ISSN No:-2456-2165

Production of Mycelium Bricks

MAJOR PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree

of

Bachelor of Technology

in

Electrical & Electronics Engineering

Kishan	Rahul Kashyap	Rohan Tyagi	Anshul Jain
Enrollment No:	Enrollment No:	Enrollment No:	Enrollment No:
08415603414	08915603414	30915603414	31115603414

MR. INDRAJEET
MR. AJEET RATHI

Department of Civil Engineering Northern India Engineering College (Affiliated to Guru Gobind Singh Indraprastha University, Delhi) Delhi – 110089

MAY 2018

CANDIDATE'S DECLARATION

It is hereby certified that the work which is being presented in the B. Tech Major Project Report entitled "PRODUCTION OF MYCELIUM BRICKS" in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology and submitted in the Department of CIVIL Engineering of NORTHERN INDIA ENGINEERING COLLEGE, New Delhi (Affiliated to Guru Gobind Singh Indraprastha University, Delhi) is an authentic record of our own work carried out during a period from January 2018 to May 2018 under the guidance of MR. INDRAJEET RATHI, MR. AJEET RATHI .

The matter presented in the B. Tech Major Project Report has not been submitted by me for the award of any other degree of this or any other Institute.

Kishan	Rahul Kashyap	Rohan Tyagi	Anshul Jain
(08415603414)	(08915603414)	(30915603414)	(31115603414)

This is to certify that the above statement made by the candidate is correct to the best of my knowledge. He/She/They are permitted to appear in the External Major Project Examination

MR. INDRAJEET
Designation Head, EEED

MR. AJEET RATHI

The B. Tech Minor Project Viva-Voce Examination of KISHAN (Enrollment No: 08415603414), RAHUL KASHYAP (Enrollment No: 08915603414), ROHAN TYAGI (Enrollment No: 30915603414), ANSHUL JAIN (Enrollment No: 31115603414); has been held on ……………………………….

(Signature of Examiner)

Project Coordinator Project Coordinator

ISSN No:-2456-2165

ABSTRACT

This investigation proposed the improvement of a development material with the accompanying attributes: develops, assemble, and repairs itself; changes with the season; utilizes the powers of nature and is in agreement with its condition; favors biodiversity and regular harmony; minimal effort and does not require impressive workforce or modern material; carbon free and waste free comes back to nature when never again being used empowers maintainable and adjusted humanity advancement. The utilization of living design to diminish or invalidate the natural expenses of structure materials i
s additionally explored. Moreover, utilization of living and development style with as meager as conceivable was investigated. Another envelope material with almost no carbon affect was experimentally investigated, and the utilization of this material to make a feasible house was actually inspected. Finding exhibits that such a development material isn't just doable yet additionally levelheaded and useful from the financial and natural point of view.

Watchwords: biodiversity, living design, doable houses, practical houses

ISSN No:-2456-2165

ACKNOWLEDGEMENT

We take this opportunity to thank NORTHERN INDIA ENGINEERING COLLEGE for giving us the opportunity to implement a project on “Production of Mycelium Bricks”. We would also like to express our profound gratitude and deep regards to our guide Mr. INDRAJEET and Mr. AJEET RATHI for her exemplary guidance, monitoring and constant encouragement throughout the course of this thesis. The blessing, help and guidance given by them time to time shall carry us a long way in the journey of life on which we are about to embark.

And we would also like to thank Ms. MANINDER KAUR, HEAD OF DEPARTMENT OF CIVIL ENGINEERING for his kind co-operation and encouragement which helped us throughout this project.

We take this opportunity to express our appreciation for the excellent support provided by all other staff members for their active involvement and their valuable inputs in making the program successful.

ISSN No:-2456-2165

ABBREVIATIONS

Abbreviations used are shown below:-

SOx – Sulphur Oxides

NOx – Nitrogen Oxides

SPM – Suspended particulate matter

W.H.O – World Health Organization

PM – Particulate matter

TSP – Total Suspended particles

CO – Carbon Monoxide

EPA – Environment Protection Agency

ALA – American Lung Association

OAQPS – Office of Air Quality Planning and Standards

TCEQ – Texas Commission on Environment Quality

CHAPTER 1
INTRODUCTION

1.1 Introduction

Mycelium is the vegetative piece of growth or fungus like bacterial settlement, comprising of mass spreading, string like hyphae. The mass of hyphae is now and then called shiro, particularly inside the pixie ring fungus (figure 1.1). Contagious states made out of mycelium are found in and soil and numerous substrates. A run of the mill single spore sprouts into a homokaryotic mycelium, which can't imitate sexually; when two homokaryotic myceliums join and frame dikaryotic mycelium, that mycelium may shape fruiting bodies, for example, mushrooms. A mycelium might be minute, shaping a state that is too little to see, or it might be broad.

Through the mycelium, an organism ingests supplements from its condition. It does this in a two-organize process. To start with, the hyphae emit catalysts onto or into the sustenance source, which separate organic polymers into littler units, for example, monomers. These monomers are then ingested into the mycelium by encouraged dispersion and dynamic transport.

Mycelium is fundamental in earthly and amphibian environments for their part in the deterioration of plant material. They add to the natural part of soil, and their development discharges carbon dioxide once more into the air (see carbon cycle). Ectomycorrhizal extrametrical mycelium, as well as the mycelium of Arbuscular mycorrhizal fungi increase the efficiency of water and nutrient absorption of most plants and confers resistance to some plant pathogens. Mycelium is an important food source for many soil invertebrates.

"Mycelium", like "fungus", can be considered a mass noun, a word that can be either singular or plural. The term "mycelia", though, like "fungi", is often used as the preferred plural form.

Figure 1.1 Mycelium

1.1.1 Structure of Mycelium

Mycelium has body structures and methods of proliferation dissimilar to those of some other eukaryotic creatures. The assemblages of most growths are made of structures called hyphae (solitary, hypha).

ISSN No:-2456-2165

Hyphae are small strings of cytoplasm encompassed by a plasma film and secured by a phone divider (figure 1.2). The cell dividers of growths contrast from the cellulose cell dividers of plants. Most growths manufacture their cell dividers out of chitin, a solid, adaptable polysaccharide that is additionally found in the outer skeletons of creepy crawlies.

The hyphae of most parasites have extra cell dividers, called cross-dividers that gap the long fibers into numerous different end-to-end cells. This makes most organism's multi cell. The cross-dividers of numerous growths have pores sufficiently substantial to permit ribosome, mitochondria, and even cores to spill out of cell to cell. The development of cytoplasm starting with one cell then onto the next enables a parasite to disseminate supplements starting with one a player in its body then onto the next.

The hyphae of a solitary growth regularly branch as they develop, shaping a joined tangle called a mycelium (plural, mycelia). The capacities of mycelium are same as the sustaining structure of a growth. Its sinewy structure boosts contact with the nourishment source. Parasites can't run, swim, or fly looking for nourishment. Be that as it may, the mycelium compensates for the growth's absence of versatility by its capacity to develop quickly all through a sustenance source. A parasitic mycelium can develop as much as a kilometer of hyphae every day as it branches inside its nourishment.

Mycelia can be tremendous. Researchers have found one gigantic mycelium in Oregon that measures 5.5 kilometers crosswise over and spreads through right around 9 square kilometers of backwoods (bigger than 1,600 football fields). Researchers additionally gauge that this parasite is no less than 2,400 years of age, qualifying it as one of Earth's most established and biggest living life forms.

A mycelium is an effective structure for the heterotrophic way of life of growths. The fanning mycelium empowers the parasite to get sustenance by absorptive nourishment, a strategy by which the growth retains little natural particles from its environment. To begin with, the parasite digests nourishment outside its mycelium by discharging intense proteins into its environment. These proteins separate complex particles into littler atoms the mycelium can retain.

The in excess of 100,000 known types of parasites have an extraordinary decent variety of size, shape, and shading. Numerous parasites assume an imperative part as decomposers. Like a portion of the microorganisms you read about in Section 16, parasites reuse supplements, for example, nitrogen and carbon by separating natural material. Regular nourishment hotspots for growths are fallen logs, assemblages of dead creatures, or the losses of living life forms. Conversely, a few types of organisms are parasites. These parasitic growths ingest supplements from the cells or body liquids of living hosts. Parasitic organisms cause around 80 percent of all plant sicknesses..

1.2 Problem definition

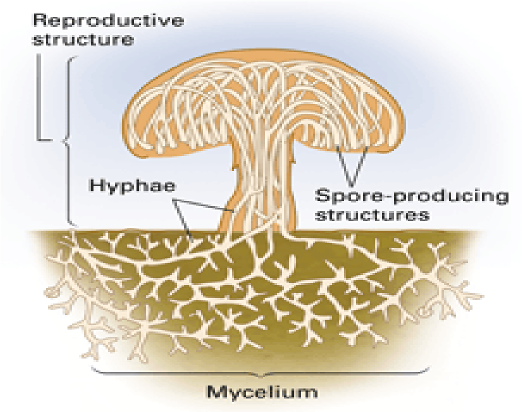


Figure 1.2 Mushroom mycelium

As indicated by carbon war room we deliver 1.23 trillion blocks worldwide on the off chance that we stack them end to end they could achieve the moon and return to earth 325 times. These are produced using the earth in the ground and terminating them in heater for solidifying them. It has been assessed that generation of this quite a bit of blocks can deliver 800 million carbon contamination into our climate consistently which is considerably more than the contamination created by the planes on the planet consistently. As indicated by William McDonough a main prestigious practical draftsman in his film squander measures up to nourishment 200 million homes are required in china if the customary material of block is utilized 25 percent of best layer of horticulture arrive is required for the mud and over portion of the coal holds in china of fuel to flame the blocks. Emanation of colossal amount of lethal components from block furnaces is causing genuine wellbeing perils. The blocks ovens radiate dangerous vapor containing suspended particulate issues rich in carbon particles and high convergence of carbon monoxide s and oxides of sulfur (SOx) that are unsafe to eyes, lungs and throat.

This air contamination stunts the psychological and physical development of children's. As indicated by the information, the essential wellspring of SOx – the significant contaminations noticeable all around – is activity vehicles (55.8%), trailed by block producing industry (28.8%). What's more, the essential wellspring of NOx (nitrogen oxides) contaminations is likewise movement vehicle (54.5%) and block producing industry (8.8%). Additionally, about 25 to 26 percent of the nation's wood generation is utilized for consuming blocks each year, causing deforestation.

1.2.1 Air pollution from brick kilns

Air contamination from block ovens are:-

1. SPM in the fuel gas which is produced predominantly because of fragmented ignition of fuel or originates from fine coal tidy, fiery debris introduce in coal and consumed dirt particles.
2. Hydrocarbons and carbon monoxide because of fragmented ignition of fuel in block furnaces.

ISSN No:-2456-2165

3. Sulphur oxides, grouping of which mostly relies upon the measure of sulfur show in the coal and is critical where high sulfur content is utilized.
4. Dust contamination produced amid evacuation and setting down of fiery remains layer on the highest point of the oven and furthermore because of smothering the reserve on the best and side of the furnace.

While the neighborhood effect of contamination caused by little segregated block furnaces situated in rustic zones isn't probably going to be huge, it is the biggest block oven group, situated in the region of substantial block request focuses that are vital reasons for concern. Fast urbanization has brought about the development of these bunches. Air contamination in these group influence the laborer, neighborhood close-by the living arrangement and additionally edits in the region.

Among different classification of laborers taking a shot at block furnaces, the fire fighter, unloaders and specialists, who handle fiery debris, has the most extreme presentation to the contaminations. Breathing in of these poisons causes aggravation of skin and eye and can causes pneumonic ailments, for example, pneumoconiosis and silicosis, which are caused by breathing in siliceous tidy. Contamination additionally affects rural yields and organic product ranches. The harm cause to mango and other organic product manors because of poisons from block ovens are notable.

Figure 1.3 Air pollution from brick kilns

1.2.2 Effects on human

Universally, it is hard to assess what number of individual cease to exist rashly or get wiped out because of air contamination since individuals are presented to such a large number of various toxins in different focuses over their lifetimes. Nonetheless, as per WHO for air contamination roughly 3 million individuals have passed on every year. Among them, 800,000 individuals pass on rashly consistently because of lung growth, cardiovascular and respiratory maladies, which are caused by outside air contamination (WHO, 2000). Roughly 150,000 of these passing are assessed to happen in South Asia alone (World Bank, 2003). Inward breath is the most widely recognized course for contaminations to enter the human body and harm the respiratory framework. Presentation to air poisons can over-burden or separate normal protection instruments in the body, causing or adding to respiratory maladies, for example, lung growth, asthma, endless bronchitis, and emphysema. Air contamination can likewise impactsly affect other critical frameworks, for example, cardiovascular framework and focal sensory

ISSN No:-2456-2165

system (Genc et every one of the 2012; Joshi and Dudani, 2008). The most huge wellbeing effects of outside air contamination are related with particulate issue (PM) (Raut, 2003). World Bank (1997) announced that the primary contributing hotspots for Add up to Suspend Particles (TSP) in the valley are bond plants (36%), block ovens (31%) local fuel burnings (14%), street re-suspensions (9%) and vehicle depletes (3.5%). In any case, particulate matter of size under 10 microns (PM10) focus, which is another significant explanation behind harming the respiratory framework; commitment by the block ovens were discovered most elevated than different sources and it was around 28% (World Bank, 1997). As EPA characterized, modest airborne particles or mist concentrates that are under 100 micrometers are all things considered alluded to as aggregate suspended particulate issue (TSP) (EPA, 2012). The vast majority of the block ovens are inadequately composed, which cause deficient ignition of coals. This fragmented burning produces Carbon Monoxide (CO), which increment for heart illnesses. On the off chance that elastic tires were utilized as fuel then alongside CO, outflow from block ovens involves fine tidy particles, hydrocarbons, Sulfur Dioxide (SO2), Oxides of Nitrogen (NOx), Fluoride mixes, and little measure of cancer-causing dioxins (Joshi and Dudani, 2008). All these run of the mill block ovens utilize woods, reused engine oils, coals, fuel oils, diesels, tires, wastes, and plastics for fuel. Truly, what they will use for fuel it mostly relies upon what is accessible for the block producers. Be that as it may, extreme the truth is that every one of these energizes are in charge of the emanation of harmful gases. In Spain, it is accounted for that the open block furnaces were additionally dependable to produce fluoride, chlorine, and bromine likewise with other harmful gases (González, Galán, and Fabbri, 2002). In Bangladesh, it is accounted for that block furnaces delivered PM2.5. This fine PM is thinking about more destructive to human wellbeing, since it has further ability to movement into respiratory framework cause untimely mortality and respiratory diseases (Guttikunda, 2009). From these PM, fundamentally both senior individuals and kids are endured more than any ages on the grounds that on these phases of life our ailment anticipation components end up weaker (OAQPS Truth Sheet, 1997). American Lung Affiliation (ALA) found in their exploration that, for the PM in air unexpected losses rate expanded three times higher than the past investigations. Tyke death rate were additionally increment for air contamination (ALA, 2006). Late investigations have uncovered that a customary broiler discharges around 863 pounds of toxins for every generation and copies covering roughly 10,000 blocks (TCEQ, 2002). A wellbeing review plainly demonstrated that individuals who are living close block furnaces will probably experience the ill effects of ailments caused by ovens contamination, contrasting the individuals who are living in zones without the furnaces. School youngsters adjacent block furnaces were had the more regrettable state of wellbeing and they were languished over higher pervasiveness of upper respiratory tract contaminations like pharyngitis and tonsillitis (Joshi and Dudani, 2008). Figure 1.3 Demonstrates the heath effect of clean from block furnaces.

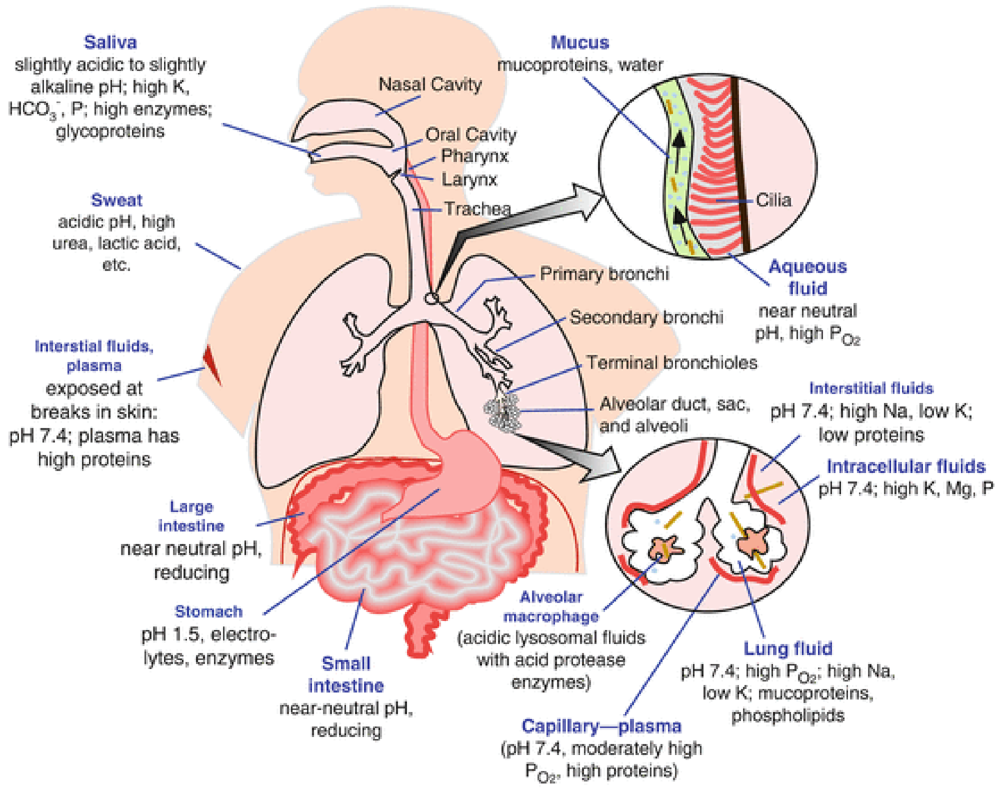


Figure 1.4 Effects of dust from brick kilns on humans

1.3 Need and Objectives

1.3.1 Need :-

In the current scenario there is a lot of need of a construction material that is cheap and environment friendly. For this purpose mycelium bricks are the best choice because they are grown not made. Besides of making brick mycelium can be used in many different things it can be used to grow structural frame to replace concrete. Also it can be used to make chairs, table all can be grown from mycelium. It can replace thermocol. And there is many usage of this technique in the future. It is a very vast topic of research.

1.3.2 Objective :-

Mycelium brick is a great replacement against standard modular bricks. As the Bricks are environment friendly as compared to standard bricks which causes too much pollution at the time of hardening. Also to provide clay soil deforestation occurs in standard brick while it is not needed in mycelium bricks. Also they can replace many materials that are providing harmful effect on our environment. Many researchers are doing work on it some of them has used the mycelium as a binding material. So in spite of bricks there is lot of uses of mycelium in future.

1.4 Methodology of work

Firstly the mushroom mycelium was grown in plastic bags. For this we need some mushroom seeds, agriculture waste, and water. The mushroom seeds are mixed in agriculture waste after sterilization and

ISSN No:-2456-2165

then some water is added and then the bag is closed and left in a cool and dark place to grow. Some chemicals also added to stop the growth of microbes that are present in agriculture waste so that they cannot interfere with the mycelium growth. It will take somewhat 7 to 10 days to grow the mycelium. Then the mycelium was transferred in the sterilized saw dust and some food is added for mycelium to eat and then the mixture was left in a dark place for the growth of mycelium. It will also take 7 days. After mycelium has eaten all the substrate the mycelium was transferred into the brick mould and then it will left in there for some time until it takes its shape after that the brick is taken out from the brick mould and left to dry and after drying it kept in the oven at 200^0 C for some time so that the bacteria will die and we get the hardened brick.

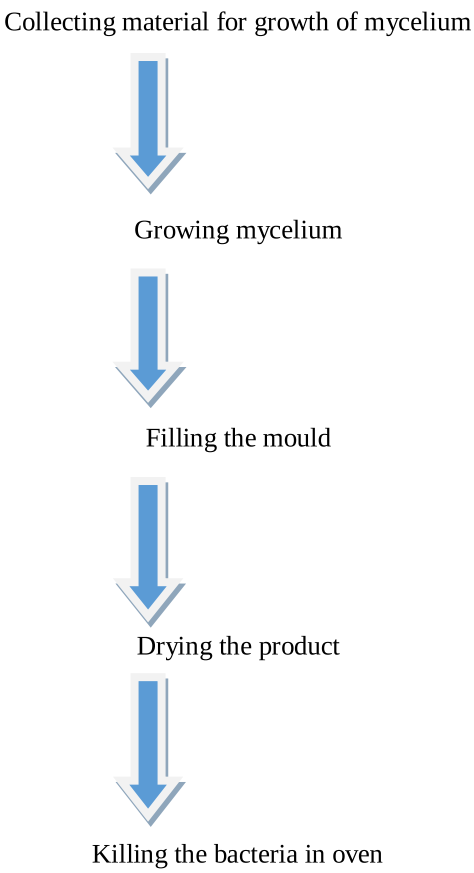


Figure 1.5 Step by Step Processes

CHAPTER 2
LITERATURE REVIEW

This chapter presents a background to the needs on the development of a mycelium bricks technology. The available published literature on mycelium bricks and usage of mycelium a type of mushroom fungus as a construction material is briefly reviewed.

2.1 Mycelium as a construction Material

1. **Sebastian Cox (2017)** studied that the vegetative part of a fungus can be used in different architectural design but he wanted to use the fungal material to create more everyday products. In his study he has used discarded goat willow was sliced up to create thin strips, which were woven together to create individual moulds. Within these moulds, the designers added a type of fungus called fomes fomentarius, which was cultivated using more wooden strips as food. As further he researched on binding material for wood for this he goes to mycelium which has great qualities his **mycelium timber** was shown at Somerset House, Strand, WC2R 1LA for the London festival which was held on September 2017.

2. **Amy Frearson (2017)** in his studies on mushroom mycelium has gone one step forward with Architect Dirk Hebel and Engineer Philippe Block by using fungi to build self-supporting structure. Hebel who led the **Sustainable Construction unit at Karlsruhe Institute of technology**, and Block who founded the **Block Research group at ETH Zurich**, have created the tree shaped structure consisting almost entirely of mycelium. According to them, the material – which is formed from the root network of mushrooms – could provide the structure of a two-storey building, if it is designed with the right geometries. Hebel and Block are presenting the idea as part of the inaugural Seoul Biennale of Architecture and Urbanism, which held at September 2017 in the South Korean capital.

3. **Asif Rahman, and Giombattista Arredia and Mohamad Yassin (2016)** in their study have found that mycelium can grow in any shape. Mycelium which is the root part of the mushroom can become an alternative to construction material that is particularly suitable for building temporary structure. Rahman, Arredia and Yassin were introduced to the material by mycologist Philip Ross, who has been looking at ways of combining mycelium with leather. The unique characteristic of the material is that can merge with the framework to which it is added. In the case of the Shell Mycelium pavilion, the material became combined with a triangulated timber framework. To make this happen, the architects created a series of tray-like cavities in the structure. These were filled with fungus then covered over with coir pith, which consists of coconut husk fibers. In time, the top

layer dried up and died, creating a protective shell over the mycelium. The shell pavilion is a pavilion made of spores and the wooden structure forms the growing ground," said the designers. "The mycelium eats it, merges with it, transforms it and grows through it. The project formed part of the programme for the Kochi Muziris Biennale 2016, which took place from December 2016 until March 2017.

4. **Aleksi Vesaluoma (2017)** in his study has developed a technique for using mushroom mycelium as an environment friendly construction material. Vesaluoma, a student at London's Brunel University, developed a technique where the mycelium material is mixed with cardboard before being moulded into what he calls "mushroom sausages" using a tube-shaped cotton bandage. The long sausages are then placed over a mould and left to grow over a four-week period inside a ventilated greenhouse. According to Vesaluoma, the resulting structure is "bound together like glue", and could provide an environmentally friendly alternative to more commonly used construction methods and materials.
5. **Aniela Hoitink (2016)** has created a dress using disk shape piece of mushroom mycelium which she believes will change the way we use textiles. Her initial intention for the experiment was to create a textile out of living product, which could be then be used to make a wearable garment. She began by combining textile elements with mycelium – the vegetative part of a mushroom fungus that many designers are turning into a biodegradable material for products and construction.

6. **Eric Klarenbeek (2014)** has created a 3D-printed chair made of mushroom mycelium. Klarenbeek's Mycelium chair, which takes its name from the extensive threadlike root structure of fungi, combines organic matter with bioplastics to make a light and strong composite material that can be 3D-printed. He adapted the 3D-printer and invented a way to print straw injected with mycelium. By infusing this mushroom it acts as a kind of glue so that all these straw parts combine together and as soon as you dry it you get a kind of cork material, which is all bound together. The chair's exterior is also 3D-printed, but is made from a bioplastics, against which the mycelium root structure grows. Klarenbeek leaves the fungus to spread throughout the 3D-printed structure, reinforcing it in the process. It could be a table, or a whole interior, and that's where it becomes interesting for me. It's really strong, solid, light weight and insulating, so we could build a house.

7. **Eben Bayer and Gavin McIntyre (2015)** have developed Mushroom Materials to provide a natural alternative to traditional plastics and synthetic packaging. The product contains mycelium, the vegetative part of a mushroom fungus, which is natural glue. This material binds with crop waste like seed husks and corn stalks to form a bioplastics. Unlike normal plastics, which are made from petrochemicals, Mushroom Materials are plant-based and fully compostable. Their Company

namely **Ecovative** has also made the packing of the dell laptop which is also made from mycelium which is replacing standard thermocol packing.

8. **David Benjamin (2014)** has developed a 40feet tower of mycelium (the root part of mushroom) and cornstalks which he named as Hy-fi tower. The structure is built from entirely from biodegradable materials. Each of the bricks used to construct the tower were grown rather than manufactured, using a combination of agricultural byproducts and mushroom mycelium – a kind of natural digestive glue. Specially designed moulds were used to cultivate the bio-bricks. These were coated in a light-refracting film developed by materials firm 3M and some were then built into the structure around the top, helping to bounce light down inside.
9. **Danielle Trofe (2015)** has developed the Mush-Lume table Lamp, Mush Bloom flower pots, Mush-Lume Hemi pendant are all made of mushroom mycelium.
10. **Surf Organics (2015)** has developed the surf boards using the mushroom materials.
11. **Lou Corpuz-Bosshart (2014)** has developed the pavement block using mushroom mycelium. In his study he has mixed the mushroom mycelium in the sterilized sawdust for two weeks after it he sent it to green house at university of British Columbia from where the mix is chipped in wood chipper and packed in the mould and left for five days after which the block were taken out and dried.
12. **Philip Ross (2014)** has developed the leather like structure from the mushroom mycelium- the root part of mushroom. And also he has made a wooden like block from the same material now he is testing the mushroom as a construction material in his company named Myco works. He has made the small samples of mycelium brick with mycelium and agriculture waste which he is growing in his lab in different conditions.
13. **Celine Park (2015)** in his study has developed a new technique in which the filter made of fungus can be used in pipes in place of needles. These pipes are used to inhale the vaccine in place of injecting them in the body. She has observed that the fungi can be used as filter as it absorbs more viruses in it.
14. **Ecovative Designs (2014)** in their study has developed a technique in which the plastic can be replaced by mycelium. In their study with a team in the International Genetically Engineered Machine (IGEM) they have grown in the shape of a drone and skinned in sheets of bacterial cellulose. These were then coated with proteins cloned from the saliva of paper wasps to create the rigid chassis of the vehicle. The drone's circuitry is printed in a silver nano particle ink – a decision that was made to keep the vehicle as biodegradable as possible. The battery, rotors and controls were all made from more traditional materials and were sourced from a normal mechanical quad copter.

CHAPTER 3
EXPERIMENTAL STUDY

3.1 Introduction

This section introduces the points of interest of improvement of the way toward making mycelium blocks. In 2013, next to no information or none and know-how of making of plastic blocks were accessible in the distributed writing. Because of this absence of data, the investigation started on restricted accessible writing on mycelium blocks. The present examination embraced a thorough experimentation process with a specific end goal to build up the mycelium blocks innovation. The focal point of the investigation was to distinguish the remarkable parameters that impacts the properties of plastic utilized as a development material. Beyond what many would consider possible the waste plastic is utilized.

The point of the activity was to facilitate the advancement of this 'new' material later on to the block business. Keeping in mind the end goal to streamline the advancement procedure, the compressive quality is chosen as benchmark parameter. This isn't uncommon in light of the fact that compressive quality has an inborn significance in the basic outline of block structure. In spite of the fact that mycelium can be utilized as a part of various development material, for example, asphalts, mycelium piece, mycelium seats, and so on.

3.2 Material Used

3.2.1 Mycelium that is grown from mushroom seeds

Mycelium is the vegetative piece of parasite or growth like bacterial settlement, comprising of mass expanding, string like hyphae. The mass of hyphae is here and there called shiro, particularly inside the pixie ring parasites (figure 1.1). Parasitic settlements made out of mycelium are found in and soil and numerous substrate. A regular single spore sprouts into a homo karyotic mycelium, which can't duplicate sexually; when two good homokaryotic myceliums are joined and frame dikaryotic mycelium, that mycelium may shape fruiting bodies, for example, mushrooms. A mycelium might be minute, framing a province that is too little to see, or it might be broad.

Through the mycelium, a parasite assimilates supplements from its condition. It does this in a two-organize process. To begin with, the hyphae discharge proteins onto or into the sustenance source, which separate organic polymers into littler units, for example, monomers. These monomers are then retained into the mycelium by encouraged dispersion and dynamic transport.

Mycelium is imperative in earthbound and sea-going biological systems for their part in the disintegration of plant material. They add to the natural portion of soil, and their development discharges carbon dioxide once more into the air (see carbon cycle). Ectomycorrhizal extrametrical mycelium, and in addition the mycelium of Arbuscular mycorrhizal growths increment the effectiveness of water and supplement retention of most plants and present protection from some plant pathogens. Mycelium is a critical sustenance hotspot for some, dirt spineless creatures.

"Mycelium", like "parasite", can be viewed as a mass thing, a word that can be either particular or plural. The expression "mycelia", however, similar to "organisms", is regularly utilized as the favored plural frame. For mycelium see figure 1.1 and figure 3.1 for mushroom seeds.

Figure 3.1 mushroom seeds

3.2.2 Substrate

A substrate is a material on which the mycelium can be grown. A substrate can be anything saw dust, wheat, agriculture waste etc.

Diverse kind of substrate as follows:-

1. Straw

Grain straw such as wheat, rye, and oat all make a good substrate. They are easy to get and also fairly cheap. As they contain microbes that can interfere in the growth of mycelium so they have to be prepared first.

Figure 3.2 Straws

2. Logs

As mentioned earlier in chapter 1 that mycelium can be grown on anything. Wooden logs are also a great substrate for mycelium. However, often any quickly decomposing hardwood that's not too dense will do. Elm, beech, alder, ash, and cottonwood are all good choices. Thicker hardwoods, such as oak,

ISSN No:-2456-2165

will take much longer to produce mushrooms. But wooden logs take too much time to colonize mycelium.

Figure 3.3 Wooden logs

3. Enriched Saw dust

Enriched sawdust is also a mushroom substrate more commonly seen with commercial rather than home cultivators. Although it works quite well with a variety of different mushrooms, there are a few factors to consider. Same as wooden logs Hardwood sawdust are best rather than softwood. Also the sawdust to be sterilizing sawdust before colonizes mycelium.

Figure 3.4 Saw dust

4. Some other substrate can be used like stumps, cardboard, coffee grounds, etc.

3.2.3 Chemicals used

1 Formalin

It is a 40 percent solution of formaldehyde in water; it is used as a disinfectant, preservative for chemical specimen.

Figure 3.5 Formalin

2 Fungicide

Fungicides are the chemical compounds or biological organisms used to kill parasitic fungi or their spores. A fungi static inhibits their growth. It is important because it is used to stop the fungi that are present in the substrate.

Figure 3.6 Fungicides

3.2.4 Cellophane sheet

Cellophane sheet is a poly propylene sheet which is used to make the mould air tight.

Figure 3.7 Cellophane sheet

3.2.5 Oven

Oven is used to kill the bacteria.

Figure 3.8 Laboratory oven

3.2.6 Brick mould

Brick mould is used to grow the mycelium in the shape of brick.

Figure 3.9 filling in the Brick mould

3.3 Preliminary Laboratory Work

The main objectives of the preliminary laboratory work were:

- To familiarize with the making of mycelium brick.
- To understand the effect of different substrate in the colonizing of mycelium
- To observe the behavior of fresh mycelium brick
- To develop the process of making the mycelium brick
- To understand basic mixture proportioning of different material of mycelium brick

The preliminary lab work revealed the following:-

3.3.1 Collection of material for colonizing of mycelium

Firstly we have collected the mushroom seeds from the mushroom farm that is located in Delhi. Also we have bought the agriculture waste from the farm. And we also taken some saw dust from the factory of wood cutting which is also in Delhi. We have taken the chemicals to stop the growth of microbes of substrate like agriculture waste and saw dust. The chemicals are formalin and fungicide. Also we have bought some cellophane tape from plastic material shop. Also we have bought some cat food; jelly and energy drink to give the fungus as a food.

3.3.2 Mixing of material in the plastic bag to grow mycelium

3.3.2.1 Step-1

1. Sterilize the Substrate i.e. the agriculture waste in this case.
2. Take a plastic bag.
3. Add the sterilized agriculture waste and formalin and fungicide.
4. Add 2-3 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 3.10 agriculture waste and mycelium bag

3.3.2.2 Trial -1

1 After growth of mycelium take a brick mould.

ISSN No:-2456-2165

2 Add the mix in the brick 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 3-5 days.

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

Figure 3.11 mycelium filled brick mould

3.3.2.3 Trial-2

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

2 Fill the brick mould with the mix.

3 Add 20g of wheat flour in it.

4 Add some water and sugar also.

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 cut to allow some air to enter in it.

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

8 After 7 days we have seen that some mycelium has grown in the air tight mould.

9 And in the second mould mushroom has grown.

10 We leave the 2nd mould and take the first mould.

11 As we can see the 1st mould is not hard enough to convert in brick so again failure. Now we have done Trial-3.

Figure 3.12 Mycelium colonizing in air tight and non air tight

3.3.2.4 Trial-3

1 Take the mycelium that we have grown in trial 2.

2 Now this time we used the saw dust as substrate.

3 In this trial we have used saw dust one with sterilization and another without sterilization.
4 Take brick mould and add some food to it.
5 In this trial we have added some jelly, energy drink lie Gatorade, Some cat food.
6 We have added the above material in different proportion.
7 Mix the material thoroughly.
8 Cover the mould with cellophane sheet and place it in a dry place for 3-7 days.
9 After 7 days take the mix out of the mould and leave it to dry in refrigerator so that the mix will get dry.
10 After drying take the sample and heat it in the oven so that bacteria will die.
11 Now we have got the brick.

Figure 3.13 Adding jelly in mycelium

3.3.2.5 Trial-4

1 Take the mycelium that is grown in trial -2.
2 As after the third trial the brick is not enough to be tested on compressive strength machine.
3 Now to make the brick hard we added some percent of white cement.
4 For this we added 30 % white cement in the mycelium and let it get hardened.
5 After the brick got hardened we placed the brick in the oven.
6 Heating it in 400^0 C to kill the bacteria of the brick.
7 Now we have got the sample block which is shown in fig 3.15.
8 Then we have tested as per IS: 1077:1992 and IS: 3495: 1992 Testing of bricks.
9 Now according to the IS Code test there are three test on brick which are shown in Appendix A-1 to A-3.
10 The results of the tests performed are shown in chapter 4.

Fig 3.14 mycelium brick.

3.3.3 Testing on mycelium brick

1 Compressive Strength test

After hardening of the brick, the compressive strength test on hardened mycelium bricks were performed on the compressive testing machine as shown in figure 3.5. Two bricks were tested of different sizes. Fig 3.8 shows the compression testing machine.

Figure 3.15 Compression testing machine

Fig 3.16 Compression testing on mycelium brick

2 Efflorescence test

The efflorescence test was done on the test sample. This test was done to check the concentration of the salts of magnesium, Calcium, Sodium and Potassium on the brick.

It is the white power that is covered on the brick when it gets reacted by water and sun.

As efflorescence alone is not a problem but it is the reason of many problems like water intrusion, Structural damage and health problems etc, Efflorescence can be removed by dry brushing and washing repeatedly. For the Test procedure refer Appendix A-2. To check which brick has less efflorescence mycelium brick or Standard brick we have tested both the bricks for the efflorescence test.

3 Water absorption test

The water absorption test was done on the mycelium bricks. This test was done to check that how much amount of water the mycelium brick can resist. For this test we have done water absorption test on both brick. And Note down the reading. The reading and results are given in chapter 4. And the test procedure is given in the Appendix A-3. As if the brick absorb more water than the weight of the brick increased which also increases the dead load of the building. Also it can cause the problem of seepage from the structure.

ISSN No:-2456-2165

CHAPTER 4
RESULTS

In this Chapter, the experimental results are presented and discussed. Each of the compressive strength test data points plotted in various graphs or stated in various Tables corresponds to the mean value of the compressive strengths of the two brick samples. The chapter shows the effect of various salient parameters on the compressive strength of mycelium bricks is discussed. Various test results of efflorescence and water absorption on mycelium brick and standard tile brick are also given.

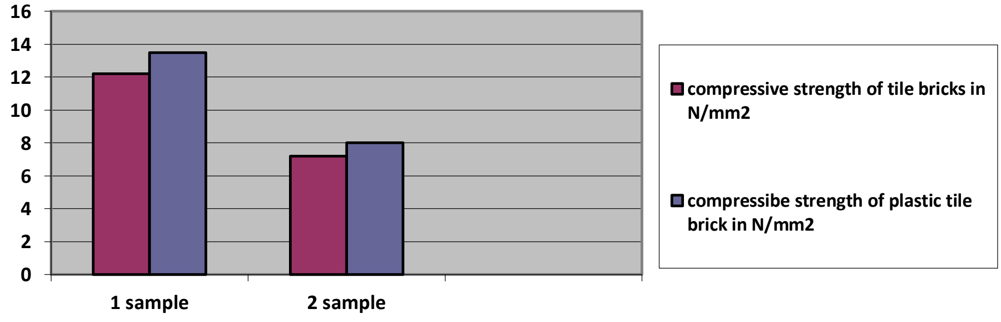
4.1Test Results

4.1.1 Compressive Test Results:

Tests show that the unit weight of the mycelium brick is lighter than the standard tile brick. The tile brick compressive strength test carried out as per IS 3495-1992 part 1 and all observations were presented in table 4.1 and the comparison with the observations of standard brick are shown in graph 4.1

S.No	Compressive strength of mycelium bricks in N/mm^2	Compressive Strength of tile brick in N/mm^2
1.	12.2	7.2
2.	13.5	8.0

Table 4.1 Compressive Strength of mycelium brick and standard tile brick



Graph 4.1Compressive strength of mycelium brick and standard tile brick

ISSN No:-2456-2165

Fig 4.1 Compression testing result on mycelium brick

Figure 4.2 Mycelium brick sample 1

Figure 4.3 Mycelium Brick sample 2

4.1.2 Efflorescence test Results:

Test shows that there is slight efflorescence in case of mycelium bricks. In case of Normal AA class Bricks the efflorescence is slight. Table 4.2 shows the efflorescence test on mycelium brick and standard tile brick.

Table 4.2 Efflorescence test on mycelium brick and standard tile brick

S.No.	Efflorescence of standard brick	Efflorescence of mycelium brick
1.	Moderate	Slight

4.1.3 Water Absorption Test:

The water absorption on the plastic bricks is 10.50% but in Normal brick this value is up to 11.56%. Table 4.3 shows the water absorption of mycelium brick and standard tile brick

Table 4.3 Water absorption of mycelium brick and standard tile brick

S.No.	Water absorption on standard brick	Water absorption on mycelium brick
1	11.56%	10.50%

CHAPTER 5
SUMMARY AND CONCLUSIONS

• Summary

This Chapter presents a summary of the present study, the major conclusion, and some recommendation for future research. When this study started in 2013, the published literature contained only limited or no knowledge on the process of making of mycelium Bricks. Most of the literature has only about the idea of making. Moreover, the exact detail regarding the making of mycelium bricks are undisclosed in the patent and commercially oriented research documents.

With the generic information available on mycelium bricks and their related topics like usage of plastic in construction material rigorous trial and error method was adopted to develop a process of production of Mycelium Brick using mycelium the root part of mushroom. After failures in the beginning, the trial and error method yielded successful results with regards to production of mycelium bricks using mushroom mycelium. Once this was achieved, tests were performed to quantify the effect of the salient parameters that influence the short term properties of mycelium brick.

• Conclusion

This project presented a brief overall review on mycelium bricks using mycelium the root part of mushroom. The strength depends on the content of mycelium. And also this project has social benefits also like if it is used to grow leather than no longer need of animal skin to make leather. Also if it used to grow synthetic wood than the deforestation will be very less as it is more stronger than wood The economic benefits and contribution of mycelium bricks for sustainable development are also been outlined.

Since the mycelium brick is a whole new concept of bricks with new technology no Indian Standards are available, so a detailed study on the chemistry behind the mycelium bricks is needed. Now a detailed study thereafter should be needed for making of bricks cheaper and useful than that of standard brick so it can be introduced into the market. Also there a detailed study is need on a method to grow mycelium faster.

CHAPTER 6
Future Scope

To date the mycelium was not so normal but rather on future premise there is part of utilization of mycelium in numerous development materials. Like it can supplant the thermocol that are utilized for protection and numerous different works Additionally it can supplant wood since the mycelium can utilized to develop engineered wood and that wood is considerably more grounded than ordinary wood and furthermore it will supplant cowhide as the calfskin we develop from mycelium are substantially more grounded and no longer creature skin is required to develop calfskin. Many things can be made of the mycelium. In future there is immense utilization of mycelium in development and in different things.

APPENDIX A-1

Test on bricks: -
Compressive Strength test

Figure A-1 compressive strength test apparatus

PURPOSE:
This test is done to determine the compressive strength of burnt clay building blocks. Brick are mostly subjected to compression and rarely to tension. The usual crushing strength of common hand molded well burnt brick is about 5 to 10 N/mm^2 (50 to 100kg/cm^2) varying according to the nature of preparation of the clay. Pressed and machine molded bricks made of thoroughly mixed clay are much stronger than common hand mould bricks made from carelessly prepared clay.

APPARATUS
1. Compressive strength testing machine Preparation of Test specimens
2. Remove unevenness observed in the bed faces to provide two smooth and parallel faces by grinding. Immerse in water at room temperature for 21 hours.
3. Remove the specimen and drain out any surplus moisture at room temperature.
4. Fill the frog (where provided) and all voids in the bed face flush with cement mortar (1 cement, clean coarse sand of grade 3 mm and down).
5. Store under the damp jute bags for 24 hours followed by immersion in clean water for 3 days.
6. Remove, and wipe out any traces of moisture.

ISSN No:-2456-2165

PROCEDURE

1. Measure dimension nearer to 1mm.
2. Place the specimen with flat faces horizontal, and mortar filled face facing upwards between two 3-ply plywood sheets each of 3 mm thickness and carefully centered between plates of the testing machine.
3. Apply load axially at a uniform rate of 14 N/mm^2 (140 kgf/cm^2) per minute till failure occurs and note the maximum load at failure.
4. The load at failure shall be the maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine.

.

ISSN No:-2456-2165

CALCULATION:

$$\text{Compressive Strength} = \frac{\text{Maximum load at failure (N)}}{\text{Area of Avg Bed face (mm}^2\text{)}}$$

Result:

The compressive Strength of Plastic Brick is _________N/m

APPENDIX A-2

Efflorescence test

PURPOSE:
This test is done to determine the efflorescence of burnt clay building blocks.

APPARATUS
1. Distilled water
2. Brick sample to be tested for efflorescence.
3. Flat bottom shallow dish made up of glass, porcelain or glazed stoneware having following detail:-
   For Square dish: - width 180mm, length 180mm depth 40mm.
   For Circular dish: - Depth 40mm, diameter 200mm.

PROCEDURE
1. Fill the distilled water in shallow dish and placed the ends of the bricks are in the dish, depth of immersion of water being 25mm.
2. Place the whole arrangement in a warm well ventilated room(between 20^0 C and 30^0 C.) until all the water in the dish is absorbed by the specimens and the surplus water evaporates.
3. To avoid the excessive evaporation from the dish, the dish containing the brick cover with suitable glass cylinder
4. When the water has been absorbed and brick appear to be dry, a similar quantity of water is placed in the dish and it allows evaporating as before. Examine the brick for efflorescence after the second evaporation and report the results.

Result:

Nil: - When there is no efflorescence in the bricks
Slight: - When the efflorescence of the brick does not cover more than 10% area of the exposed bricks.
Moderate: - When the efflorescence of the brick more than 10% and less than 50% of the exposed area of the bricks.
Heavy: - When the efflorescence of the brick more than 50% but the deposit do-not powder or flake away the brick surface.
Serious: - When the deposits are heavy and powder or flake away the brick surface.

Figure A-2 Efflorescence test on bricks

ISSN No:-2456-2165

APPENDIX A-3

Water absorption test

Purpose

This test is done to determine the percentage of water absorption of bricks

Figure A-3 Water absorption test on bricks

Apparatus

A sensitive balance capable of weighing within 0.1% of the mass of the specimen and ventilated oven

Specimen

Three numbers of whole bricks from samples collected for testing should be taken.

Procedure

1. Dry the specimen in a ventilated oven at a temperature of 105 °C to 115°C till it attains substantially constant mass.
2. Cool the specimen to room temperature and obtain its weight (M_1) specimen too warm to touch shall not be used for this purpose.
3. Immerse completely dried specimen in clean water at a temperature of 27+2°C for 24 hours.
4. Remove the specimen and wipe out any traces of water with damp cloth and weigh the specimen after it has been removed from water (M_2)

CALCULATIONS

Water absorption, % by mass, after 24 hours immersion in cold water in given by the formula,

$$W = \frac{M_2 - M_1}{M_1} X\ 100$$

The average of result shall be reported.

ISSN No:-2456-2165

Result

Water absorption of the given bricks = …………. %

Specification

When tested as above, the average water absorption shall not be more than 20% by weight up to class 125 and 15% by weight for higher class.

ISSN No:-2456-2165

REFERENCES

1. Stamets, Paul. Mycelium Running, Ten Speed Press, U.S.A 2005 (p45 caption to figure 60)
2. Kile Meredith (September 13 2013). "How to replace foam and plastic packaging with mushroom experiments." Al jazeera America.
3. "Composting -Compost microorganisms. Cornell University Retrieved 17 April 2014.
4. Epstein, Eliot (2011). Industrial Composting: Environmental Engineering and Facilities Management. CRC Press ISBN 143984531X.
5. Sebastian Cox (20 September 2017) "Self Supporting Structural Column made from mycelium". Amy Frearson. Dezeen
6. Dirk Hebel (4 September 2017) "Tree shaped structure made from mycelium". Amy Frearson Dezeen
7. Aleksi Vesaluoma (20 June 2017) "Sausage shaped structure made of mushroom". Alice Morby Dezeen.
8. Asif Rahman, Giombattista Arredia and Mohammad Yassin (26 August 2017) "Pavilion a Shell like structure made of mycelium". Amy Frearson Dezeen
9. Aniela Hotlink (1 April 2016) "Dress made of mycelium." Alice Morby Dezeen.
10. Journal of Aerosol Medicine and Pulmonary Drug Delivery, Vol 25 No 5.
11. Ecovative Design (20 November 2014) "Drone made by mycelium." Tamlin Magee Dezeen.
12. Ecovative Design (25 March 2015) "Made a mushroom growing Kit to replace plastic". Maudie Manton Dezeen.
13. Erik Klarenbeek (06 March 2014) "used mycelium as a binding material in his chair". James Pallister Dezeen.
14. David Benjamin (1 July 2014) "Made Hi-fy tower from mycelium". Amy Frearson Dezeen.

IS Codes

1 IS Code 1077:1992 for the Compressive strength classification of Bricks

2 IS:3495:1992 part 1 to part 4 for the Testing of Bricks

3 IS:5454:1918 for Classification of Bricks