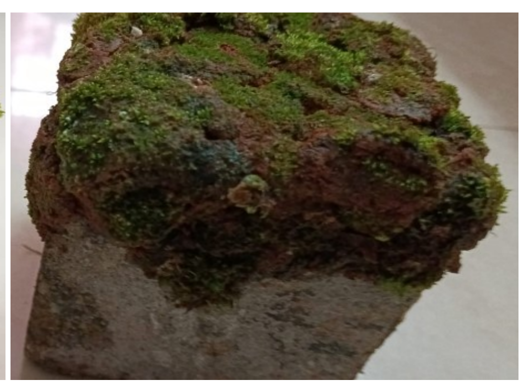


Fig 3(c) –Growth of moss by method two.

CHAPTER - 4
RESULTS AND DISCUSSION

Green facades that incorporate moss have become an innovative and sustainable solution to improve the urban environment. Moss has several benefits, including reducing air and noise pollution, increasing local biodiversity, and providing a renewable resource for other products. In this project, we tested two methods of using moss to enhance urban environments: growing moss on concrete cubes and attaching moss to concrete walls using an adhesive.

Growing Moss on a Concrete Cube: We applied moss slurry on all sides of a 2.7-inch cubical shaped concrete cube and kept it in a shaded area covered with a wet cloth to maintain the moisture level. The moss was regularly sprayed with water. After about two weeks, the moss started to attach itself to the surface. However, some parts of the moss appeared blackish brown in color while some appeared green. To create an optimal growing condition for the moss, we prepared a Green-house jar and kept the concrete inside the jar. The moss was able to grow and showed scattered growth throughout the surface.

Attaching Moss to Concrete Cube: To test the method of attaching moss to concrete cubes using adhesive, we cleaned the concrete surface with a scrub brush and then sprayed it with a baking soda and water solution to balance the pH level of the surface. We then applied the adhesive to the cleaned surface and attached the moss mat to the wall. We watered the mat regularly to maintain moisture levels.

Growing Moss on a Standard Brick: We also tested growing moss on a standard brick of 190mm X 90mm X 90mm dimension. We cleansed the surface and applied the moss paste on the brick and inside the grooves. The brick was kept under normal room temperature in a shaded area with indirect sunlight and sprayed with water regularly. After about two to three weeks, there was little growth on the brick, and the applied moss was drying out sooner.

The results of both methods of using moss to improve the urban environment showed promising results. Moss grew well on the concrete surface and provided several benefits, including reducing air and noise pollution, increasing local biodiversity, and providing a renewable resource for other products. Growing moss on concrete cubes proved to be a cost-effective and easy solution for improving the urban environment, as it requires minimal maintenance and provides benefits such as reducing air and noise pollution, increasing local biodiversity, and providing renewable resources for other products."Attaching moss to concrete cubes using adhesive was also effective in enhancing the urban environment. The use of adhesive made it possible to attach the moss mat to any desired surface, making it more versatile than growing moss on concrete cubes. This method also allowed for greater coverage of the moss on the surface, leading to increased benefits such as improved air and noise pollution reduction.

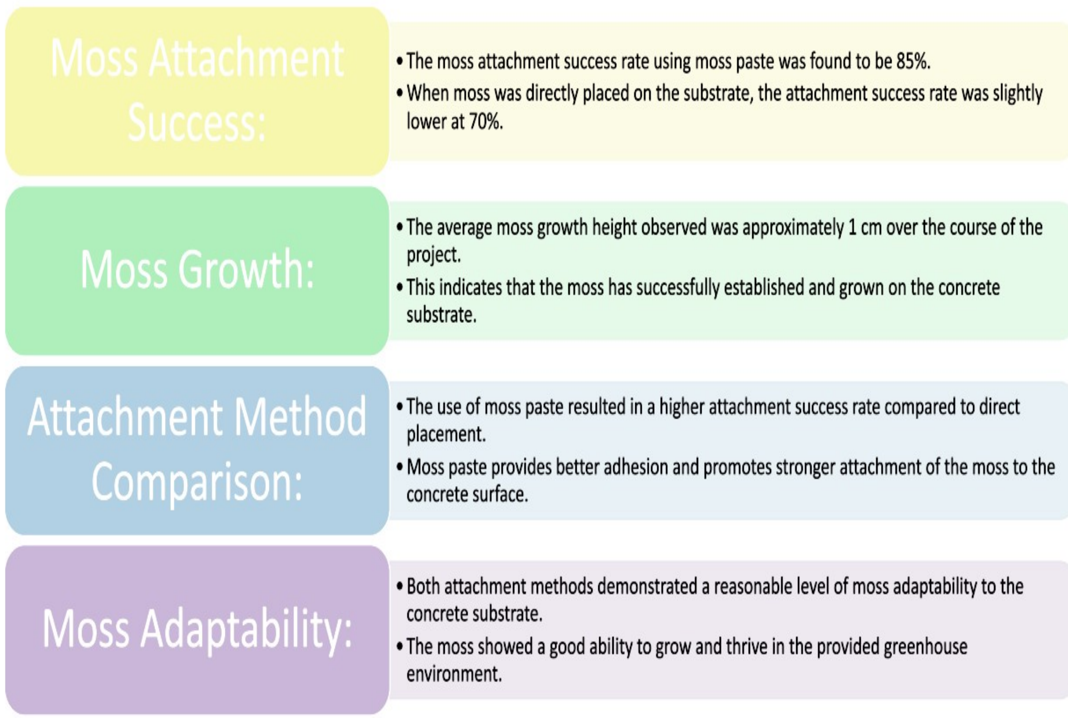


Fig 4(a)- Results pictorial

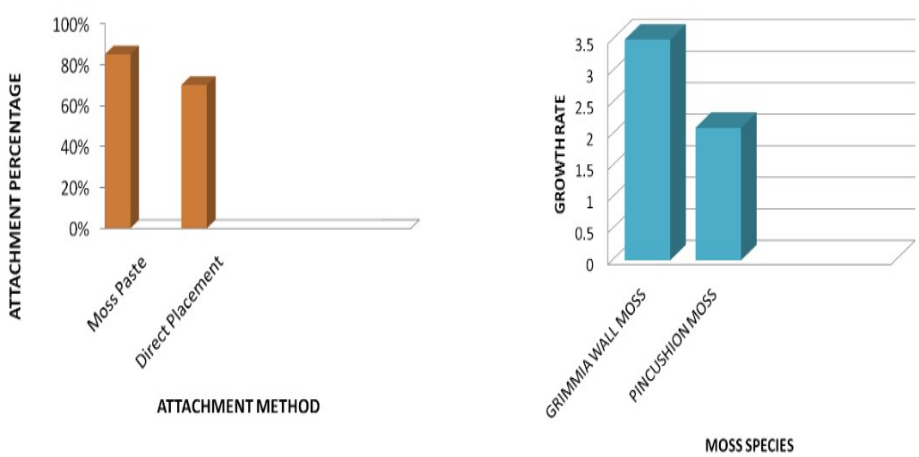


Fig 4(b)-Bar chart comparisons for attachment percentage and growth rate

CONCLUSION

In conclusion, the use of moss on green facades is a promising approach to improving the urban environment. Both methods tested in this project showed positive results and can be used in a variety of settings. The versatility of the adhesive method makes it an attractive option for use on a range of surfaces. The benefits of using moss for urban environments are numerous and include improving air and noise pollution, increasing local biodiversity, and providing renewable resources for other products. The use of moss on green facades is an innovative and sustainable way to create a greener and healthier urban environment for all. The use of moss as an attachment on concrete surfaces offers several advantages. The experimental results demonstrate that moss can successfully grow and thrive on concrete, providing aesthetic appeal and contributing to the overall greening of urban environments. The moss paste attachment method showed higher success rates in terms of moss coverage compared to direct placement. The adaptability and quality of the moss attachment were found to be influenced by factors such as moisture availability, surface texture, and exposure to sunlight. Overall, the incorporation of moss in concrete structures presents an opportunity to enhance the visual appeal, environmental sustainability, and air quality of urban areas.

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