International Journal of Research in Engineering, Science and Management
Volume-2, Issue-10, October-2019
www.ijresm.com | ISSN (Online): 2581-5792

Bio-Materials in Architecture

Vaishali Agnihotri[1], Suhas Choudhari[2], Shubhangi Mishra[3]
[1,3]*Fourth Year Student, Department of Architecture, SDPS Women's College, Indore, India*
[2]*Assistant Professor, Department of Architecture, SDPS Women's College, Indore, India*

***Abstract*: Building construction has a huge effect on the environment, every step of construction involves a noticeable impact on the environment. In India, 35% of energy consumption is performed by the building sector. This increasing growth acts as a challenge for the designing of energy-efficient buildings. Due to lack of space and overpopulation in metropolitan cities, every construction project was taken up results in the emission of carbon dioxide, methane and many wastes. Architecture involves structure, function, design, and form, most importantly material which is the backbone of building's construction, since building technology is advancing day by day. Bio-material is also used for building construction which provides us with a chance to capture and explore characters of nature provides certain performance. New Delhi is the capital of India witnesses' enormous construction all over the city. This research examines the properties of building construction materials and their impacts on the environment. Also explains how to deal with these impacts by using bio-material and increase the quality of material in a polluted city like Delhi. The main interest in this research is not only to explore the development of a material database for sustainable buildings but also to reduce the pollution by absorbing the pollutants around the building by using bio-material for construction. The research gives a review of Mycoform technology which involves growing building material using mycelium, a type of fungal spores. The result is 100% organic involving minimum waste and energy. The material involves outstanding property like good strength, thermal compatibility, sound-absorbing, self-maintained and many more which is actually helpful as a material for future construction.**

***Keywords*: Bio-materials, sustainable development, energy efficiency, responsive architecture**

1. Introduction

Building construction has a huge impact on the environment, every step of construction involves a noticeable impact on the environment. With an increase in global warming, it is essential to know the impact of construction on the environment, how we can reduce it and calculate its impact in future. Construction projects involve many processes such as mining, transportation. Construction's impact on the environment shows climate changes, due to the process involved in construction projects.

For over a decade we use the same material for building construction, whereas, with the advancement of technology new materials have been introduced for construction which involves basic changes in designing of building, many other material systems were explored already such as not able to deal with biological matters for example - hydro gel has been majorly used in tissue engineering and biotechnology industry, but its application is rarely in use for building construction. Delhi is one of the most populated and polluted metropolitan city in the world. It is difficult to design in Delhi due to its composite nature. Due to the lack of green spaces and over the construction of industries the PM rate is 2.5 which is the highest concentrated form of air pollution is supposed to be a very serious matter. The construction industry plays a very crucial role in energy conservation.

Biomaterial has the property of growing bacterial cellulose and cellulose can grow in an only designed shape or fashion layer by layer and it requires no waste or energy. Bio-materials provide a chance to capture and explore characters of nature provide certain performance. The primary interest in the research is to explore how biomaterial can reduce waste due to present usage of construction material, and also the biomaterial has good properties which will help to clean the damage outside, it is important to increase the quality of building construction. Biomaterial have changing nature which is very helpful for building due to regular climate changes, they also have self-maintenance. Due to recent developments in construction, few studies focused on the durability of the material. Bio-based material used as a prefabricated cladding sheet which is fixed to the exterior as well as the interior of the building.

The major aim of environment research is to check the workability and sustainable development of the material which is metabolic or distinctly biological. Usage of biomaterial and recycled material for building construction can significantly reduce the effect of construction and wastes it generates. Also giving emphasis on biomaterial, it can help to clean the air and absorb noise. By studying the situation in Delhi, this paper focuses on various biomaterials which can be used for building construction in a composite climate like Delhi. It also lays focus on studying the impact of construction there, the article discusses the impact of the construction project on the environment, and how the contractors and firms can work to reduce these problems. Generally, biomaterial shows less impact on the environment than traditional materials do. The research highlights development in sound transmission property of bio-based material also.

2. How construction project reacts to environment?

The building construction process has many crucial impacts on the environment. With the change in climate

scientists believe that the earth is getting warmer due to human activities such as the contribution of carbon dioxide through construction industries. Every stage of a construction project results in the emission of carbon dioxide, methane and other waste products which pollutes the environment and contribute to global climatic changes, for example, the cement industry contributes 50% carbon dioxide emission. There are multiple sources on buildings to pollute water, also including diesel and other fossil fuels, paint, solvent and toxic chemicals. In the development of the world, there are often less stringent requirements for the disposal of toxic construction waste product, resulting in a significant local environmental damage following a building project. Building accounts for 40% of total energy usage worldwide. It is necessary to use green material because they can be synthetically produced, we could even recycle, eliminate the need to engage in destructive and costly mining practices that use a lot of fossil fuels, green material can be recycled and cause less environmental impacts.

3. Climatic condition of Delhi

Delhi is located at 28°C 35' N latitude & 77° 12'E longitude geographically and at an altitude of 216 meters above sea level. Delhi is situated on the banks of Yamuna River. The climatic conditions of Delhi are so extreme. Delhi comes under composite climate are neither very hot & so dry nor warm and humid. The primary cause of pollution is the haphazard growth of the population is deteriorating the environment. In Delhi, the development of the industries and factories are so unplanned, 80% of industries are set up in the commercial and residential areas. Because of the metro, there has been a huge rise in traffic, air pollution and noise pollution. NEERI (National Environmental Engineering Research Institute) reported that in Delhi 8,000m tones of solid waste are being generated every day. There has been no proper technology to treat such waste in the city.

A. What is biomaterial?

The present trend is of designing sustainable building and spreading environmental awareness which is reviving bio-architecture as an alternative to construction techniques. The primary advantages of biomaterial are they result in a low impact on the environment due to renewability and numerous uses. Biomaterials enable prefabrication and fast installation. Their naturalness and other assets compatible with the human physiological derivation. Since trees absorb carbon dioxide from the atmosphere and store carbon in wood generates lower environmental impact in comparison with other building materials. Consequently, biomaterials have become recognized as an alternative to several traditional building materials.

By comparison biomaterial with traditional building material. Traditional materials show a noticeable impact in nature while Biomaterials have a tendency to absorb sound as well as carbon dioxide which is clear benefits of natural material on human health, childhood development. It should be mentioned, however, that industrial transformation, post-processing and modification may highly affect human perception of material “Naturalness".

4. Mycoform technology

This is the time we need to get back to nature we have already explored many eco-friendly building materials like hemp and straw for insulation. This has been researched and found that mycelium could fill a form by growing in any shape layer by layer. Such as large blocks which are actually made of organic waste material and then it's heat-treated to kill the spore growth. This is totally economical as well as biodegradable need no maintenance. The mycoform building block production is low tech low energy process. Few inexpensive readily available tool and agricultural byproducts, 80 F humidity is all needed to compact and grow a mycelium building block. Mycelium needs at least need 10 days to grow in a shape.

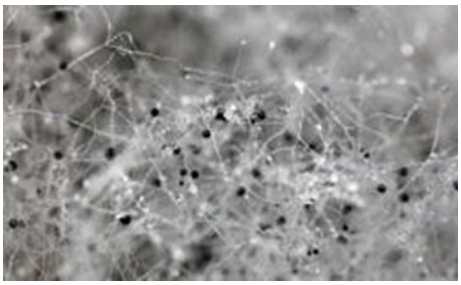

Fig. 1. Mycelium spores

Mycelium is a fibrous material mainly composed of natural polymers as chitin, cellulose, protein, etc. Due to its unique structure and composition, we foresee the production of large amounts of mycelium based materials. Mycelium has been identified as the largest living organism on earth. Mycelium has good sound-absorbing property such as mycoform is also in use for insulation as well as for acoustic purposes.

Mycoform structures are grown from stains into fungi specific 3d fabricated geometry. By combining fungal mycelia with varying types of organic substrates and carefully controlling their expansion within prefabricated moulds. The polypore fungal species Ganoderma lucidum processes enzymes that readily digest a wide variety of cellulose-based organic by-product. The rapid growth of branching mycelia results in a dense matrix capable of structural support.

A. Bio-based blocks

One of the most important considerations for these days is green manufacture, investigating ecological ways to design sustainable buildings material. A company "Planetary One" experimenting by using mushroom roots to create Mycoform building mushroom roots create mycoform building blocks. They have created brick block moulds with the combination of recycled aluminium sheet and grows mycelium spores inside the form. These blocks are strong as compared to traditional blocks but require a little amount of energy to create. The

expected life of the blocks is 20-30years. These blocks are strong as compared to traditional blocks but require a little amount of energy to create. The expected life of the blocks is 20-30 years.

Fig. 2. Mycoform form mushroom blocks

These blocks are strong as compared to traditional blocks but require a little amount of energy to create. The expected life of the blocks is 20-30years.

B. Brick breath

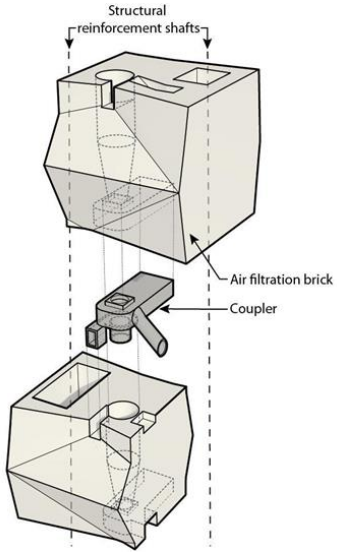

Fig. 3. Breath brick modules are connected via coupler that aids in collecting particles, protect the cyclone and facilitates modules alignment during construction. Image@ carmen Trudell & Natacha Schindler.

The design of breath brick is done in such a way that building can get regular ventilation system, with a double-layered facade design. Bricks on the outside complemented by a standard internal layer providing insulation. Centre of a breath brick includes a function of cyclone filtration, inspired by the vacuum cleaner, which separates polluted particles from the air and drops them into a removable hopper at the base of the wall.

Breath brick composed of two parts. Concrete brick and recycled plastic coupler, help to create a route from outside into the centre of brick. The concrete bricks having a faceted feature which allows direct airflow into the system and create caving for inserting steel. Structure of this system and create a cavity for inserting a steel structure. This system can perform both mechanical and passive ventilation. As such brick simply delivers air into the plenum, this air can also be delivered to the interior of the building through mechanical equipment. In the wind tunnel test, the system filtered 30% of fine particles and 100% of the dust. As the centre system is relatively inexpensive.

As given above, Mycelium has a suitable property for building blocks. These bricks are used to construct a building were grown, this organic brick structure known as "Hy Fi" tower which is constructed of 10,000 bricks and reached 40 feet in New York designed by David Benjamin. Mycoform brick is stronger than concrete brick so, if we use these bricks to construct our future building not only for making it sustainable but also to purify pollutants from the air by creating a vacuum in these bricks as same as breath brick as mentioned above. By using mycelium instead of concrete we can make our building more sustainable and can reduce air pollution from the environment as well. The making process of breath brick is mentioned above, so if we use Mycoform blocks instead of concrete for making breath brick will be more helpful for creating a sustainable environment. The visual portion of mycoform only shows a minute fraction of fungus, beside the surface Mycelium can grow out thread-like roots. Such that whatever shape we want them to grow in, it can be easily done.

Breath bricks involve good ventilation inside the building. Mycelium also shows insulation property and Mycelium spores can make the building thermally compatible which is beneficial for future construction. Mycelium doesn't need any maintenance; it is self-maintained.

C. Bio based furniture's

Mycoform is also in use for furniture making, it's a combination of mushrooms, wood chips and oat bran toughened by a fungus called Ganoderma lucidum surrounded by an external skin of bacterial cellulose. This combination results in a hard polymer which is suitable for furniture designing. The designing of the furniture is done by using digital programming which predicts the material behaviour and shape before designing it.

Fig. 4. Mycoform furniture

The prototype form part of a series of experiment with biologically produced furniture that is grown rather than manufactured in the traditional sense.

Mycelium spores are sound absorbing in nature, it is being researched that mycelium is one of the best agriculture by-product mixture best for furniture work as well as for future construction. Mycelium can easily deal with flexibility so it is easy to design furniture. In comparison to the traditional foam for insulation, the mycelium is more promising and low cost high performing alternative. Examination of the acoustic property of mycelium result as effective porous and sound absorbers. The sandwich panel is more useful to increase sound insulation. Biomaterials are naturally grown as it offers improved insulation and also absorbs carbon dioxide.

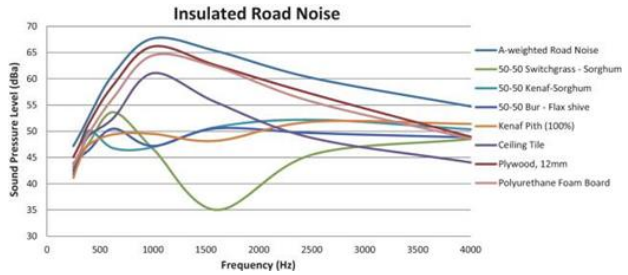

Fig. 5. A test comparing the audio spectrum, A-weighted with typical road noise excitation, between mycelium based acoustic absorption boards ranging from best to worst performers alongside a few traditional absorbers for reference, such as plywood and a typical 25mm thick polyurethane insulation board

According to the aim of the research, we need a material that can increase the quality of construction and clean the environment as well. Mycelium is good in absorbing sound, we can use mycelium to absorb sound inside and outside of the building as well. To reduce noise benches can be designed for streets made of mycelium, ultimately mycelium comes from byproduct so it is cheaper than tradition material. Mycelium stands as the best inexpensive material because it is easy to install and does not show any terrible impact on nature. Noise can be reduced by providing an insulation panel of mycelium in building facade.

5. Limitation

Biomaterial having a property that is less understood and remains difficult to control. Biomaterials have the disadvantage of being combustible, thus they are perceived as less safe than steel and masonry. Biomaterials cannot be used for heavy structures because of the low strength and density as compared to concrete. Biomaterial involves several properties, it is important to take precautions before and while operating. Biomaterials enable prefabrication and fast installation.

6. Scope

Give awareness among designers, contractors and common people. Show consideration about quality of construction materials, because traditional materials are not good enough to use in future. Biomaterials have several outstanding properties which not only help to design sustainable but also make the environment pollution free.

Biomaterial does not show any harmful impact on nature, as it is green material and easily available due to being cheap and a by-product of agriculture waste. A biomaterial is aesthetically appealing we use building blocks, furniture, insulation panel and many more for buildings made of biomaterials. There's still research going on for more uses in the construction world.

To reduce the impact of construction material we need to have a better substitute and biomaterial is one of the wonderful solutions for increasing the quality of building material, which is important due to the present condition of the environment.

7. Conclusion

The paper represents a brief study of biobased material to construct better buildings for the future. The research specifically aims to illuminate the environmental possibilities, with mycoform one of the most excellent materials. It has been created as a prototype of building material that's grown from strains of fungi added precise and a compacted form of inert waste. The process involves a combination of parametric design with synthetic biology having curved shapes being a digitally cut and specific shape or design being grown. The combination of mycelium organic substrates leads to an expansion which we controlled by prefabricated aluminum sheets. The main objective is to establish a smart, sustainable, self-maintained self-sufficient construction technology. The result says 100% organic with minimum waste, energy expenditure and also easy lookout to developing the world. Mycoform can be decomposed back to nature.

The resulting study shows that mycelium stands as a promising material for building block insulation as well as compared to traditional ones. Agriculture by-product is best for future construction, some recent results show mycelium has great flexibility and good strength in layers in any shape. Mycelium has both viability and also marketability this natural feature reduces the carbon footprint of the building and improves thermal insulation and acoustics as well.

In a city like Delhi, buildings should be constructed of sustainable materials like mycelium, due to the detrimental condition of the environment. As such, there's no space left to continue construction we need to clean the environment rather than designing a sustainable building. It is high time to be concerned about the cleaning of the environment the research says pollution can be reduced in Delhi by using biomaterials for building construction by doing this, organic waste can be reduced because mycelium is a byproduct of agricultural waste only. As mentioned above Delhi throws uncountable waste on a daily basis so if it is used for construction purpose which helps the environment both ways and could turntable as far as the pollution level of Delhi is concerned. Delhi is a city which is highly polluted and populated as well, the present environment affects the people living there so it is important to figure out the

solution for such a dangerous situation.

The study concludes that if we use a material like a mycelium for construction it will be helping to control air and noise pollution as well. Because mycelium involves useful property it is promising for future construction also. Mycelium blocks can be used as breath brick that can absorb dust from outside the building. Mycelium is also capable of giving thermal compatibility inside the building. It also involves self-maintenance.

References

[1] https://en.wikipedia.org/wiki/Environmental_issues_in_Delhi
[2] https://www.downtoearth.org.in/news/urbanisation/rapid-urbanisation-in-delhi-ncr-creating-heat-stress-abetting-climate-change-58915
[3] https://www.youtube.com/watch?v=-jw8osY5QJM
[4] https://www.youtube.com/watch?v=umSK0Y_7TX4
[5] https://www.youtube.com/watch?v=V17Lp1X0_ao
[6] https://www.mapsofindia.com/my-india/cities/delhi-tops-in-pollution-how-can-it-be-controlled
[7] https://www.citymetric.com/skylines/9-building-materials-made-entirely-waste-products-932
[8] https://www.power-technology.com/news/cheap-sustainable-material-absorbs-pollution/
[9] https://geniebelt.com/blog/10-innovative-construction-materials
[10] https://www.archdaily.com/771767/this-innovative-brick-sucks-pollution-from-the-air-like-a-vacuum-cleaner
[11] https://www.fastcompany.com/3047345/mit-students-create-a-brick-that-could-end-pollution-from-dirty-brick-kilns
[12] https://blog.amacorp.biz/pollution-absorbing-bricks/
[13] https://esub.com/environmental-impacts-of-construction-projects/
[14] https://www.omicsonline.org/open-access/noise-reduction-in-buildings-using-sound-absorbing-materials-2168-9717-1000211.php?aid=93322
[15] https://materialdistrict.com/article/the-cool-brick/
[16] http://discovermagazine.com/2013/julyaug/13-mushrooms-clean-up-oil-spills-nuclear-meltdowns-and-human-health
[17] https://home.howstuffworks.com/home-improvement/construction/green/10-green-advances-residential-building6.htm
[18] https://home.howstuffworks.com/home-improvement/construction/green/10-green-advances-commercial-building10.htm
[19] https://interestingengineering.com/future-construction-mushroom-buildings
[20] Limin Peng, Boqi Song, Junfeng Wang, and Dong Wang, “Mechanic and Acoustic Properties of the Sound-Absorbing Material Made from Natural Fiber and Polyester,” Advances in Materials Science and Engineering, vol. 2015, 2015.
[21] Haneef, M., Ceseracciu, L., Canale, C. et al. Advanced Materials from Fungal Mycelium: Fabrication and Tuning of Physical Properties. Sci Rep 7, 41292 (2017)
[22] Limin Peng, Boqi Song, Junfeng Wang, and Dong Wang, “Mechanic and Acoustic Properties of the Sound-Absorbing Material Made from Natural Fiber and Polyester,” Advances in Materials Science and Engineering, vol. 2015, 2015.