# Discovering the Potential of Organic Material in Architecture

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**Abstract.** Indonesia is abundant with natural resources in the form of organic materials from the earth and floral ecosystem. Based on natural resources, Indonesia's buildings are built using the organic materials from their surrounding area, such as woods, palm trees, bamboos and rattans that can be used as architectural elements. The organic material reflects the architectural development in Indonesia, starting with a single raw material via the joining of different building parts up to the finished building. It also visualizes the identity which will be presented with local wisdom from the knowledge and the ideas. This paper aims to identify main organic materials in Indonesia regarding the physical properties and aesthetic values that are encountered by human senses. Materiality acknowledges as a flux that is passing processes of continual transformation; it is commonly called "thingliness" or "woodiness". Furthermore, it encompasses three components, medium, substance, and surfaces, which are not separated or dominant from nature; it is built as a unified whole. This study proposes an idea to give impacts of the build environments on traditional and contemporary design. By adopting a sustainability approach to organic material selection and specification extends the inspiration in the design stage of the building process.

## 1 Introduction

Indonesia faces several challenges in developing the natural resource. Indonesia's natural resources are spread over a vast scattered country, making their exploitation and marketing difficult[1]. Indonesia has the world's third-largest forest covered (944320km2, 52% of the land area) located mainly in Sumatra, Kalimantan and Papua. These lands are mostly used in an agricultural sector such as rice, palm oil, maize and rubber. Meanwhile, the advantage of having many natural resources are hampered by the limited knowledge and techniques in production become the obstacles in the utilization of natural resources. Processing of raw materials into ready-to-use materials requires several stages and specific tools for the processing.

Indeed, producing natural resources can reduce poverty and provides employment for the Indonesian population in harvesting raw materials[1]. However, this will be disadvantageous when the raw material is exported and processed further by other Countries; as a result, material prices become expensive when it is sold in Indonesia. In addition, extracting and selling raw commodities risk complacency, as it does not foster the development of high value-added industries. This shows a lack of Indonesia's involvement in global value chains in the resources sector.

Nowadays, Architecture and construction industries stand out as one of the sectors that consume natural resources and energy which support human activities. It becomes seriously concern in the environment because of excessive consumption of natural resource[2]. Then, the use of resources should be done efficiently and correctly, which relates to the concept of embodied energy in building material are by the extraction of raw materials, the production and transportation of construction materials, and the building construction could be translated into energy expended during all these processes. Therefore, the processing for Indonesia's natural resources as a building material becomes profitable, the one that makes the most effective ways to save energy and increases value chains of natural resources.

The natural resources itself comes from two primary resources, derived from the earth in the form of minerals, soil, and fossil fuels, and derived from living organism. The latter is originated from plants and animals that leads to the useful products in architecture. Many commonly used materials are derived from the unlikely combination of ingredients from an astonishing variety of different sources[3]. For example, Wood as the local material of Indonesia is represented by the identity of Indonesia's design[5]. Wood becomes a part of Indonesia's culture because of its development from vernacular design to contemporary architecture. Also, there are also common materials such as bamboo and rattan that are widely grown in Indonesia and developed in various sectors of industry. The development of these materials should be considered from the production of

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raw materials to be processed into ready-made materials in Indonesia.

Meanwhile, the innovation of the utilization of the materials in the field of architecture often only comes from the explorations of scientists or engineers who rarely interact with the material. Materials are implemented as a functional building material but less developed in terms of aesthetics and creativity of design. This causes, the architect as the material user, to not be satisfied with the building materials because of the existing material is not packaged as desired. In this case, the material innovation process needs to be done not only by engineers but also involving architects, by providing the idea of processing related materials. The active involvement of architects at the material level becomes critical when we as architects begin to investigate new materials[4].

## 2. A Greater Understanding for Material's potential by Materiality

A deep exploration the knowledge of natural resources is a first step in understanding the utilization of materials in architecture. It is established that raw material passes through various stages in its processing to become a material that is entirely ready to use in buildings. Moreover, Among human activities, the construction industry stands out as one of the sectors that consume more raw materials and energy, this way, no society can achieve a sustainable development unless the construction sector, which gives it support, goes through deep transformations[2]. Thus, in addition to the effort to increase the optimization of construction in materials in the building, an architect needs to know the potential of the material by understanding its materiality.

Understanding the material's potential in its use of architecture can be through materiality. Materiality refers to how a material represents our mind to an object so that the human sense can accept it. The substance of material works in translating our mind to the form, such as texture and colour in the world, so, it has a particular surface that can be felt. Therefore, materiality in architecture tells how an object is formed from the various processing of material substance with respects to qualities and spirit of the material[7].

In the world of materiality is not only seen from the outermost layer of material. When intending to present certain properties, a craftsman or an architect needs experiencing its material thoroughly in the process to compose the best quality. It is necessary to consider the main characteristic of the material. The role and importance of materiality thus include much more than structural properties but equally informs a person's experience of a building through its aesthetic, visual, and haptic qualities as well as its associated social, cultural, and historical meaning[6].

Experimentation allows an understanding of a material's ability to bend, stretch, hold its shape, and withstand external forces[4]. This can be useful for generating ready to use the material product that is surfaced not only general properties but also a detailed look at the inherent qualities of material which will provide a range of opportunities and unlimited creativity in working with the materials.

### 2.1 Substance

The Substance is the physical foundation of materials that furnish its life. They include all kinds of more or less solid stuff like rock, gravel, sand, soil, mud, wood, concrete and so on[3]. Substance builds up the material so that it can be possibly felt by our senses through them. So it gives the characteristic of the material and distinguishes one material with others.

There are two ways to examine the idea of understanding materials, by the materiality of the object through the properties and the qualities of materials. Every material has inherent properties that can be either expressed or suppressed in use[3]. The idea is discovering the "true to the material" by respecting its properties rather than riding roughshod over them. This has been pioneered by sculptors and craftspeople who put forward the knowledge and experience of workmanship, the ones that treat such materials elegantly. Thus, Material has some inherent natural characteristic that determines the possible structures it allows for and thus the form that is possible to realize[6].

The material properties are a combination of the appearance and the physical aspects of the materials, the appearance of a material refers to the objective parameters that affect almost all of the physical form and performance of the materials[8]. So it is a tangible aspect that becomes the guidance for architects in the determination of materials.

However, some materials exhibit properties while being worked that they lose once the job is done. For example, the ceramic craftsman uses clay as the main ingredient in his creation. The clay is soft and easily formed by adding water, and it becomes hard after it is burned. In Addition, this harden ceramic material cannot return to its properties again as clay. The same thing happened to the smith that utilizes the ability of metal that was initially liquid and flexible to be formed in the beginning. When the metal has been shaped according to the wishes of craftsmen and metal becomes hardened, its property is also lost, hence the solidity of metal. Thus the process of material utilization shows the expression of the material in the form of qualities.

The qualities of material are merely revealed in personal preference that is concerning the material to make things. Therefore, in order to measure the qualities in such tests, the result may be subjected. The knowledge of craftsmen who pursue the certain materials such as the stonemason, smith, potter, and carpenter, is built from a lifetime's experience of working with the material. This is a knowledge born of sensory perception and practical engagement, not of the mind of the material world[3].

Both properties and qualities play an essential role in the formation of materials. Both work together to show the materiality that endows every worldly object with its inherent 'thingliness', which is formed from various

processes to provide the characteristic to the materials. The material, to be subordinate to design and take a role in transforming abstract ideas into physical artefacts[6] .

### 2.2 Surface

The surface is a particularly and relatively persistent layout, a degree of resistance to deformation and disintegration, distinctive shape and a characteristically non-homogenous texture[3]. It is where radiant energy is reflected or absorbed, where vibrations are passed to the medium, where vaporization or diffusion into medium occurs, and what our bodies come up against in touch. Therefore, surfaces are the outermost part of the materials that are perceived by our senses.

Each of craftsmen would compose a different palette of materials based on the intuition, relates to how they anticipate on the appearance[7]. Surface indicates the outer layer of materials that is considered when determining the appearance of an object or artefact. It starts with a certain quality such as colour and texture to achieve the desired design. It becomes the face of form that expresses the eagerness of its creator.

Because its position is turned outward, the surface is related to the treatment received by the material. It is executed to absorb in the form of technique and material cultivation. These aspects can be the origin of the manufacturer which is defined as the aspects that relate to the production process (poured, pre-fabricated, hand-formed) assembly (dry connection, column and beams, seamless) and finishing techniques (polished, varnished, coloured). Therefore, the perceived value of a material is not always inherent within itself, but in the care, difficulty, and craft of its treatment within a culture[4]. This begins by giving a mechanical treatment such as cut, rubbed or sharpened to show particular qualities of the material, until it is given another material to make a significant change. For example, the limestone powder, known as cement, will become liquid dough when it is given water, but it will harden again when it is dried. Here the surface of the artefact or building is not just of the particular material from which it is made, but of materiality itself as it confronts the creative human imagination[3].

### 2.3 Medium

The medium is basically an environment around the world that offers us a little resistance. It allows us to feel everything in the surrounding. It also transmits radiant energy and mechanical vibration, so that we can see and hear; and it allows us to smell, since the molecules that excite our olfactory receptor are diffused in it[3]. The Medium can be formed as an element or additional material that is around the primary material, ranging from air, water, and fire that can change the substance or surface of the material. For example, a coral reel with a cavity shaped is caused by the blast of waves and the trunk of wood has dried in the forest due to sunlight. This is the role of the medium in the formation of processes that are continuously accepted by the material.

Therefore, the medium helps the artisan in making his work from raw material. for example, the clay, as the raw material, can be hardened to become a brick by burning process, here the medium, the fire, plays a role to help the process of soil hardening the clay. Thus, the interrelation of material and medium can be a process of raw material processing into finished material in the form of a mixture to strengthen the quality of its material.

## 3 Methodologies

This paper uses the experimental method which is the preliminary step to discover the potential of organic material to become the ready-made material on architecture. A personal understanding of materials prevents an architect from applying them to his or her concepts in a way that is prosaic or an acquiesce to the latest material trend[4]. Therefore, the hands-on experimentation and research into their physical and qualities make-up lead to an understanding of the potential expression and characteristic of a material.

## 4 Study Case and result

There are three natural resources that are investigated to understand the potential of the organic materials, Cornhusk, Coconut fibre, and banana leaf. These materials are produced in Indonesia but uncommonly used as architectural materials. However, these can be developed by knowing their potential's further.

### 4.1 Cornhusk

*Kelobot* or cornhusks are the leaf sheets that warp the corn cobs. Corn plants have no branched stems, cylindrical, and consist of a number of segments. In the segments there are shoots that can be developed into a cob (*tongkol*). This cob, which later can be harvested into a new corn, is made up of stump. It is a hard rootstock containing sap, commonly known as *kelebot* leaf, the layering protective husk with the corn in it. The top cob grows first and becomes larger than the bottom. Each cob consist of 10-16 rows of husk whose numbers are always even. The dimension of the cornhusk is approximately 20cm length with 12cm width. Usually, the dried corn husk can be used as craftsmanship and an organic paper to create a cigarette.

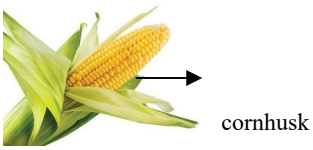


**Fig. 1.** The cornhusk

#### *4.1.1 Substance of Cornhusk*

The cornhusk in the form of sheets that layered has properties in the thickness and transparency. The difference in thickness of the sheets is based on its location to the corn; if it is getting deeper, it becomes thinner and gentler, while if it is getting out, it becomes harder and rougher. This results in variations in transparency due to its thickness. It also has a sap that makes these leaves stick to the corn and become hardened. There is a difference between old and young cornhusk. The latter is not so curved, but the smaller the leaves, the more it curves. Meanwhile, the old cornhusk is more curved than the younger once, and the smaller is also more twisted.

The cornhusk also has fibre that causes the potential properties of transparency, where this fibre has a thin binding area so the fibre looks like a bones. The fibre extends upward in the direction of corn length and coarse texture; also depends on the thickness. So, cutting the leave splits is easier in the same direction of the fibre, while other direction makes the leaves broken.

Transparency that is caused by a thin layer between fibre creates the possibility of the cornhusk to shrink. However, it can be stretched and shows more transparency. This contraction occurs as aging and drying of the cornhusk, but not eliminating its transparency; still visible when stretched. This shows that the flexibility of cornhusk. The quality of transparency and the moist of leaves prove that the cornhusk has active pores, causing the possibility of absorption of liquid.

### *4.1.2 Surface of Cornhusk*

The cornhusk has a very thin leaf and has two sides of surfaces, plane and line. Because of its thinness, the skin surface has varying transparencies and textures. In the plane, there are lines become segments or bone of the leaf. The thicker the surface, the texture of the segment is increasingly felt. Among the segments, there are fillers that unite the sections to form the plane. It is soft and thinner than the segment, so when it is touched, it will be immediately felt the texture of the sections.

In order to understand the surface of cornhusk, there are several treatments that explore the strength and weakness of cornhusk. When the cornhusk is torn perpendicular to its fibre, the surface becomes jagged ruptures while tearing toward the fibre a part, forming a richer texture though difficult to control the quality of fibre rips. When it is twisted, it becomes so small and rigid that the texture can be felt without damaging or breaking the cornhusk.

When it is crushed by hand and held for 10 seconds, the crust creates a new texture on the cornhusk but only survives and does not return to the previous surface, especially on dried leave. In the young cornhusk, the crust only creates a curve like a slightly tangled shirt and the skin tends to retain its shape to extend its original shape. However, if the fattening is held longer, the crust will stand still on all type of surface, young, old and dried cornhusk. In the young leave, the fracture will be more visible when it is done folds with intention. Thus, creating a folding effect and a fracture texture on the fibre is seen although the fracture is perpendicular to the fibre direction.

The cornhusk is so thin that slicing the leaf becomes difficult. The slicing treatment sometimes even makes the leaf hollow and can only be done on the thicker leaf, only slashing in the segment where the thicker part to another. The incision forms a sharp texture and is only visible when the leaf is curved.

When slicing the leave, it also looks the sap out of the surface. In the cornhusk, the deeper contains the more sap, where the sap-containing part is attached to the corn stump that brings together all the leaves. Fracture in the sap will create a brown colour and completely broken if it is left to dry so that the texture becomes rough.

### *4.1.3 Medium of Cornhusk*

There are several medium that is added to the cornhusk in order to see the potential value of its material. When the cornhusk is burned, the leaves, in both young and old cornhusk, always start from its outer part. The younger cornhusk is more difficult to burn because it still contains water. When it is burned, the leave will curl onto the surface of the thick one (facing inward). It takes a quite long time for the leave to completely burn. After it is burned, the property of the leaf becomes hardened and not moist anymore.

Furthermore, the exploration continues by using the water as the medium. When the cornhusk is added the water, it does not change significantly. It is only increasing moisture quality so that the texture becomes soft. Meanwhile, on the old cornhusk, the quality of leaves becomes flexible to bend. Then, when it is added organic coloured water from saffron, the water absorbs and the colour of leaves change from light green to yellow based on the coloured water. The boiling process in water can improve the properties and qualities of the cornhusk. It gets mushy and the colour becomes faded.

## 4.2 Coconut Fibre

The coconut fibre is one part of the coconut, precisely the middle skin. The fibre is often used as handicraft products such as broom fibres, mats. It is also known in a different product such as coco fibre, coir fibre, coir yarn, and coir yarn. The colour of coconut fibre will change according to the age and its types. When the coconut is still young, it has yellow fibre, when it is older it changes to a brown black colour.

**Fig. 2.** The coconut fibre.

#### *4.2.1 Substance of coconut fibre*

Coconut fibre consists of fine threads, among which some fibres unite between the threads. When the coconut fibre is removed from its coconut fruit, it is still fused together by the fine fibres between its threads. When it is separated, based on the texture, there are thick and thin threads. The thick thread has a coarser texture and sharper edges. It also tends to be stronger and not easily broken compared with the thin one.

The coconut fibre has a variety of textures and patterns. The top and bottom parts are denser and smoother, while in the middle, it becomes thicker and coarser. In addition, the texture and the thickness between young and old fibre are different. It is a lighter colour and thick texture when it is still young, while it is darker colour and thin texture when it becomes old. The coconut fibre has a strength that is not easily broken even though it has thin properties like a thread. Moreover, when it put together, there is a tensile strength so that it is not easily dislodged. Its more rigid but easily formed so its properties make potentially to process such as twisted, woven and braids.

#### *4.2.2 Surface of coconut fibre*

In general, coconut fibre has coarse surface and it is not easy to arrange. The texture is defined into two categories based on the thickness. The thick coconut fibre has coarse and sharp texture and the thin one has soft texture. Therefore, the first treatment to see the potential of coconut fibre is trying to arrange its fibre. It starts with combing the material to separate the fibre. It is established that the thick fibre is hard to comb because of its properties, coarse and stiff, while thin fibre is easy to comb.

In the experiment putting together the coconut fibre by braiding, the coarse fibre creates a neat surface event though it is difficult to comb. On the other hand, a fine fibre produces a smooth surface but resulting in a messy braiding, as many individual fibres stick out. The same result with twisted treatment. The thick fibre, although the texture is rough, seems to individually stay together unlike a fine fibre which sticks out easily. Besides, the braid treatment product of coconut fibre produces a stronger and solid rope compared with twisting treatment.

#### *4.2.3 Medium of coconut fibre*

The nature of coconut fibre that tends to blend with its treads triggers the addition of medium to bring the coconut fibre together to make it stronger. The first medium added is water. When the water is added in a coconut fibre compound, it is more attached because it is wet. Then when the fibre is dry, the fibre becomes hard but still easy to be separated by hand. The resulting texture remains rough but can be shaped to flat by pressing the fibre in accordance with the desire when it is still wet.

Furthermore, one way of treatment to unify the coconut fibre is to add adhesive elements such as glue. Each type of glue gives a different effect. For example, when using paper glue that has a small adhesive element level, the fibre becomes fused and coated but easy to curve when it is dried. Then, when the fibre is given glue with high adhesive level, it creates two different results. The first one creates a hard texture but becomes brittle and easily broken and porous. And the second one creates soft and flexible texture of coconut fibre. In addition, the fibre is also not easily broken and porous to produce a flat surface according to emphasis when it is still wet. These conditions depend on the type of glue that is added to the coconut fibre. If there are more chemical ingredients in the glue will ruin the texture of the fibre.

### 4.3 Banana Leaf

Banana plant has a soft form of stems, which are pseudo-surface, looks formerly leaf midrib. This plant has no branches, with wet trunked, so that the stem of this plant is shrouded by its leaf midrib. This plant is widely found in various regions in Indonesia. Banana leaf itself is commonly used as a wrapper of traditional food and craftsmanship materials for small industries.

**Fig. 3.** The banana leaves.

#### *4.3.1 Substance of Banana leaf*

Banana plant has a slim-shaped leaf and very thin form. It has a pinnate-shape bone and a slippery wax-lined in both top and bottom surface. This banana leaf is elongated but also slightly widened. The colour is light green when it is young and becomes darker when it is old.

The banana leaf itself consists of several parts. The main one is the wide leaf following the height of the tree. Banana leaf has a lot of sap and fibre that make it last longer when it is left at temperature room. Then, the banana leaf itself is united by a leaf bone that combines two sides of the leaf. This leaf bone is tougher that the leaf but also has fibre in it. Furthermore, the unite of the bone between leaves, there is shoot in the middle of the tree. This shoot as an inter-leaf adhesive so it has the most fibre content but it is hard because it serves as a plant structure.

The quality of the leaf itself is unique than other plants. It has a pore that is solid and slippery surface. The fibre line is perpendicular to the leaf bone so it is easy to torn from this direction. Whereas if it wants to remove from the bone, it is easier to follow the fibre leaf parallel to the bone so that leaf off all without damaged.

### *4.3.2 Surface of Banana leaf*

The texture of the surface becomes the characteristic of this banana leaf. It is smooth and slick which is obtained from the sab like a wax of the leaf. This texture will give luminous quality if it reflects light. However, the older the leaves get, the sap will be more lost that makes it is not as smooth and slick as the younger one. Therefore, the leaf surface treatment will affect its quality. If the leaf is rubbed with a rough material, it will break the wax layer so that the quality becomes damaged. The leaf will also quickly change colour to a brown and dry surface.

Furthermore, this leaf has a bone of leaf and fibre that can help if torn without causing damage. After being torn by following the fibre, the aging process of the leaf is not affected. On the other hand, if the leaf is torn in the opposite direction, the process will be faster. It will become brown and dry, beside the tearing process tends to fall apart.

The banana leaf is often used as a food wrapper where there is a leaf fold treatment until it is stabbed with a sharp object in order to bind the leaf. When it is folded or kneaded, the leaf is strong enough and not torn so it can return to its original shape. There are marks on the leaf, but if it is not too hard, it does not cause a damage of the surface. Meanwhile, when it is stabbed with a sharp object, the leaf shows the marks among the changes in green leaf colour to black colour if it is left in a long time.

### *4.3.3 Medium of Banana leaf*

Banana leaf has a long enough ability to experience the quality change. For that reason, this leaf requires treatment to maintain the properties and qualities than can be utilized as ready-made materials. One effective way is to give the water as medium to the leaf. When the leaf is soaked in water, the leaf colour does not change, and when it is removed, the aging process is also quite long. However, when the leaf is boiled in water, the leaf colour turns yellowish green and lead becomes limp. This proves that the water medium affects the aging process in the leaf.

On the other hand, if the leaf is given a heat medium, the resulting qualities will be different. If the leaf is given a direct fire, the leaf surface will be blackened directly and can damage the wax above it. Whereas if the heat is given indirectly, as a hot conductor, the leaf shape will last long according to it desired shape, but its colour will fade. Thus, the banana leaf can be preserved if they are heated indirectly.

## 5 Discussion

The development of organic material has ever been before initiated in Indonesia. Mycotech is the result of the development of a building material made by fungus[10]. This material originally derived from soybean which is then processed into brick through the process of fragmentation. Mycotecth uses environmentally friendly materials to create ready-made materials. After this development, it is triggered that other organic materials can be developed as building materials.

**Fig. 4.** The Mycotech. The organic material from soybean

The organic material is one of sustainable approaches which focuses its attention on affecting the environments. It has no emission in its raw materials and some are based on reused waste material. Clearly, this is not only its strongest potential in replacing the chemicals materials but it can also be produced in ways that are environmentally friendly and architecturally functional in aesthetic forms. However, before using the organic materials in any construction purpose, it is necessary to be critical with its potential.

Each organic material is produced from living organism with means that it is producing much less energy and waste. It is established that manufacturing processes from the raw one to ready-made materials is an essential stage in calculating the environmental impact, including the addition of other materials. Furthermore, during its process, it uses a medium or energy to reach certain qualities. These processes require modest amounts of energy and produce extremely minimum waste.

There are some possibilities for raw living materials that can be conducted to be a ready-made material. For example, coconut fibre, due to its united and hard shape, has the potential to be a structural material and architectural barrier element, yet lightweight because of its light quality when it is put together. Furthermore, the coconut husk is transparent and flexible to be formed, which makes this material potential to be explored as an architectural upholstery element or bring up its transparency properties incorporated with the lamp medium. Likewise with a banana leaf that has surface qualities that can be durable. These possibilities can shift the paradigm of using the chemical materials to organic materials which are more sustainable and environmentally friendly. Clearly, they have similar potentials yet competitive qualities in the same functions.

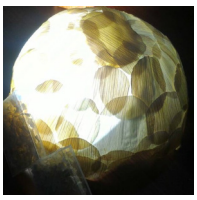

**Fig. 5.** The exploration of cornhusk in transparency

## 6 Conclusion

The experiment of materials which are consisting of substance, surface, and medium, can direct architects and

engineer to discover the potential of each material to be used as the ready-made material. It is established that each organic material has its own properties and qualities that can be triggered in the formation of architectural space. In addition, organic material can also replace the conventional building materials to obtain a more sustainable and affordable materials in Indonesia.

On the other hand, the initial treatment on the organic material is essential to maintain the quality because the organic content such as fibre and sab that can change if it is not properly maintained in the long term, besides producing the desired surface on the design. Therefore, it is necessary for further processing of organic material so that the material is durable and not easily damaged when used as an architectural material. The process can also be the addition of medium or energy that can slow or even stop the aging process on the material so that the organic material is ready to use. Therefore, the organic materials will give impacts in the term of creating the environmentally friendly by adopting a sustainability approach.

## References

1. R. Dutu. *Making the Most of Natural Resource in Indonesia.* OECD Economics Department Working Papers, No. 1236, OECD Publishing, Paris. (2015)
2. B. Marques, C. R. Loureiro. *Sustainable Architecture: Practice and Methods to Achieve Sustainability in Construction.* IACSIT Journal of Eng. and Tech., **5** No. 2 (2013)
3. T. Ingold. *Material Against Materiality.* Archeological Journal Dialogs. Cambridge University Press. (2007)
4. T. Schroepfer. *Material Design: Informing Architecture by Materiality.* Birkhäuser GmbH Basel (2011)
5. D. Susanto, D.P. Angelia, T.A. Ningsih. *Local Material as A Character of Contemporary Design in Indonesia.* ICSADU (2017)
6. M. Kretzer. *The Ever-Changin Nature of Materiality and the Meaning of Material in Architecture and Construction.* Springer International Publishing Switzerland (2017)
7. D. Susanto. T. A. Ningsih. *Exploring Materiality in Learning Interior Architecture* (Proceeding INARCH 2018)
8. L. Wastieals. I. Wouter. *Material Consideration in Architectural Design.* Proceedings of the Design Research Society Conference. Sheffield, UK. (2008)
9. L. S Karina. *Materiality and Architecture*. London: Routledge. (2016)
10. F. Falah. Mycotech: *Bahan Bangunan dari Jamur yang Kuat dan Ramah Lingkungan Inspirasi dari Tempe*. (2016)