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Barriers of Using Bamboo in The Malaysian Construction Industry

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Abstract: *Bamboo plant is unique and the use of these materials is widespread not only as building materials and construction scaffolding but also as element in the space of a building for the purpose of either aesthetic or the culture value of it. Green construction concept which emphasizes in using sustainable materials in the construction of buildings is an effective method and the uses are environmentally friendly. The concept of bamboo as a green, environmentally friendly material attracts architects and engineers to experiment with the plant. This research aim is to analyse the barriers faced when using bamboo materials in Malaysia from developers' perspectives. In this paper, the methods used are structured questionnaire survey. The respondents are 20 government agencies in the developer sector and 369 developers in Selangor, Malaysia. To achieve that, 200 copies of the questionnaire were distributed to the selected organization. However, only 87 out of 200 respondents gave feedback. The data obtained were analyzed using descriptive analysis techniques and Relative Importance Index (RII). The findings revealed 10 barriers of using bamboo as building material in the Malaysia Construction Industry with the highest ranking being Competition from other building material, refer to Table 4. The paper's results also show a few suggestions in promoting bamboo as a building material in Malaysia's construction industry.*

Keywords: Bamboo, Bamboo Construction, Green Construction

1. Introduction

The concept of green construction has been practiced now even in design, functional, or construction work. On the other hand, green construction, also known as sustainable construction, refers to the construction of buildings using environmentally friendly and effective methods. Various construction types use green materials to produce environmentally friendly environments. The importance of emphasising the green concept in the construction industry needs to be practiced. According to Nguyen (2018), the danger from the devastation of the environment is becoming more and more serious, greatly affecting the life of every species on Earth. Referring to sustainable construction, the research found that bamboo has the potential as a building material used for construction.

Learning indigenous knowledge in every region about the utilisation of bamboo will be useful for understanding cultural values (Wawan, 2018). Unlike other countries, Malaysia also has its

own understanding of the cultural value of bamboo. It depends upon the local wisdom and culture in every region. Wawan, (2018) mentions that, even for the same bamboo species, the parts that are used and the preparation and application methods are not the same in every region. However, bamboo has been forgotten and replaced with other materials like precast concrete in this new era. Therefore, this paper attempts to identify challenges in utilising Bamboo as building material that potentially using bamboo in the Malaysian construction industry.

2. Problems Statement

Many governments in the world have already introduced various policy measures to promote the application of bamboo as a building material (Shen, 2019). Malaysia also takes an approach by using green materials in the construction industry. Although bamboo material is less practiced in the industry, its usage can have impacts on the environment, hence resulting in several policies being introduced under sustainable construction.

Most developers have no experience in using bamboo as one of the concepts in the building. Lack of experienced professionals or technical staff will affect stakeholders' and clients' confidence in green technology implementation (Ha, 2020). The smaller number of these categories of people is discouraging the use of this concept in building construction, hence other plants and methods are preferred as alternatives.

Although bamboo is a natural and ecologically friendly material, serious environmental issues could emerge during the manufacturing process of bamboo products (Wei, & Shuqiang, 2019). Various issues may arise while promoting this product because developers cannot anticipate what will happen later when using this product.

Previous studies have investigated various barriers affecting the application of bamboo materials from different perspectives, but they mainly concentrated on single perspectives such as the physical or chemical properties of bamboo (Shen, 2019). Various perspectives will be faced in promoting this material in the design, especially on its value, maintenance, demand and supply or effect used, and others. Also, it is especially important to create and develop educational programs for rural communities, so that they could use bamboo resources scientifically and sustainably (Wei, & Shuqiang, 2019). Exposure to bamboo-related information is lacking among communities and developers in Malaysia. The lack of this knowledge limits us from understanding the real symbolism and uses of these materials, especially in building concepts.

There are no studies that emphasize the roles of bamboo in sustainable design and the incentives for designers, contractors, and investors to develop bamboo applications for eco-design, and environmental sustainability (Nguyen 2018). Because of this, many developers are concerned about using these materials in their building concept. However, the cost of these materials is expensive due to the rare supply in the market resulting from the lack of bamboo cultivation in Malaysia.

Table 1 shows barriers and code for green building implementation in the Malaysian construction industry.

Table 1: Barriers and code for green building implementation

Code	Barriers
G	**Barriers related to government and policy**
G1	Lack of green building regulations and codes
G2	Lack of subsidies on green technology
G3	Lack of training related to green building technologies
K	**Barriers related to knowledge and awareness**
K1	Lack of awareness of existing incentives
K2	Lack of awareness on the benefits of green building technologies
K3	Lack of environmental awareness among developer and consultant
K4	Lack of information and databases on the green technologies
K5	Low market demand by clients
P	**Barriers related to local professionals**
P1	Lack of research in local context on green building technologies
P2	Limited time for green practices implementation
P3	Resistance to change by the supply chain agents
E	**Barriers related to economic and finance**
E1	High cost
E2	Limited finance support for the up-front cost
E3	Clients' preference on the instant payback benefits
E4	Risk and uncertainties for new green technologies

Sources from: Wong, 2021

In this study, the barriers hindering the development of the widespread use of bamboo in Malaysia have been analysed in 3 categories namely technology, application, and government policy. The categories are shown as in Figure 1.

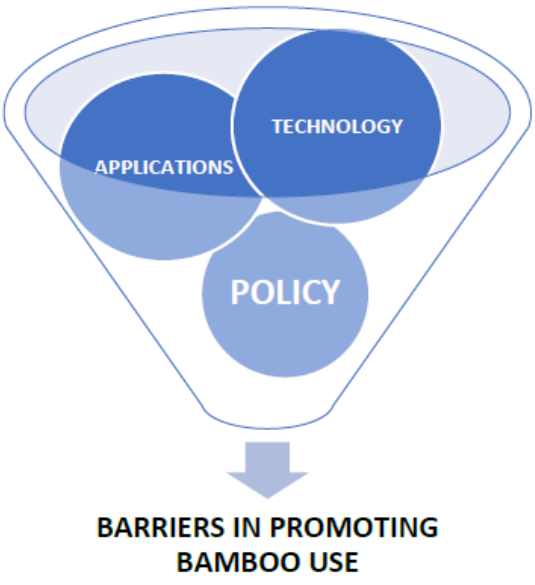

Figure 1: Bamboo Development Barriers
Source: Mahat, 2019

i. Technology Barrier

In Malaysia, the usage of bamboo materials is still limited and there is a lack of expertise. Lack of management skills in the use of bamboo is due to less research and in-depth study of bamboo material's properties. Even if there are many examples of green building technology deployment, there are still problems with the industry's slow adoption of it. Mahat (2019) mentioned that using modern technologies such as the application of green building materials is considered costly due to the need for technical capacity, and lack of competition, and is mostly manufactured abroad.

According to Liyin, (2019), bamboo materials are often prone to moth, corrosion, and mildew in untreated conditions, which leads to damage of the mechanical properties of the materials. Bamboo is a green material that is highly susceptible to fire and the environment rather than concrete.

ii. Application Barrier

Alohan and Oyetunji (2021) mentioned that supplying green features and developments is considerably more expensive than conventional features and advancements. The lack of applications of green materials in building development causes the price to surge higher than the applications of the use of other conventional materials. According to Mwero and Aduda (2019), initial cost is a significant factor. After all, the cost incurred when purchasing more efficient technologies involved higher initial costs, which many consumers did not want to spend on, and which low-income consumers may not be able to afford because they have limited capital. Consequently, most parties are unwilling to apply green materials in their building development.

Besides bamboo being expensive material and a rare item in industry, people have negative perceptions that these material products are cheap and low in quality for building construction purpose. This is due to lack of promotion regarding the quality of bamboo products as an effort to increase consumers' trust to use and buy bamboo materials.

iii. Government Policy Barrier

In Malaysian, there is a lack of code of practice and incentive policy pertaining to bamboo applications in the construction industry. The main cause for concern is that most developers and designers prefer using conventional construction techniques rather than using green technologies, despite the recent government support for the construction of more green buildings and widespread public awareness of environmental issues on a global scale (Jaffar et al., 2022). The introduction of a new mechanism for technology and the certification for bamboo materials should be considered to be introduced to further increase the use of bamboo materials in the Malaysian industry.

2. Using Bamboo in the Malaysian Construction Industry

Bamboo is very popular in countries where they have their historical traditional uses. Bamboo was very famous in humid and hot areas, especially in Asia. Martha, (2012) has mentioned that native people in Central and South America, Asia, and Africa used bamboo for housing. Same as Malaysian people that use bamboo as their material for building houses. Their architecture was called vernacular, a term used to categorize methods of construction that used locally available resources and traditions to address local needs and circumstances without the intervention of an architect or made by empirical builders (Martha, 2012).

According to Martha, (2012), due to the fact that the primitives were the ones who used bamboo for housing and the way people got the material (rural roads and construction debris) bamboo has been associated with and recognized as “the wood for the poor" or “the poor man’s timber,” there is no difference in countries around the world: poor people usually build a modest home, but after the wealth of the family improves over time, and with more knowledge of the material, their houses improve. Settlements that use bamboo as a house-building material are usually in rural areas because they are close to forest resources. Since these materials are easy to find and naturally do not require cost for construction, people that use bamboo or wood are categorized as poor people.

Bamboo plant structures are rhizome, roots, shoot, sheath, culm, node, branch, and leaf. The bamboo part consists of the above-ground and underground axis. Rhizome and roots are underground axis and culm, branches and leaf are above ground.

Woody bamboo can be broadly divided into two groups: clumping and running. Clumping species sprout their new shoots close to the base of the existing culm, while running species may send their shoots as far out as 30m from an existing culm (Kaminski, S. et al 2016). These two groups have their growth characteristics. Woody culm can grow to 30 m tall. Most bamboo’s culms are hollow but some species of bamboo have solid culms. Culm consists of segments called internodes and between culms, internodes called nodes to create a line on the culm. The line of nodes grows leaves and branches. Kaminski, S. et al (2016) have mentioned that once fully grown, culms typically take three to five years to mature to full strength, during which they experience solidification and lignification. Bamboo needs time to mature before use or marketing because the best bamboo quality when conditions are bamboo yang mature. However, after several years, bamboo’s strength will decrease as it ages.

Bamboo is high tensile, lightweight, tough, flexible, and cheaper than other building materials like steel. Bamboo can be used in various building works. In industries, bamboo is commonly used as a material, especially a culm’s bamboo. Bamboo generally has very good parallel-to-fiber structural properties, with allowable stresses in bending, tension, and compression all around 15N/mm2 for one of the main species of bamboo used structurally called Guadua Angustifolia Kunth and a wider bamboo range of between 10- 20 for most species of bamboo (Kaminski, S. et al 2016). Although the structure of bamboo is strong, bamboo is also a natural resource that is vulnerable to insect attack and decay. Kaminski, S. et al (2016) stated that bamboo still has less natural durability than most woods, owing to a shortage of some naturally occurring chemicals present in wood that enhance durability. Almost all the product structures are always chemically treated.

The shape of bamboo is not even across the length of a culm. It is usually a broader diameter at the base and tapers gently as it moves along to the top of the culm. Most bamboo species' culm can end up bent or split either during growth or during treatment and drying if special care is not taken. As such, standardized uniform bamboo culms are not readily available as there is difficulty in getting reliable suppliers, due to the nature of the material. This can cause challenges in construction. Specifications can be difficult to be met directly, especially where replication and duplication of various members are necessary, due to discrepancies from culm to culm.

Table 2: Comparing the efficiency of materials for strength and stiffness

Material	Strength (Nmm^{-2})	Weight by volume	Ratio*	Stiffness (Nmm^{-2})	Weight by volume	Ratio*
Concrete	8	2400	0.003	25000	24000	10
Steel	160	7800	0.02	210000	7800	27
Wood	7.5	600	0.013	11000	600	18
Bamboo	10	600	0.017	20000	600	33

*Ratio = stregth or stiffness / weight by volume, Janssen (1981)

Source: Anokye, 2016

Refer to Table 2, Anokye (2016) found that bamboo's strength when in use is higher than concrete and wood but lower than steel. Bamboo's strength-to weight by volume ratio, was also found to be second only to steel in their studies.

Table 3: Mechanical Strength Properties

KN /square centimeters	MATERIALS Spruce wood	Bamboo	steel
Elastic modulus	1100	2000	2100
Compressive Strength	4.3	6.2-9.3	14
Tension Strength	Spruce wood 8.9	bamboo 14.8	Steel 16
Bending Strength	6.8	7.6-27.6	14
Shearing Strength	0.7	2.0	9.2

Source: Anokye, 2016

Gutu, (2013) found similar results when comparing spruce wood and steel to bamboo as shown in Table 3. With the elastic modulus of steel being at 2100 kilo-newtons per square centimetres, 2000 kilo-newtons per square centimetres for bamboo and 1100 for spruce wood in his findings. That research also found the tension strength with bamboo being at 14.8 kilo-newtons per square centimetres, spruce wood being lower at 8.9 kilo-newtons per square centimetre, and steel being higher than bamboo at 16 kilo-newtons per square centimetre. All these results show that bamboo has favorable mechanical properties as a structural material for structures made from wood and concrete, at least if designed properly.

According to Wei, (2019), as one of the most important non-wood forest resources, bamboo represents an ideal wood substitute, and could effectively minimize timber demand pressure on forest wood production. Not only it can reduce the use of wood that leads to forest exploration, but promoting bamboo can also help in developing construction and agricultural industries. By promoting the diversity of innovation, bamboo uses in manufacturing, production, and so on can increase the use of this material and reduce wood.

Other than that, bamboos also have benefits for the surrounding ecosystem. This plant produces the same oxygen as other trees, and its growth does not damage the soil. Abolghassen, (2020) stated that bamboo plants are one of the most important plants in improving climate change due to the high bamboo biomass stocks and carbon storage. This means that bamboo plants store a high capacity of carbon dioxide to restore it to oxygen. It plays an important role in improving ecosystems.

Also, its roots could leach heavy metals from the soil and efficiently draw water closer to the surface due to its strong water absorption capability (Wei, 2019). It has an important role in coordinating soil nutrients, soil pH, and soil structure. The growth of bamboo in an area can help to strengthen the soil with its roots. Typically, tree growth is usually from the stem while bamboo growth is from rhizomes. Rhizomes prepare all the things needed for the growth of culms: they grow and produce two things: rhizome necks and buds (Xiaobing, 2007).

The Malaysian Government has also taken the initiative to increase the bamboo industry in Malaysia by providing opportunities to individuals or groups who wish to develop the bamboo industry in agriculture and industry from bamboo products. Based on the National Forestry Policy 1987 (Amendment 1992), the country has outlined the need for non-timber forest resources to be implemented to ensure the importance of the resource-based industry. From this policy, bamboo and rattan are included in the category of non-timber forest resources. With a program like this, residents who want to cultivate their vacant land with bamboo businesses are allowed to join.

One of the programs implemented is Malaysia's World Bamboo Day (WBD), which is celebrated on September 18 every year. It is organized by the world bamboo organization. The WBD2022 celebration program on 20 September 2022 involves 3 main programs which are the WBD Malaysia 2022 Opening Ceremony, the Bamboo Industry Seminar, and the Bamboo Industry Exhibition held at the FRIM Kepong Auditorium. The objective of the WBD celebration is to raise awareness of the use of bamboo at the global level, protect natural resources and the environment, ensure the sustainable use of bamboo, and promote bamboo cultivation as a new industry. With a program like this, the policy for non-timber forest resources can be expanded.

4. Research Methodology

The methodology is set to gather the data. There are a few methods that are required in research for the purpose of objective achievement. In this research, the following methods have been adopted to achieve the objectives which are literature reviews and questionnaire survey. This paper focuses that related with developers' firms that are involved in building construction projects. From that, the respondents are from the company that handling the project either using bamboo materials or not in the project.

The methods used to distribute the questionnaire to the respondents were by hand distribution method and by email and other platforms that can reach respondents. Selected developers from the public sector are from the Ministry of Works. This Ministry comprises the following agencies as Public Works Department (JKR), Construction Industry Development Board (CIDB), Malaysian Highway Board (LLM), Board of Engineers of Malaysia (BEM), Board of Architects, Malaysia (LAM), Board of Surveyors of Malaysia (LJT). About 20 agencies from the public sector are selected to be respondents in this study. While for the private sector, the selection of the 69 respondents is based on companies that are registered in Real Estate & Housing Developers Association Malaysia (REDHA) Selangor Branch with a total of 369 members.

There are 20 government agencies in the developer sector and 369 developers in Selangor, Malaysia. Therefore, 200 copies of the questionnaire were distributed to the selected

companies. However, only 87 out of 200 respondents gave feedback. The remaining 113 respondents are rejected due to the inability in getting their feedback.

This paper method is descriptive analysis, which is used to summaries the overall characteristics of a collection of data. It contains methods such as mean and relative interest index (RII) that must be calculated manually using data from Google Forms as well as data from interviews and questionnaires. The information included in the survey questionnaire will be collected and analyzed using the statistical approach known as the Statistical Package Software System (SPSS). This SPSS is a piece of software that do the calculations based on the information and data provided by respondents. As a result, the findings of this research will be obtained from the data collected for analysis.

5. Analysis of Data and Discussion of Finding

Using the same dataset from the respondents, this section analyzed the challenges faced in using bamboo in the Malaysian construction industry. In this section, the respondents are asked about their point of view on the challenges faced in promoting bamboo in construction industries. The table below shows the summary of the mean and relative interest index (RII) for this section.

Table 4: Mean and RII values of the challenges faced in using bamboo in the Malaysian construction industry.

The challenges faced in using bamboo in the Malaysian construction industry	No	Mean	Relative Interest Index (RII)	Ranking
Competition from other building material	87	4.48	0.896	1
Treated bamboo is expensive	87	4.45	0.890	2
Highly susceptible to fire	87	4.43	0.886	3
Architects do not in specify for building projects	87	4.25	0.850	4
Limited style in design	87	4.22	0.844	5
Lack of management skill in the use of bamboo	87	4.13	0.826	6
Expensive and Rare Item in Industry	87	4.06	0.812	7
Government Policy	87	4.05	0.810	8
Negative perception toward bamboo materials	87	3.94	0.788	9
Less understanding the symbolic of bamboo	87	3.82	0.764	10
Average RII			**0.837**	

Based on the Table 4, there is 10 challenges item for this section. The overall RII calculation of each of the challenges faced in using bamboo in the Malaysian construction industry in Table 4 found that the most important challenges are competition from other building material which is ranked first compared to other challenges (RII=0.896). Meanwhile, treated bamboo is expensive is the second most important challenge, with RII=0.890 and followed by highly susceptible to fire which is the third most important challenge (RII=0.886). Next is the operational and architects do not specify for building projects which ranks fourth most important (RII=0.850) followed by limited style in design which ranks fifth most important (RII=0.844), and the final the challenges faced in using bamboo in Malaysia's construction industry is less understanding the symbolic of bamboo (RII=0.764). The average relative interest index (RII) is 0.837. Whereas the mean score value for each positive maintenance culture indicator was between 3.82-4.48.

6. Conclusion

In conclusion, the use of bamboo as a building material has a big potential and needs to be prioritized in construction industries to improve the economy. Besides the understanding of the nature and properties of bamboo, knowledge about the structure, system, and method is also needed. From the analysis of findings, Three main barrierrs faced are competition from other building materials and treated bamboo being expensive and highly susceptible to fire. Based on the item of competition from others building, it cannot be expected to know that bamboo cannot exceed the advantages of other building materials such as cement, reinforcement, and wood because of the limitation of knowledge about accurate studies related to bamboo. The studies done are very limited and not widely applied in the field of construction. The developer thinks not to suggest using this method to contractors or architects because of the risk they will bear. The sensitivity to moisture can cause swellings and shrinkages, which decrease the bonding between bamboo and concrete or mortar in the case where bamboo is used as reinforcement. Its use will damage the concrete structure.

In addition, treating bamboo are expensive. Unfortunately, it is quite difficult to treat bamboo: the outside and inside are covered with a tight layer of cells, and the vessels through which any liquid can enter the bamboo cover only about 10 percent of the cross-section of a culm. Many steps have to be taken to treat bamboo well. Bamboo needs to be treated because the the plant can absorb water extremely well. That is why bamboo needs to be treated before being applied as building materials. There are several existing procedures to reduce bamboo's moisture absorption, and improve its durability; but in several cases, chemical treatments were used, which may make the treated bamboo material less environmentally friendly and more expensive, and treated bamboo also can prevent the bamboo highly susceptible to fire.

Future study on improving the level of implementation of the usage of bamboo in building development is needed. The result indicated that not only do developers play important roles to act in overcoming the barriers in implementing these materials, but the government also should play active roles to take serious action in order to make it successfully developed. In order to increase the level of awareness among the developers, they should hold programs that promote the use of bamboo such as introducing suppliers of building materials from bamboo materials, standard methods of construction that use bamboo materials, and others.

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