JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

FABRICATION AND ANALYSIS OF MYCELIUM BIO COMPOSITES

Sivasankaran.P [1], Balasundaram.J [2], Mukesh.R [3], Prathapan [4] & Gajendiran.P [5]

[1] Associate Professor, Department of Mechanical Engineering, Manakula Vinayagar Institute of Technology, Pondicherry – 605 107, India.

[2],[3],[4] &[5] B.Tech (Mechanical Engineering) Final Year , Department of Mechanical Engineering , Manakula Vinayagar Institute of Technology , Pondicherry – 605 107 , India.

Mail: sivasankaranmech@mvit.edu.in , sivasankaran.panneerselvam@yahoo.com

Abstract:

In specific nature, there is no point of considering the material which is going out of the external environment. The waste material can be recycled in various possible ways to develop a product with more challenging features. The aim of our project is to develop a car dashboard using mycelium composite. In this current technology world, there were many new technologies been introduced for the growth of the country, reducing the risk of accidents, customer comfort, etc. On the other side, we need to see for the development of eco-friendly for both surrounding and customers. The conventional materials there were used for making automobile components are made of steel, aluminum, magnesium, copper, plastics which will undergo corrosion at any point of time. To overcome such problems, alternate natural composites we prefer in this work namely mushroom (i.e.) Mycelium. In this project work attempt has been made to perform analysis using FEM (Finite Element Modeling) method to perform simulation test on tensile and thermal analysis using ANSYS in addition to that density and water absorption test also carried ou to study the characteristics of materials .

Keywords: Mycelium, eco-friendly, Light weight, bio-degradable, flame resistance, easily shaped, ANSYS, FEM.

1. Introduction:

Due to the rapid growth in the economy, the continual extraction of natural resources for manufacturing, and the rate of consumer's consumption are the main factors constituting environmental decline. The construction industry has been a major cause of increased resource consumption. A sustainable development design strategy is a deliberate global concern towards a healthy ecology. Researchers have been looking into bio- composites and bio-based materials to meet these goals. The major factor for using bio-composites is its way of utilizing biological wastes such as husks, waste fibers, and residual stems. Early use of fungi in bio-composites began in the early 1990s with Japanese scientist

Shigeru Yamanaka. In 1991, Yamanaka filed a patent regarding a new method to make paper, without a beating step, to increase the strength of paper. In the patent, he describes his research on the complex structures of fibrous structures and fungi where he discovered that allowing the two to grow together leads to the fungi bonding to the fibrous structures. Since then, research on mycelium has expanded to commercialize the material. Current applications include packaging material, insulation, leather, and different objects and furniture.

2. Problem Statement

In our society, many persons have basic knowledge about edible mushrooms for nutritional and medicinal values (growth of mycelium biomass) but they know some amount of knowledge or nothing about the fungal network growing underneath the surface, known as mycelium.

One of the latest innovations involves harvesting the web-like network of mycelium to stick organic materials together into a rigid product.

Growing fungus in proper condition results in a material with properties similar to cement, engineered wood, or plastic, depending on the manufacturing method.

This innovative design is a biological additive manufacturing that includes a combination of bio-engineering, structural architecture, and the commercial use of mycelium biocomposites since 2007 and is slowly replacing environmentally degradable materials.

However, there is limited scholarly research about this innovation, inadequate knowledge of the structural properties, potential applications and few of the mycelium products exist in the market. Therefore the proposed work directed towards knowing the mechanical properties, suitable applications, and possible improvements of the mycelium-based materials is needed.

3. Lack of Knowledge

There are only a few companies in the world able to know the complete characterization of mycelium. The major company in the US is Evocative Design, based in Green Island, New York. Due to the small number of companies holding the material, the majority of research on mycelium has used material from these specific companies.

In addition, due to industrial secrecy, these companies have not published any of the production processes they have utilized. As a result, there is a lack of technical literature on mycelium as most of the literature that has been published on the materials is related to design and ethical aspects. Regarding the studies that have been conducted and published, the lack of standardized testing procedures for the material has resulted in many different experiments and results that are hard to compare and replicate. The exploration of literature on mycelium is still an ongoing research topic, with many possible combinations of fungi and substrates that have not been explored yet.

4. Motivation

In nature there is practically no waste, it is altogether a renewable system. The concept of waste is entirely conceived by humans. Over the decades, the linear concept of produce-use-dispose has proven unsustainable in the face of limited resources; hence William McDonough and Michael Braungart created a concept. It suggests an approach that tends to achieve waste elimination by incorporating material resources into a biological and technical cycle such that generated waste becomes nutrients for other systems and energy generation is achieved through the use of renewable resources.

The growing global understanding of ecological footprints and environmental pollution creates by humans is gainfully affecting our material design practice, pushing the search for new materials and solutions. As the environmental ecology continues to worsen, it has become a persistent public concern in developed countries and it has in recent times awakened developing countries to the green movement. This present global concern for sustainable ecology has sparked the emergence of new design practices, motivates the researchers and material scientists to find eco-friendly bio-based alternatives to traditionally used materials such as plastic. Emphasis is placed on recyclability and sustainability.

5. Aim and Objectives

This project placed focus on a fungal mycelium-based bio-composite that is grown rather than manufactured or synthesized. This present study aims to give a robust investigation of the physical and mechanical characterization of indigenous mushroom-wood composite. In order to achieve this goal, it was necessary to achieve the following objectives;

1. Locate the most suitable fungi-substrate combination for further exploration and development.
2. Evaluation of the microstructure of the grown bio-composite.
3. Investigation of the mechanical properties of the grown biocomposites.
4. Recommendation of possible applications of the developed bio-composites.

6. Literature Review:

ETINOSA OSAYMEN PRECIOUS [1] The growing global understanding of ecological footprints and environmental pollution invented by humans is affecting our material design practice. This study aims to provide an insight into the production methods of mycelium-based materials and an indication of the structural performance of these bio-based materials. Several fungi species were grown on varied local agricultural-growth wastes, and different growing conditions were carefully elucidated to evaluate which pair of fungi-plant material provides the most suitable combination for product applications. The fungi; PolyporusSquamosus, Pleurotusostreatus, and Volvariellavolvacea were grown on woodchips of Mansoniaaltissima and Hemp.

The maximum flexural stress for the optimum composition (hemp with oyster mushroom) was obtained at 0.397 MPa. The samples were also tested for selected properties including water absorption rate, density, and quality impression. The current stage of the research shows that the most efficient integrations were the samples of Polyporusostreatus grown on Hemp woodchips. The material properties introduce innovative characteristics and functions over existing industrial products and applications.

KEVIN CROWTHERS [2] To grow, more emphasis is being placed on renewable resources and a sustainable economy. The progress construction industry has been a major cause of increased resource consumption. Although the progress leads to greater infrastructure and new technologies, the use of mainly non-renewable resources and the pollution caused by the construction industry heavily contribute to global warming. As a result, there has been a demand to develop an eco-friendly building material that has low energy consumption, is sustainable, and is functional. Researchers have been looking into bio-composites and bio-based materials to meet these goals. The major factor for using bio-composites is its way of utilizing 18 biological wastes such as husks, waste fibers, and residual stems. Current applications include packaging material, insulation, leather, and different objects and furniture.

ELISE ELSACKER [3] The current physical goods economy produces materials by extracting finite valuable resources without taking their end of life and environmental impact. Mycelium-based materials offer an alternative fabrication paradigm, based on the growth of materials rather than on extraction. The mycelium-based material is heat-killed after the growing process. In this paper, we investigate the production process, the mechanical, physical, and chemical properties of mycelium-based composites made with different types of lignocellulosic reinforcement fibers. This is the first study reporting the dry density, Young's modulus, the compressive stiffness, the stress-strain curves, the thermal conductivity, the water absorption rate, and an FTIR analysis of mycelium-based composites and five different types of fibers (hemp, flax, flax waste, softwood, straw) and fiber processing (loose, chopped, dust, pre-compressed and tow). The thermal conductivity and water absorption coefficient of the mycelium composites with flax, hemp, and straw has an overall good insulation behavior in all the aspects compared to conventional materials such as rock wool, glass wool, and extruded polystyrene. The methodology used to evaluate the suitability and selection of organic waste streams proved to be effective for mycelium-material manufacturing applications.

Carolina Girometta[4] Reducing the use of non-renewable resources is a key strategy of a circular economy. Mycelium-based foams and sandwich composites are an emerging category of biocomposites relying on the valorization of lignocellulosic wastes and the natural growth of the living fungal organism. While growing, the fungus cements the substrate, which is partially replaced by the tenacious biomass of the fungus itself. The final product can be shaped to produce insulating panels, packaging materials, bricks, or new-design objects. Mechanical properties are inferior in comparison to expanded polystyrene (EPS), which is the major synthetic competitor. Nevertheless, mycelium-based composites can display an enormous variability based on: fungal species and strain; substrate composition and structure; and incubation conditions.

Daniele Dondi [5] A heat press and reinforcement study aims at increasing the bending strength of my-plates. This is achieved by studying the heat-press process and by mixing different fibers to form a natural reinforcement material. Mycelium is the root network of a mushroom, which is used as an inherent binder to link fibrous biomass such as straw. By growing the mycelium through fibers, a composite material is obtained. The composite is then heat-pressed to create board like materials. These materials have the potential to replace conventional toxic board materials, such as MDF. Together with the project partners Recell Group BV, Fungalogic, and V8 Architects, the research group Bio-based Building explored the heat pressing process of mycelium composites.

C. R. Rejeesh[6] Mycelium is a fast-growing vegetative part of a fungus which is a safe, inert, renewable, natural, and green material that grows in a mass of branched fibers, attaching to the medium on which it is growing and can be originated from mainly biological wastes and agricultural wastes. The self-assembling bonds formed by mycelium grow quickly and produce miles of tiny white fibers which envelopes and digest the seed husks, binding them into a strong and biodegradable material. Mycelium-based materials have the potential to become the material of choice for a wide variety of applications, with the advantage of the low cost of raw materials and disposal of polystyrene posing an environmental issue. This paper reviews the achievement and current status of technology based on mushroom cultivation for bioremediation of agro-industrial wastes and also emphasizes mycelium-based material for packaging and insulation applications as a sustainable alternative for polystyrene.

Agata Bonenberg [7] Mycelium-based composites (MBCs) have attracted growing attention due to their role in the development of eco-design methods. As a part of our technological experiments, we have created several prototype products used in architectural interior design. Following the synthesis, these sources of knowledge can be concluded: 1. MBCs are inexpensive in production, ecological, and offer a high artistic value. 2. The scientific literature shows that the material parameters of MBCs can be adjusted to certain needs, but there are almost infinite combinations during the growth and subsequent processing of the MBCs. 3. An effective method to increase the density and the search for technologies to obtain a more homogeneous internal structure of the composite material. 4. Some disadvantages of MBCs can be considered advantages. Such an unexpected advantage is the interesting surface texture resulting from the natural in homogeneity of the internal structure of MBCs, which can be controlled to some extent.

Mariel Dougoud[8] Materials are biodegradable and decompose when microorganisms (bacteria, fungi, and actinomycetes), macro organisms (insects), and aerobic bacteria break down the plant matter and ingest and bind the particles together. The decomposing material provides food for organisms in the form of carbon and nitrogen. Humans have created products that are manufactured from petroleum, the end product of a few million years of natural decay. These chemical components are manufactured to link together and create bonds that are used in many of our materials today. When we recycle materials, we are breaking them down chemically and converting them into something of typically lesser value. Materials that are unable to decompose are in a linear metabolism where the product is a one way commodity that results in waste. To avoid this we need to create products that are part of a circular process that results in nutrients for another life cycle and nothing is wasted.

Jillian Silverman [9] This research aims to solve problems of solid waste, resource depletion, and material toxicity in the footwear industry. Mycelium, the root structure of mushrooms, acts as natural glue and binds together substrate materials as it grows outward, offering opportunities for natural composite development. By utilizing mycelium alongside agricultural waste and other natural materials, a fully biodegradable composite with potential shoe sole applications was created. A comparison of this material to other materials used in footwear indicated that mycelium composite requires moderate embodied energy in production and scores fairly well on compressive strength. While it has a lower compressive strength than many existing composites or synthetic materials, its sustainable attributes help balance out its performance limitations. This mycelium composite overall showed good compressive strength and provides opportunities for renewable and biodegradable footwear inputs.

Yangang Xing[10] To improve the energy performance of buildings, insulation materials (such as mineral glass and rock wools, or fossil fuel-based plastic foams) are being used in increasing quantities, which may lead to potential problems with materials depletions and landfill disposal. One sustainable solution suggested is the use of bio-based, biodegradable materials. Several attempts have been made to develop biomaterials, such as sheep wood, hempcrete, or recycled papers. In this paper, a novel type of bio insulation material – mycelium is examined. The aim is to produce mycelium materials that could be used as insulations. The bio-based material was required to have properties that matched existing alternatives, such as expanded polystyrene, in terms of physical and mechanical characteristics but with an enhanced level of biodegradability. The testing data showed mycelium bricks exhibited good thermal performance. Future work is planned to improve the growing process and thermal performance of the mycelium bricks.

Nitin Girdhar Shinde and Dilip Mangesh Patel [11] Day by day Automobile sector is going through new innovative trends in all aspects like design, appearance, performance, and economy. When choosing an automobile for personal use, the customers always look for aesthetics, economics, and safety measures. The first and far most of an automobile that appears before the user, is the dashboard. It acts as a console for various components and holds the sense of pleasantness of occupant space. In this paper, a brief review of various types of material used in the making of the dashboard is taken into account based ona detailed literature survey. Various types of the dashboard are discussed along with their manufacturing methods. The ideal properties of a dashboard material are also taken into consideration. Testing techniques for dashboard materials are mentioned thereafter. Finally, the concerns with the dashboard materials are highlighted.

7. Fabrication Process of Composite Materials:

Sterilization Process

- The sterilization process is performed in clean environment.
- Substrate i.e. the paddy straw was kept in prepared hot water for 24 hours for sterilization.

Figure 7. 1 for Sterilization of substrate

Atmospheric Condition

- Darkness to be maintained Humidity
- Temperature
- These conditions were maintained during Mycelium network Growth

7.1.1. MIXING OF MATERIAL IN THE PLASTIC BAG TO GROW MYCELIUM

7.1.2. STEP – 1

1. Sterilize the Substrate i.e. the paddy straw in this case.

2. Take a plastic bag.

3. Add the sterilized paddy straw.

4. Add 8-10 Milky mushroom seeds in it.

5. Pack the plastic bag and place in a dark place for 3-7 days.

6. After 3-7 days the mycelium will start growing.

Figure 7. 2 Growth of Mycelium

7.1.3 STEP – 2

1. Sterilize the Substrate i.e. the paddy straw in this case.

2. Take a plastic bag.

3. Add the sterilized paddy straw.

4. In this step we add 8-10 Oyster mushroom seeds in it.

5. Pack the plastic bag and place in a dark place for 3-7 days.

6. After 3-7 days the mycelium will start growing.

7.1.4 DEVELOPMENT OF FINAL PRODUCT

TRIAL -1

1. After growth of mycelium take a mould.

2. Add the mix in the mould that is made in step-1

3. Pack the mould with cellophane sheet to make it air tight.

4. Leave the mould in the dark place for 5-7 days.

5. After 7 days the mycelium should be grown but in this case it is not grown properly. So we move to next trial.

A B

C D

Figure 7.3. (A) Loose Material (B) Filling in the mould (C) & (D) Final Material in TRAIL – 1

NOTE : This trial is performed in our room , the temperature of the room may be an reason for failure in Trail – 1.

TRIAL-2

1. Take the mix that is made in Step-2.
2. Fill the mould with the mix.
3. Add 30g of All purpose flour in it.

4. Add some water.

5. Again pack the mould with cellophane sheet.

6. But this time we made 2 moulds. One is air tight and in another mould we make cutto allow some air to enter in it.

7. Leave it for 7 - 10 days in a dark and cool place.

8. After 10 days we have seen that some mycelium has grown in air circulationmould.

9. As we can see it is not hard enough, so again failure. Now we have done Trial-3.

(A) (B)

Figure 7.4 (A) the material is grown without air circulation & (B) material is grown with air circulation

TRIAL-3

1. Take the mix that is made in Step-2.

2. Fill the mould with the mix.

3. Add 30g of All purpose flour per kg in it.

4. Add some water.

5. Again pack the mould with cellophane sheet.

6. Leave it for 7 days in a dark and cool place.

7. After 7 days we have seen that some mycelium has grown.

8. Upon completion of the growth period the samples were remolded and allowed todry in open air for 24 hours.

Figure 7.5 Final Materials in TRAIL – 3

9. Afterwards they were transferred to an oven at 70 ˚C for 2 – 3 hours until theirweight stabilized and thus all water was evaporated.

(A)

(B)

(C)

Figure 7.6. (A) Hot Air Oven (B) & (C) Drying Process

10. This is to render the material inert and ensure the fungi does not continue its growth.

(A)

(B)

Figure 7.7 (A) & (B) Finished product in TRAIL – 3

8. Testing

DENSITY

- The density of any object is its mass per unit volume.
- Density, $\rho = m/v$
- Where, m=mass in kg
- Volume in m^3

Samples	Mass in kg	Volume in m^3	Density in kg/m^3
Sample 1	0.143	0.00043	317.77

Table 8.1 Density calculation

WATER ABSORPTION

Water absorption, % by mass, after 2 hours immersion in water in given bythe formula,

$$W\ \% = \frac{M_2 - M_1 \times 100}{M_1}$$

Mass of the material before immersion in waterin grams(M_1)	Mass of the material after immersion in waterin grams(M_2)	Water absorption % by mass (W)
143	173	20.97 %

Table 8.2 Water absorption calculation

(A)

(B)

Figure 8.3 (A) Before immersion (B) After immersion

- Average water absorption was 20.97 %

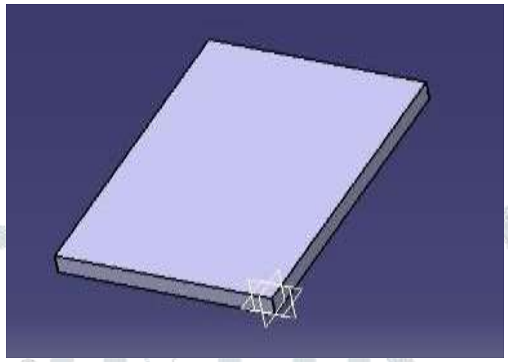
FLAME TEST

- The flame test is carried out on the specimen for one minute .
- The specimen didn't catch fire.

Figure 8.4
(A) Before flame test (B) During flame test (C) After flame test

9. STRUCTURAL ANALYSIS OF THE MATERIAL IN ANSYS

Model of the Material



DIMENSIONS 100 x 150 x 10 mm

Figure 9.1 Model of the material

9.1.1. Loads and Constraints

After meshing, loads and constrains are applied. A static load whose components are500N, 1000 N, 1500N along Z-axis direction as shown in fig respectively.

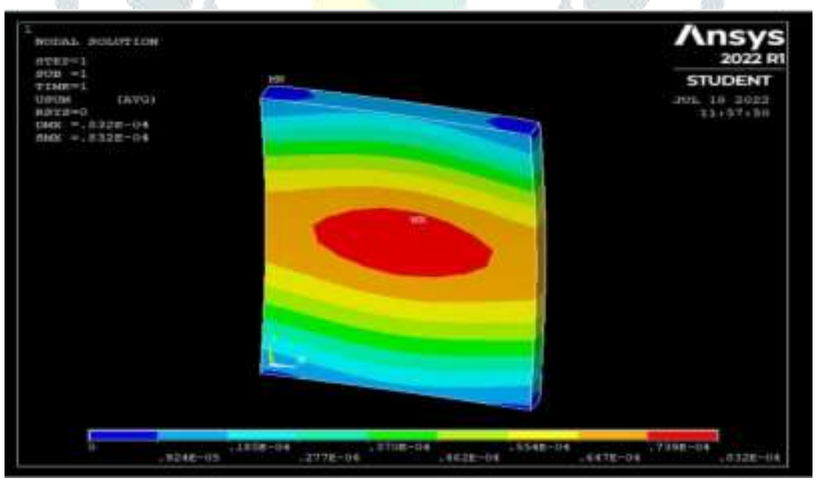


Figure 9.2
Deformation through Nodes of the material at 500N

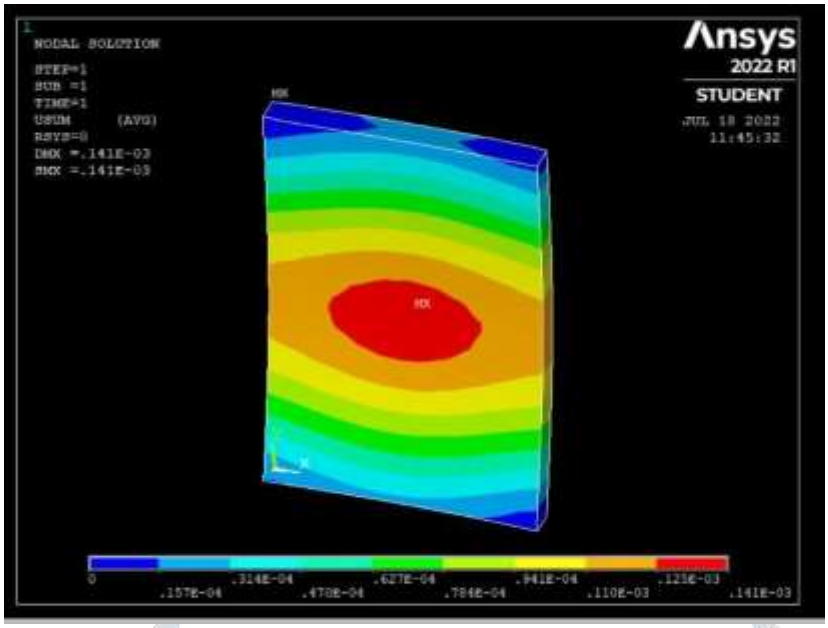


Figure 9.3
Deformation through Nodes of the material at 1000N

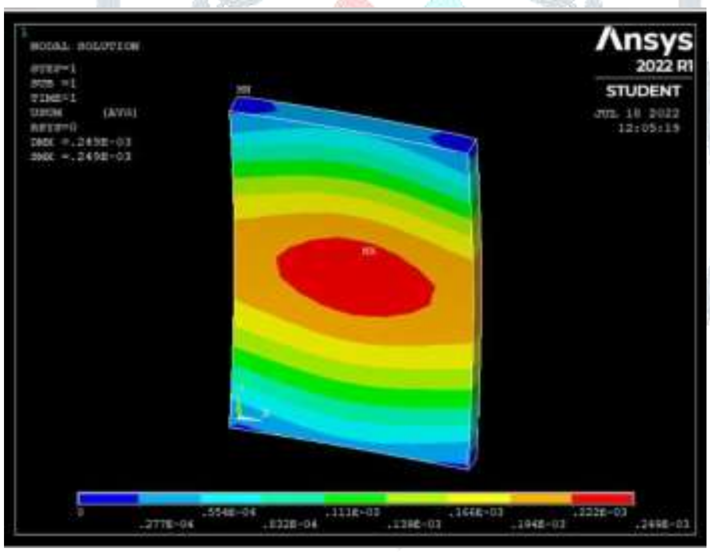
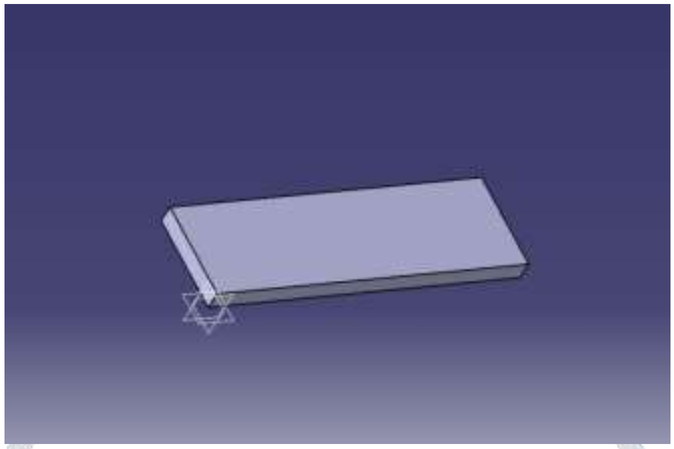


Figure 9.4
Deformation through Nodes of the material at 1500N

10. Tensile Test Analysis

Model Of The Material



DIMENSIONS 150 x 50 x 10 mm

Figure 9.5 Model of the material

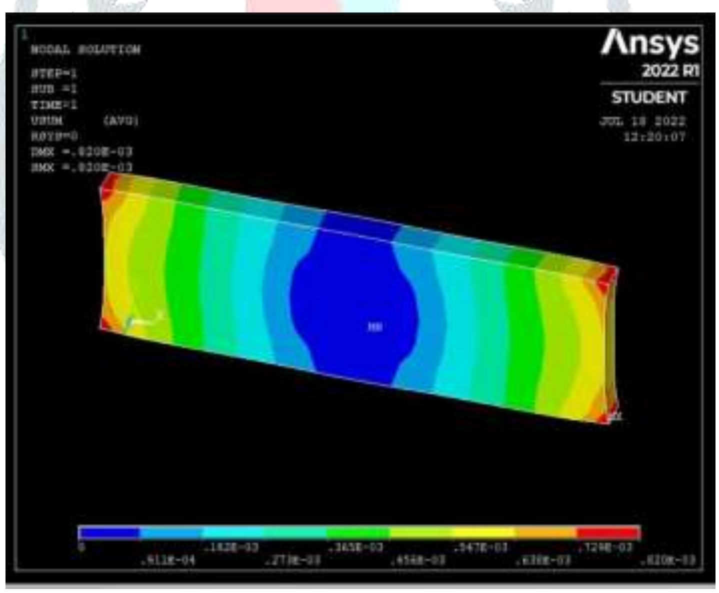


Figure 9.6
Tensile test analysis at 1000N

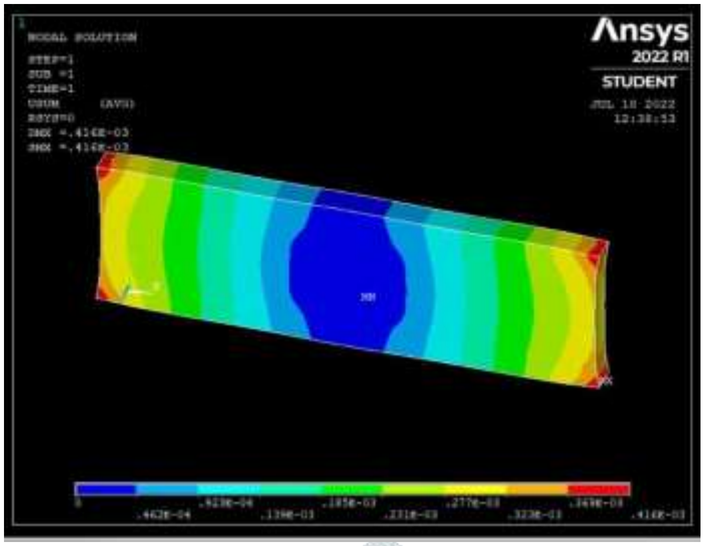


Figure 9.7
Tensile test analysis at 2000N

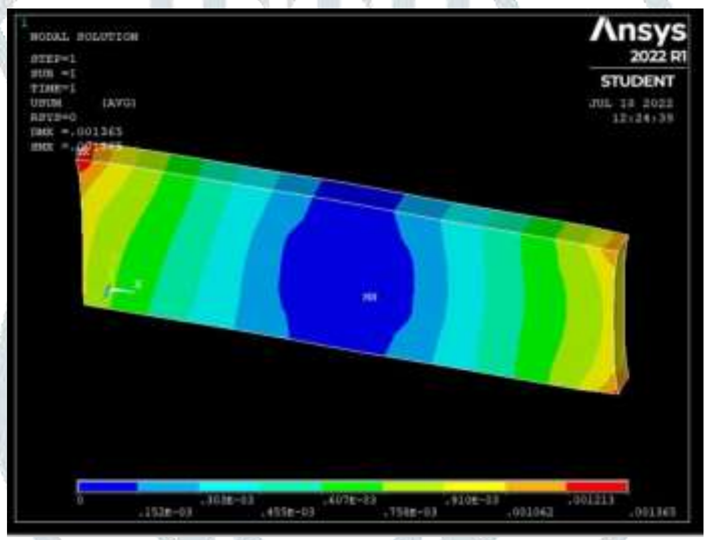


Figure 9.8
Tensile test analysis at 3000N

10. Future Applications of Mycelium Materials

- Fungi continue to play a critical role in many aspects of life, from antibiotic medicines, to food products, such as beer, wine, bread, soy sauce, temper and meat substitutes.
- However, our studies and commercialization efforts have also demonstrated the significant potential of mycelium materials and mycelium composites, specifically in the areas of packaging , thermal insulation and acoustic absorption foams with fire resistant properties in addition to paneling, flooring and furnishings .
- The academic and industrial traction that this success has generated could see the widespread use of these materials in the construction sector in the future.

11. Conclusion

- In this project work, focus is made on natural fiber composites namely mycelium bio composites.
- The concept is to replace the wastage by reusing the degradable materials at very low cost, eco-friendly in nature.
- We suggest to use this composite material to the packaging material substitute for polystyrene because, Polystyrene is slow to degrade, and if disposed of improperly, the foam can leach chemicals into the environment harming water sources.
- Polystyrene manufacturing is an enormous creator of hazardous waste. Furthermore, polystyrene manufacturing greatly contributes to global warming.
- Styrofoam is made from petroleum, which is a non-sustainable resource, the production of which creates heavy pollution and accelerates climate change.
- Styrofoam is the 5th largest component of hazardous waste broken or combusted. The release of Styrofoam's chemicals can contribute to the breaking down of the ozone layer.
- Mycelium blocks can be classified as novel class of renewable bio-material grown out of mushroom fungi and very less value agricultural wastes.
- It forms light weight compostable material which can be used within many products including insulation panels and protective packaging.
- Still research need to be done to enhance load bearing capacity of mycelium blocks to achieve required strength and make it sustainable.

REFERENCES:

[1]. Etinosa Osaymen Precious;Design And Testing Of MyceliumBiocomposite; (2019)

[2]. Amy Wu; Mycelium Bio-composites; (November 24, 2020)

[3]. Elise Elsacker 1,2, Simon Vandelook2, Joost Brancart3, Eveline Peeters2, LarsDe Laet1 Mechanical, physical and chemicalcharacterization of mycelium-based composites with different types oflignocellulosic substrates

[4]. Carolina Girometta 1 , Anna Maria Picco 1,, Rebecca Michela Baiguera 1, Daniele Dondi 2,Stefano Babbini 3, Marco Cartabia 1,3, Mirko Pellegrini 3 and Elena Savino 1; Physico-Mechanical and Thermodynamic Propertiesof Mycelium-BasedBiocomposites: A Review

[5]. R. Abhijitha, Anagha Ashoka, C. R. Rejeesh Sustainable packaging applications from mycelium to substitutepolystyrene: a review ; 2017

[6]. Maciej Sydor 1, Agata Bonenberg 2, Beata Doczekalska 3 and Grzegorz Cofta Mycelium-Based Composites in Art, Architecture, and Interior Design: A Review

[7]. Robert Corser, Kathrina Simonen, Christopher Meek; Mycelium Infrastructures for Impermanent Futures ; 2018