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ORGANISED BY

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ENGINEERED WOOD PRODUCTS (EWP) AND THE PERCEPTIONS OF MALAYSIA'S ARCHITECTURAL PRACTITIONER TOWARDS THE APPLICATION OF EWP IN BUILDINGS

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Abstract

Construction activities cause the running out of natural resources and adverse environmental pollution. By substituting EWPs for traditional building materials such as concrete or steel, the total fossil fuel footprint of building construction can be greatly reduced. Despite being one of sustainable materials, the building construction industry has been reluctant to adopt engineered wood products for a number of reasons, including poor and inconsistent quality, connections with low social standing and fire performance, and costly and unpredictable material prices. This paper will study different types of (EWP) and the Malaysia architectural practitioner perception towards the application of engineered wood products as a building material. One hundred sets of questionnaires have been distributed to a targeted group of architectural practitioners namely architect, graduate architect, building draughtsman, inspector of work and building technologist in Malaysia that accounted for 52 respondents respectively. The data was analysed using Microsoft Excel through basic statistical analysis. It was found local architects have positive perception about the application of EWPs for building in Malaysia as shown by the survey findings. In contrary, it was found that most of the inspector of work do not have much knowledge about the application of EWP in building. It is suggested that the EWP has the potential in replacing steel and concrete and as option for a more sustainable building material. The mean values also charted more than 3.0 which show high confidence in them in using EWP as building material. Most of the senior practitioners are aware of the product and open towards the integration of EWP in their designs. It is hoped that EWP production can be further improved to suit various needs and requirements in building design.

Keywords: *Engineered wood, sustainable architecture, timber construction, architect perception, sustainable material*

INTRODUCTION

Frequent construction activities cause the running out of natural resources and adverse environmental pollution (Wu et al., 2018). According to studies, the increased use of engineered wood products in the construction industry has a positive impact on the environment because it is a lightweight and renewable material. Engineered Wood Products (EWPs) are defined as timber composites formed from various wood components (and sometimes non-wood components such as plastic and metals) in combination with adhesives. Wood components of (EWPs) consisting of sawn laminates, veneers, strands, particles, flakes or fibres are reconstituted together with adhesives, usually involving heat and/or pressure, into both structural and appearance sections. Some of the principal advantages compared to solid wood products are:

- they can be manufactured from lower grade wood resources and small pieces;
- much greater flexibility in product dimension possibilities;
- reduced waste and higher recoveries of product; and
- higher design strengths, greater uniformity and substantially reduced variation instructural properties (Leggate, 2018)

By substituting EWPs for traditional building materials such as concrete or steel, the total fossil fuel footprint of building construction can be greatly reduced. (Milaj et al., 2017). Architects have a significant influence on the selection of building materials, and their perceptions may lead to an increase in the application of EWP in construction.

(Mahapatra & Gustavsson, 2008). In the literature, there have been many studies on the technological, environmental, economic, and social aspects of engineered wood products, but there have been relatively few studies that specifically focus on EWPs for buildings from the standpoint of stakeholders. This study paper examines the architect's assessment of the deployment of engineered wood products (EWP) in building construction in Malaysia, as well as their perceived advantages in construction.

Research Background

The application of engineered wood products (EWP) in the building is incredibly minimal despite the abundance of timber in Malaysia (Wong, 2008). Jumaat et al. (2006) expressed regret over the Malaysian building construction industry's reluctance to use the material. The building construction industry has been reluctant to adopt engineered wood products for a number of reasons, including poor and inconsistent quality, connections with low social standing and fire performance, and costly and unpredictable material prices (Ismail et al., 2008). Construction professionals continue to be hesitant to use timber in buildings like in other European nations. As the use of EWPs expands, so too do concerns about their long-term durability performance. The vast majority of EWPs in Europe and North America are not preservative treated and The vast majority of EWPs in Europe and North America are not preservative treated The vast majority of EWPs in Europe and North America are not preservative treated and are used internally or in weather-protected situations. Because EWPs contain wood, they are subject to the same deterioration agents that effect all wood products. This includes damage by fungi, insects, fire and weathering (Leggate, 2018).

It is challenging for industry professionals to assess the real building viability of mass timber owing to the lack of case study projects in Malaysia. There is a substantial knowledge gap that is limiting the development of timber products in the Malaysian building sector. For instance, in 2008 the construction industry in Malaysia only employed wood goods to make up 8% of the total materials they used, which is much lower than the 23% each for cement, concrete, iron and steel. (SEAISI, 2008).

Research Aim and Objectives

The literature review is lacking studies that specifically provide a comprehensive understanding of architects' perception related to the application of engineered wood products (EWP) for buildings in Malaysia. This research is to understand different types of (EWP) and to understand the perception of Malaysia architects in the application of engineered wood products for building in Malaysia. As such, the architects in Malaysia are selected as the target group for this research effort as they are the key decision-makers and play an important role in the selection of building materials for every building construction project. The objectives of the research are as follows:

1. To identify the type of engineered wood products like the glue-laminated timber crossed laminated timber and laminated veneer lumber and other EWPs for the building.
2. To determine the understanding and perception of Malaysia architects in the application of engineered wood products for building.

LIRERATURE REVIEW

Several research have been published on engineered wood products and their usage in building construction. Early in the 20th century, reinforced concrete dominated the building materials industry. (Brandner et al., 2016). In the past two decades, however, wood has recovered its market dominance, while mineral-based building materials are being rapidly substituted. The commercial introduction of engineered wood products as a construction material is a major factor in this market share growth (Schickhofer et al., 2010), including cross laminated timber (CLT), glued laminated timber (glulam), and laminated veneer lumber (LVL), which are increasingly used for building applications. They can be factory-fabricated with exact dimensions, allowing for a quicker erection and less construction waste (Zhou et al., 2017).

Cross Laminated Timber

Cross-laminated timber (CLT) is a prefabricated, solid, engineered wood panel on a massive scale. Superior acoustic, fire, seismic, and thermal characteristics, combined with a low weight and high strength. Multiple layers of structural-grade softwood boards are laminated to produce large CLT panels (Mohammad et al. 2012). This panel is produced by adhering layers of solid sawn timber together. It is strengthened by gluingthe wide sides of each panel and layering them perpendicularly. In building projects, the materials are used as floor slabs, load-bearing walls, and shear walls. CLT is quick and simple to install, generates nearly little waste on-site, enables design flexibility, and has few environmental implications. Therefore, it is considered as the ideal alternative to conventional building materials like concrete, brick, and steel, particularly in multifamily and commercial construction. (Zhang et al., 2017).

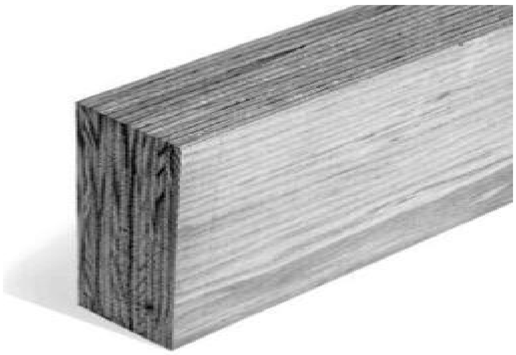
Figure 1
Cross laminated timber

Laminated Veneer Lumber

Laminated veneer lumber (LVL) is produced from veneer and intended for structural framing, where high strength and stiffness are required. A veneer is an extremely thin layer of wood, often as thin as one-thirtieth of an inch (Walker,2005). Plywood, a popular sheet material, is perhaps the most well-known construction material made from veneer. Plywood is used for several light-duty construction and furnishings applications. A more contemporary product is inspired by plywood, but its veneer-based structure differs from plywood's. The laminated veneer lumber (LVL) composite wood product optimises veneer composition for structural applications. LVL products consist of laminated veneer sheets formed into dimensioned members (APA, 2008). Different from plywood, which is only available in sheet form, LVL members are available in sizes equivalent to those of standard sawn boards. There are other differences between the two items in the veneer layouts. The grain orientations of all veneer laminates are aligned in the longitudinal direction of the members when LVL is fabricated. The number of veneer layers on an LVL member depends on the member's desired thickness.

Figure 2

Laminated Veneer Lumber member with visible glue lines



Glued Laminated Timber (Glulam)

Glulam is an evolved technology industrial product that overcomes the defects of wood through technological production (Vecchi et al., 2008). Glued laminated timber is a high-performance building material with high mechanical properties compared to solid wood (Guitard, 1994). Glulam is an engineered wood product that enables designers to overcome the dimensional restrictions of standard lumber. Its components consist of a number of wood laminations that are glued together with an adhesive (Wiley & Sons, 2012). During the processing, the boards are pressed using hydraulic machinery to establish strong connections. Typically, dimensioned softwood lumber is used for the laminations, and care is taken to ensure that the grain of the boards runs parallel to the longitudinal axis of the glulam component. Using finger-jointed timber, the size of GLT members are theoretically restricted only by the manufacturer's production and shipping capabilities. Lamination parts are frequently joined at the ends to produce glulam members with lengths that exceed traditional lengths of stock lumber.

Table 1
List of study of application of EWP in contemporary architecture

Building & Year	Architect	Parameter	Building Photo
Tamedia Headquaters expansion Zurich, Switzerland (2013)	Shigeru Ban Architect	7-storey building primarily supported with refabricated large glulam beams and columns. Cross laminated timber panel is used for the building flooring. External wall is by glazing curtain wall.	
Treet Residential Building Bergen, Norway (2015)	Sweco/ ARTE Architect	14-story apartment with a height of 163 feet. The framework of the building comprises of a glulam truss system that supports 62 modular residential units that were manufactured off-site using CLT panels. On top of the reinforced floors and the concrete garage, prefabricated building modules are stacked. CLT is used in the elevator shaft, the interior walls, and the balconies but CLT is not a part of the main load bearing system. The stairwells and elevator shafts are made of CLT panels, which provide increased lateral strength. The glulam components are joined by steel plate dowels, resulting in connections with good mechanical strength.	
Grandview Height Aquatics Centre-Surrey, British Columbia (2016)	Fast + Epp/ HCMA	This aquatics centre makes excellent use of continuous glulam beams to take advantage of wood's flexural strength. The glulam beams helped reduce energy consumption and emissions during construction and the final product is suitable for humid and corrosive swimming pool settings. The roof with a wave-like shape was supported by glulam beams and concrete.	

Metropol Parasol Seville, Spain (2011)	Arup/ J. Mayer H. Architect	One of the most unorthodox and biggest wooden structures in the world. The 92-foot-tall building is comprised of six umbrella-shaped wood forms rising from solid concrete plinths and linked at the top by a timber framework. The finished project demonstrates the effectiveness of LVL sheet material with hybrid wood joints for protecting structural composite lumber.	
Glulam Gallery Johor, Malaysia (2011)	KAZ Akitek	The main glulam portal frames were constructed from Resak and Keruing hardwood from Malaysia, while the roof was shingled with Belian (estimated over 350,000 pieces). In addition, the wood wall covering is made from Kekatong and the timber fins are made from Balau.	
Yusuhara Wooden Bridge Museum, Takaoka, Japan (2010)	Kengo Kuma Architect	The Yusuhara Museum by Kengo Kuma connects two public facilities by a single bridge structure. Designed as a passageway, living space, and workshop, the museum employs a structural system comprised of tiny components. The huge cantilever was constructed using overlapping glulam and wooden members.	

Depending on their characteristics, engineered wood products are employed in a variety of building applications. The table below summarises briefly the many application areas.

Table *2*
List of different applications of EWP in the building construction sector

Product	Possible application
Glulam	• Massive wall element • Rood elements • Beams
Cross laminated timber (CLT)	• Massive wall elements • Roof elements • Floor and bridge decks
Plywood	• Sheating • Façade panel • Structural stabilisation • Interior applications
Structural composite lumber Laminate veneer lumber (LVL) Laminated veneer lumber (LSL)	Structural applications
Parallel strand lumber (PSL)	
Fibre board	• I-beam • Wall and roof diaphgrams
Medium density fibreboard (MDF)	• Interior application • Furnitures
Particle board	• Intermediate floor layer • Interior cladding • Furnitures
Oriented strand board (OSB)	• Beam • Wall diaphragms • Roof elements

(Kolb,2008 & Lidelow, 2016).

MATERIALS AND METHOD

To address the Objective 1, this paper uses quantitative approach by using Structured Literature Review (SLR) from past research publications. SLR is a process that allowed to collect relevant evidence on the given topic that fits the pre-specified eligibility criteria and to have an answer for the formulated research questions. Undertaking a review of the related literature assessment is an important part of any discipline (Hart, 2018). It helps to maps and assesses the existing knowledge and gaps on specific issues which will further develop the knowledge base. Systematic literature review (SLR) differs from traditional narrative reviews by adopting a replicable, scientific, and transparent producers (Mengist Et al., 2019). Publications related to EWP have been reviewed from a reputable peer reviewed journal. The purpose of using this method is to identify the type of engineered wood products like the glue-laminated timber, crossed laminated timber and laminated veneer lumber for the building.

As for Objective 2, a questionnaire survey will be randomly distributed online among practitioners in Architectural field. Due to adverse limitations such as access to architectural firms, the targeted number of respondents are 100 respectively. The survey is used to collect opinion and to investigate the perceptions of local architectural practitioners working in a registered firm with the Board of Architects Malaysia (LAM). They were selected as respondents because of their direct participation in every project's conception, planning, design, and construction. The research questionnaire includes 2 parts. The first part is the demographic information such as name, gender, working experience, academic and professional background. The second part is about th eir knowledge and opinion about the application of EWPs for buildings. The questions were set in closed ended and open ended such as five-points Likert scale, question with options and questions asking their opinion and justification. Such scales are commonly used in social science research to elicit attitudinal information (Rea and Parker, 2005). The entire questionnaire was developed following the structure of previous studies that have been tested and validated (Chueh and Kao, 2004; Crosby et al., 2003; Rogers, 2003; Amabile, 1982).

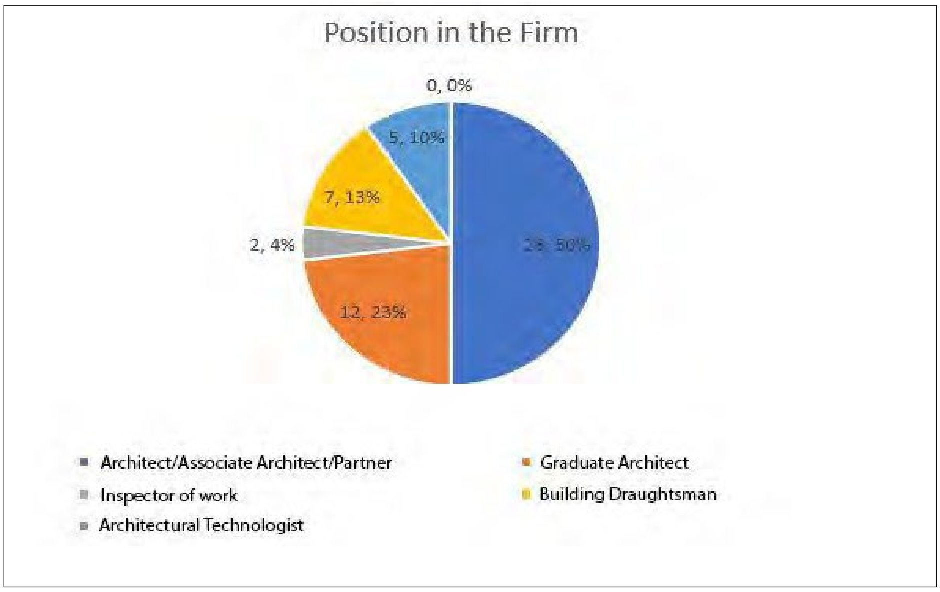
RESULTS AND DISCUSSION

Based on the result of the questionnaire survey, out of 100 sets of questionnaires, only 53 respondents participated by answering the survey voluntarily. Out of the 53 respondents, 1 respondent has been removed from the data sets due to the lack in confidence of the data. It can be seen that all questions were marked the same answers. Therefore, this analysis will discuss results from the 52 sets of questionnaire surveys.

As shown in Figure 3, it was found that there are 26 Architect/Associate Architect/Partner have participated in this survey that is accounted for 50% of the total population followed by Graduate architect 23% and Building Draughtsman 13% respectively. There are also a small number of Inspector of work participated in this survey which is accounted for 4%. This data demonstrated that the majority of the respondents hold high and important positions in the respective firms which are involve in design and making decision in the proposed projects.

Figure 3

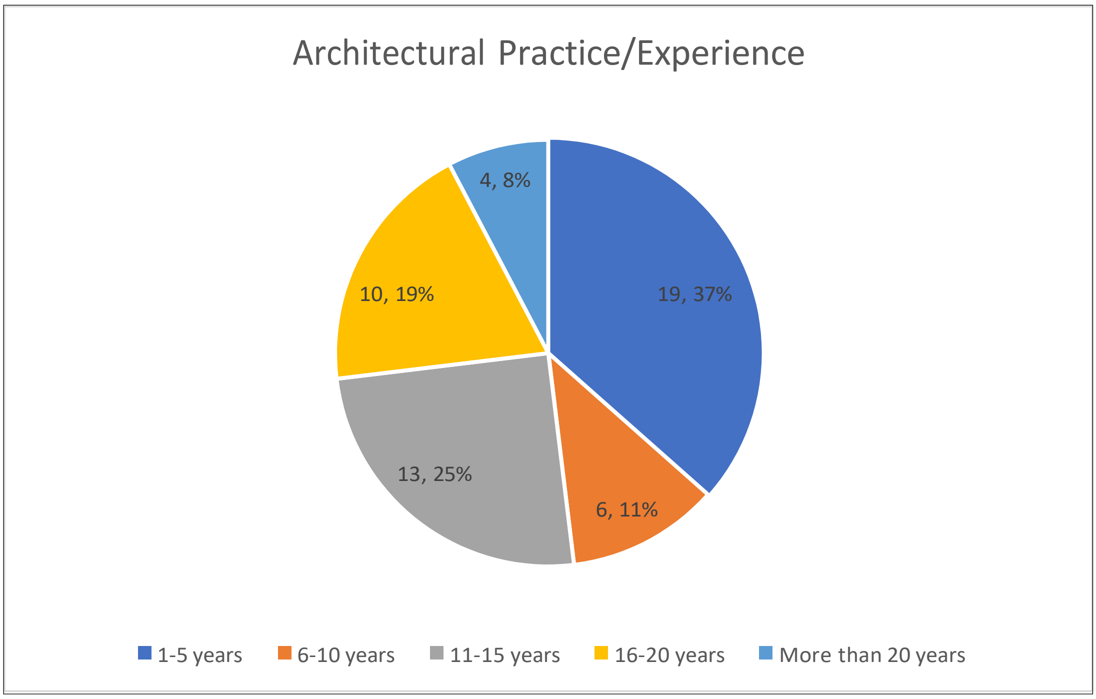
Role or position of architectural practitioners in the architecture firms



This survey also shows that most of the respondents have more than 11 years of experience in architectural practice. By referring to Figure 4, it can be seen that 25% of the respondents have at least 11-15 years of experience, 19% of them have 16-20 years of experience and a friction of the respondents have vast experience of more than 25 years. Another half of the respondents are young practitioners experience of less than 10 years which is accounted for a total of 48%. This data demonstrates that the respondents who are participating in this survey are well experienced and involve with many projects throughout their practicing career.

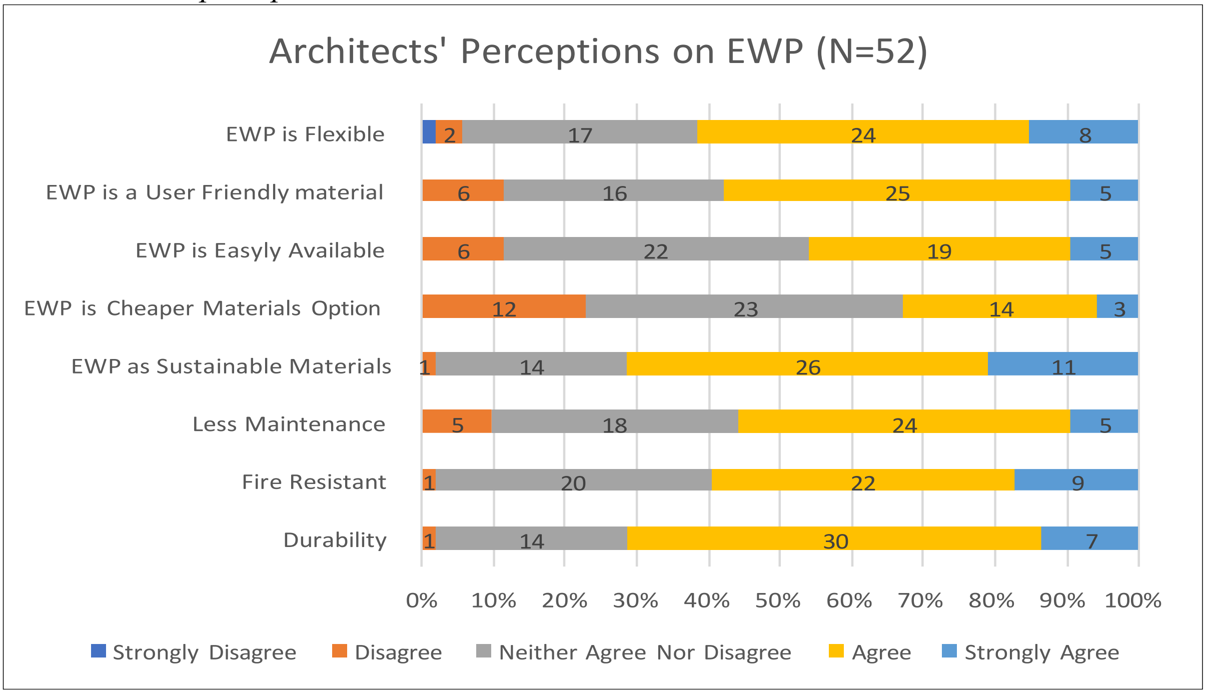
Figure 4

The experience in architectural practice in the firm



The respondents were questioned on their familiarity with the advantages of engineered wood products. The survey shows that most respondents use concrete as their conventional materials followed by steel and timber which is accounted for 90%, 6% and 4% respectively. It was found that none of the architecture practitioners uses EWP as their conventional material especially in building structural components. The survey further asked the respondents questions to understand their impression and perception towards EWP. A 5 likert-scale rating is used in the survey in order to understand the respondents' perceptions. As illustrated in Figure 5, it was found that most of them agree that EWP is a user-friendly material which flexible to fit with many design proposals. The mean value of the flexibility of EWP as building material is accounted for 3.92 and the mean value of the EWP as a user-friendly material is accounted for 3.56. These data show quite high confidence in the respondents' perception towards EWP.

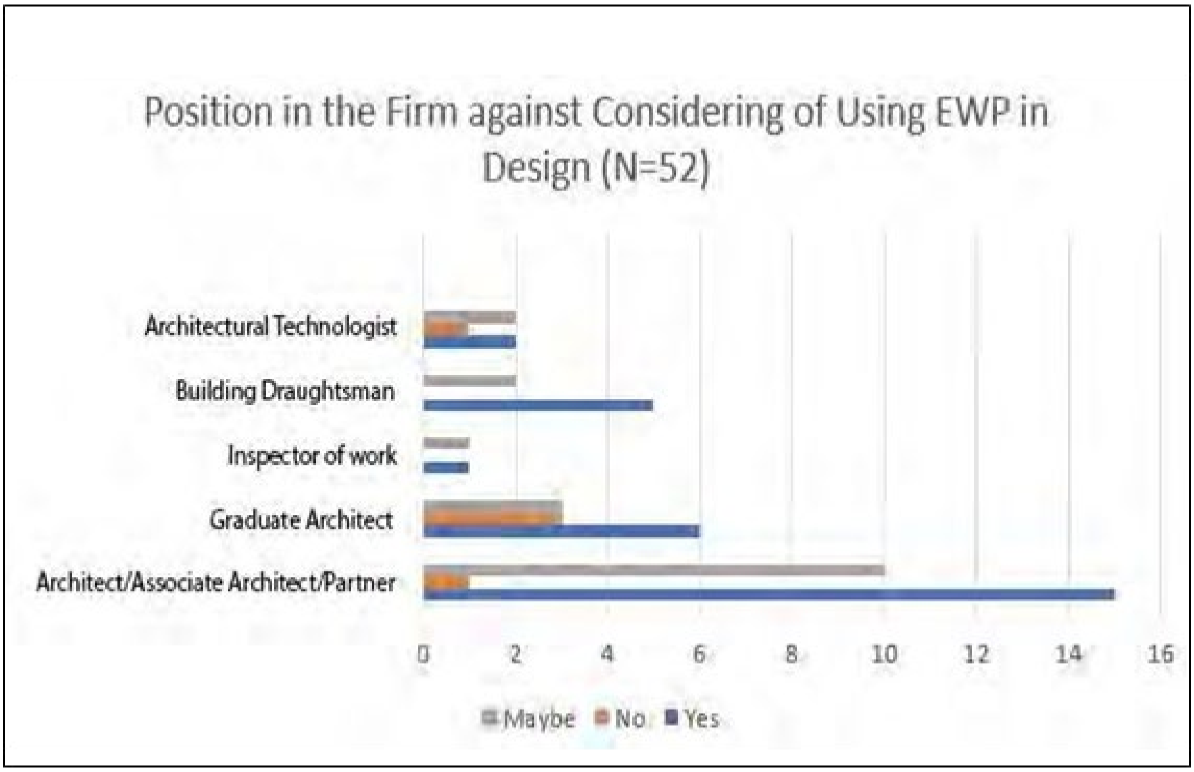
Figure 5
The architects' perceptions on EWP.



It was found that not many respondents think that EWP is an affordable material. Only 14 respondents which is accounted for 26.9% agree that EWP is a cheaper material compared with other conventional materials such as concrete and steel. Most of them are undecisive whether EWP is a cheap material and quite a number of respondents thought that EWP is not a cheaper solutions of building materials that accounted for 23%. However, it can be found that many of the respondents thought that EWP is a sustainable material with 26 respondents agreed and 11 respondents strongly agreed that are accounted for 50% and 21.2% respectively. This data can be furthr vrified with the data found by (Roth, 2015). Most architects are aware of the advantages of engineered wood products, including better longevity and stability of wood as well as a greater aesthetic value. It is feasible to exploit underutilised timber resources, and the modification process is ecologically beneficial, however the production of engineered wood products is expensive (Roth, 2015).

In this survey, it shown high confidence among the respondents on the ability of the materials in resisting fire as well as the durability of EWP as building material. There are 42.3% of the respondents agreed that EWP have the fire-resistant properties with 17.3% strongly agreed. The same tendency can be seen in the durability of EWP as building material with 57.7% agreed and 13.5% of the respondents strongly agreed. The mean value of the perception towards fire resistant and durability are 3.75 and 3.83 respectively. In contrary, these results are against the finding by (Kozak & Cohen, 1999; O'Connor et., al 2004). In their research, it was found that the disadvantages or weakness about the EWPS mainly the concern of fire flammability, strength and durability and maintenance being rated highly as concern about us of wood products.

Figure 6
The consideration of using EWP in building design in relation to the position of respondents in the architecture firm.



As illustrated in Figure 6, it can be seen that all architectural practitioners are open in considering EWP as building material in their design proposal. However, there are a quite a large number of them who are still unsure whether to use EWP as part of building materials which is accounted for 34.6%. Based on the open-ended question which asked on the general views of EWP, some of the concerns are on the performance of EWP, protection against moisture and fungi, perception on the cost and labour, and the lack of promotion and awareness on EWP. On the other hand, many are still optimistic on the potential of EWP as building material in replacing conventional timbers, stronger, cheaper and eco-friendly material with various selection of colours. As a product, 30.8% the respondents have rated EWP with 3 star, 55.8% have rated EWP with 4 stars and 13.4% have rated 5 stars with the mean value of 3.83. This data shows the potential of EWP to be applied in design by the practitioners due to their high exception on the material itself based on their understanding.

CONCLUSION

Based on the results it was found most of the respondents agreed and strongly agreed towards the questions asked on their perceptions towards EWP. The mean values also charted the value of more than 3.0 which show high confidence in them in using EWP as building material. Most of the senior practitioners are aware of the product and open towards the integration of EWP in their designs. However, there are still doubts and concern on EWP as building materials due to lack on promotion and information on the product. The main concern is on the cost of the product as well as the performance of the product. It is hoped that EWP production can be further improved to suit various needs and requirements in designs especially dealing with the tropical climate of Malaysia and how to reduce the production cost in making the product more accessible and affordable to Malaysian. As for future research, more studies can be conducted on the performance of EWP especially on the thermal performance, durability, fire resistant as well as the performance against the hot and humid climate of Malaysia.

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