ISSN (e): 2250 – 3005 || Volume, 08 || Issue, 01|| January – 2018 ||
International Journal of Computational Engineering Research (IJCER)

Mycelium Composites: An Emerging, Sustainable &Green Building Material

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Abstract: *The race to find the next sustainable technology or material that will greatly reduce our ecological footprint as well as improve our environment is causing countless new materials to develop which hold the possibility of helping to achieve this generation's sustainability goals. One of the newest and most promising is the mycelium brick. A mycelium brick is an organic brick that is formed from organic waste and the mycelium of fungus. Mycelium are the thin root-like fibers from fungi which run underneath the ground, when dried it can be used as a super strong, water, mould and fire-resistant building material that can be grown into specific forms, thus reducing the processingrequirements.*

Spawn (mushroom spores) are collected and placed in a PDA material for initiating the growth of mycelium fibers from the spores. These fibers are transferred into the substrate and allowed them to grow for few days. Substrate and the mycelium fibers are further condensed into a mould to form a brick. This brick is burnt to get a strong green building material: Myceliumbrick.

The result obtained from the compressive tests is 0.347N/mm², water absorption test is 33.81% .This value is similar to the values of ecovative company.

Key Words: Mycelium 1, Spawn 2, Substrate 4 ,PDA 5, RTF 6, ecovative 7.

I. INTRODUCTION

Building practices, materials and technologies have evolved through ages. The use of soil, stone, unprocessed timber, cement etc, commence the science and art of building construction. Hardly any energy is spent in manufacturing and use of these natural materials for construction. Some problems associated with the durability of the natural materials like soil, thatch/leaves, timber, etc. lead to the exploration for durable building materials ever since the man started construction activity. Burning bricks is one of the oldest and earliest method adopted using thermal energy for manufacturing of durable building materials. Lime and lime based products,metalproductsrepresenttheothermanufactured energy-consuming materials used for the construction. Discovery of pozzolonic materials (natural inorganic binders) resulted in lime- pozzolana (LP) cement and this paved the way for the invention of Portland cement in 1824.Revolutionary changes in every part of twentieth century was bought by steel and Portland cement. And so on plastic and plastic products entered the construction industry. As we moved away from zero energy materials to more modern materials for the construction activities, it became imminent to spend more energy and natural resources. In the context of carbon emission reductions and the issues of global warming, there is a need to pay attention to use of modern building materials with reference to (i)) natural resources and raw materials consumed, (ii) impact on environment, (iii) energy intensity of materialsand(iv) recycling and safe disposal.

1.1 RESEARCHOBJECTIVE

'Mushroom materials' are a novel class ofrenewablebiomaterial grown from fungal mycelium and low-value non-food agricultural materials using a patented processdevelopedbyEcovative Design. After being left to grow in a former in a dark place for about five days during which time the fungal mycelial network binds the mixture, the resulting light robust organic compostable material can be used withinmanyproducts,including buildingmaterials,thermalinsulation panels and protectivepackaging.

1.2 SCOPE OF THISWORK

The process uses an agricultural waste product such as cotton hulls, cleaning the material, heating it up, inoculating it to create growth of the fungal mycelium, growing the material for period of about five days, and finally heating it to make the fungus inert. During growth, the material's shape can be molded into various products including protective packaging, building products, apparel, car bumpers, or surfboards. The environmental footprint of the products is minimized through the use of agricultural waste, reliance on natural and non-controlled growthenvironments, and home compostable final products. The intention is that this technology should replace Styrofoam and other petroleum-based products that take many years to decompose, or never doso.

II. MATERIALS

Mushroom spores (spawn): Spores are the reproductive part of the mushrooms. Gills of the mushroom which are present underside of the cap, bear the spores. Spores are extracted by spore print.

Potato dextrose agar (PDA): Potato dextrose agar and potato dextrose broth are common microbiologicalgrowth mediamadefrom potato infusion, and dextrose. Potato dextrose agar (abbreviated "PDA") is the most widely used medium for growing fungi andbacteria.

Substrate: Substrate is the natural environment in which an organism lives or the surface or medium on which an organism grows or is attached. The substrates which are used here in these experiments are paddy straw, fine paddy powder, saw dust. These materials must be sterilized before using them as substrate

III. METHODOLOGY

Preparation of potato dextrose agar (PDA): Take 5gm of PDA and dissolve it completely in 166.6ml of water. Heat the above mix till it forms a normal consistency. Allow it to cool to room temperature. Transfer the PDA into a conical flask and cover its mouth with cotton to prevent water from entering it. Place the conical flask inside a Le Chatelier Water Bath for sterilization. Sterilize it for 30minutes. Remove the conical flask from the water bath, cool it and transfer it to Petri dishes for further use.

Growth of mycelium in the presence of PDA: The PDA is transferred to Petri dish for the cultivation of mycelium. Some of the spawns from the spawn bag are transferred to the Petri dish such that the entire spawn is immersed in the PDA. The Petri dish is further covered and left for 3 to 4 days for the growth of mycelium. The temperature is maintained to be around 26-27^{0}C.

Growth phase of the mycelium: The substrate bag must be kept in a cool place and should avoid direct contact of sunlight. A temperature of 25-27^0 C must be maintained throughout the growth phase ofmycelium. Preferably these bags are kept in an air- conditioned room with water sprinkled on the floor and on the walls. Proper air ventilation must be provided for a better growth.

An intensive growth of the mycelium fibers can be observed after 7 to 15 days. White patches are seen in the bag on the substrate, this indicates the growth of the mycelium.

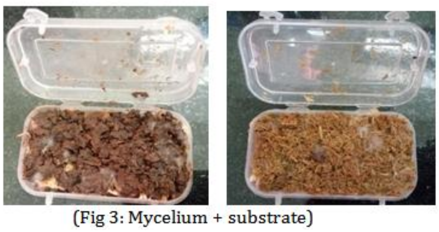
Extraction of mycelium fibers from the polythene bag: Once the entire bag turns white due to the growth of mycelium it can be used for compaction for the formation of a brick. The entire substrate along with mycelium is taken out of the bag for compaction. Parts which has more growth are opted over normal areas and patchy areas.

Placing the mycelium fibers into a mould: The selected mycelium hyphe are placed in layers in a mould. After the preparation of mould this is kept aside for about 7days for it to grow completely after which this brick will be burnt and taken for strength test.

Burning of bricks in a hot air oven: The obtained brick must be burnt in a hot air oven at 100^0 C for about 30 to 45 minutes. The temperature must be increased gradually and continuous evaluation must be done. After 30 to 40 minutes, the bricks must be taken out of oven and let for cooling.

(Fig1:spawn+substrate)

(Fig 2: RTFbag)



(Fig 3: Mycelium + substrate)

IV. Results

The results obtained from compression test is 0.347N/mm², water absorption test is 33.81%, density is 250kg/m³(hence it proves light weight of the brick).

V. Conclusion

'Mushroom materials' are a novel class ofrenewablebiomaterial grown from fungal mycelium and low-value non-food agricultural materials using a patented process developed by Ecovative Design. After being left to grow in a former in a dark place for about five days during which time the fungal mycelial network binds the mixture, theresulting light robust organic compostable material can be used within many products, including buildingmaterials,thermalinsulationpanels and protectivepackaging.

The following conclusions were drawn from the work carriedout.

1) A mycelium brick which form a light weight green building material isproduced.

2) Carbon footprint of the brick can be reduced by adopting green building materials like mycelium bricks in constructionindustries..

3) Various methods and materials need to be adopted for increasing the strength of the brick and to make it a sustainablematerial.

4) This material can be used in construction may be in a non load bearing wall until and unless more research are done in this field to achieve the required strength.

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