THE IMPLEMENTATION OF POLLI-BRICKS IN MALAYSIAN CONSTRUCTION INDUSTRY

CHU CHIA NING

A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Science (Hons.) Quantity Surveying

Faculty of Engineering and Science
Universiti Tunku Abdul Rahman

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

Signature : _____

Name : Chu Chia Ning

ID No. : 09UEB05772

Date : _____

APPROVAL FOR SUBMISSION

I certify that this project report entitled **"THE IMPLEMENTATION OF POLLI-BRICKS IN MALAYSIAN CONSTRUCTION INDUSTRY"** was prepared by **CHU CHIA NING** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Science (Hons.) Quantity Surveying at Universiti Tunku Abdul Rahman.

Approved by,

Signature : _____

Supervisor : Dr. Chong Heap Yih

Date : _____

Specially dedicated to
Lord and my beloved family

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ABSTRACT

Polli-Brick is a building material made from post-consumer polyethylene terephthalate (PET). The wide application of Polli-Bricks is believed to be able to reduce the plastic wastes in the country. In Malaysia, plastic is one of the highest municipal solid wastes (MSW) generated and it is having an increasing trend. Therefore, the implementation of Polli-Bricks in Malaysia could be an effective way to reduce the plastic wastes in Malaysia. The objectives of this study are (i) to identify the level of awareness towards sustainability among the construction professionals in Malaysia, (ii) to investigate the challenges for the implementation of Polli-Brick in Malaysia, and (iii) to suggest the strategies for the application of Polli-Brick into Malaysian construction industry. This study employed mix method approach. Questionnaire and semi-structured interview were used as data collection tools. It was found that low awareness towards Polli-Bricks among respondents and low public awareness impose critical challenge for the implementation of Polli-Bricks in Malaysia. Three (3) utmost challenges for the implementation of Polli-Bricks were identified. Three (3) most effective strategies in promoting Polli-Bricks were determined. Architect or design personnel and client were identified to be the most influential in materials selection. Internal partition is the most preferable application to introduce the implementation of Polli-Bricks in Malaysia. At the end of this research, it is able to find out the strategies of implementing Polli-Bricks in Malaysia through better understanding of the challenges faced.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS / ABBREVIATIONS

AAC	Autoclaved Aerated Concrete
EE	Energy Efficiency
EPA	Environmental Protection Agency
GBI	Green Building Index
GBIF	Green Building Index Facilitator
IAQ	Indoor Air Quality
MGBC	Malaysian Green Building Confederation
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
PAM	Pertubuhan Arkitek Malaysia
PET	Polyethylene Terephthalate
RII	Relative Importance Index
VOCs	Volatile Organic Compounds

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

According to the data calculated by CO_2Now (1960), there is a total increase of 20.72 parts per million (ppm) for carbon dioxide (CO_2) level and the average annual rate of increase was 2.07ppm per year during the interval year of 2002 to 2011. The concentration of atmospheric CO_2 elevated to 391.57ppm in the year 2011, which exceeded the upper safety limit of 350ppm (CO_2Now, 1960).

This is especially notable in the fast developing countries like China and India. According to Netherlands Environmental Assessment Agency (2006), China overtook United States becoming the world's largest CO_2 emission country in 2006. As for Malaysia, the level of urbanization is increasing due to the country's rapid development, from the 62.0 percent to 71.0 percent (Department of Statistics Malaysia, 2010). This causes a significant incline of energy consumptions and Green House Gasses (GHG) emissions in the cities. Data from the World Bank (2008) showed that the CO2 emissions in Malaysia increased from 6.4 metric tons per capita in 2003 to 7.6 metric tons per capita in 2008.

According to the data provided by Department of Statistics Malaysia (2010), Malaysia population was growing from 13.7 million in 1980 to 28.3 million in 2010. The increasing population and humans' pursuant on higher living standards are the main reasons for the climate change. With the growing in the population, the amount

of municipal solid waste (MSW) generated also increasing. The MSW generated in Peninsular Malaysia is increasing every year, from the 3,066,000 tonnes in 1996 to 7,655,000 tonnes by 2007 (Tarmudi, Z. et al., 2009).

In Malaysia, the most common municipal solid waste management (MSWM) is landfill. According to Alam Flora Sdn Bhd, one of the largest private solid waste management contractors in Malaysia shows that only 76 percent of solid wastes are successfully collected in Malaysia and only around 5 per cent is recycled while the remaining 95 percent wastes collected are disposed at the country's 112 landfills (Papargyropoulou, E. et al., 2011). Besides methane gas (50-55%), carbon dioxide contributes about 40-45% of the landfill emissions (Johari, A. et al., 2012). Looking at the impacts of landfill, a better waste management strategy has to be figured out while recycling could be a better choice.

In November 6, 2010, the EcoArk namely the 'Pavilion of New Fashion' in Taipei, Taiwan successfully grabbed attention from worldwide media. Media focus was paid to its building enclosure. The curtain wall façade was built up by bricks which consisted of 1.52 million recycled post-consumer plastic bottles. The brick is known as Polli-Brick. Green building materials are expected to have characteristics like low toxicity, minimal chemical emissions, ability to be recycled, and durability (Hoang C. P. et al., 2009). This new invention is a good concept of turning trash into building materials. Besides, it is able to address the carbon emission issue which is happening globally.

Construction industry is the main thrust for the economy growth in Malaysia. It has been steadily contributing for about 3% to 5% of the national GDP in the past 20 years (Abidin, N. Z., 2009). Since there is such a great demand in the construction industry, it is believed that the plastic waste (which is 24% as stated before) generated could greatly be reduced through recycling it and becoming building materials. Furthermore, the low embodied energy of the Polli-Bricks is believed to be able to reduce the carbon footprint to the environment.

1.2 Issues and Problem Statements

1.2.1 Low Awareness towards Sustainability

The concept of sustainable development was introduced in the Brundtland Report 1989 and was being emphasized in 1992 at earth Summit in Rio (Ali, M. M. and Armstrong, P. J., 2008). However, it started to be aware by Malaysia only during the Ninth Malaysia Plan. The awareness of the community towards the concept of 'sustainability' is still remaining low in Malaysia. Hence, more efforts should be carried out in order to increase the green awareness among the Malaysian society.

1.2.2 Perception towards Green Products

Consumers have perceptions that green products are costly and inferior in quality (D` Souza et al., 2006; Gan, C., et al., 2008). Companies prioritise the profitability instead of protecting the environment (D` Souza et al., 2006). This makes the level of environmental consciousness inconsistent with the green products selection, which the level of green products utility is much lower than the environmental awareness level. The long term benefits of green products are not being appreciated by the consumers. Most of the people could not see the value of the green products.

1.2.3 New Green Products

It is always not easy for new green products to enter a new market. A research done by Gan, C. et al. (2008) showed that consumers are reluctant to purchase green products which they are unfamiliar with. The brand loyalty to conventional brands creates barrier for new green product to enter the new market. Consumers tend to have low confidence level towards the new product and its unknown future implications.

1.3 Aim

The aim of this research is to encourage the implementation of Polli-Bricks through better understanding of the challenges faced.

1.4 Research Objectives

The following objectives are formulated in order to achieve the aim of the research:

(a) To identify the level of awareness towards sustainability among the construction professionals in Malaysia.

(b) To investigate the challenges for the implementation of Polli-Brick in Malaysia.

(c) To suggest the strategies for the application of Polli-Brick into Malaysian construction industry.

1.5 Research Scopes

This research was limited to the study of Polli-Bricks. Comparison was made between the Polli-Bricks and other green building materials in Malaysia. Questionnaire was set to find out the sustainability awareness among Malaysian construction professionals, challenges and strategies of implementing Polli-Bricks in Malaysia. The respondents were mainly the construction professionals in Malaysia.

1.6 Research Significance

This research is important as it identified the local sustainability awareness. The challenges of Polli-Brick to enter the Malaysian construction market were determined. By having better understanding on the challenges, it is easier to formulate the implementation actions of Polli-Brick in Malaysia.

1.7 Research Methodology

(a) Preliminary Study and Topic Selection

A general topic was studied. The research was studied from the secondary sources such as articles, previous researches, and other websites or forums. The topic selection was also being done through researcher's observation. The scope of study was being narrowed down and the research topic was formulated.

(b) Literature Review

Literature review was carried out to strengthen and verify the research topic. The literature review was being done through studying the secondary sources such as journals articles, previous researches, books and official reports. This could give clarity and focus to the research problem. Research aim and objectives were formulated.

(c) Data Collection

Data collection was done through questionnaires in order to acquire the primary data. Questionnaires were designed, reviewed and approved. The questionnaires were distributed to the targeted respondents. Interview will be conducted with two respondents who have knowledge about Polli-Brick.

(d) Data Analysis

The data collected was analysed based on the suitable methods. Data analysis reported the raw data collected.

(e) Writing-up

The research write-up was done based on the data analysis. Suggestions and recommendations were given for future development of this research.

1.8 Research Methodology Flow

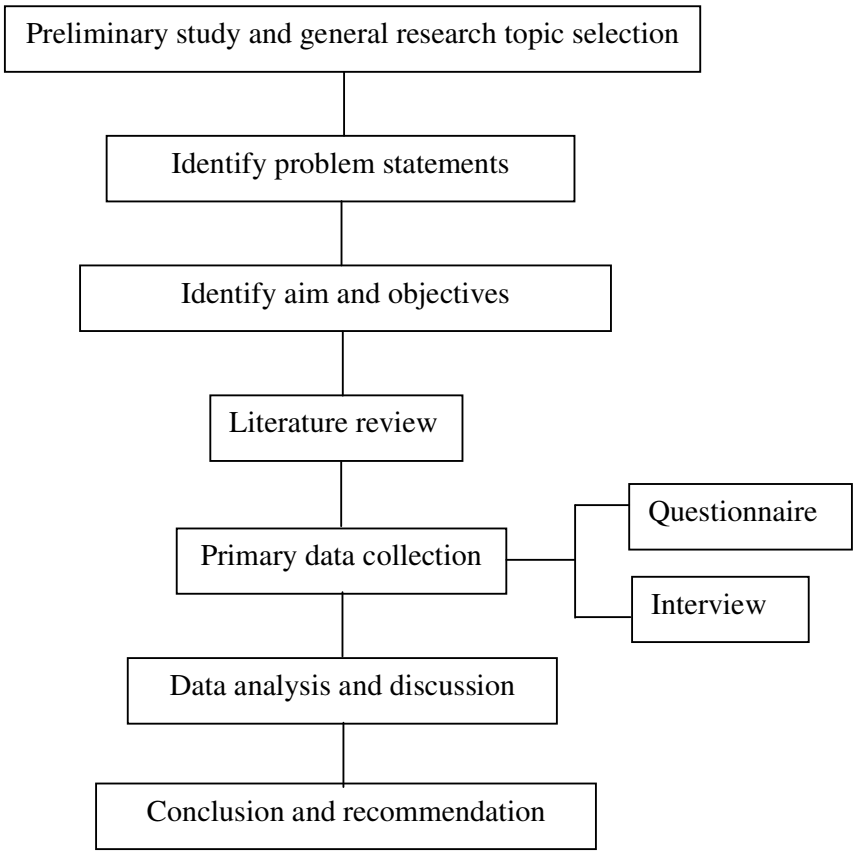


Figure 1.1: Research Methodology Flowchart

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

2.1.1 Sustainable Building Materials

Building materials play an essential role in enhancing the overall performance of a building. However, it could lead to many environmental impacts without proper management throughout its whole lifecycle. The conventional building materials often consumed large amount of non-renewable resources, causing depletion of natural resources (Ofori, G., 2002; John, G. et al., 2005). Large amount of energy was used during the extraction, production and transportation of the building materials.

Looking at a series of issues caused by the building materials, the construction players started to aware of the sustainability of building materials. Besides cost, availability and appearance, the environmentally suitability of materials is another important factor that is being considered by many of the construction practitioners nowadays (Asif, M. et al., 2007; Akadiri, O. P., 2011).

The sustainability of a building material can be determined by its "green features" throughout the whole building life-cycled phase (i) manufacturing phase (ii) building operations (iii) waste management. Table 2.1 illustrates the criteria of green building materials for the whole building life-cycle phase.

Table 2.1: Key Criteria of Sustainable Building Materials

Green Features		
Manufacturing Process (MP)	**Building Operations (BO)**	**Waste Management (WM)**
Waste Reduction **(WR)** Pollution Prevention **(P2)** Recycled **(RC)** Embodied Energy **(EER)** Natural Materials **(NM)**	Energy Efficiency **(EE)** Waste Treatment & Conservation **(WTC)** Nontoxic **(NT)** Renewable Energy Source **(RES)** Longer Life **(LL)**	Biodegradable **(B)** Recyclable **(R)** Reusable **(RU)** Others **(O)**

Source: Kim J.J et al., 1998

2.1.2 Municipal Solid Waste (MSW) in Malaysia

The national average solid waste generation in 2009 was 0.8 – 0.9 kg/capita and it is expected to grow linearly (Saeed, M. O. et al., 2009).With such a growing rate, the MSW is projected to reach 2.23 kg/ capita by 2024 (Saeed, M. O. et al., 2009). Table 2.2 illustrates the MSW generation in Peninsular Malaysia by states.

Table 2.2: Solid Waste Generation in Peninsular Malaysia by States ('000tonnes)

States	1996	1997	1998	1999	2000	2007	Average growth rate (1998-2000, in %)
Kuala Lumpur	n.a.	n.a.	1,058	1,070	1,082	1,168	1.14
Selangor	n.a.	n.a.	1,169	1,204	1,240	1,504	3.04
Pahang	n.a.	n.a.	202	206	210	239	1.98
Kelantan	n.a.	n.a.	123	126	120	110	1.22
Terengganu	n.a.	n.a.	119	122	125	147	2.52
Negeri Sembilan	245	250	267	278	291	387	4.69
Melaka	192	200	208	216	225	293	4.30
Johor	854	890	927	956	1005	1,321	4.49
Perlis	26	27	28	28	29	33	1.79
Kedah	507	538	569	569	631	873	5.49
Pulau Pinang	570	591	611	611	648	785	3.03
Perak	672	696	719	719	763	926	3.06
Total	3,066	3,192	6,000	6,137	6,378	7,655	2.86

n.a. – not available

Source: Tarmudi, Z. et al., 2009

The average components of MSW consist of food waste (45%), plastic (24%), paper (7%), iron (6%), glass and others (3%) (Tamudi, Z., 2009). Out of the MSW generated, plastic waste is the most common solid waste generated in Malaysia, accounting for 7 to 12 percent by weight and 18 to 30 percent by volume of the residential waste generated (Frost.com, 2007)

2.1.3 Turning Plastic Waste into Building Materials

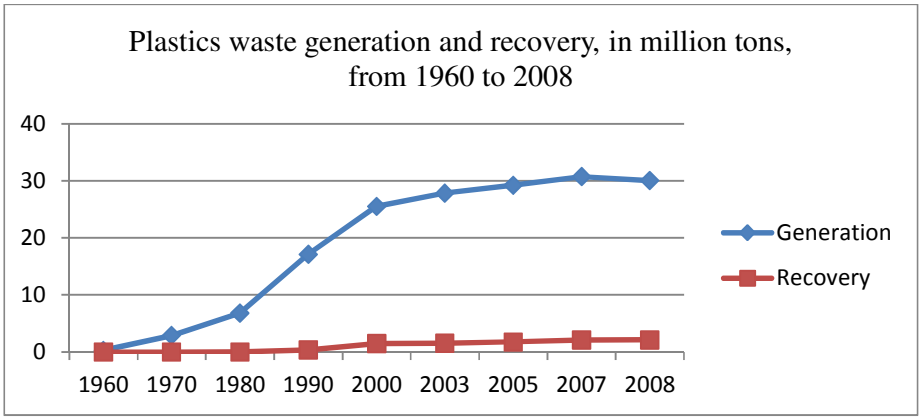
Over the years, Taiwan has been the country with highest plastic waste generation (Lu, L. T. et al., 2005).

Table 2.3: Comparison of the MSW Composition in Taiwan and other Countries in 2000

Countries	MSW composition in percentage (%)					
	Paper	Food & garden waste	Plastics	Glass	Metals	Textiles & others
USA	38	23	11	5	8	15
Japan	33	34	13	5	3	12
Korea	26	25	7	4	9	29
Netherlands	28	39	5	6	3	19
Hong Kong	27	33	17	3	3	18
Singapore	21	50	6	1	3	20
Taiwan	26	31	22	7	4	9

Source: Lu, L. T. et al., 2005

The increasing demand in plastic industry causes an increase in the plastic waste generation. However, the recovery rate of plastic is far lower from its generation.



Source: U.S. Environmental Protection Agency

Figure 2.1: Plastic Waste Generation and Recovery from 1960 to 2008

Under the "Waste Management Hierarchy", it has minimization, recovery and transformation, and land disposal. Among these waste management methods, minimization is the most preferable method. It consists of two basic operations which are source reduction and recycling (Bai, R. and Sutanto, M., 2002). Recycling, whereas is the most desirable method to deal with the existing plastic waste generated.

Out of the various plastic types, PET is the most common and widely used plastic in packaging industry. It can easily be found in every household and office. The application of recycled PET bottles in construction industry include concrete, insulation, asphalt concrete-mixes and road stabilisations (Yesilata, B. et al., 2009). The application of plastic waste in building materials is expected to improve the mechanical strength, lightweight properties and cost efficiency while reducing the plastic waste stream (Ismail, Z. Z. and Al-Hashmi, E. A., 2008).

2.2 Polli-Brick – The Special Features

2.2.1 100% Made from Trash

The PET plastic can be recycled through various methods: primary, secondary, tertiary and quaternary (Ismail, Z. Z. and Al-Hashmi, E. A., 2008). Table below illustrates the terminology of different types of plastic recycling (Hopewell, J. et al., 2009). Chemical recycling and mechanical recycling are two main types of plastic recycling.

Table 2.4: Plastic Recycling and Recovery Terminology

ASTM D5033 standard definitions	Equivalent ISO15270 standard definitions	Other equivalent terms
Primary recycling	Mechanical recycling	Closed-loop recycling
Secondary recycling	Mechanical recycling	Downgrading
Tertiary recycling	Chemical recycling	Feedstock recycling
Quaternary recycling	Energy recovery	Valorisation

The production of Polli-Bricks is done through the mechanical recycling. The recycling does not require any chemicals and virgin materials and it uses only water and heat to produce a new PET material (Anthony K., 2011). The raw materials, those collected PET trash is processed by physical means which include grinding, shredding and melting.

2.2.2 3D - Honeycomb Shape Interlocking Units

The shape of Polli-Bricks is specially designed to be polygonal in shape with interlocking grooves. This allows Polli-Bricks to be jointed without any adhesive. The interlocking principle of Polli-Bricks is similar to the interlocking mortarless hollow block masonry. The adhesive-free interlocking system provides a high strength to the structure itself (Thanoon, W. A. et al., 2004). The interlocked Polli-Bricks can be assembled into rectangular panel or any form in customized dimension.

When the interlocking units are stacked, it forms a panel with honeycomb appearance. The honeycomb structure Polli-Bricks forms a core offer a structural support to the laminate layers. The Polli-Bricks interlocked in three dimensions forming cellular structures called foams. The honeycomb structure is proven to exhibit excellent mechanical strength and provide a high strength to weight ratio to the wall panel (Kee Paik, J. et al., 1999; He, M. and Hu, W., 2008).

2.2.3 Low-VOCs (Volatile Organic Compounds)

Volatile Organic Compounds (VOCs) are large common air pollutants emitted from building materials and furnishings (Yu, C. W. F. and Kim, J. T., 2010). Many adhesives, paints, cleaners and sealants contain VOCs. VOCs emissions from building materials have adverse health effect.

VOCs emitted from the building materials and household products are the main contributor affecting human comfort, health and productivity and various sickness (Xu, Y., et al., 2004). Poor indoor air quality caused illnesses such as Legionnaires' disease, asthma, hypersensitivity pneumonitis, and humidifier fever, are called 'Sick Building Syndrome' (SBS) and have been traced to specific building problems like indoor air quality (IAQ) (Gou, Z. and Lau, S. S. Y., 2012). The application of low VOC materials can reduce the impact on the IAQ.

2.3 Polli-Brick – The Advantages

2.3.1 High Strength to Weight Ratio

The light weight of wall panel is mainly contributed by two factors which are the material of the brick and the structure of the wall panel. The greatest advantage of plastic made building materials is due to its lightweight properties (Hopewell, J. et al., 2009; Thompson, R. C. et al., 2009). On the other hand, the structure refers to the honeycomb structure formed by the interlocking units. The honeycomb structure acts as the core and is sandwiched by nano treated PC hard coats. The PC hard coats serve the purpose to protect the wall panel from UV radiation, enhancing the durability of wall panel.

The strong bond between the Polli-Bricks is tested to be able to withstand both earthquake and hurricane-resistant. The wall panel can resist over 3000Pa of lateral wind forces and withstand up to Category 5 hurricane (Miniwiz Sustainable Energy Development Ltd).

2.3.2 Low Embodied Energy

The basic components of the embodied energy consist of extraction, production and transportation of the building materials (Hammond, G. P. et al., 2008). The embodied energy can be produced indirectly or directly. Indirect energy occurs in the acquiring, processing and manufacturing of the building materials, including any transportation related to these activities (Dixit, M. K. et al., 2010). Direct energy consumed when transporting the products to the site (Dixit, M. K. et al., 2010). Studies have proven that the embodied energy is closely related to carbon emissions.

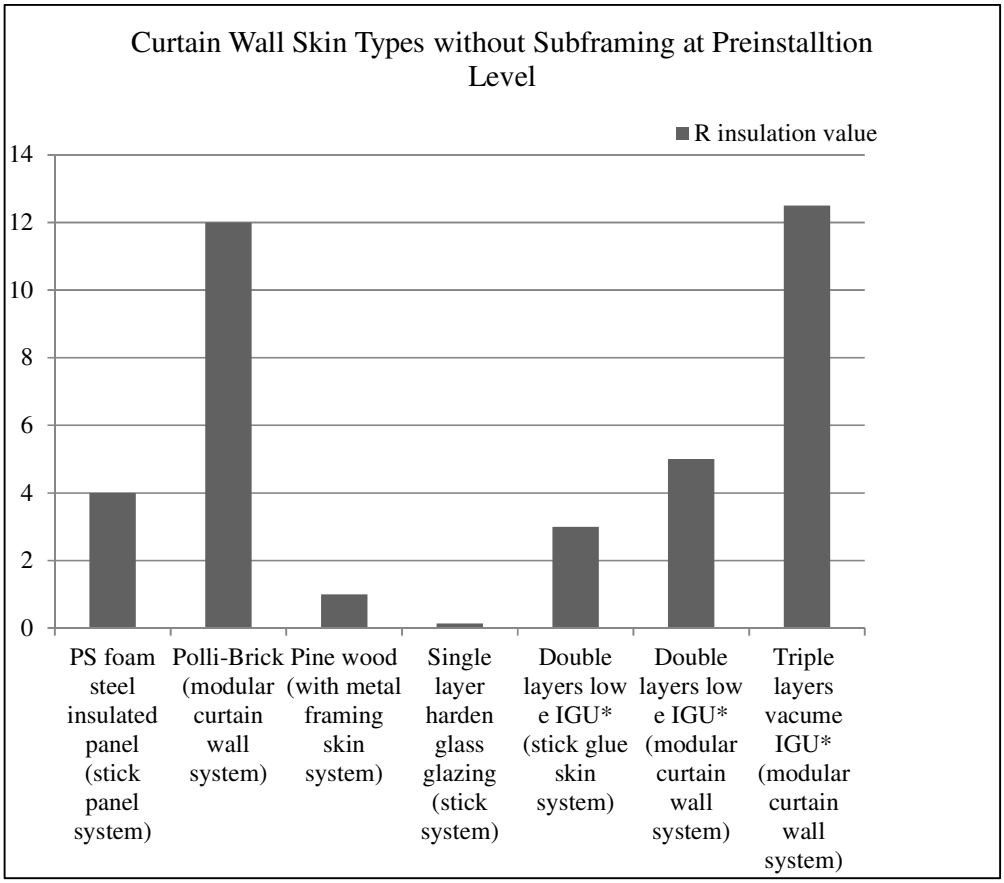
The indirect embodied energy is reduced as Polli-Bricks are made from post-consumer PET bottles. The incorporation of waste materials from industrial processes or households into usable building products reduces the waste stream and the demand on virgin natural resources (Kim, J. J. et al., 1998). Studies of Shen, L. et al. (2010) showed that bottle-to-fibre recycling can save 40 to 85 percent of non-renewable energy consumption and 25 to 75 percent global warming potential. The direct embodied energy is reduced due to its lightweight feature. It allows the reduction of fuel consumption during the transportation. This leads to lower embodied energy.

2.3.3 Good Insulation Properties

Insulation is the best way to reduce energy consumption and building operating costs (Kim, J. J. et al., 1998). The interlocking system of Polli-Brick panel gives a seamless surface to the structure. This provides the panel with better insulation properties.

The air-filled Poll-Bricks are able to enhance the thermal resistance of the structure. Thermal resistance is important especially to building materials serving the purpose as building envelope. Building enclosure is good when the thermal conductivity is low, meaning a high R-value. Besides the seamless structure, the PET plastic itself has good insulation properties.

The empty vessel of the Polli-Brick has a tested R-value of around R-6 which when compared to a glass curtain wall system, easily outperforms the R- 4.35 of double glazed, argon filled, and hard coat low-e system. It is proven that when a Polli-Brick is filling with nothing, is equivalent to 260 litre/square metre of air pocket insulation. Figure 2.2 represents the product testing of Polli-Bricks and it is shown that Polli-Brick wall panel has an insulation value of R-12 on the assembly.



Source: Miniwiz Sustainable Energy Development Ltd

Figure 2.2: R-insulation Value of Various Curtain Wall Skin Types

2.3.4 Improve Energy Efficiency (EE)

The population growth causes an increase in the demand for energy worldwide. This is followed by the increase in the carbon and GHG emissions. In order to address the global warming, energy efficient products are being pushed to the market. Depending on the type, the energy-efficiency of building materials can be measured using factors such as R-value, shading coefficient, luminous efficiency, or fuel efficiency (Kim, J. J. et al., 1998).

The translucent Polli-Bricks have good thermal insulation properties. Good thermal insulation enhances the thermal comfort while translucency allows sufficient daylight to penetrate into the building. The translucent units allow daylight to enter the building hence reducing the utility of electricity. The improved thermal comfort and day lighting are important to achieve energy efficiency (Akadiri, O. P., 2011).

2.3.5 Simple and Fast Installation

The installation of Polli-Bricks is simple. The wall panel is formed by stacking it together like a Lego-system. It is then sandwiched by the multilayer protection sheets and each brick will be locked with the bottle cap forming the panel. After that, it can be installed onto the structure.

Besides simple installation, Polli-Brick panel is lightweight. This allows the panel to be installed within the shortest period. In every project, time is crucial. Fast installation allows earlier occupancy of the building while reducing interest payment and capital outlays (Thanoon, W. A. et al., 2003). Easy installation reduces the chances of employing large heavy plants thus achieving cost-saving.

2.3.6 Indoor Air Quality (IAQ)

EPA studies have shown that IAQ is 2 to 5 times worse than the outdoor air quality (US EPA, 1992). Among the indoor air pollutants, VOCs are the major pollutants which create negative impact to human health as mentioned earlier. Polli-Bricks which are non-toxic and required no adhesive is believed to have a significant and long-lasting impact to the IAQ.

2.3.7 Aesthetic Value

Besides practicability, building aesthetic is always the concern to most of the design professionals like interior designers and architects. Aesthetic may not be the most important criterion but it can add some credits to the products or buildings.

The Polli-Brick itself has a unique polygonal shape. The structure formed by the interlocking units gives it a honeycomb appearance which is able to create a special print to the wall. It can be integrated with other features like LED lighting to give another visual sensation.

2.3.8 Recyclable and Reusable

3Rs concept indicates reduce, reuse and recycle. 'Reduce' consumption is the best solution in preventing more waste generation, and non-renewable and raw materials utilisation. However, when a product has been used, it is preferable to reuse it if necessary. Alternatively, it is better to recycle it as compared to other waste management methods like landfill disposal and incineration.

The assembling of Polli-Bricks does not require chemical cohesive, hence reducing the possible damages to Polli-Bricks during dissembling. This in turn

increases its reusability. Besides, it can also be fully recycled after service life (Miniwiz Sustainable Energy Development Ltd).

2.4 Current Application of Polli-Brick

Polli-Bricks were first being used as internal partition during the CES2009. After that, its application extended to performing as the building envelope to a nine-storey height box structure, namely EcoArk. Currently, the common applications of Polli-Bricks include internal walls and external cladding. Below are some projects taken from the Miniwiz Sustainable Development Ltd website, showing the current application of Polli-Bricks (Miniwiz Sustainable Energy Development Ltd).

EcoArk

Location: Taipei, Taiwan

Application: Building envelope

NIKE the Feather Pavillion

Location: Beijing, China

Application: Decorative wall

Eco House – Earth Day 2012

Location: Taipei Main Station – Taipei, Taiwan

Application: External wall

Besides internal partition and external wall, Polli-Brick can be used as ceiling, roofing and flooring. Its application is not only limited to as former mentioned. It is believed to have more other applications waiting to be explored.

2.5 Polli-Bricks versus Other Building Materials

2.5.1 Glass Curtain Wall System

There is an increasing trend in the application of glass curtain wall system to both high-rise and low-rise buildings. Besides aesthetic pleasant, glass curtain wall provides numerous advantages. The widespread of glass curtain wall system is a result of current emphasize of energy efficiency for sustainable development.

According to the standard module provided by Miniwiz, the Polli-Brick wall panel has a thickness of 36.8cm for exterior usage while 11.8cm and 17.8cm for interior usage. This is obviously much thicker than the glass wall panel. Thicker wall panel reduces the usable floor area in a building. This could be a shortcoming for

Polli-Brick wall panel if space is an important concern of the client. However, there is more air cavity within the Polli-Brick wall panel. Larger air cavity within the wall panel gives better thermal resistance properties (Aviram, D. P. et al., 2001).

One of the factors that make plastic application popular is its lightweight properties. Glass, on the other hand, is lighter than many other building materials like conventional bricks and blocks. However, the conventional glass wall panel is still heavier than Polli-Brick wall panel which is made from plastic. Polli-Brick facade is 1/5 lighter than conventional glass facade (Miniwiz Sustainable Energy Development Ltd).

According to Miniwiz, the Polli-Brick cladding system costs only ¼ of conventional glass cladding system. The construction costs can be saved due to the lightweight feature of Polli-Bricks. Lightweight feature of Polli-Bricks can also make the installation easier which in turn shorten the construction period needed.

Table 2.5: Simple Comparison between Polli-Brick and Conventional Glass Wall Panel

Elements	Polli-Brick	Conventional Glass Wall Panel
Physical Features		
Thickness	Thicker	Thinner
Weight	Lighter	Heavier
Translucency	Transparent and can be customized	Transparent and can be customized
Aesthetic	Honeycomb appearance	Classy and aesthetic pleasant

2.5.2 Green Building Materials in Malaysia

One of the challenges for Polli-Bricks to enter Malaysian construction industry is the competitive local market. In Malaysia, there are many other green building materials. The growing of sustainable awareness increases the demand towards green building materials. This leads to expanding in the market for green building materials. The latter section introduces a few examples of green building materials selected from Green Pages Malaysia which are available in Malaysia.

2.5.2.1 EXXOMAS Bio Brick

The application of clay bricks in Malaysian construction industry is common. It is inexpensive and easily available. Besides, the fire-proof clay bricks are durable and require very little maintenance. However, the CO_2 released during the manufacturing process of clay bricks causes high energy consumption and it is one of the contributors to global warming (Deboucha, S. and Hashim, R., 2011). In dealing with the environmental impacts caused by clay bricks, attempts were made to incorporate wastes into bricks production. Wastes which can be incorporated with the clay bricks include sludge, fly ash, polystyrene, processed waste tea, rice husk, pineapple leaves, straw, sawdust, tobacco residues, grass, paper, cigarette butts and others (Abdul Kadir, A., 2012).

EXXOMAS Bio Brick is made from dust particles generated by the industrial waste generator. The utilisation of industrial waste is able to reduce the consumption of virgin natural resources like sand, mud, clay or lime. Less energy input is required during the production and hence reducing the carbon dioxide emission. EXXOMAS Bio Brick has low thermal conductivity, which is three times lower than conventional clay bricks and seven times lower than concrete. The thermal resistance properties make the indoor environment to be three times cooler than using clay bricks (Green Pages Malaysia). The autoclaved unit results in cost saving on plastering.

2.5.2.2 Autoclaved Aerated Concrete (AAC) Block

Aerated concrete is a lightweight concrete which air voids are trapped in the mortar matrix by suitable aerating agent (Narayanan, N. et al., 2000). It utilises the industrial wastes like fly ash and slag as raw materials. The production of AAC Block consumes energy 2 to 3 times lower than other building materials such as burnt bricks (Green Pages Malaysia).

Besides lightweight properties, AAC Blocks are also good in thermal and sound insulation, durable, fire resistance, breathable, and non-toxic. Although it is lightweight due to the porosity, it creates higher chance for water and water vapour to trap within the block (Narayanan, N. et al., 2000). It was found that the thermal conductivity can goes six times higher in capillary water saturation state (Jerman, M. et al., 2013). Precautionary actions shall then be taken to overcome the poor hygric properties when using the AAC Blocks.

Table 2.6: Simple Comparison of Polli-Brick versus EXXOMAS Bio Brick and AAC Block

	Polli-Brick	**EXXOMAS Bio Brick**	**AAC Block**
Recycled Content	Plastic wastes (mainly PET plastics)	Industrial wastes as mentioned under Section 2.5.2.1	Industrial wastes as mentioned under Section 2.5.2.2
Sample size for normal exterior wall	6000ml/ approximately 350mm x 170mm x 170mm	215mm x 99mm x 64mm	600mm x 300mm x 200mm
Translucency	Transparent or none (can be customized accordingly)	No	No
Moisture resistance	High	Poor	Very Poor

2.6 Challenges of Implementing Green Building Materials in Malaysia

Malaysia is a country with vast amount of natural resources. This attracted many foreigners come over Malaysia for visit and investment. The demand from the local and foreign investors leads to an increasing demand in the construction industry in Malaysia. With the high demand in the construction industry, this creates a competitive Malaysian construction market.

The sustainable concept has begun to settle within Malaysian construction industry, however, it is still at an infancy stage (Abidin, N. Z., 2009). This is further supported by UNESCAP (2003) stating that environmental awareness in Malaysia is still the preliminary stage (Hong C.W. and Chan, N. W., 2010). Findings showed that the environmental awareness among the construction players and public is one of the important barriers for the implementation of sustainable building materials and technologies (bin Esa, M. R. et al., 2011). However, findings of Abidin, N. Z. (2009) showed that the developers are aware of the importance of sustainable construction yet there has no equivalent level of actions taken versus the level of environmental consciousness (D` Souza et al., 2006; Abidin, N. Z., 2009).

The low awareness among the society leads to low demand of the green building materials. The poor demand from the market is a crucial challenge for the sustainable building materials implementation (Choi, C., 2009). A review by Akadiri, O. P. (2011) stated that one of the barriers to use the sustainable materials is lack of demand from client but the idea circle of blame was found. Pinpointing occurred where party A say that party B do not demand for it while party B say that there is no supply from party A. Furthermore, in the research done by Abidin, N. Z. (2009) earlier, one of the reasons that led to low implementation level of sustainable practices was pointing fingers.

For every new product, there is always the uncertainty in the demand from the market. This issue becomes even more significant for the products made from recycled materials. There is poor demand for the recycled content goods (Gesing, A., 2004). The quality of the recycled content products is of doubt by consumers. People

tend to worry that the recycled content products are not as good and long lasting than the virgin content products.

Cost is the main concern of many investors and consumers. Higher costs results in a higher price and the costs will be transferred to the end users (Abidin, N. Z., 2009). Besides, it was found that one contributing barrier for the sustainable materials application is the real or perceived financial cost and risk (Akadiri, O. P., 2011). Another factor that hinders the implementation of green building materials is the low investments and participation from the Government and private companies in the green building movement (bin Esa, M. R. et al., 2011). Abidin, N. Z. (2009) suggested that government should pay more efforts in promoting sustainable construction through strong legislation enforcement, devising new policy, or providing incentives to developers who want to pursue sustainable projects.

Despite there are large amount of plastic wastes can be used to make the Polli-Bricks, there are still many challenges to be overcome before entering to Malaysian market successfully.

2.7 Efforts to Promote Green Building Materials in Malaysia

2.7.1 Green Building Index (GBI)

Green Building Index is a local assessment tool in building level. It was introduced on 3 January 2009 during the Green Design Forum organised by the Pertubuhan Akitek Malaysia (PAM). It is created to:

- define green building establishing a common language and standard of measurement;
- promote integrated, whole-building design that provides a better environment for all;
- recognise and reward environment leadership;
- transform the built environment to reduce its negative environment impact; and
- ensure new building remains relevant in the future and existing building are refurbished and upgraded to improve the overall quality of building stock.

Source: Green Building Index

GBI comprises of six key criteria which include Energy Efficiency (EE), Indoor Environmental Quality (EQ), Sustainable Site Planning & Management (SM), Material and Resources (MR), Water Efficiency (WE) and Innovation (IN). The application of green building materials is able contribute marks to the GBI points.

Each of the criteria is given a portion of points forming a total score of 100 points. The scoring portion of each criterion will be based on the projects. Currently, there are five GBI Building Rating Tools and the scoring distribution is shown on Table 2.7.

Table 2.7: Scoring Distribution based on Different GBI Rating Tools

GBI Rating Tools	Points Distribution of 6 Key Criteria						
	EE	EQ	SM	MR	WE	IN	TOTAL
Residential New Construction (RNC)	23	11	39	9	12	6	100
Non-Residential New Construction (NRNC)	35	21	16	11	10	7	100
Non-Residential Existing Building (NREB)	38	21	10	9	12	10	100
Industrial New Building (INB)	33	22	18	10	10	7	100
Industrial Existing Building (IEB)	38	22	10	8	12	10	100

Source: Green Building Index

Buildings will be assessed based on the six key criteria in order to get the green building certification. The GBI rating is classified into four levels which are Platinum, Gold, Silver and Certified.

Table 2.8: GBI Classification

POINTS	GBI RATING
86+ points	Platinum
76 to 85 points	Gold
66 to 75 points	Silver
50 to 65 points	Certified

Source: Green Building Index

2.7.2 Malaysia Green Building Confederation (MGBC)

MGBC is a non-profit making organisation to promote sustainable building in Malaysia supported by Pertubuhan Arkitek Malaysia (PAM) and Association of Consulting Engineers Malaysia (ACEM). It was officially registered in April 2009.

As efforts to promote green building development in Malaysia, MGBC has been actively organising and participating in the conferences, exhibitions and seminars (Mgbc.org.my., 2013).

2.7.3 Green Pages Malaysia

Green Pages Malaysia is the only directory for green building products and services in Malaysia. It was the effort of MGBC in promoting the utility of green building materials. It aims to help project sustainability in the built environment through the spread of awareness of available green building products in the market. The first edition was in 2011 while it will be updated from time to time. Besides the hardcopy edition, it is also available on the website.

In the product directories, there are many product data sheets. Under every product data sheet, it shows the applicable GBI credits of the product. This gives a clearer picture for users to check on the products' contribution to the green building index.

2.7.4 Conferences and Exhibitions

One of the efforts to increase the green building awareness of Malaysian society is through the exhibitions and conferences. Conferences are one of the sources of knowledge in enhancing the sustainability awareness (Abidin, N. Z., 2009).

Conference and exhibition are able to introduce new green building products from other places. Besides, it is also helpful in exchanging the knowledge and experience among the construction professionals. The examples of sustainable development related exhibitions and conferences that were held in Malaysia include ARCHIDEX, ECO-B Malaysia Eco Building and Design Exhibition, International Greentech & Eco Products Exhibition & Conference Malaysia (IGEM).

2.8 Conclusion

The inclined plastic waste need to be treated seriously while recycling it into building materials is one of the best solutions towards sustainable development. However, there are possible threats imposed to Polli-Bricks and other new green building materials to enter the local market. Various efforts are taken by the Government and construction players in wide spreading sustainable concepts among the Malaysian construction industry.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

Research methodology is a systematic way to find out the result on the research problem (Kothari, C. R., 2012). It is a science of studying how research is to be carried out. Research methodology describes the work plan of research. In this chapter, the research methodology of this research was described. In this chapter, the research methodology was described.

3.2 Research Design

Research design is a framework explaining the collection and analysis of data (Creswell, J. W., 2009; Bryman, A., 2012). The research design is essential to provide the foundation of the entire research work. There are many types of research design for example experimental design, cross-sectional design, longitudinal design, case study design and comparative design. Both cross-sectional design and longitudinal design employ self-completion questionnaire or interview. However, main distinction between the two designs is the time frame (Bryman, A., 2012). Longitudinal design takes longer duration and more costly than cross-sectional design but it allows study of phenomenon to be made (Rindfleisch, A. et al., 2008; Bryman, A., 2012).

In this research, due to the limited time frame, cross-sectional design was chosen. Mixed methods which combined the application of questionnaire and semi-structured interview were employed in the data collection.

3.3 Literature Review

Literature review is defined as *"the selection of available documents (both published and unpublished) on the topic, which contain information, ideas, data and evidence written from a particular standpoint to fulfil certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed."* (Hart, C., 1998). It was carried out to strengthen the validity of the information (Bryman, A., 2012). Literature review allowed the researcher to have better understanding on the topic studied. In this research, the literature review was being done through reviewing the articles journals, dissertations, books, official reports, and other useful websites. It is not as simple as just summarization. In fact, only important and useful information were chosen and included in this research paper in order to support the findings.

3.4 Data Collection Method

3.4.1 Mixed Method Approach

Mixed method approach is the combination of both quantitative and qualitative research methods. The idea of mixed method was originated in 1959 (Creswell, J. W., 2009). Mixed method was employed in this research as it provided a more comprehensive data for the enquiry (Bryman, A., 2012).

Quantitative research involves the collection of numerical data which aims to find out the relationship between the variables (Creswell, J. W., 2009; Bryman, A., 2012). It is measured with numbers and analysed using statistical techniques. In this research, questionnaire was use as the tool for quantitative approach.

Qualitative research allows researchers to explore and understand the social behaviours through empirical inquiry with individuals or groups (Creswell, J. W., 2009). The qualitative approach used in this research was semi-structured interview. The greatest advantage of semi-structured interview is the allowance of flexibility (Bryman, A., 2012).

3.5 Data Collection Tool

3.5.1 Survey Questionnaire

The self-administered questionnaire was used in this research. The questions were set to find out the sustainability awareness among Malaysian construction professionals, challenges and strategies of implementing Polli-Bricks in Malaysia. According to Bryman, A. (2012), self-administered questionnaire is low cost, time-saving, and convenient for respondents.

An introduction was given to brief the respondents on the research topic, aim and objectives. It was then followed by a quick summary of Polli-Bricks which was made based on the brochure. This could make the respondents to have a brief knowledge on Polli-Bricks.

There were two sections for the self-administered questionnaire. Section A was the personal particulars of the respondents. Section B was questions to achieve the research objectives. Rating questions and multiple choices with multiple answers were used in the survey questionnaire.

The questionnaires were sent to Architects and GBI facilitators (GBIFs) in Malaysia by email. The brochure was attached together in the email for respondents to have more detailed and better understanding on Polli-Bricks.

3.5.2 Semi-Structured Interview

In this research, two semi-structured interviews were conducted with two interviewees. The semi-structured interviews were conducted through email and face to face. Face-to-face interview or in-person interview is the most common form of survey data collection (Lavrakas, P. J., 2008). Email interviewing is expected to be become popular due to the easy access of internet nowadays (Meho, L. I., 2006). The advantages ('+' sign) and disadvantages ('-' sign) in terms of time, cost and data quality of both email and face-to-face interviewing are summarised in Table 3.1.

Table 3.1: Pros and Cons between Email Interviewing and Face-to-Face Interviewing

Elements	Email Interviewing	Face-to-face Interviewing
Time	+ Eliminates time of travelling and making appointment - Longer duration as time is needed to wait for the reply	+ Short duration as answers can be acquired right after questions raised - Time of travelling and making appointment
Cost	+ Eliminates expenses of travelling	- Expenses of travelling (not so significant if the travel distance is short)
Data quality	+ Data are more focused on questions asked + Easy to obtain systematic answers as more time for participants to convey opinions and experience systematically - In-depth information is not always easy to obtain	+ In-depth information is easier and quicker to obtain - Clear and systematic responses are obtained only when participants are focused during the interview

First interview was conducted through email with the expert in Taiwan who has experience in dealing with Polli-Bricks. The interview was mainly to find out challenges faced and strategies employed for the implementation of Polli-Bricks to overseas.

The second semi-structured interview was conducted face to face with an expert who is active in the sustainable development of Malaysian construction industry. The second interview aimed to find out the interviewee's opinions on potentials, challenges and strategies of Polli-Bricks implementation in Malaysia.

3.6 Data Analysis

Statistical Package for Social Sciences (SPSS) is software for data analysis with comprehensive statistical tests. SPSS 20.0 was used in carrying out the data analysis in this research.

3.6.1 Frequency Analysis

Frequency analysis was used to analyse the frequencies or percentage for the demographic of respondents which included the respondents' profession and working experience. The frequency tables were further interpreted in pie chart and bar chart to give a clearer view of the frequency. Mean or average index of the data was calculated.

3.6.2 Relative Importance Index (RII) Analysis

Relative Importance Index (RII) analysis was employed to measure the Likert (ordinal) scale. In this study, five scale rating was used and the weight was give as below:

1 – *Strongly Disagree/ Most Important*;
2 – *Disagree/ Of Little Importance*;
3 – *Neutral/ Moderately Important*;
4 – *Agree/ Important*;
5 – *Strongly Agree/ Most Important*

The RII was calculated by using the formula as below (Othman, A. A. et al., 2005):

$$RII = \frac{\Sigma w}{AN}$$

Where,

w = weight of scale;

A = highest weight ('5' in this case);

N = total number of respondent

3.7 Research Framework

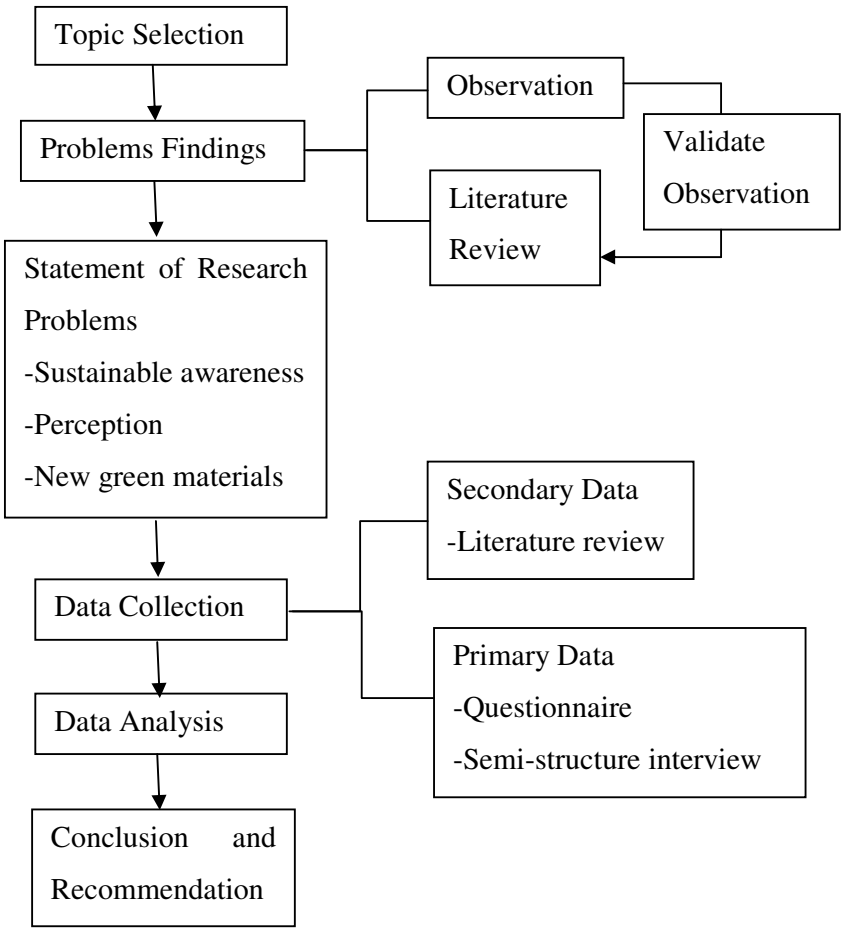


Figure 3.1: Research Framework

3.8 Conclusion

This chapter illustrated the methods and procedure employed in acquiring the data and results to solve the research questions. Mixed method approach was selected to get a more detailed Malaysian construction professionals' sustainability awareness level, challenges and strategies for the implementation of Polli-Bricks in Malaysia. Three methods used to collect the primary and secondary data which included literature review, survey questionnaire and semi-structured interview. Frequency analysis and RII analysis were used to interpret the data collected.

CHAPTER 4

ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter discussed the analysis outcome from the data collected. It covered questionnaires analysis, semi-structured interview and discussion of the findings. The questionnaires were distributed to Architects and GBIFs in Malaysia. The questionnaires were set to find out the sustainability awareness among Malaysian construction professionals, challenges and strategies for implementation of Polli-Bricks in Malaysia. The data was analysed by calculating the frequencies, mean and other related tests. On the other hand, the semi-structured interviews were conducted with the Polli-Brick design company based in Taiwan through email in order to find out the challenges faced by them in promoting Polli-Bricks and strategies taken to promote the product. Another semi-structured interview was conducted with one of the GBIFs to find out the potentials, challenges and strategies for the implementation of Polli-Bricks in Malaysia. Discussion on the results was made to render a better insight and understanding of the research.

4.2 Questionnaire Analysis

The data was analysed based on the data collected from the respondents which consisting Architects and GBIFs. 500 questionnaires were sent out by email and 50 sets were returned to the researcher. The return rate of less than 10% was rather low.

4.2.1 Questionnaire Analysis: Section A

4.2.1.1 Profession

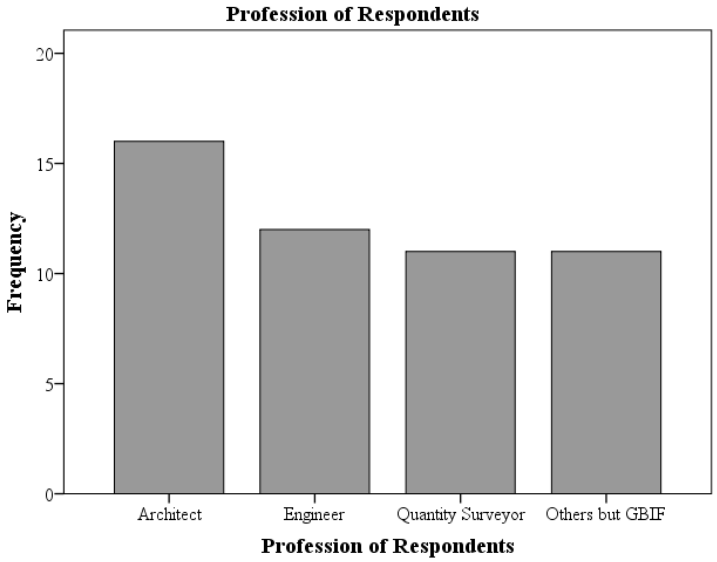


Figure 4.1: Profession of Respondents

Table 4.1: Profession of Respondents

		Frequency	Percent	Cumulative Percent
Valid	Architect	16	32.0	32.0
	Engineer	12	24.0	56.0
	Quantity Surveyor	11	22.0	78.0
	Others but GBIF	11	22.0	100.0
	Total	50	100.0	

The profession categories of all respondents are shown in Table 4.1 and Figure 4.1. Majority of the respondents are Architects, which is accounted for 16 (32%) respondents. The second largest group of respondents is Engineer which consists of 12 (24%) respondents. There are 11 (22%) respondents work Quantity Surveyors. The rest of the 11 (22%) respondents are from other construction professions who at the mean time are also GBIFs.

4.2.1.2 Working Experience

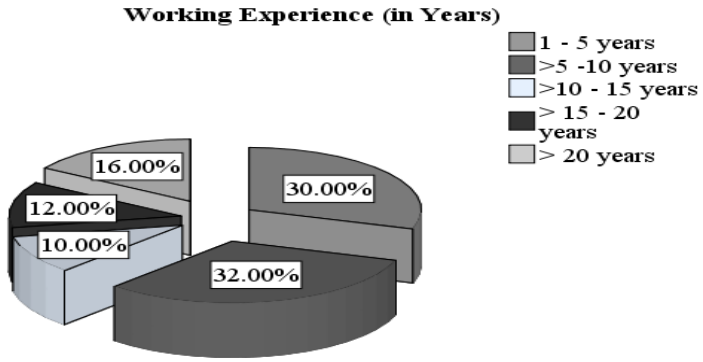


Figure 4.2: Working Experience of Respondents (in years)

Table 4.2: Working Experience of Respondents (in years)

		Frequency	Percent	Cumulative Percent
Valid	1 - 5 years	15	30.0	30.0
	>5 -10 years	16	32.0	62.0
	>10 - 15 years	5	10.0	72.0
	> 15 - 20 years	6	12.0	84.0
	> 20 years	8	16.0	100.0
	Total	50	100.0	

From Figure 4.2 and Table 4.2, it is shown that 15 respondents (equivalent to 30%) have 1 to 5 years of experience. 16 respondents (equivalent to 32%) have 5 to 10 years of experience. 5 respondents (equivalent to 10%) have 10 to 15 years of experience. 6 respondents (equivalent to 12%) have 15 to 20 years of experience. There are 8 respondents who have more than 20 years of experience which make up 16% of the overall respondents.

4.2.2 Questionnaire Analysis: Section B

4.2.2.1 Sustainability Awareness, Challenges and Strategies for Polli-Brick Implementation

Table 4.3: Recycling is a Better MSWM Method Comparing to Landfill and Incineration

		Frequency	Percent	Cumulative Percent
Valid	Neutral	2	4.0	4.0
	Agree	17	34.0	38.0
	Strongly Agree	31	62.0	100.0
	Total	50	100.0	

From Table 4.3, it can be justified that none of the respondents 'Strongly Disagree' and 'Disagree' that recycling is a better MSWM method comparing to landfill and incineration. 2 respondents or 4% of respondents neither agree nor disagree that recycling is batter solution to manage the MSW. 17 respondents which equivalent of 34% respondents agree that recycling is a better way to manage the MSW. Majority of the respondents strongly agree that recycling is a good way to manage the MSW it is made up of 31 respondents or equivalent to 62% respondents.

Table 4.4: Construction Industry Consumes Vast Amount of Natural Resources and Raw Materials

		Frequency	Percent	Cumulative Percent
Valid	Disagree	2	4.0	4.0
	Neutral	2	4.0	8.0
	Agree	16	32.0	40.0
	Strongly Agree	30	60.0	100.0
	Total	50	100.0	

Based on the Table 4.4, none of the respondents 'Strongly Disagree' that construction industry consumes vast amount of natural resources and raw materials. However, 2 respondents or equivalent to 4% of respondents disagree that construction industry consumes large quantity of natural resources and raw materials. 2 respondents or 4% respondents are neutral on the natural resources consumption by construction industry. 16 respondents which are 32% of the respondents agree that construction industry has huge consumption of natural resources and raw materials. More than half of the respondents which is 60% of respondents and consists of 30 respondents strongly agree that construction industry consumes large amount of natural resources and raw materials.

Table 4.5: Recycled-Content Building Materials Greatly Reduce the MSW

		Frequency	Percent	Cumulative Percent
Valid	Disagree	1	2.0	2.0
	Neutral	4	8.0	10.0
	Agree	23	46.0	56.0
	Strongly Agree	22	44.0	100.0
	Total	50	100.0	

According to Table 4.5, minority of respondents are at disagreeing side which no respondent 'Strongly Disagree' and only one respondent (2%) disagrees that recycled content can greatly reduce the MSW. 4 respondents (8%) neither agree nor disagree that MSW can be reduced by recycling it to building materials. Majority of respondents are at agreeing side which consists of 23 (46%) 'Agree' scale and 22 (44%) 'Strongly Agree' scale.

Table 4.6: Green Building Materials Important towards Sustainable Development

		Frequency	Percent	Cumulative Percent
Valid	Neutral	3	6.0	6.0
	Agree	13	26.0	32.0
	Strongly Agree	34	68.0	100.0
	Total	50	100.0	

From Table 4.6, almost all of the respondents are showing positive attitude for the important role of green building materials towards sustainable development. None of the respondents 'Strongly Disagree' and 'Disagree' that green building materials are important towards sustainable development. 3 respondents (6%) are 'Neutral', 13 respondents (26%) are 'Agree' while 34 respondents (68%) are 'Strongly Agree' that green building materials are contributory factor towards sustainable development.

Table 4.7: Demand of Green Building Materials in Malaysian Construction Industry

		Frequency	Percent	Cumulative Percent
Valid	Very Poor	2	4.0	4.0
	Poor	16	32.0	36.0
	Good	26	52.0	88.0
	Very Good	6	12.0	100.0
	Total	50	100.0	

The rating scale being used for this question is from 1 – 'Very Poor' to 5 – 'Excellent'. Based on Table 4.7, none of the respondents rate the green building materials demand in Malaysian construction industry as 'Excellent'. In fact, more than a quarter of respondents rate the demand level at negative side which 2 (4%) respondents rate the demand as 'Very Poor' whereas 16 (32%) respondents rate the demand as 'Poor'. On the other hand, 26 (52%) respondents rate the demand as 'Good' while 6 (12%) respondents look at the demand of green building materials in Malaysian construction industry as 'Very Good'.

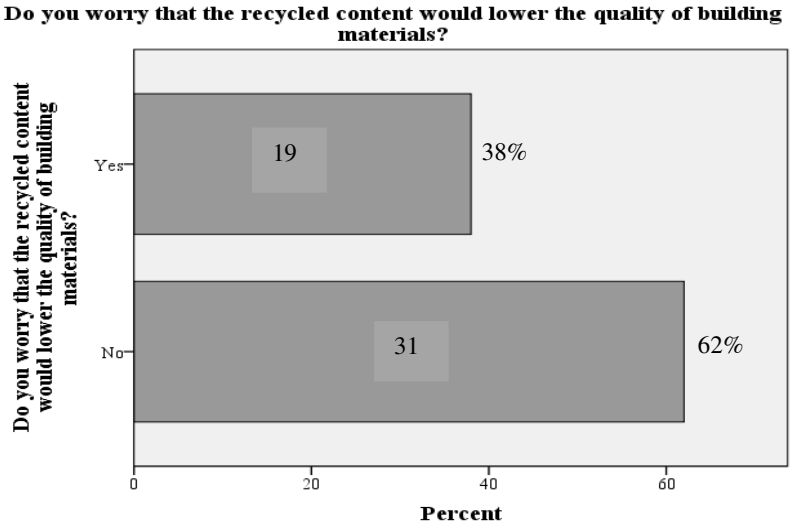


Figure 4.3: Worries of Recycled Content Affect Quality of Building Materials

Based on Figure 4.3, 38% or 19 respondents are worried that the recycled content would reduce the quality of building materials. The other 62% or 31 respondents are not worried that recycled content results a poor quality of building materials.

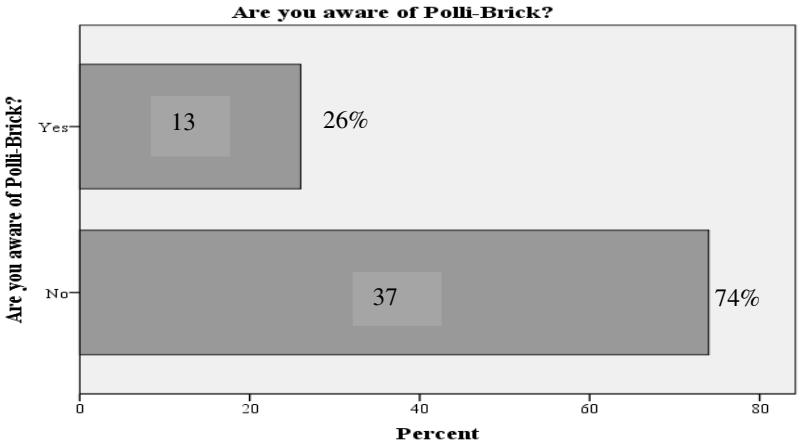


Figure 4.4: Level of Awareness towards Polli-Brick

According to Figure 4.4, majority of the respondents are still not aware of Polli-Brick. Only 26% or 13 respondents are aware of Polli-Brick while the remaining 74% or 37 respondents have not heard of Polli-Brick.

Table 4.8: Awareness towards Polli-Brick Cross-tabulation

Professions		Awareness towards Polli-Brick		
		No	Yes	Total
Architect	Count	13	3	16
	Awareness towards Polli-Brick in %	35.1%	23.1%	32.0%
Engineer	Count	10	2	12
	Awareness towards Polli-Brick in %	27.0%	15.4%	24.0%
Quantity Surveyor	Count	8	3	11
	Awareness towards Polli-Brick in %	21.6%	23.1%	22.0%
Other but GBIF	Count	6	5	11
	Awareness towards Polli-Brick in %	16.2%	38.5%	22.0%
Total	Count	37	13	50
	Awareness towards Polli-Brick in %	100.0%	100.0%	100.0%

Table 4.8 shows the awareness towards Polli-Bricks according to the position of respondents. Although Architect takes the highest portion among all other professionals, the level of awareness towards Polli-Brick is not the highest which is only 3 out of the 16 Architects. Comparatively, respondents from other professions but who are GBIF, even though has the same portion with the Quantity Surveyor yet having the highest level of awareness towards Polli-Bricks which is 5 out the 11 respondents.

Out of the 13 respondents, one respondent aware of Polli-Brick through an overseas exhibition, one respondent from IEM publication, 3 respondents from newspaper, 4 respondents from internet, and 4 respondents from TV programme.

Table 4.9: Ranking for Polli-Brick Criteria in the Application as External Façade and Internal Partition

	External Façade			Internal Partition		
Criteria	Relative Importance Index	Std. Deviation	Rank	Relative Importance Index	Std. Deviation	Rank
Aesthetic	0.74	0.141	5	0.79	0.153	4
Performance	0.83	0.110	3	0.82	0.145	3
Cost	0.76	0.132	4	0.82	0.156	3
Durability	0.85	0.095	1	0.85	0.139	1
Environmental Impacts	0.84	0.109	2	0.84	0.160	2

The existing applications of Polli-Brick are external façade and internal partition. The above are the five (5) criteria to be considered when choosing the building materials for the two existing applications of Polli-Brick. Based on Table 4.9, all five criteria possess the same or similar ranking. First of all, durability is the main concern by respondents for both applications. The second important criteria for both applications are also the same which is the environmental impacts. There are three criteria having the third rank, which is the performance (for both external façade and internal partition) and cost (for internal partition) issues. However as for overall, performance is at the third ranking. For external façade, cost is the fourth concern of respondents. Next is the similar ranking presented by aesthetic criterion, it is the least important factor to the respondents while considering the criteria for external façade and internal partition.

Table 4.10: Respondents' Preference on Advantages of Polli-Brick

Profession of Respondents	High strength to weight ratio	Low embodied energy	Good insulation properties	Tendency to improve energy efficiency	Fast and easy installation	Least impact to Indoor Air Quality (IAQ)	Aesthetic value	Tendency to improve salvage value
Architect								
RII	0.85	0.76	0.88	0.89	0.74	0.75	0.83	0.61
Std. Deviation	0.155	0.131	0.100	0.126	0.141	0.115	0.144	0.115
Engineer								
RII	0.90	0.80	0.90	0.92	0.75	0.83	0.82	0.67
Std. Deviation	0.135	0.148	0.160	0.103	0.124	0.115	0.159	0.156
Quantity Surveyor								
RII	0.80	0.78	0.80	0.85	0.82	0.82	0.80	0.67
Std. Deviation	0.155	0.166	0.155	0.129	0.166	0.108	0.126	0.135
Other but GBIF								
RII	0.87	0.78	0.87	0.89	0.73	0.78	0.75	0.69
Std. Deviation	0.162	0.166	0.101	0.104	0.185	0.060	0.093	0.164
Total								
RII	0.86	0.78	0.86	0.89	0.76	0.79	0.80	0.66
Std. Deviation	0.151	0.147	0.131	0.115	0.153	0.107	0.134	0.140
Overall Ranking	2	5	2	1	6	4	3	7

**RII = Relative Importance Index*

By referring to Table 4.10, the most important advantage of Polli-Brick to respondents is 'tendency to improve energy efficiency' (RII = 0.89). It is followed by 'high strength to weight ratio' and 'good insulation properties' (RII = 0.86), 'aesthetic value' (RII = 0.80), 'least impact to IAQ' (RII = 0.79), 'low embodied energy' (RII = 0.78), 'fast and easy installation' (RII = 0.76), and 'tendency to improve salvage value' (RII = 0.66).

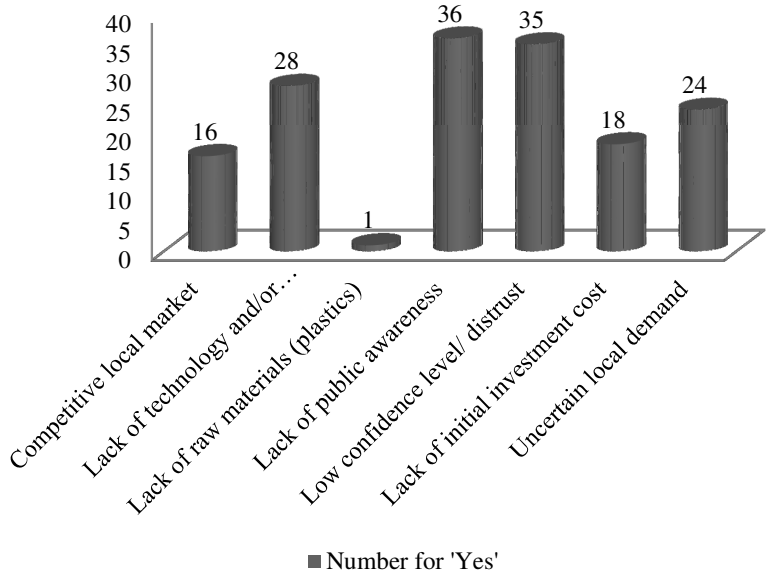


Figure 4.5: Possible Challenges for Polli-Brick Implementation

Table 4.11: Potential Challenges for Polli-Brick Implementation

			Profession of Respondents				
			Architect	Engineer	Quantity Surveyor	Other but GBIF	Total
Potential Challenges[a]	Competitive local market	Count	5.7	3	4	4	16
		% within Professions	31.3%	25.0%	36.4%	36.4%	
	Lack of technology and/or expertise	Count	10.3	3	6	9	28
		% within Professions	62.5%	25.0%	54.5%	81.8%	
	Lack of raw materials (plastics)	Count	1	0	0	0	1
		% within Professions	6.3%	.0%	.0%	.0%	
	Lack of public awareness	Count	14.1	8	7	7	36
		% within Professions	87.5%	66.7%	63.6%	63.6%	
	Low confidence level/ distrust	Count	11.2	8	7	9	35
		% within Professions	68.8%	66.7%	63.6%	81.8%	
	Lack of initial investment cost	Count	6.5	2	4	6	18
		% within Professions	37.5%	16.7%	36.4%	54.5%	
	Uncertain local demand	Count	7.4	4	8	5	24
		% within Professions	43.8%	33.3%	72.7%	45.5%	
Total		Count	16	12	11	11	50

Figure 4.5 and Table 4.11 illustrate the potential challenges faced by Polli-Brick if it were to be implemented in Malaysia. The sequence for the potential challenges ranking is: (1) lack of public awareness; (2) low confidence level or distrust; (3) lack of technology and/ or expertise; (4) uncertain local demand; (5) lack of initial investment cost; (6) competitive local market; (7) lack of plastic as raw materials.

From Table 4.11, it can be observed that the potential challenges agreed by Architects are having the same trend as the overall ranking. To Engineers and Quantity Surveyors, uncertain local demand is the most critical potential challenge. It is then followed by lack of public awareness and low confidence level. Other professions in opinion that lack of technology and/or expertise and low confidence level are the most and equivalent important challenges that need to be considered. Lack of raw materials does not seem to be a problem for the implementation of Polli-Bricks in Malaysia as only one of the 50 respondents agreed with it.

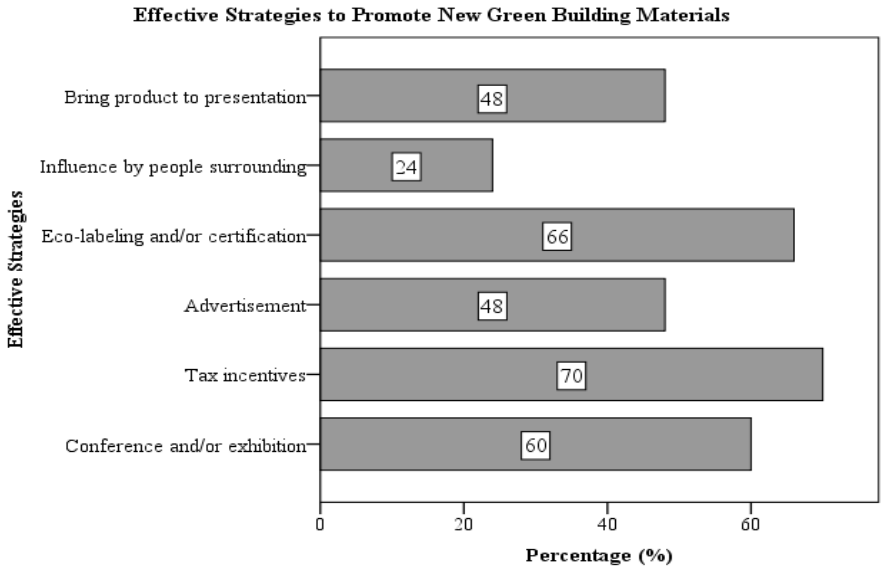


Figure 4.6: Effective Strategies to Promote New Green Building Materials

Table 4.12: Effective Strategies to Promote New Green Building Materials

			Profession of Respondents				
			Architect	Engineer	Quantity Surveyor	Other but GBIF	Total
Effective Strategies[a]	Conference and/or exhibition	Count	14	5	7	4	30
		% within Professions	87.5%	41.7%	63.6%	36.4%	
	Tax incentives	Count	12	10	7	6	35
		% within Professions	75.0%	83.3%	63.6%	54.5%	
	Advertisement	Count	8	4	4	8	24
		% within Professions	50.0%	33.3%	36.4%	72.7%	
	Eco-labeling and/or certification	Count	11	7	7	8	33
		% within Professions	68.8%	58.3%	63.6%	72.7%	
	Influence by people surrounding	Count	7	1	0	4	12
		% within Professions	43.8%	8.3%	.0%	36.4%	
	Bring product to presentation	Count	11	4	5	4	24
		% within Professions	68.8%	33.3%	45.5%	36.4%	
Total		Count	16	12	11	11	50

Percentages and totals are based on respondents.
a. Dichotomy group tabulated at value 1.

Figure 4.6 presents the effective strategies voted by respondents to promote green building materials. The ranking for the effective strategies is: (1) tax incentives; (2) eco-labeling/ certification; (3) conference and/ or exhibition; (4) advertisements; (4) bring product to presentation; (5) influence by people surrounding. 'Advertisements' and 'bring product to presentation' are having the same number of votes of 24 hence they have the same ranking.

A cross tabulation of the profession of respondents and the effective strategies is presented on Table 4.12. From the table, it is found that majority (87.5%) of Architects agrees that conference and/or exhibition is the most effective strategy to promote green building materials. It is then followed by tax incentive which is agreed by 75% of the Architects. Eco-labeling appears to be the third useful strategy to promote green building materials which is agreed by 68.8% of the Architects. To Engineers, tax incentive is the most effective strategy to promote green building materials which 83.3% of them agreed with it. Eco-labeling is the second most effective strategy among Engineers (58.3%) to promote green building materials. For Quantity Surveyors, conference and/or exhibition, tax incentives and eco-labeling are equally effective in promoting green building materials. However, the 63.6% is still not as high as the first most effective strategy of Architects and Engineers. Respondents which are from other professions but GBIFs give advertisement and eco-labeling the most votes in promoting green building materials.

Table 4.13: Influential Level of Various Parties in Materials Selection

Profession of Respondents		Client	Architect and/or designer	Quantity Surveyor	Engineer	Product supplier
Architect	RII	0.88	0.93	0.51	0.63	0.48
	N	16	16	16	16	16
	Std. Deviation	0.191	0.100	0.231	0.144	0.218
Engineer	RII	0.92	0.88	0.53	0.57	0.37
	N	12	12	12	12	12
	Std. Deviation	0.103	0.103	0.098	0.253	0.239
Quantity Surveyor	RII	0.93	0.89	0.47	0.55	0.40
	N	11	11	11	11	11
	Std. Deviation	0.101	0.187	0.185	0.221	0.126
Other but GBIF	RII	0.82	0.93	0.49	0.56	0.31
	N	11	11	11	11	11
	Std. Deviation	0.140	0.135	0.187	0.196	0.104
Total	RII	0.88	0.91	0.50	0.58	0.40
	N	50	50	50	50	50
	Std. Deviation	0.146	0.129	0.182	0.199	0.192
	Overall Ranking	2	1	4	3	5

According to Table 4.13, the most influencing parties in material selection is Architect and/ or designer (RII = 0.91). Client or developer is second influential (RII = 0.88). Engineer plays the third influential parties in material selection (RII = 0.58). The fourth position is taken by Quantity Surveyor (RII = 0.50). Supplier has the lowest influencing level towards the materials selection (RII = 0.40). Respondents from Architect and other professions agreed that Architect and/ or designers have the greatest influence towards the materials selection. However, respondents from Engineer and Quantity Surveyor professions place Client at the highest influential level towards materials selection. For the influential level of Quantity Surveyor, Engineer and product supplier are having the same ranking trend as the overall ranking regardless the respondents' professions.

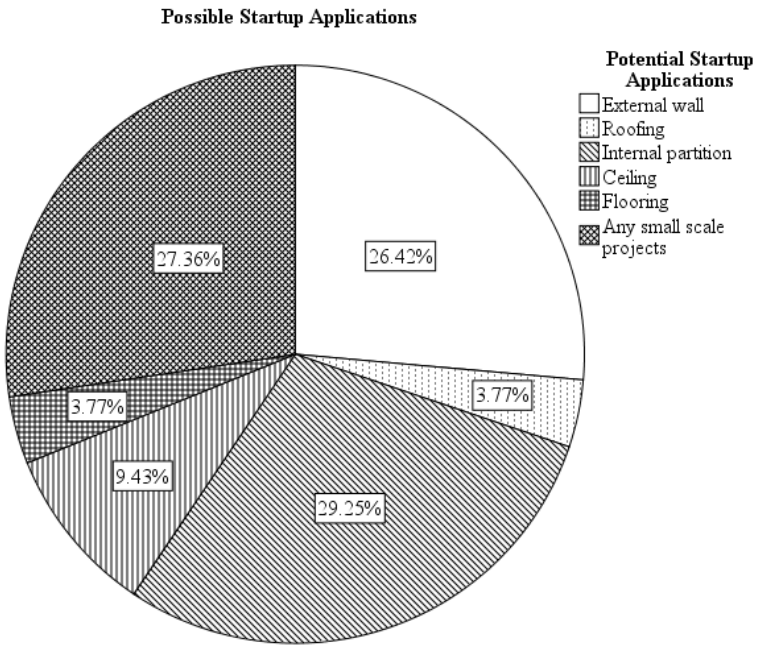


Figure 4.7: Potential Start-Up Applications

Table 4.14: Potential Start-Up Applications

		Responses		Percent of Cases
		N	Percent	
Startup Applications[a]	External wall	28	26.4%	57.1%
	Roofing	4	3.8%	8.2%
	Internal partition	31	29.2%	63.3%
	Ceiling	10	9.4%	20.4%
	Flooring	4	3.8%	8.2%
	Any small scale projects	29	27.4%	59.2%
Total		106	100.0%	216.3%

a. Dichotomy group tabulated at value 1.

According to Figure 4.6 and Table 4.14, internal partition is at the first position (29.25%). It is then followed by 'any small scale projects' (27.36%). Next, the third ranking falls to external wall (26.42%). Ceiling is the fourth highest application (9.43%). Roofing and flooring are having the 3.77% out of 100% makes the possible applications to be ranked 5.

4.3 Semi-Structured Interview

4.3.1 Interviewee 1

First interview was conducted with the expert from Taiwan. Interviewee 1 has knowledge and experience in dealing with Polli-Bricks. The purpose of the first interview was to find out the challenges faced by MINIWIZ, strategies taken to promote Polli-Bricks and other issues related to Polli-Bricks.

During the researcher's visit to EcoArk in Taiwan, the researcher observed that the Polli-Brick wall panel seemed to be lack of maintenance. Therefore, a question was asked regarding the maintenance of the Polli-Bricks and its wall panel. According to interviewee 1, Polli-Bricks itself do not need maintenance. It has lifespan of up to 25 years, at which at the end of the product lifecycle, it is less effective due to extreme UV exposure. Indoor Polli-Bricks have longer life span. The period and methods of maintenance are subjected to the owner's preference.

Until today, the application of Polli-Bricks is mainly focus in Taiwan and China. Therefore, a question was asked regarding the problems or challenges faced when promoting Polli-Bricks to other countries. According to interviewee 1, the main challenges faced is not having a local partner who can be trusted or full branch office in the new market.

On the other hand, strategy employed to promote Polli-Bricks included participating in trade shows, events and conferences. The participation was not merely to promote Polli-Bricks. It was an effort to share the awareness on green building materials and the future of the industry.

4.3.2 Interviewee 2

An interview was conducted face to face with one of the GBIFs. Interviewee 2 is active in sustainable development in Malaysia and has knowledge with Polli-Bricks. The interview aimed to find out the potentials, challenges and strategies for the implementation of Polli-Bricks in Malaysian construction industry.

4.3.2.1 Potentials

According to interviewee 2, there are potentials for Polli-Bricks to be implemented in Malaysia as some people may like the unique design of Polli-Bricks which can make the building to be an iconic building. Besides, interviewee 2 strongly agreed that recycling is a better solution to manage the MSW compared to landfill and incineration. The implementation of Polli-Bricks might be able to reduce landfill.

4.3.2.2 Challenges

Plastic wastes can be collected from dumping site and other waste management bodies. However, the plastic wastes collected are dirty and impure. Pure raw materials or plastic waste are needed to produce high quality Polli-Bricks. Problems would arise in acquiring pure and clean raw materials. The problems include costs, time and facilities to process the plastic wastes to clean and pure raw materials for Polli-Bricks production.

Next problem that has to be considered is the supply consistency. This problem might not be a problem in the short-run as the quantity might not be large enough to affect the current supply. However, it will become significant as time goes by. When the demanded quantity is low, the supply may be acquired from one site. However, when the when the demand increases, more supply sources will be needed. Then, location of the other supply sources creates another problem. The long distance can cost extra transport fees meanwhile increase the embodied energy to the material production.

Polli-Bricks are produced through mechanical recycling process. During the melting process of plastic wastes, harmful gases might be released to the environment. This could defeat the purpose of having green building materials. On top of that, if the Polli-Bricks were to produce in bulk, it might disturb the current strategies in dealing with plastic wastes.

Next, locality is another challenge. As Polli-Brick is a very new building material to Malaysian construction industry, expertise and labour skills from the production to installation might become another challenge. Special machine is needed to produce the Polli-Bricks. Availability of machine, expertise and labour skills locally are the issues that should be looked into. It would be expensive and bring not much benefit to local plastic wastes if Polli-Bricks could not be produced locally. Higher costs might be incurred due to availability unless the client is low cost concern.

In most of the time, the initial costs of going green are higher than the conventional ways. Furthermore, the users can only benefit from it in long-term which to them is rather indirect, for example impacts on health and to environment. People might not be able to appreciate the long-term benefits of these green technologies. For example, developers would spend the least costs for maximum profit. On the other hand, buyers are more willing to purchase a house at lower price says other alternatives are having the similar characteristics. Most of the people are more concerned about the direct return, for example, lower price.

4.3.2.3 Strategies

Demonstration project was suggested as one of the strategies to introduce Polli-Bricks in Malaysia. By having a demonstration project locally, it is able to gain confidence from local society. This can be achieved whereby supplier reduces the profit margin by matching it with cost of the initial proposed building material to a project. By doing so, it increases the client's chance to accept the proposed new material and the supplier is able to promote his product.

Another strategy proposed was by aiming the most influential parties in the project. During the interview, interviewee 2 shared the 'Time vs. Level of Influence' principle to explain this strategy. When promoting a product, it is always better to start from parties who have higher authority or decision making power as less time would be needed to get the final decision and approval. Most of the time, client and Architect are the category of 'high influential level'. The importance of contractor in influencing the materials selection was highlighted. Contractor can influence the material selection by making counter proposal. However, the influential level is somehow depends on the structure of the particular project.

Besides talking directly to the parties with higher influential level, other parties should not be neglected. A '3 x 3 x 3' principle was explained by interviewee 2. This theory explained the importance of every party in the construction industry. In every project, it involves many parties. Some have decision making power but some have no. Despite without the decision making power, they might have certain influential level. Therefore, promoting the product should not be just focus on the 'main characters' but spreading it to as many people as possible.

4.4 Discussion

4.4.1 Discussion on Sustainability Awareness among Construction Professionals in Malaysia

From the analysis, the awareness on sustainability among the Malaysian construction professionals is in satisfactory level. The average index and standard deviation for statements to test the sustainability awareness is shown on Table 4.15.

Table 4.15: Statements for Sustainability Awareness

Statements	Average Index	Std. Deviation
Recycling is a better MSWM method comparing to landfill and incineration.	4.58	0.575
Construction industry consumes vast amount of natural resources and raw materials.	4.48	0.762
Recycled-content building materials can greatly reduce the MSW.	4.32	0.713
Green building materials play an important role towards sustainable development.	4.62	0.602

The rating scale is illustrated as below (Majid. A and McCaffer, R., 1997):

Rating Scale	Importance Index Range	Attributes of Indices
1	$0.00 \leq$ Average Index < 0.30	Strongly Disagree/Least Important
2	$0.30 \leq$ Average Index < 0.50	Disagree/Of Little Important
3	$0.50 \leq$ Average Index < 0.70	Neutral/Moderately Important
4	$0.70 \leq$ Average Index < 0.90	Agree/Important
5	$0.90 \leq$ Average Index < 1.0	Strongly Agree/Most Important

Out of the four statements, two statements have average index falls under 'Strongly Agree' category. Respondents strongly agree that recycling is a better solution for MSWM (average index = 4.58) and recycled-content building materials can greatly reduce the MSW (average index = 4.62). Overall, respondents agree that construction industry consumes large amount of natural resources and raw materials (average index = 4.48) and green building materials are important towards sustainable development (average index = 4.32).

In addition, from the criteria ranking of Polli-Bricks as shown on Table 4.10, it was found that there is high concern from respondents towards the environmental impacts of building materials regardless the professions. This strengthened the sustainability awareness among the Malaysians' construction professionals.

4.4.2 Discussion on Challenges towards the Implementation of Polli-Brick in Malaysia

Local demand is important for every new building material to enter a new market. However, with average index of 2.72 ('Neutral' or 'Moderate' category), it was found that green building materials are still not highly demanded in Malaysia. Based on the answers provided by respondents, the green building materials application is mostly limited to people who are environmental conscious, less cost conscious and clients or developers who aiming for some green award or certification. Interviewee 2 also mentioned that people tend to focus on direct return instead of long-term benefits. Besides, D` Souza et al. (2006) also found that profitability is the concern to most of the companies rather than environmental impacts.

Besides, the low awareness (26% of respondents 'Aware' as shown in Figure 4.4) towards Polli-Bricks could also impose a great challenge for the implementation in Malaysia. Table 4.16 presents the top three identified potential challenges. Although the sustainability awareness among the construction professionals in Malaysia is at a satisfactory level, the low of public awareness towards sustainability is still the most critical challenge for Polli-Bricks to be implemented in Malaysia. Low awareness among the society can affect the local demand of a particular green building product. When the awareness towards a product is low, it can lead to low confidence level or distrust towards the reliability of the product. The availability of technology and expertise locally is treated as the third most critical obstacle for the implementation of Polli-Bricks in Malaysia. Extra costs would incur in transferring the technology and expertise from overseas.

Table 4.16: Identified Top Three Potential Challenges

Rank	Potential Challenges
1	Lack of public awareness
2	Low confidence level/ distrust
3	Lack of technology and/ or expertise locally

4.4.3 Discussion on Strategies for the Implementation of Polli-Brick in Malaysia

Table 4.17 shows the top three effective strategies to promote green building materials in Malaysia. The importance of tax incentives were mentioned in the study carried out by Abidin, N. Z. (2009). For the second effective strategy, eco-labels do have impact to consumers' purchasing decisions (Rashid, N. R. N. A., 2009). Conference and exhibition are ranked as third most effective strategy in promoting green building materials. A study by Abidin, N. Z. (2009) showed that conferences are one of the sources of knowledge in enhancing the sustainability awareness. Therefore, the strategy employed by interviewee 1 which is by attending tradeshows, events and conferences seemed to be an effective strategy to promote the Polli-Bricks. Newspapers and websites were also mentioned by Abidin, N. Z. (2009). In this study, quite a number of respondents knew about Polli-Bricks from newspapers and websites too.

Table 4.17: Identified Top Three Effective Strategies

Rank	Effective Strategies
1	Tax incentives
2	Eco-labelling/ certification
3	Conference and/ or exhibition

From the analysis, the influence by people surrounding does not seem to be an effective strategy to promote the green building materials which accounted the least number of votes from respondents. However, it does have certain level of impacts to widespread a product. A positive way of influencing plays similar purpose as educating. As suggested by Abidin, N. Z. (2009), education should be expanded to stakeholders including the potential buyers instead of just construction players as demand and supply are closely related to each other. This is supported by the interviewee 2 which green building materials should be promoted to as many parties as possible as every party does have certain level of impacts to materials selection.

From the analysis, Architect or designer personnel and client are the two most influential parties in making the decision. Client, as the money payer is the most influential in materials selection. However, their knowledge towards materials might not be as good as an Architect. Hence, they would listen to advices of the Architect. This probably makes Architect becomes the most influential party in materials selection.

Table 4.18 illustrates the top three applications that can be used to initiate the implementation of Polli-Bricks in Malaysia. There are two probabilities that can make the internal partition to become the first preference: (i) the available of existing application and (ii) lower risk. Although External façade has been used for the EcoArk in Taiwan, it is still too risky for new market to accept its application. This is because external application has greater exposure to the environmental damages like bad weather.

Table 4.18: Identified Top Three Start-Up Applications

Rank	Start-up Application
1	Internal partition
2	Any small scale projects
3	External wall

4.5 Conclusion

In conclusion, the respondents have good awareness towards sustainability. However, the application of sustainable building materials is still not common in Malaysian construction industry. According to the respondents, it is shown that low awareness from the public imposes a key possible barrier for the implementation of Polli-Bricks in Malaysia. Polli-Bricks can be promoted more effectively through tax incentives, eco-labelling/ certification and conference and/ or exhibition.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

In this chapter, it explained to what extend that the objectives have been achieved. The limitations were discussed in this chapter. Recommendations were proposed for further study in related to the issues on Polli-Bricks.

5.2 Summary of Findings

This research has successfully achieved the three (3) objectives set in the Chapter 1. The objectives are as shown as below:

(a) To identify the level of awareness towards sustainability among the construction professionals in Malaysia.
(b) To investigate the challenges for the implementation of Polli-Brick in Malaysia.
(c) To suggest the strategies for the application of Polli-Brick into Malaysian construction industry.

5.2.1 Objective 1: Level of Awareness towards Sustainability among the Construction Professionals in Malaysia

The level of awareness towards the sustainability was acquired from the perspectives below:

(a) Recycling is a better MSWM method comparing to landfill and incineration.
(b) Construction industry consumes vast amount of natural resources and raw materials.
(c) Recycled-content building materials can greatly reduce the MSW.
(d) Green building materials play an important role towards sustainable development.

It was found that majority of respondents agree that are aware of the role of construction industry towards environment importance of recycling and green building materials.

5.2.2 Objective 2: Challenges for the Implementation of Polli-Brick in Malaysia

Understand the local environment is important when a business is seeking to enter a new market. Therefore, the potential challenges faced in Malaysia were identified. The three main challenges were summarised and the sequence is as shown as below:

(1) Lack of public awareness
(2) Low confidence level/ distrust
(3) Low confidence level/ distrust

5.2.3 Objective 3: Strategies for the Application of Polli-Brick into Malaysian construction industry

Besides challenges, effective strategies for a new green building material to enter the Malaysian construction industry are important to study. This could ease the product suppliers to enter the Malaysian construction industry. The strategies were acquired from three perspectives and are summurised in Table 5.1.

Table 5.1: Strategies from Three Perspectives

Item	Perspectives
	Ways to promote
1	Tax incentives
2	Eco-labelling/ certification
3	Conference and/ or exhibition
	Parties to aim
1	Architect and/ or designer
2	Client and/ or developer
	Start-up applications
1	Internal partition
2	Any small scale projects
3	External wall

5.3 Limitations of Research

Although the research has achieved its objectives, there are still some limitations. First of all, the sample size of 50 is considered as small as there are so many construction professionals in the whole Malaysia. Therefore, the results might not be able to present all construction professionals in Malaysia. Second, due to the limited time frame and information, case study on the Kesidang Pavilion project in Malacca which intended to use Polli-Bricks in application could not be carried out. It would be useful if could take the project as case study.

5.4 Recommendations

In this research, the awareness towards sustainability among the construction industry, challenges and strategies for the implementation of Polli-Bricks were discussed. However, further research can still be carried out. The following is the suggested studies:

(a) To investigate reasons causing the Kesidang Pavilion, Malacca to be on hold indefinitely

(b) Case study on overseas projects with the application of Polli-Bricks. (For example, cost implication and maintenance issues)

(c) To study the technical aspects of Polli-Bricks (For example, strength, insulation properties and etc.)

(d) To carry out a life cycle assessment on Polli-Bricks

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APPENDICES

APPENDIX A: Supporting Letter

Supporting letter was prepared to verify the undertaking of researcher in Final Year Project.

APPENDIX B: Final Year Project Cover Letter

Final Year Project Cover Letter was prepared to invite the respondents to participate in the questionnaire survey. It informed the potential participants on the project title and brief related to questionnaire survey.

APPENDIX C: Questionnaire Form

Questionnaire survey form consisted of Introduction (with Polli-Brick brochure attached), Section A and Section B.

The Implementation of Polli-Brick in Malaysian Construction Industry

Background

Recently, it was found that there is a new green building material called Polli-Brick. It is made from recycled PET[1] (Polyethylene Terephthalate Polymer) plastic wastes. Besides environmental friendly, it only costs ¼ the price of conventional curtain wall system. Since Malaysian construction industry is in large demand, the implementation of Polli-Bricks could be a good way to reduce the MSW[2] (Municipal Solid Waste) and address the climate changing problem.

The objectives of this survey are:

1. To identify the sustainability awareness among Malaysian construction professionals.
2. To investigate the challenges for the Polli-Brick implementation in Malaysia.
3. To find out the strategies for the application of Polli-Brick into Malaysian construction industry.

Note:

The data will only be used for academic purposes. All information provided will be kept confidential.

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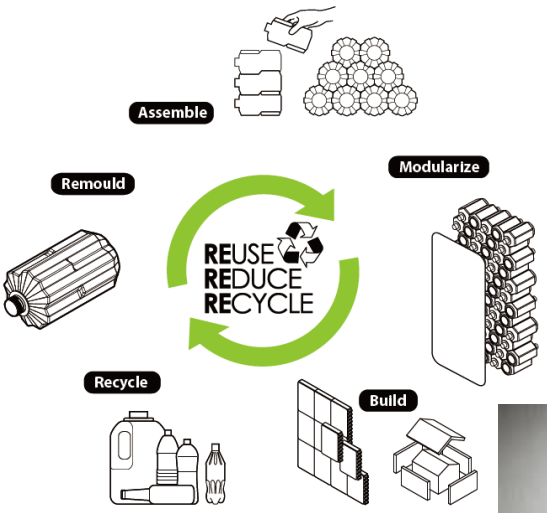
[1] Polyethylene Terephthalate Polymer is type of plastic commonly used to produce food and liquid container such as water bottle (Source: Wikipedia).
[2] Municipal Solid Waste is a waste type consists of everyday items discarded by public, also known as garbage (Source: Wikipedia).

Quick Summary of Polli-Brick ***(Kindly refer to the attached brochure for more information)***



Distinctive features:

- Made from recycled materials
- Reusable and recyclable
- Non-toxic
- Low-VOC (Volatile Organic Compounds)
- Construction on site

Advantages:

- Super strong
- Ultra-light
- Air-insulated
- Translucency
- Simple installation
- Optional LED+IT integration

(Source: Polli-Brick Brochure)

Instruction: Kindly indicate your answer with 'x' in the box/ boxes [ ], where appropriate.

Section A –Personal Details

1. Name:
2. Profession:
3. How long have you been working in construction industry?

Section B – Sustainability Awareness among Malaysian Construction Professionals, Challenges and Strategies of Polli-Brick Implementation

1 – *Strongly Disagree*; **2** – *Disagree*; **3** – Neutral; **4** – *Agree*; **5** – *Strongly Agree*

1. Recycling is a better MSW management method comparing to landfill and incineration.
   [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5
2. Construction industry consumes vast amount of natural resources and raw materials.
   [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5
3. Recycled-content building materials can greatly reduce the MSW.
   [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5
4. Green building materials play an important role towards sustainable development.
   [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5
5. How well do you think the demand of green building materials in Malaysian construction industry?
   [ ] Very poor [ ] Poor [ ] Good [ ] Very Good [ ] Excellent
6. Do you worry that the recycled content would lower the quality of building materials?
   [ ] Yes, I am worried [ ] No, I am not worried
7. Are you aware of Polli-Brick?
   [ ] Yes [ ] No
8. If yes, how did you get to know about Polli-Brick? (Open ended question)
   Answer/s:

9. Below are the current applications of Polli-Bricks. Rate the importance from 1 to 5 (i.e. 1 – the most important; 5 – the least important) of the 5 criteria when selecting a green building material for the applications below.

	Current Application	
5 Criteria	External façade	Internal partition
- Aesthetic -Performance -Cost -Durability -Environmental impacts		

10. Below are the 8 advantages of Polli-Brick. Rate the importance (i.e. 1 – the most important; 5 – the least important) for you to consider Polli-Brick.
    [ ] High strength to weight ratio
    [ ] Low embodied energy
    [ ] Good insulation properties
    [ ] Tendency to improve energy efficiency
    [ ] Simple and fast installation
    [ ] Least impact to indoor air quality
    [ ] Aesthetic value
    [ ] Tendency to improve salvage value

11. Based on your experience, what are the possible challenges for Polli-Brick to enter Malaysian market? (can choose more than 1)
    [ ] Competitive local market
    [ ] Lack of technology and/or expertise
    [ ] Lack of the raw materials (Plastic)
    [ ] Lack of public awareness
    [ ] Low confidence level/ distrust
    [ ] Lack of initial investment cost
    [ ] Uncertain local demand
    [ ] Others, please specify:

12. Based on your experience, what are the effective strategies to promote or widespread a new green building material? (can choose more than 1)
    [ ] Conference and/or exhibition
    [ ] Tax incentives
    [ ] Advertisement
    [ ] Eco-labeling and/or certification
    [ ] Influence from people surrounding
    [ ] Bring product for presentation to people
    [ ] Others, kindly suggest:

13. For the parties below, how influential they are in material selection? (i.e. 1 – the least influential; 5 – the most influential).

	1	2	3	4	5
Client	[ ]	[ ]	[ ]	[ ]	[ ]
Architect & designer	[ ]	[ ]	[ ]	[ ]	[ ]
Quantity Surveyor	[ ]	[ ]	[ ]	[ ]	[ ]
Engineer	[ ]	[ ]	[ ]	[ ]	[ ]
Product Supplier	[ ]	[ ]	[ ]	[ ]	[ ]

    Others, kindly suggest:

14. Below are the current and possible application of Polli-Brick, which do you think can be the startup for the implementation of Polli-Brick in Malaysia? (can choose more than 1)
    [ ] External wall
    [ ] Roofing
    [ ] Internal partition
    [ ] Ceiling
    [ ] Flooring
    [ ] Any small scale projects
    [ ] Others, kindly suggest:

15. Based on your experience, who will use green building materials?
    Answer/s:

End of Questionnaire

= Thanks for your precious time and patience =

~ Have a good day ~

Note: Should you have any enquiries, please do not hesitate to contact Chu Chia Ning via h/p (+6016-7257681) or email (chianing1990@gmail.com). Thanks!