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Replacement Of Acoustic Insulation Material With Engineered Mycelium Composite For Sound Proofing In India

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Abstract - *This study aims to enhance the sustainability of building materials by drawing inspiration from biology for the next generation of bio-materials. The fungi kingdom is a fascinating group of eukaryotic microorganisms with an ancient evolutionary history, and mycelium fungi is one of the newest and most promising bio-materials. Mycelium refers to the thin root-like fibers that run beneath the ground, which can be dried and used as a super-strong, water-resistant, sound-proofing, and fire-resistant building material that can be grown into specific forms, reducing processing requirements. To initiate the growth of mycelium fibers, spawn (mushroom spores) are collected and placed in a PDA material. These fibers are then transferred into a substrate and allowed to grow for a few days. The substrate and mycelium fibers are further condensed into molds to create construction materials that can be used in various functions of construction. This paper analyzes the properties of mycelium composites and proposes the replacement of traditionally used acoustic materials with mycelium composite bio-fabrications.*

Key Words: **Sustainability, Mycelium, Acoustic material, Bio-material, Spores , Spawn , Mycelium cultivation, sound proofing**

1. INTRODUCTION

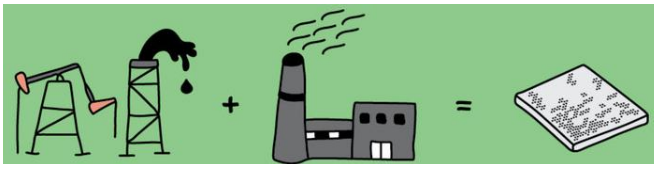
In recent years, mycelium has been studied as a potential building material due to its natural strength, which is comparable to industrial-level strength. This emerging material has the potential to be used as literal building blocks for future homes. It's possible for a single spore to develop into a mycelium, and from it, fruiting bodies like mushrooms can sprout. The potential of mycelium is just starting to be explored for a wide range of applications beyond its natural environment. Researchers and engineers are now testing various ways to use this versatile material and leverage its unique qualities to create better medicines, materials, bio-fuels, and other products that are part of our daily life.Mycelium can be used to make building materials that are fire-resistant, stronger, lighter, and have acoustic properties. It can also be utilized in the fashion industry to mimic the look, texture, and utility of leather. Additionally, in some cases, mycelium can serve as a bonding agent for building materials such as bricks and insulation panels. Due to its inherent properties, mycelium is a renewable resource that can be recycled and regrown multiple times, making it an eco-friendly and sustainable option.

2. METHODOLOGY

1. Preliminary research assessment and gap identification
2. Identification of the need's and formulating the objectives (Synopsis, Literature survey and Problem justification)
3. Literature survey
4. Formulation of Research design and methodology
5. Collecting and analyzing the data related to the paper
6. Discussion and synthesis of the module
7. Conclusion

3. RESEARCH MOTIVATION

Facing environmental damages due to the extraction of resources and the discarding of materials at the end of life, multiple sectors have started a transition towards closed-loop and bio-based strategies.



(Fig 1 Conventional material manufacture process)

(Fig 2 Mycelium composite material manufacture process)

(Source - https://theconstructor.org/building/building-material/mycelium-construction-material/565623/)

The development of mycelium materials can change the architectural culture from one that "uses" materials to one that "grows" materials

Despite the significance of fungal systems in terrestrial ecosystems, there has been a lack of understanding and application of their principles in materials science. By gaining a deeper insight into how fungi operate, including their self-organization, adaptation, decay, and resilience, we can apply these principles to human-made materials. By mimicking the way fungi fabricate their tissues, we can develop innovative material applications. Capturing the biological addictiveness of mycelial processes can be particularly useful for creating self-growing materials.

4. PROCESS OF Mycelium composite

1. Fungal inoculation
2. Substrate colonization
3. Mold preparation
4. Mycelium growth in the mold
5. Composite inertization
6. Commercialization

5. COMPONENTS

1. Fungal species (spores)
2. Feed stock (Spawn)

6. ADVANTAGES

1. Sustainable and eco-friendly: Mycelium composite is a sustainable and eco-friendly material because it is made from renewable resources and does not produce harmful byproducts during the manufacturing process. It can be grown using agricultural waste, such as corn stalks and sawdust, and does not require large amounts of energy or water.
2. Lightweight and strong: Mycelium composite is lightweight, yet strong, making it an ideal material for use in various applications, including packaging, construction, and furniture. It can also be molded into various shapes and sizes, making it versatile and adaptable to different design needs.
3. Biodegradable: Mycelium composite is biodegradable, meaning that it can break down naturally in the environment, reducing waste and pollution. This also makes it an ideal alternative to synthetic materials that take a long time to decompose.
4. Acoustic Insulative: Mycelium composite has insulative properties, making it an ideal material for use in building insulation and sound proofing

7. DISADVANTAGES

1. Limited structural strength
2. Slow growth rate
3. Sensitivity towards moisture
4. Limited versatility in shape and size
5. Not applicable in all climatic conditions

8. CASE STUDIES

1. Hi-fi pavilion, New York
2. Shell mycelium, Kochin
3. Myco-tree, London
4. Monolito mycelio, New York
5. Growing pavilion, Dutch

8.1. HI-FI PAVILLION

Project - Hi-fi pavilion

Location - New York

Year of completion – 2014

Types of component - Mycelium brick

These Mycelium bricks are made up of corn stalks as a substrate and Spores of Ganoderma lucidum (Red reishi mushroom)

Structure - Wood and Steel

Post treatment - Heat treatment

The Hi-fi pavilion was constructed at the MoMA PS1 art museum in New York using mycelium-composite blocks created by Ecovative. These blocks functioned similarly to bricks of a masonry wall, and approximately 10,000 of them were used in the construction of the pavilion. Hi-fi is currently the largest construction project to utilize mycelium composite materials and stands at a height of 13 meters.

8.2. SHELL MYCELIUM

Project - Shell mycelium

Location - Dutch warehouse, Kochin

Year of completion – 2017

Type of component - Mycelium composite

These Mycelium bricks are made up of Coir pith as a substrate and Spores of Oyster mushroom

Structure - Wood and steel

Post treatment - Natural heat treatment

The aim was to create a lightweight and detachable structure suitable for temporary events, and to achieve this, a load-bearing wooden grid shell was utilized. Helium-inoculated substrates were placed within the plywood frames' cavities on top of the pavilion. Truss elements were connected using steel connectors. One of the primary characteristics of this pavilion is that the mycelium substrate mixture was not pre-grown in sterile conditions, but was instead allowed to grow on-site in open air. The designers also intended to allow the mycelial components to dry naturally through exposure to sunlight.

Environmental responses

Shell Mycelium is a living structure that originates from nature and ultimately returns to nature. Architects built the structure by creating a series of tray-like cavities that were filled with fungus, and subsequently covered with coir pith composed of coconut husk fibers. As time passed, the top layer dried up and died, forming a protective shell over the mycelium. As the mycelium grew and formed a white covering over the roof of the pavilion, the structure continued to evolve throughout the duration of the biennale.

8.3. MYCO-TREE

Project - Myco - tree

Location - London

Year of completion – 2017

Type of components – Mycelium brick

These Mycelium bricks are made up of Sugarcane, Casava root as a substrate and Spores of Pleurotus ostreotus

Structure - Steel/Wood

Post treatment - Heat treatment

During the Seoul Biennale for Architecture and Urbanism, the Myco-Tree was constructed as a self-supporting interior installation. Mycelium composite is the main source for the structure which is used in the digital parametric in this project. To be more precise, the installation's design employed three-dimensional Graphic Statics, a structural form-finding technique that generates compression-only funicular structures. A joint system consisting of bamboo plates and steel dowels was utilized to offset the material's low rigidity and to bear other forces beyond the compression absorbed by the mycelium.

8.4. MONOLITO MYCELIO

Project - Monolito mycelio

Location - New York

Year of completion – 2020

Type of component - Monolith

These Mycelium bricks are made up of Hemp as a substrate and Spores of Ganoderma lucidum (Red reishi mushroom)

Structure - Wood and steel

Post treatment - Naturally dried

This pavilion was built for the school's exhibition in Atlanta and used about 800 kg of mycelial composite mixture and had a size of 2.5×2.5×2.5m. The underlying idea of the designers was to solve structural, insulation and sound proofing problems with one material to save construction time. The designers use mycelium composite for the compressive force. The outer shell of the structure was designed using oriented strand-board (OSB) and manufactured using computer numerical control (CNC). Holes were drilled into the outer mold to promote oxygenated mycelial growth. To keep the mycelial mixture in shape during the growing stage, the disinfected OSB frame was covered with polypropylene geotextile, which contained and secured the mycelium composite against the wooden frame.

8.5.GROWING PAVILLION

Project - Growing pavilion

Location - Dutch

Year of completion - 2020

Type of components - Mycelium panel

These Mycelium bricks are made up of Hemp, cattail and Mace as a substrate and Spores of Ganoderma lingzhi (Reishi mushroom)

Structure - Wood

Post treatment - Heat treatment / Weather coating

This project is a study of bio-based construction that involved testing and utilizing various biological materials and bio-manufacturing techniques to create the final product.The pavilion has a cylindrical geometry, with wooden frames comprising the main structure and composite mycelial panels forming the outer walls. The panels (200×70 cm) manufactured by company 'Grown' under Ecovative's licence (C2C Gold certifcation), are mounted on the wooden frame leaving exposed their sculptural surface. The pavilion was constructed using a diverse range of biomaterials. As for the interior of the pavilion, the draping was created using organic cotton, and the flooring was constructed from Biolaminate. Additionally, two types of bio-coatings were employed to increase the weather resistance of the pavilion and to address a significant issue related to the use of mycelium composites in open-air environments.

8.6 CASE STUDY INFERENCE

Project / Year of completion	Location	Type	Structure	Fungus	Substrate	Post -treatment	Creators
HY-FI (2014)	Outside	Brick	Wood, Steel	*Ganoderma lucidum*	Corn stalks	Heat treated	The Living Studio
SHELL MYCELIUM (2017)	Outside	Panel	Wood, Steel	Information not available	Coir pith	Naturally dried	Studio Beetles 3.3 Yassin Arredia Design
MYCOTREE (2017)	Inside	Block	Bamboo, Steel	*Pleurotus ostreatus*	Sugar cane, Cassava root	Heat treated	Sustainable Construction KIT Karlsruhe Block Research Group ETH Zürich
MONOLITO MICELIO (2020)	Outside	Monolith	Wood, Steel	*Ganoderma lucidum*	Hemp	Naturally dried	Georgia Institute of Technology School of Architecture
GROWING PAVILION (2020)	Outside	Panel	Wood	*Ganoderma lingzhi*	Hemp, Cattail, Mace	Heat treated, Weather resist-ant biocoating	Company New Heroes E. Klarenbeek

(Fig 3 Case study inference)

8.7. TESTING ACOUSTIC PROPERTIES

8.7.1 CULTIVATION FOR MYCELIUM BASED COMPOSITE

After an initial growth experiment, a new methodology was developed for growing mycelium-based samples that took into account material shrinkage.The mycelium composite that grown in the petri dish in the previous experiment has the property of sound absorption. However, the resulting material shrunk and warped considerably upon drying, which prevented accurate results from being obtained. In the subsequent experiment, material shrinkage was taken into consideration to prevent this issue from occurring again.

8.7.2 SUBSTRATE PREPARATION

It seems like the researchers prepared six different substrate mixtures using shredded cardboard, fine cardboard, shredded paper, fine paper, shredded newsprint, and fine newsprint. Every single unique material was splitted to make 6 samples each was set for the cultivation.All 6 mixtures were then supplemented with 10% (w/w) wheat bran and mixed thoroughly. Supplementary subastance as wheat bran is used to speedy the process of mycelium composite growth by adding nitrogen to the substrate mixtures. Finally, the researchers adjusted the moisture content of each prepared substrate mixture to 65% by adding water. The substrate containes 100g of dry material, 185g of liquid, and 18g of wheat.

8.7.3GROWTH PROCESS OF LOW-FREQUENCY SAMPLES AND RESULTING MATERIALS :

Prepared Substrates in the size of 80mm × 80mm square

Mycelium Mixtures in Form works in the dimension of 250mm × 125mm × 38mm

Composite Materials After Drying in the dimension of 250mm × 125mm × 38mm

8.7.4 PRELIMINARY TESTING FOR SOUND OBSORPTION

The impedance tube method is commonly used for measuring the acoustic properties of materials. In this method, sound waves are generated by a loudspeaker and passed through a tube filled with the sample material. The sound waves then reach a second microphone at the end of the tube, which measures the sound pressure level. By comparing the sound pressure level at the two microphones, it is possible to calculate the material's sound absorption coefficient, which indicates how much sound energy is absorbed by the material.In this study, two replicates of each sample were tested three times using an impedance tube. The samples were 38 mm thick, and the measurements were taken using BrUel and Kjær's Impedance Tube Kit, which covers a frequency range of 50 Hz to 6.4 kHz. The ASTM E1050-12 standard was followed to ensure accurate and consistent measurements.

1.100 mm diameter tube (large tube)

A.Frequency range: 50 Hz to 1.6 kHz;

B.Material sample size requirements: 100 mm diameter, 200 mm max sample length.

2. 29 mm diameter tube (small tube)

A.Frequency range: 505 Hz to 6.4 kHz;

B.Material sample size requirements: 29 mm diameter, 200 mm max sample length.

9 FINDINGS

Outperforming the fine cardboard samples. The results also show that increasing the sample size did not significantly affect the acoustic performance of the materials. However, it is important to note that the mycelium composite samples still need to be optimized for commercial use as sound-absorbing materials. The study highlights the potential of mycelium composites as sustainable and biodegradable alternatives to traditional sound-absorbing materials, but further research is needed to fine-tune the materials and production processes for practical use in real-world applications.

10 CONCLUSION

Replacement of the Mycelium composite instead of the traditionally used acoustic insulation panel is possible. The foam board panel used in the project X has a high usage of petroleum and crosses a lots of industrialization process which made the material with high carbon emitting agent, instead we proposed a material which is sustainable, made with the agro-waste and mycelium substrate, The budget of the project X was initially 42,00,000/- and the material has to be transported from other states need pre order formalities and has standard dimension of 6M x 3M ; 12M x 4M so that the wastage that remains will not degrade and creates non eco friendly waste. But the Mycelium material which is been grown and processed can be done in any dimension and in any thickness so that the wastage is also lesser compared to the Foam paneling and the costing when analyzed is the 1/3 cost of the total budget with the limitation of only materials and the value is been decreased to 30,00,000/- , If the mycelium is the acoustic paneling material it could achieve the lead certificate. Compared to the other material Mycelium composite has less carbon emission. If this product is introduced to the market the material may be available without demand, since it is new to this industry the material which in replaced will be available by crossing its all manufacturing process. This paper is been concluded with the experimental research of the Mycelium composite, Manufacturing of the material with the regionally available Substrates and sprouts, Finding the versatile composite material with various property which is functionally used with the raw material content as a sprout and substrate. Low carbon emission material. The material which is been used in the Non-load bearing structures.

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