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A STUDY ON THE IMPACT OF MOSS-GROWING CONCRETE AS A NEW SUSTAINABLE MATERIAL IN THE INTERIOR ARCHITECTURE INDUSTRY

Tapanwita Saha¹, Dr. Bigith V.B.²

¹PhD Scholar (Design), Lovely Professional University, Phagwara, Punjab, India

²Assistant Professor, Department of Architecture and Urban Planning, Lovely Professional University, Phagwara, Punjab, India

*e-mail: tapanwitasaha@gmail.com

Abstract

The study aims to investigate the impact of moss-growing concrete as a new sustainable material in the interior architecture industry. As concerns about environmental degradation and resource depletion mount, the search for innovative and environmentally friendly construction materials becomes paramount. Moss-growing concrete, combining the structural properties of concrete with the ecological benefits of live moss growth, has garnered interest. This study explores its potential impact as a new sustainable material in the interior architecture industry. Concrete's widespread use contributes to environmental issues due to its high energy consumption and carbon dioxide emissions. Moss-growing concrete incorporates living moss into the concrete matrix, offering benefits like carbon sequestration, air purification, thermal insulation, and aesthetic appeal. The interior architecture industry, focused on creating functional and visually appealing indoor spaces, can benefit from moss-growing concrete. This material can enhance the indoor environment by improving air quality and contributing to biophilic design principles. The research will explore its technical feasibility, performance characteristics, and perceptions of architects, designers, and end-users. The study aims to provide insights into revolutionizing the interior architecture industry sustainably through material analysis and survey questionnaires. Moss-growing concrete holds promise in transforming interior spaces into healthier, more sustainable environments. The study emphasizes the need for enhanced interior space efficiency, given that individuals spend a substantial portion of their time indoors. Architects and designers should prioritize integrating eco-friendly materials like moss-growing concrete.

Keywords: Air Purification, Biophilic Design, Bio-Receptive Concrete, Moss-Growing Concrete, Sustainable Material, Indoor Environment, Green Design

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Introduction

The fields of architecture and green design have undergone a profound transformation, driven by a growing awareness of environmental concerns and the urgent need for sustainable practices. As a response to these challenges, innovative materials and techniques have emerged, seeking to harmonize human-made spaces with the natural world. Among these advancements, the integration of moss-growing concrete has emerged as a fascinating and promising development, poised to revolutionize the interior architecture industry. Concrete has long been a staple of construction, offering durability, versatility, and structural integrity [9]. However, its widespread use has also contributed to environmental degradation due to the high carbon emissions associated with its production and the disruption of ecosystems caused by resource extraction. As the world grapples with the consequences of climate change and resource depletion, there is a pressing need to reimagine conventional construction materials. Moss-growing concrete, a fusion of concrete and organic life, offers a compelling solution by infusing sustainable principles into interior spaces.

Moss-growing concrete embodies the principles of biophilic design, a concept that seeks to reconnect people with nature through architecture. This innovative material is a marriage of technology and ecology, where concrete acts as a substrate for moss to flourish. Moss, a hardy and low-maintenance plant, possesses air-purifying qualities and contributes to improved indoor air quality, making it a natural fit for interior environments. Verdant appearance also introduces a sense of tranquility and visual interest, transforming sterile spaces into inviting havens [4]. The impact of moss-growing concrete extends far beyond its aesthetic appeal. One of its most compelling features is its ability to sequester carbon dioxide, thus functioning as a carbon sink. This attribute aligned seamlessly with the architecture industry's increasing commitment to reducing the carbon footprint of buildings. By integrating moss-growing concrete into interiors, designers can contribute to carbon offset initiatives and promote a more sustainable future.



Figure 1: Basic structure of moss-growing concrete [5]

The introduction of moss-growing concrete into the interior architecture industry holds the potential to redefine spatial experiences. Traditional design often separates nature from the built environment, resulting in disconnected, sterile spaces. Moss-growing concrete challenges this paradigm by introducing a dynamic living element into interiors. The tactile and visual connection with nature not only enhances human well-being but also encourages a more profound sense of harmony within space [5]. Technical considerations, such as moisture regulation, maintenance, and compatibility with existing architectural systems, must be thoroughly addressed. Additionally, as with any new material, questions about its long-term viability and durability will need to be answered through rigorous research and testing.

1.2 Aim and objective:

The study aims to investigate the impact of moss-growing concrete as a new sustainable material in the interior architecture industry.

The main objectives of the study are:

- a) To explore the impact of moss-growing concrete in the interior spaces of the occupants.
- b) To analyze the interior air quality condition for human well-being.
- c) To suggest how sustainable products can be a supporter in this process.

The main research question of the study is:

- What is the extent of carbon dioxide sequestration achieved by integrating moss-growing concrete in interior architecture?
- How does the presence of moss-growing concrete within interior spaces contribute to the improvement of indoor air quality, particularly in terms of pollutant filtration?
- In what ways can moss-growing concrete be effectively integrated into various interior green design styles and aesthetics?
- What are the key factors influencing the long-term viability and maintenance requirements of moss-growing concrete as a sustainable material in interior architecture?

Literature Reviews

Moss-growing concrete presents a novel approach to addressing environmental concerns within the construction industry. Its unique composition offers remarkable potential for carbon sequestration, contributing to the reduction of carbon dioxide in the atmosphere. Through photosynthesis, the mosses integrated into the concrete absorb and convert carbon dioxide, effectively acting as a carbon sink. This characteristic offsets emissions from the concrete production process and provides a mechanism for actively removing greenhouse gasses from the air. Quantifying the extent of carbon sequestration achieved by moss-growing concrete and comparing it to traditional materials, this research unveils its significant role in mitigating the carbon footprint of interior architecture[7]. Exploring these environmental benefits underscores the material's sustainability and capacity to revolutionize the construction landscape, offering a pragmatic solution to climate change challenges.

The integration of moss-growing concrete in interior architecture introduces a compelling dimension beyond aesthetics and structure—improved indoor air quality. Mosses possess inherent air-purifying properties, making them a natural choice for enhancing the environments we inhabit [8]. As part of moss-growing concrete installations, these plants effectively act as living air filters, removing pollutants and particulate matter from the indoor air. This natural filtration mechanism contributes to the reduction of allergens and harmful volatile organic compounds (VOCs), which are often associated with conventional construction materials.

Research into the impact of moss-growing concrete on indoor air quality delves into the extent of pollutant removal and the subsequent enhancement of occupant health and well-being. The presence of moss within interior spaces fosters a healthier atmosphere, potentially reducing instances of respiratory ailments and improving total comfort. Through comprehensive air quality assessments and comparative studies, this research seeks to quantify the tangible benefits of using moss-growing concrete in terms of air purification

[10]. Hereby, understanding the positive effects on indoor air quality adds a crucial layer of significance to the material's role in sustainable interior design, promoting spaces that not only look appealing but also contribute to the health and vitality of their occupants.

The incorporation of moss-growing concrete into interior design introduces a captivating synergy between the natural world and human-created spaces. This innovative material transcends the boundaries of conventional design by offering a harmonious fusion of organic life and architectural form. The lush and verdant appearance of moss-growing concrete brings an element of biophilic design into interiors, evoking a sense of tranquillity and connection to nature. Exploring the aesthetic and green design integration of moss-growing bio-receptive concrete involves investigating its adaptability across various design styles and settings [5]. From minimalist modern spaces to rustic or even futuristic green designs, moss-growing concrete offers a versatile canvas for creative expression. This research seeks to uncover how moss-growing concrete can be seamlessly incorporated into interior environments, enhancing visual interest and imbuing spaces with a touch of natural allure.

The long-term viability and maintenance of the moss-growing concrete stand as crucial factors in assessing its practical applicability within the realm of interior architecture. This innovative material, which seamlessly marries organic growth with structural elements, necessitates a thorough investigation into its resilience and durability over time. Research into the long-term viability of moss-growing bio-receptive concrete involves comprehensive field studies and durability assessments. Understanding how this material withstands varying environmental conditions, moisture levels, and wear and tear is essential to ensure its sustained functionality and aesthetic appeal [1]. Moreover, investigating the potential impact of maintenance practices on the health and vitality of the integrated moss is of paramount importance.



Figure 2: Advantages and Disadvantages of Moss-Growing Concrete

Delving into the maintenance requirements of moss-growing concrete, the research aims to identify strategies that balance its aesthetic benefits with the practical demands of upkeep. This includes exploring optimal watering frequencies, light exposure, and any specialized care needed to sustain the vitality of the moss over extended periods. Insights gained from expert interviews, surveys, and real-world observations will contribute to developing best practices for maintaining the material's visual allure and ecological benefits [3]. Comprehending the long-term viability and maintenance considerations of moss-growing concrete is pivotal in determining its feasibility as a sustainable material in interior

architecture. The research underscores the importance of achieving a harmonious coexistence between human-made environments and the natural world, and it informs designers and practitioners on how to effectively integrate this innovative material while ensuring its ongoing vitality and aesthetic impact.

The Biophilic Material Integration Theory serves as a conceptual framework that underscores the transformative potential of moss-growing bio-receptive concrete within the interior architecture industry. Rooted in the principles of biophilic design, this theory accentuates the innate human connection to nature and posits that integrating organic elements, such as moss-growing concrete, into built environments fosters a harmonious synergy that enriches both aesthetic and functional dimensions. The theory proposes that the incorporation of moss-growing concrete transcends traditional interior materials by infusing spaces with living, breathing organisms [11]. This dynamic integration taps into humanity's inherent affinity for nature, invoking feelings of tranquillity, connection, and well-being. The theory highlights how moss-growing concrete not only enhances visual appeal but also contributes to improved indoor air quality, carbon sequestration, and a complete sense of biophilic enrichment. In the Biophilic Material Integration Theory, interior architects and designers are encouraged to consider moss-growing concrete as more than a static element, but rather as a living, integral component that dynamically interacts with occupants and the environment. This theory calls for a holistic approach to design, where the utilization of moss-growing concrete transcends aesthetic preferences and becomes a conscious choice to establish symbiotic relationships between interior spaces and the natural world.

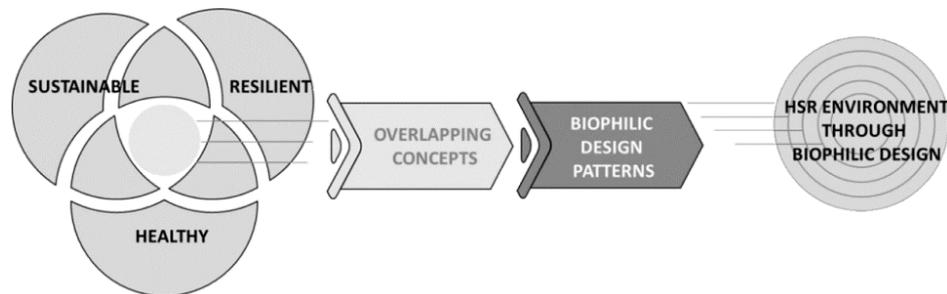


Figure 3: The Biophilic Material Integration Theory [11]

Methodology

This research philosophy is firmly rooted in the belief that objective reality exists and can be accessed through empirical observation and measurement. The positive philosophy forms the foundation of this study, as it seeks to gather concrete and factual information about the impact of moss-growing concrete on the interior architecture industry [12]. This approach emphasizes observable and measurable phenomena, aligning with the study's goal of uncovering tangible insights. In line with the research philosophy, a descriptive research design is chosen to systematically document the characteristics and features of the phenomenon under investigation. The aim is to comprehensively describe the impact of moss-growing concrete as a sustainable material in interior architecture. This design proves effective in capturing a wide range of information related to the material's implications, providing a holistic view of its influence on industry. Within this framework, an inductive research approach is adopted, which involves drawing generalized conclusions from specific observations [2]. This approach suits the study's intention to uncover patterns, trends, and emerging insights from qualitative data collected through interviews. Employing an inductive approach, the research aims to derive meaningful conclusions that contribute to a deeper understanding of the impact of moss-growing concrete.

The primary method of data collection chosen for this study is semi-structured interviews. This approach enables direct engagement with key stakeholders, including architects, interior designers, and potential end-users. These individuals possess valuable first-hand insights into the material's practical applications, benefits, and challenges. The semi-structured nature of the interviews allows for flexibility in exploring diverse viewpoints, experiences, and opinions, ensuring that a comprehensive range of perspectives is considered. The interview questions will be open-ended, encouraging participants to provide detailed responses and share their thoughts freely. This methodology is consistent with the research philosophy of positivism, as it aims to gather concrete information directly from those who have interacted with or have insights about moss-growing concrete [6]. Conducting interviews, the study aims to delve into the nuances of the material's impact, garnering rich qualitative data that contributes to a thorough exploration of its potential within sustainable interior design. The chosen research methodology aligns the positivist philosophy with a descriptive research design and an inductive approach. Utilizing semi-structured interviews as the primary data collection method, this approach aims to comprehensively explore the impact of moss-growing concrete in the interior architecture industry. The integration of these elements allows for a robust and nuanced investigation into the practical implications of this innovative sustainable material.

Findings

Question 1: What is the major benefit of using moss-growing concrete?

Group 1 Respondents	We think Carbon Sequestration and Emission Reduction are the major benefits of the use.
Group 2 Respondents	Improved Indoor Air Quality is the major benefit that can be obtained from the sustainable product.
Group 3 Respondents	In our view, Biophilic Aesthetics and Connection to Nature are the main parts of the situation.

Group 1 Respondents highlight the pivotal role of Carbon Sequestration and Emission Reduction as the primary advantage of this approach. Incorporating moss-growing concrete, the potential to capture and store carbon dioxide from the atmosphere is a significant stride toward mitigating climate change. This sustainable practice not only offers an innovative solution for construction but also contributes to a healthier planet by lowering greenhouse gas emissions.

In contrast, *Group 2 Respondents* underscore the value of improved indoor air quality as the standout benefit of this eco-friendly innovation. The integration of moss-growing concrete into indoor spaces serves as a natural air purifier, filtering pollutants and enhancing the

quality of the air occupants breathe. This dual functionality of sustainable construction aligns with the growing importance of healthy living environments and the well-being of occupants.

Group 3 Respondents present a different angle, emphasizing biophilic aesthetics and connection to nature as the essence. Moss-growing concrete resonates with the innate human desire to be connected to the natural world, creating visually appealing environments that evoke tranquillity and well-being. Blending urban landscapes with elements of nature, this approach offers a harmonious and aesthetically pleasing architectural solution that not only delights the senses but also provides psychological and emotional comfort.

Question 2: What is the long-term maintenance of moss-growing concrete?

<i>Group 1 Respondents</i>	Moisture Management is one of the main maintenances that needs to be adopted.
<i>Group 2 Respondents</i>	In our view, Regular Inspections are the long-term maintenance impact present in the scenario.
<i>Group 3 Respondents</i>	Pruning and Grooming are the most hectic part that needs to be adopted for the long term.

Group 1 Respondents emphasize the crucial aspect of Moisture Management as a primary maintenance consideration for moss-growing concrete. The inherent nature of moss to retain moisture could lead to potential issues such as surface deterioration, cracks, and reduced structural integrity. Effective moisture management strategies must be implemented to ensure the concrete's longevity and prevent undesirable consequences stemming from excessive water retention.

On the other hand, *Group 2 Respondents* highlight the significance of Regular Inspections as a vital component of long-term maintenance. Continuous monitoring and assessment of the moss-growing concrete are essential to detect any signs of wear, damage, or overgrowth. This proactive approach enables timely interventions and ensures that any maintenance needs are promptly addressed, contributing to the sustained performance and aesthetic appeal of the material.

Group 3 Respondents draw attention to the demanding task of Pruning and Grooming as a critical maintenance requirement. While moss contributes to the unique aesthetic of concrete, its growth can become unruly over time. Regular pruning and grooming are essential to maintain a balanced and controlled appearance, preventing the moss from overwhelming the surface and ensuring that the visual impact remains cohesive and appealing.

Question 3: What is the negative impact of moss-growing concrete?

<i>Group 1 Respondents</i>	We think Structural Integrity and Durability are the major diversities present in the setup.
<i>Group 2 Respondents</i>	Slippery Surfaces are the main problem that can be faced by the application.
<i>Group 3 Respondents</i>	The most challenging part of the setup is Manufacturing Challenges that reduce the entire sustainability.

Group 1 Respondents underscore the critical concern of Structural Integrity and Durability as a significant diversity within the moss-growing concrete setup. While the integration of moss and other organisms offers ecological and aesthetic benefits, it introduces potential challenges to the concrete's long-term stability. Factors such as increased moisture retention and the growth of plant materials could compromise the structural integrity and complete durability of the concrete. Addressing these issues is essential to ensure that the innovative approach doesn't compromise the fundamental properties of the construction material.

Group 2 Respondents highlight the potential obstacle of Slippery Surfaces as a primary issue faced by the application of moss-growing concrete. The growth of moss and other vegetation on concrete surfaces can create slippery conditions when wet, posing safety risks to pedestrians and vehicles. This concern must be effectively managed through design considerations, texture modifications, or other solutions to prevent accidents and ensure the safety of those using the space.

Group 3 Respondents bring attention to Manufacturing Challenges as a formidable hurdle impacting the sustainability of the setup. The incorporation of living organisms and plants into concrete mixes introduces complexities in terms of production, transportation, and storage. Maintaining the viability of these components during the manufacturing process poses technical difficulties that need to be addressed to ensure the feasibility and long-term viability of moss-growing concrete as a sustainable construction material.

Question 4: How does moss-growing concrete improve aesthetic nature?

<i>Group 1 Respondents</i>	Softened Appearance is the main factor that influences aesthetic nature.
<i>Group 2 Respondents</i>	Eco-Friendly Image is another part that attracts customers.
<i>Group 3 Respondents</i>	Enhanced Architectural Design is the main factor that improves the aesthetic nature.

Group 1 Respondents underscore the pivotal role of softened appearance in shaping the aesthetic nature of moss-growing concrete. Introducing natural elements like moss onto concrete surfaces, the harsh and utilitarian aesthetic of traditional concrete is transformed into a more inviting and organic look. The juxtaposition of the soft, textured greenery against the solidity of concrete adds a touch of nature's beauty, creating visually pleasing spaces that resonate with people's innate desire for natural harmony.

Group 2 Respondents highlight the compelling allure of an eco-friendly image as a significant factor in attracting customers. Moss-growing concrete aligns with sustainable practices by promoting carbon sequestration and contributing to emission reduction. This

environmentally conscious approach appeals to individuals and organizations seeking to make responsible choices in construction materials, fostering a positive reputation and engaging a clientele interested in sustainable solutions.

Group 3 Respondents draw attention to the transformative impact of enhanced architectural design on the aesthetic nature of moss-growing concrete. This innovative construction material allows architects and designers to experiment with intricate patterns, designs, and even logos on surfaces. The marriage of functional construction with artistic expression gives rise to visually captivating architectural creations that stand out in urban landscapes, enriching the visual fabric of the surroundings and elevating the entire aesthetic experience.

Conclusions

It can be concluded that the fact that individuals spend a substantial 80%-85% of their time indoors emphasizes the need for enhanced interior space efficiency. The emergence of eco-friendly moss-growing concrete aligns with sustainable architectural choices, including green roofs and terrace gardens, aimed at elevating environmental consciousness. Although this concrete variant commands a 10-30% price premium over conventional options, its merits, such as air purification, noise mitigation, and temperature regulation, validate the investment. As interior spaces evolve into havens of well-being, integrating eco-friendly materials like moss-growing concrete stands as a meaningful step towards holistic sustainability in architectural design and human well-being.

It can be determined that moss-growing concrete emerges as a pioneering solution that addresses both environmental and aesthetic concerns within the realm of interior architecture. Its unique composition presents a significant potential for carbon sequestration, acting as a proactive measure against climate change by actively absorbing and converting carbon dioxide. This transformative capability positions moss-growing concrete as a pragmatic response to the urgent need for sustainable construction materials. Furthermore, the material's integration fosters a notable enhancement in indoor air quality, underscoring its role in creating healthier and more conducive interior environments. Functioning as living air filters, moss-growing concrete contributes to reducing pollutants and allergens, thereby promoting the well-being and comfort of occupants.

Moss-growing concrete's aesthetic and design integration introduces a captivating dimension that transcends conventional boundaries. Through a harmonious fusion of organic life and architectural form, this material resonates with biophilic design principles, invoking a sense of tranquillity and a stronger connection to nature. This integration allows for creative exploration across diverse design styles, enriching the visual appeal of interior spaces while maintaining an inherent connection to the natural world. The potential benefits of moss-growing concrete are clear, but its long-term viability and maintenance remain crucial considerations. Robust research into its durability, resilience, and practical upkeep strategies is essential to ensure its sustained functionality and aesthetic allure over time.

Recommendations

Considering the findings, several recommendations emerge. Architects and designers should prioritize the integration of eco-friendly materials like moss-growing concrete, recognizing their potential to foster healthier indoor environments. Industry stakeholders must collaborate to address the maintenance challenges associated with such materials, seeking innovative solutions to ensure long-term viability. While the higher cost of moss-growing concrete is acknowledged, exploring cost-effective production methods could make it more accessible.

Educational initiatives should be promoted to raise awareness among professionals and users about the benefits of sustainable materials, hence, driving wider adoption and contributing to a more sustainable and harmonious built environment.

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