MEASURING THE AWARENESS OF ARCHITECTURE STUDENTS ON THE USE OF BAMBOO FOR THE MAIN ELEMENTS OF A BUILDING

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ABSTRACT

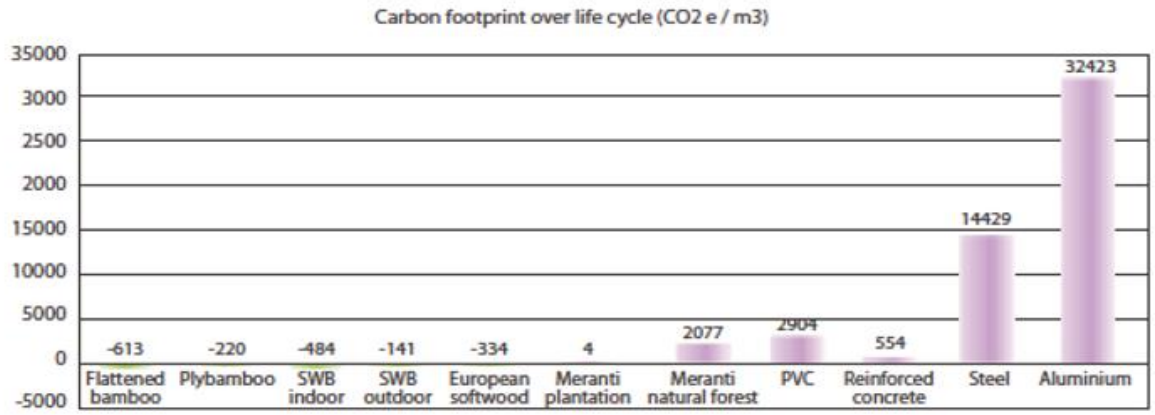
The future is in the hands of the young the young are molded in universities around the world to take charge of the future. As such, it is relevant to know the level of readiness the young have to deal with New World Problems. In the area of the built environment it is public knowledge that the use of cement and steel in construction is harmful to the environment due to their methods of fabrication. Thus, it is necessary to gauge the level of knowledge new and emerging architects, designers and other paraprofessionals in the construction industry have on the alternative sustainable materials which can be used in construction and hence, secure a better future. This paper, is based on a survey of students of Bachelor of architecture of the Universiti Sains Islam Malaysia testing their awareness and knowledge on the use of bamboo as a construction material, focusing on the main elements of the building, namely; the floor, wall, roof and columns. Architects and designers need to have a basic knowledge of these aspects in order to use the materials as they are conventionally or traditionally used, or begin to innovate new ways to create realistic, sustainable pieces of architecture, using this alternative material. The issue of sustainability is a concern for all and sundry and permeates all aspects of life. With buildings taking up to 30% of energy globally, hence in terms of architecture, awareness is necessary for all, not just those enrolled in specialized sustainable architecture programs. this is highly relevant because without knowledge or even basic awareness of the existence of such alternatives they will just follow the status quo of using reinforced concrete and steel, which has been proven through research to be highly harmful to the environment.

Key words: Sustainability, bamboo, materiality

INTRODUCTION

The destruction of the environment around the world is no secret and researchers have determined that much of the blame for this lies at the hands of human practices. Within the realm of architecture and building, much of the adverse effects on the environment, are realized and exacerbated through the propagation of unsustainable building practices. In order to counter the harm already down, as well as address the ever-growing need for buildings in the world, sustainability has to be a guiding principle for the design and construction of infrastructure around the world. Sustainability can be broken down into 4 key areas, according to Steffens et al, 2017 and Chel et al,2017 with regards to the built environment. namely;
Zero energy passive building design
Energy efficient equipment
Use of renewable energy where applicable
Embodied energy of materials used

Of these, embodied energy of materials is of particular interest to this paper, because findings from Ibn-Mohammed (2013) determined that embodied energy can account for 2 to 80 percent of whole life carbon emissions of a building whilst Sturgis et al (2010) found it to be up to 90% in industrial warehouses. As such, the importance of material selection in creating a sustainable building, cannot be over stated.
Bamboo is one of the most sustainable building materials known to man. Even when processed, the embodied energy is comparatively low, when compared to other materials that are considered sustainable, namely wood.



Carbon footprint over life cycle (kg CO2e / m3 building material) for various common building materials (based on data developed for this report, Idemat's 2014 and 2015 databases and Vogtländer et al. 2014).

As can be seen from the figure above, bamboo has the lowest carbon footprint when compared to other common building materials. Flattened bamboo, which is treated bamboo split open to form a sheet has the lowest carbon footprint of all the materials studied. Although European softwood had a lower carbon footprint than the bamboo composite materials (namely ply bamboo and strand woven board), these materials also had a negative carbon footprint, namely; -220 for ply bamboo, -484 for indoor strand woven bamboo and -141 for outdoor strand woven bamboo. This means that the use of ply bamboo, indoor and outdoor strand woven bamboo, takes OUT 220, 484 and 141 kilograms of carbon dioxide emissions per meter cube of the material produced over its life cycle and thus, proves that bamboo is a sustainable material, which has the capacity of reducing the embodied energy of a building.

As all sustainable building rating systems place a premium on reducing the embodied energy of the building and the selection of materials, bamboo stands out as a champion material for sustainable building.

Bamboo is a grass from the family Poaceae, subfamily: Bambusoideae. It is a giant grass, with the capacity for its culms to grow and mature in 3 to 5 years, and has favorable modulus of elasticity and compressive strengths as a raw material when compared to other materials (Rittironk et al, 2008) both in its raw form and as a composite material. As evidenced by the table below, comparing certain properties of laminated bamboo lumber (LBL) to common wood lumber species used in construction (Rittironk et al, 2008)

	Density	Modulus of elasticity		Compressive strength*	
Commercial lumber	pcf	ksi	Mpa	psi	Mpa
Ash	41	1,740	12,000	7,411	51.1
Birch	41	2,016	13,900	8,166	56.3
Douglas fir	32	1,827	12,600	7,426	51.2
Elm	37	1,537	10,600	7,049	48.6
Maple	46	1,827	12,600	7,832	54.0
Oak	36–57	2,045	14,100	8,601	59.3
LBL (Horizontal)	*49*	*2,509*	*17,300*	*12,750*	*87.9***
LBL (Vertical)	*47*	*2,403*	*16,570*	*12,280*	*84.7***

* parallel to grain

** Bansal and Prasad, 2004

Hence the replacement of wood with bamboo in building or elements of buildings made from bamboo lumber is feasible as both the compressive strength and modulus of elasticity is found to be higher in laminated bamboo lumber than in other common lumber materials, generally known for their strength properties, such as oak and maple.

However, the use of bamboo and bamboo composites is not common practice in contemporary formal architecture in Malaysia, despite the climatic and geographic conditions being very favourable to the growing of bamboo locally. Furthermore, findings from Awalludin et al, 2017 found selected Malaysian bamboos to have favourable mechanical properties, to be used for construction.

Very few formal architectural installations have been designed, commissioned and built in contemporary times in Malaysia with bamboo. Bamboo has been used as a main building material by Dr. Elina Jameel in the bamboo playhouse installation in Perdana Botanical gardens, by Ar. Mohd Ihsan in the masjid Gua musang in Kelantan and Tadom Hill Resort in Negeri Sembilan, amongst a few others. Structural columns in the bamboo playhouse are made out of bamboo. The floors of certain areas in the

Tadom Hill Resort are made out of bamboo, whilst the walls and various roofing elements are the selected material for both Tadom Hills Resort as well as Masjid Gua musang.

Giesakam et al, 2016 identified inadequate knowledge and skills as a key factor that hinders the adoption of sustainable practices in the construction industry. The entire construction process, is predicated on the design and the design of formal architectural installations, is determined by an architect. An architect's design scope is influenced by the architect's knowledge on the proposed materials, its characteristics and uses and the forum for an architect to gain such knowledge is during one's time as an architectural student. Hence, this paper tests the perception of architectural students in the use of bamboo for the design and construction of the main building elements; floors, walls, columns and roof members.

There is a need to research the perception on the use of bamboo, as a positive perception shall indicate a high confidence in bamboo as a building material and shall result in the use and propagation of this sustainable material, whilst a negative perception shall result in the opposite. At present, the level of bamboo use in construction across Malaysia in contemporary times is largely undocumented, hence, its reflection in formal architectural education and localised case studies, is highly limited.

MATERIALS AND METHODS

The method selected was to conduct a survey on the entire batch of first, second- and third-year students registered to the USIM architectural program during the month of June, 2019. As this month is at the tail end of the academic year, the students will have been well versed in their level of study at this point of time, as they were either awaiting or conducting their final exams during the data collection period. Thus, providing a clearer picture on how their thinking has been shaped after a full period of study, with regards to the use of bamboo in their proposed designs. A physical survey was conducted, with the results being keyed in to SPSS for testing and analysis. Survey questions were on a 5-point Likert scale. All the students are studying towards a Bachelors in science of Architecture, culminating in them taking the LAM part 1, the initial exam of 3 on the road to becoming a PAM architect, which is the Malaysian architect's association.

There was a total of 55 respondents, which represents over 95% of the total student population of the USIM architecture student body. 11 questions were asked of the respondents, and their age and year of study was also inquired about, to make it a total of 13 items of inquiry. Of the 11 questions, 3 were investigating the students' stance on sustainability as regards to their chosen profession, 4 was regarding the use of bamboo in various elements of the building and the other 4 measured the students views on using wood as the material for the same building elements, as a control study to compare with bamboo.

Traditionally, bamboo is used in Malaysia as a main building material by the orang asli tribes, such as the Iban, for the construction of their long houses,(Salleh, 2006). These were nomadic tribes and hence were constantly on the move. The type of building usually associated with these tribes is known as the long house. In contemporary times, the nomadic lifestyle has been abandoned. As recently as April, 2019, the new straits times on line newspaper reported that many long houses were razed with fire in Sarawak. The government reconstructed the long houses, using cement and reinforced concrete to give the buildings more fire safety. The traditional long house was made out of untreated bamboo.

In contemporary times, the bamboo playhouse located at the Perdana Botanical gardens in Kuala Lumpur is the most recognized bamboo structure, locally and internationally in Malaysia and is hailed as the spark for renewed interest in bamboo as a construction material in Malaysia, by key industry players.

RESULTS AND FINDINGS

Cronbach's Alpha test was performed on the respondent's data to determine the reliability of the results and internal consistency. And a score of 0.816 was attained which reflects that the data is highly reliable.

96.4% of the respondents agreed that sustainable buildings are important and the exact same total percentage agree that material selection is important in designing sustainable structures. However, only 89.1 agree that the promotion of sustainable materials is the responsibility of an architect or designer in a project. For material selection, 52.7% agreed that bamboo can be used to design structurally acceptable columns whilst the number for wood was 72.7%. 54.5% of respondents agreed that bamboo floors are highly durable, whilst it was 60% for wood. In terms of roof members, 58.2% agreed that bamboo is a suitable material, whilst 69.2% determined that wood is a suitable material. Finally, 63.6% perceived bamboo to be a suitable walling material, whilst 78.2% agreed the same to be true for wood.

Table 1:Designing sustainable buildings is important

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	**43**	**78.2**	**78.2**	**78.2**
agree	**10**	**18.2**	**18.2**	**96.4**
neutral	**1**	**1.8**	**1.8**	**98.2**
strongly disagree	**1**	**1.8**	**1.8**	**100.0**
Total	**55**	**100.0**	**100.0**	

Table 2: Material selection is important in designing sustainable architecture

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	36	65.5	65.5	65.5
Agree	17	30.9	30.9	96.4
Disagree	1	1.8	1.8	98.2
strongly disagree	1	1.8	1.8	100.0
Total	55	100.0	100.0	

Table 3: Promoting sustainable materials is the responsibility of the architect/designer in a building project

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	19	34.5	34.5	34.5
agree	30	54.5	54.5	89.1
neutral	3	5.5	5.5	94.5
disagree	2	3.6	3.6	98.2
strongly disagree	1	1.8	1.8	100.0
Total	55	100.0	100.0	

Table 4: Bamboo can be used to design structurally acceptable columns

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	7	12.7	12.7	12.7
Agree	22	40.0	40.0	52.7
Neutral	21	38.2	38.2	90.9
disagree	4	7.3	7.3	98.2
strongly disagree	1	1.8	1.8	100.0
Total	55	100.0	100.0	

Table 5: Bamboo floors are highly durable

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	5	9.1	9.1	9.1
Agree	25	45.5	45.5	54.5
Neutral	20	36.4	36.4	90.9
Disagree	3	5.5	5.5	96.4
strongly disagree	2	3.6	3.6	100.0
Total	55	100.0	100.0	

Table 6: Bamboo is a suitable material to design roof members

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	11	20.0	20.0	20.0
agree	21	38.2	38.2	58.2
neutral	14	25.5	25.5	83.6
disagree	7	12.7	12.7	96.4
strongly disagree	2	3.6	3.6	100.0
Total	55	100.0	100.0	

Table 7: Bamboo walls are sturdy and durable

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	10	18.2	18.2	18.2
agree	25	45.5	45.5	63.6
neutral	17	30.9	30.9	94.5
disagree	3	5.5	5.5	100.0
Total	55	100.0	100.0	

Table 8: Wood can be used to design structurally acceptable columns

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	10	18.2	18.2	18.2
agree	30	54.5	54.5	72.7
neutral	8	14.5	14.5	87.3
disagree	6	10.9	10.9	98.2
strongly disagree	1	1.8	1.8	100.0
Total	55	100.0	100.0	

Table 9: Wood floors are highly durable

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	6	10.9	10.9	10.9
agree	27	49.1	49.1	60.0
neutral	15	27.3	27.3	87.3
disagree	6	10.9	10.9	98.2
strongly disagree	1	1.8	1.8	100.0
Total	55	100.0	100.0	

Table 10: Wood is a suitable material to design roof members

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	16	29.1	29.1	29.1
Agree	22	40.0	40.0	69.1
Neutral	13	23.6	23.6	92.7
Disagree	3	5.5	5.5	98.2
strongly disagree	1	1.8	1.8	100.0
Total	55	100.0	100.0	

Table 11: Wood walls are sturdy and durable

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	11	20.0	20.0	20.0
Agree	32	58.2	58.2	78.2
Neutral	10	18.2	18.2	96.4
Disagree	1	1.8	1.8	98.2
strongly disagree	1	1.8	1.8	100.0
Total	55	100.0	100.0	

DISCUSSION AND RECOMMENDATION

Most of the respondents deemed sustainability to be a worthwhile endeavour for architects, however, less of that majority believed that the actual responsibility of instituting sustainability in design projects lay at the feet of the architect, primarily. This means that the students, outlook as a whole is in line with modern thinking of taking responsibility of the earth and promoting sustainable practices. It should be noted that although a smaller percentage of the students believe that the architect is responsible for maintaining g or instituting sustainability in their designs, however, that percentage still stood at 89.1%, which still accounts for the vast majority of them.

Overall, the respondents agreed that bamboo can be used for the building elements, however, the percentage with a positive response (lowest 52.7% regarding columns and highest being 63.6% regarding bamboo as a walling material), was marginal and not as definitive as those for wood (lowest 60% regarding floors and highest 72.7 regarding wooden columns). The comparative positive response was higher for wood than bamboo when compared across all elements. This can be interpreted that there is more confidence in the use of wood than bamboo as a building material, however, there is still awareness on the use of bamboo as a building material amongst the students as evidenced by more than half of them agreeing that bamboo can be used for elements that one can construct with wood.

The lower confidence level in bamboo can be attributed to a lack of extensive knowledge on the properties of bamboo and the empirical evidence shown in this paper, in which researchers determined the physical properties of bamboo and bamboo composite materials to be equal to or superior than its wooden counterparts.

Further studies should be conducted on students in other universities, in similar departments and programs, also studying to eventually become PAM architects in order to determine if these results are as a result of the LAM curricula and guidelines or whether they are due to some other pedagogical factors, peculiar to USIM. Either way, the results do reflect that greater exposure

to bamboo and is properties is needed, for the architects of the future to have confidence, to design for and with this most sustainable of building materials; bamboo.

CONCLUSION

This research findings shall be important to education policy boards, both within the university and nationally as well. Within the university of University Sains Islam Malaysia, it shall help determine whether the ideals of a "baraka" campus the university aspires to is being instilled into architecture students, with regards to their role and responsibilities, vis-a-vis, sustainability. Nationally, it can be determined whether, the issue of sustainability is a central focus for emerging architects under the current curriculum.

The agro-forestry industry can also use the results to project, that there could be an increased demand for bamboo and its construction products in the future, making it a ripe area for investment as a possible new local market.
The findings are limited in that, the research is based upon only one university, hence, it cannot be determined whether results are solely due to the national curricula or whether there are contributing local factors.

The paper gives a clear indication to education policy makers that the agenda of sustainability is high for students, however the level of knowledge on the use and properties of locally available sustainable building materials, particularly bamboo, is lower than it should be. Hence students are ill-informed of their choices, with regards to selecting sustainable building materials particularly bamboo, for various elements in their building designs.

ACKNOWLEDGEMENT

This paper is based on part findings on the research of thesis currently titled; "The perception on the use of bamboo for formal architecture in Malaysia", which was still ongoing at the completion of this paper.

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