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LITERATURE REVIEW ON GREEN COST PREMIUM ELEMENTS OF SUSTAINABLE BUILDING CONSTRUCTION

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ABSTRACT

Despite evidence that sustainable construction practice has numerous environmental, economy and societal benefits, many construction practitioners have failed to support sustainable construction practice due to perceive higher initial cost known as "*green cost premium*" when compared to traditional construction practice. Hence, the factors of green cost premium that are commonly cited as a crucial barrier toward sustainable construction practice must be investigated. Based on the analysis of the existing literature (e.g.: conference paper, journal article), there are 27 factors, that classified into seven elements, that contribute to the cost differential. However, few studies have been conducted on green cost premium in developing countries. Therefore, this study attempts to fill this gap and is expected to contribute to the discussion on green cost premium to improve sustainable construction implementation.

Keywords: Building construction cost; Green cost premium; Sustainable building construction; Sustainable building construction cost

1. INTRODUCTION

Today, people has become more aware of the negative impacts of unsustainable economic growth, rapid development, the industrial revolution, and increased natural resource consumption (Whang & Kim, 2015; UNDP, 2017). The importance of sustainable development to protect the environment and to ensure peace and prosperity has been gaining recognition around the world (UNDP, 2017). The construction industry is one of the biggest contributors to environmental problems due to improper construction activities (Afzan, 2016), which lead to increased carbon emissions, climate change, resource scarcity, and waste generation (Dadhich et al., 2015). Wu et al. (2014) found the building sector could help in minimizing the environmental impact if appropriate construction practice, sustainable materials, and sustainable technologies were used. Therefore, sustainable construction has been introduced to mitigate these issues (Afzan, 2016; CIDB, 2016), and it is considered one of the most important factors to attain sustainable development (Whang & Kim, 2015).

However, even though numerous researches have highlighted the benefits of sustainable construction practice (Abidin, 2010; Sundayi et al., 2015; Whang & Kim, 2015; Afzan, 2016; Meron & Meir, 2017), construction practitioners seem to have little interest in adopting sustainable construction practice (Yahya & Abidin, 2013; Brennan & Cotgrave, 2014; Rostami

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et al., 2015; Afzan, 2016; Darko et al., 2017). Surveys have indicated this lack of support is due to the higher initial cost of sustainable building construction, which is termed "green cost premium" (Ahn et al., 2013; Bahaudin et al., 2013; Hwang & Ng, 2013; Brennan & Cotgrave, 2014; Shang & Peng, 2014; Qian et al., 2015; Sundayi et al., 2015; Afzan, 2016; Dodge Data & Analytics, 2016; Dwaikat & Ali, 2016; Mao et al., 2016; Amiril et al., 2017; Hwang et al., 2017). The following are several examples explaining the current problem regarding sustainable building construction and its higher initial cost:

- A study conducted on various types of sustainable buildings, such as residential, educational, office, commercial, public buildings, and health facilities, showed that the additional cost to construct such buildings is up to 12.5% (WorldGBC, 2013) and 5% to 10% (Hwang et.al, 2017) of the total construction budget.
- To construct sustainable schools, there were additional construction costs of 2% (Kats, 2014), 2.5% to 2.7% (ILGBC, 2014), and an average of 14.5% (Meron & Meir, 2017), as compared to traditional school construction.
- Suruhanjaya Tenaga, with a platinum certificate, and the First Avenue office building, with a gold certificate, incurred green cost premiums of 6% and 9%, respectively (GBI, 2017).
- Based on a case study analysis of 10 sustainable office buildings, additional construction cost is found to be 5% to 8% (Halim, 2012).
- To provide environmentally sustainable buildings and development, the cost was about 10% to 15% higher than traditional building construction (Shari & Soerbarto, 2012).

As higher cost is widely being acquainted with sustainable building construction, this study will extensively review the literature on sustainable construction cost. This study hopes to solve the issue of higher initial cost through viable strategies and to increase construction practitioners' interest and commitment to invest in sustainable building construction.

2. METHODS

Sustainable construction consists of three principles: economic sustainability, environmental sustainability and social sustainability. The systematic literature review identified, 132 studies related to sustainable construction: 30 studies highlighted management (e.g., awareness, readiness, adoption, and implementation), 50 studies highlighted environmental sustainability (e.g., material, practice [recycle, reuse, reduce], tools, and technology), 21 studies highlighted social sustainability (e.g., construction stakeholders' experience, commitment, behavior, and knowledge), and 31 studies highlighted economic sustainability (e.g., cost management, green cost premium, and policy). This study excluded literature on management, environmental, and social, as this study focuses on economic sustainability regarding green cost premium and, there were 17 studies that highlighted green cost premium between 2013 and 2017.

This review procedure involved journal articles and conference papers identified from EBSCOhost, ScienceDirect, and Scopus database searches within the context of Asia, Europe, the United States, Africa, and the Oceania continents.

3. LITERATURE REVIEW

This section presents the discussion of the existing literature in the area of sustainable construction and it starts by defining and explaining sustainable construction followed by the differences between sustainable construction and sustainable building. As this study focuses on cost in relation to sustainable buildings, the construction cost, building construction cost, and sustainable building construction cost are defined and discussed.

3.1. Sustainable Construction

Sustainable construction is also known as a modernized construction practice or an improvement to the traditional construction practice (Afzan, 2016). Traditional construction focuses on three objectives: cost, quality, and performance; however, sustainable construction uses a new standard: the minimization of resource depletion, the minimization of harmful emissions, and the minimization of environmental degradation, as well as the preservation of biodiversity (Huovila & Koskela, 1998). The terms sustainable construction and sustainable building are sometimes used interchangeably (Hwang et al., 2017). However, sustainable buildings are buildings that efficiently use resources, –such as energy, water, materials, and land realizing long-term economic benefits and being more responsible for social health (Darko et al.,2017; Hwang et al., 2017). Sustainable construction is the process applied during construction to achieve sustainable development (Kamar & Hamid, 2011), and it involves the integration of three principles: (i) economic sustainability, which is a commitment to a financial mechanism to increase profitability; (ii) environmental sustainability, which is a commitment to carefully use natural resources; and (iii) social sustainability, which is a commitment toward people's needs (Hussin et al., 2013).

Since sustainable building is an essential part of sustainable construction, many developed and developing countries have introduced sustainable building assessment tools to evaluate sustainable buildings, such as BREEAM in the UK, LEED in the US, Green Star in Australia, CASBEE in Japan, SBAT in South Africa, GBI and MyCREST in Malaysia, Green Mark in Singapore, and the Estidama (sustainability) rating system in Abu Dhabi (Hussin et al., 2013; Whang & Kim, 2015). Furthermore, continuous research is being conducted in the field of sustainable construction (Ametepey et al., 2015; Whang & Kim, 2015; Hwang et al., 2017), and several models have been developed to embrace sustainable construction practice, such as Green Construction Assessment (Tam et al., 2004), the implementation of green construction (Shi et al., 2013), the green construction framework (Qi et al., 2010), the path to achieving sustainable construction (Abidin, 2010), and the green construction model (Afzan, 2016). Figure 1 shows the differences between sustainable building and sustainable construction in the building life cycle. However, most studies conducted on sustainable construction have focused on the environmental aspect, and limited studies have been conducted on the economic aspect, even though cost is a crucial barrier toward sustainable construction implementation.

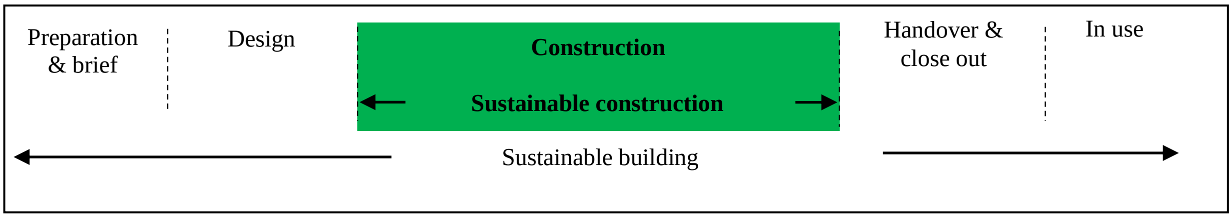

Figure 1 Differences between sustainable building and sustainable construction in building life cycle (Source: Kamar & Hamid, 2011; Afzan, 2016; Hwang et al., 2017; RIBA plan of work. 2013)

3.2. Building Construction Cost

Building construction cost can be categorized into: (i) initial cost; (ii) operation; maintenance and repair, and replacement cost; (iii) disposal cost, residual value, and financial charges (Sundayi et al., 2015). Latief et al. (2017) stated the costs associated with buildings fall into four categories: (i) initial cost; (ii) resources cost; (iii) replacement cost; and (iv) operation and maintenance cost. In addition, El-Haram et al. (2002) categorized building construction cost into preliminary cost, capital cost, facility management cost, and disposal cost. However, this study only focuses on initial cost since the main problem in sustainable buildings' construction is due to the higher initial cost.

According to Fuller (2016), the initial cost is a capital investment cost for land acquisition, construction, renovation, and the equipment needed to operate the facility, while Qian and Foong (2013) found that initial cost includes all costs associated with procurement, supply, delivery, and installation of materials and products. The initial capital cost can be categorized into: (i) tendering cost; (ii) commissioning and hand over cost; (iii) capital management cost; (iv) capital overhead cost; (v) design cost; (vi) prefabricated cost (off site factory); and (vii) construction cost (El-Haram, 2002). For the purpose of this study, the author will refer to initial cost as the cost incurred during the preparation, design, and construction stages of building construction. Additionally, due to higher initial costs, contractors sometimes need to reduce other costs to fulfill the green requirements (Afzan, 2016). Thus, it is critical to identify the green costs premium elements to provide viable solutions for minimizing the initial project cost.

3.3. Sustainable Building Construction Cost

Sustainable building construction is commonly mentioned to be more expensive than traditional building construction due to the green cost premium. To date, there is no exact meaning of green cost premium (Dwaikat & Ali, 2016), nor a comprehensive methodology to describe the components of green cost premium (Hwang et al., 2017). Green cost premium can be defined as the differential cost between a green and traditional version of the same building types (Kats, 2014). Houghton et al. (2009) defined green cost premium as additional design and construction costs in relation to green components, while, Hwang et al. (2017) defined green cost premium as the additional capital cost of green building features. In this study, the author defines green cost premium as an additional cost in relation to sustainable building elements. A systematic review of the existing literature, determined seven elements of green cost premium.

3.3.1. Sustainable material

The higher cost of sustainable materials arises from the scarcity of sustainable materials, which in turn leads to high construction cost (Afzan, 2016; Hwang et al., 2017). Therefore, special orders and manufacturing are required (Hwang et al., 2017). In addition, some of these materials must be imported, as green markets are still new, particularly in Malaysia (Shari & Soerbarto, 2012; Saleh & Alalouch, 2015; Afzan, 2016). Amiril et al. (2017) also claimed that the shortage of sustainable materials has been one of the reasons for project delays and the poor implementation of sustainable construction, resulting in higher initial cost. Zhang et al. (2011) found that the cost of sustainable materials is 3% to 4% higher than traditional construction materials. Sustainable materials normally require more effort in testing and code approval, which leads to an increase in research and development costs (Malin, 2002; Hwang et al., 2017). Furthermore, the lack of information on sustainable materials also contributes to higher costs, as construction practitioners are unable to utilize sustainable products efficiently (Hwang et al., 2017).

3.3.2. Sustainable equipment

The usage of sustainable equipment, such as water- and energy-saving equipment and highly effective insulation protection, often increases costs (Shi et al., 2013). Qian and Foong (2013) found that the installation process of sustainable equipment is complex, and it is difficult to match the sustainable equipment with the design requirements, which can also lead to increased project costs. In addition, Nurul Zahirah and Abidin (2012) found that the use of sustainable equipment, such as heat pumps, radiant flooring, and electric radiant heating systems, require additional costs and more time to install.

3.3.3. Sustainable technology

A significant improvement on the construction method can be achieved through advanced technology, such as Building Information Modeling (BIM) and the Industrialized Building System (IBS) (Hussin et al., 2013). However, Darko et al. (2017) found that almost every stakeholder concerned about cost when it comes to applying new technology. Bandy et al. (2007) stated that the application of sustainable technology is one of the main obstacles to sustainable building construction, as it may increase project cost by 2% to 7% (Darko et al., 2017). The application of BIM is essential to drive the industry toward sustainable construction, which underlines long-term affordability, quality, and efficiency (CREAM, 2014). However, the higher cost of BIM implementation has also led to an increase in the capital cost of sustainable building construction projects (CREAM, 2014; Hwang et al., 2017). Furthermore, the possibility of recovering ROI is uncertain since the initial capital cost of BIM implementation is high and will subsequently affect the project's cash flow (CREAM, 2014).

IBS is known as a construction technology in which components are manufactured in a controlled environment either on site or off site, and transported, positioned, and assembled into a structure with minimal additional work (CIDB, 2003). However, Hamid (2016) found that IBS technology received less demand from construction practitioners due to its high cost and current cheap labor rate. In addition, the cost of precast components drives the higher costs of IBS technology, increasing cost by 31% to 81% due to machinery costs, management costs, assembly costs, model costs, and transportation costs (Mao et al., 2016). Higher assembly cost is one of the main reasons for the higher construction cost of sustainable buildings (Mao et al., 2016). Assembly cost is mainly due to PC installation cost, jointing cost, and machinery cost. The assembly cost will be higher depending on how often a tower crane is used (Mao et al., 2016). In a traditional construction practice, the tower crane enters the site once for approximately nine months (Mao et al., 2016). However, in the sustainable construction practice, a tower crane enters the site twice for approximately eight months (Mao et al., 2016). Furthermore, Mao et al. (2016) claimed that the higher cost of IBS technology is due to the transportation cost, which involves two stages: (i) transporting raw materials to the prefabrication sites; and (ii) transporting prefabricated elements to the construction site.

3.3.4. Sustainable design

The previous literature has shown that sustainable design cost can be reduced if sustainability goals are implemented at an early stage of the design process (Nurul Zahirah & Abidin, 2012). According to Mao et al. (2016), design cost has insignificant influence on the sustainable building project cost, as it occupies a lower percentage of the total project cost. However, in China, the maturity level of sustainable design has yet to be achieved; thus, developers must consult with foreign companies, resulting in increased consulting fees (Mao et al., 2016). Consulting cost also include requests for extra fees for the architect and engineer due to intensive design exercises to consider any sustainability aspects, as required by the sustainable building rating system and the certification activities (Nurul Zahirah & Abidin, 2012).

The fees for the consultants are higher when compared to the traditional construction method due to the longer time needed for design and the need for supplemental meetings to agree on design decisions (Nurul Zahirah & Abidin, 2012). Furthermore, the consultants' experience in producing sustainable design also contributes to increasing the consulting fees (Mao et al., 2016). However, Hwang et al. (2017) argued that higher consultant and designer fees were insignificant factors, as it is not difficult to get specialized consultants and designers. Furthermore, sustainable building construction requires additional detailed designs concerning the green elements, which increases the types and quantity of the drawing and, ultimately the total project cost (Mao et al., 2016).

Arumugam et al. (2015) found that the cost differential between sustainable building and conventional building in terms of managing design, which includes sustainable design, architectural and engineering (A&E), design time, and modeling cost is 9.91%. Hwang and Ng (2013) found that alterations and variations related to design during the construction process are significant issues, and such changes occur frequently in sustainable construction projects. This is due to the lack of architect consistency in providing sustainable drawings (Hwang & Ng, 2013). Furthermore, enormous variations due to the imperfect specifications might also lead to additional costs (Saleh & Alalouch, 2015; Hwang et al., 2017). In addition, numerous variations such as, if sustainability aspects are to be incorporated at a later stage, will result in increasing the total project cost (Hwang & Tan, 2012).

3.3.5. Tendering

The success of developing and implementing a sustainable design greatly depends on the type of contract used (Hwang & Ng, 2013). Since design cost is contributed to green cost premium, choosing the correct type of contract for project delivery is critical and may affect the total project cost (Hwang & Ng, 2013). Arumugam et al. (2015) found there are about Rs 187,000 thousand cost differentials in tender document preparation between sustainable building and traditional building construction. Furthermore, Mao et al. (2016) stated that the tendering cost for a sustainable construction project becomes higher due to additional items, such as selecting the prefabricated manufacturer.

3.3.6. Contractors' experience

The productivity of sustainable building construction has been found to be less effective, as compared to traditional building construction, due to the contractors' unfamiliarity with sustainable technologies (Hwang et al., 2017). Furthermore, contractors need more time to learn and become experts, which not only affects the project schedule but also increases the construction cost due to rework (Hwang et al., 2017). Less competition among contractors may also contribute to the increased total project cost (Afzan, 2016). Grade 7 contractors currently dominate sustainable building construction projects, thus increasing the construction cost (Afzan, 2016).

3.3.7. Insurance

Implementation of sustainable construction has been considered too risky due to the long-term benefits that are more for the environment than for financial gain (Brennan & Cotgrave, 2014). Additionally, contractors will be exposed to new risks that are usually uncommon in traditional building construction to achieve the sustainable building standard (Nurul Zahirah & Abidin, 2012). The unique qualities of the sustainable building construction process also require standard insurance forms to be enhanced and added values to be included in the coverage provision (Nurul Zahirah & Abidin, 2012). Hence, these requirements will contribute to the green cost premium for a sustainable building construction project.

4. RESULTS AND DISCUSSION

Using a systematic literature review, the study determined 27 factors of green cost premium that contribute to the cost differential between sustainable building construction and traditional building construction, and these factors can be classified into seven elements, as depicted in Table 1. Most of the existing reviews have identified only the factors that influence cost premium but did not classify them. The author found that it is critical to classify factors of green cost premium according to building stages so that the additional costs incurred during the initial stage are identifiable. The mentioned seven elements are: sustainable material, sustainable equipment, sustainable technology, sustainable design, tendering, the contractor's experience, and insurance; these factors have been embedded according to the building process that is presented in the Royal Institute of British Architects (RIBA) outlined work plan (2013). The author decided to use the RIBA work plan because it has been used for over 100 years as a framework to guide all stakeholders to work in a coordinated manner (Qian et al., 2015).

Table 1 Elements and factors affecting sustainable building cost

Building Life Cycle Cost		RIBA Work Stages	Sustainable Building	
			Elements	Green cost premium factors
Initial Cost	Preliminary Cost	1. Preparation and Brief		
	Design Cost	2. Design Concept 3. Design Development 4. Technical Design	E4	1. Experience of consultants in sustainable building design. 2. Higher consultant fees. 3. Complexity of sustainable design –longer design time needed. 4. Additional design concerning sustainability. 5. Maturity level of sustainable design. 6. Inconsistency of drawing. 7. Imperfect specification.
	Construction Cost	5.Construction	E5	1. Types of contract use. 2. Appointment of prefabricated manufacturer.
			E6	1. Lack of proficiency with sustainable technology. 2. Less competition among contractors (dominated by G7).
			E1	1. Scarcity of materials. 2. Research and development (more testing and code approval required). 3. Lack of information on sustainable materials.
			E2	1. Complexity of installation process. 2. Expensive. 3. Difficulties in matching the equipment with the design requirements.
			E3	IBS 1. Higher management cost. 2. Higher transportation cost – raw materials to prefabrication site and prefabricated elements to construction site. 3. Assembly cost –special PC installation, frequency of tower crane usage, higher jointing cost. 4. Higher machinery cost. BIM 1. Higher implementation cost. 2. Uncertain ROI recovering.
			E7	1. Additional values of the coverage provisions.

Legend: E1-sustainable material, E2 –sustainable equipment, E3 –sustainable technology, E4 –sustainable design, E5 –tendering, E6 –contractor's experience, E7 –insurance

According to Table 1, construction cost is the largest component of the initial cost, and six elements fall under construction cost and one element fall under design cost. To attain sustainable development, specific materials, equipment, and technology are required in the construction of sustainable building. Hence, this contributes to green cost premium. Furthermore, the cost to acquire a sustainable building construction project becomes higher as compared to a traditional building construction project due to additional items, such as the appointment of a prefabricated manufacturer as a result of applying IBS. A higher grade of contractor with unlimited tender capacity usually monopolizes sustainable building construction projects. Thus, the construction cost becomes higher due to the lack of competition. Variations during the sustainable building construction process may also occur, resulting from the contractors' unfamiliarity with sustainable technology, leading to an increased green cost premium. Insurance for a sustainable building construction project is higher, as compared to a traditional building construction project, due to the unidentifiable long-term financial benefits. Thus, this new risk, which is unusual in traditional building construction, may be mitigated through additional coverage provisions, further increasing the cost of sustainable construction. Additionally, a sustainable building construction project usually has a more complex design than a traditional building construction, and this contributes to green cost premium. However, the sustainable design's complexity may be eliminated once the sustainable design maturity level has been achieved.

In Malaysia, there are also several issues that arise regarding the sustainable building construction cost that are aligned with worldwide scenarios, as highlighted in the previous section. However, most of the literature found on the green cost premium was conducted in the United States and Europe. Therefore, this study's findings were well construed for the American and European contexts; however, few studies related to the green cost premium were conducted in Asian countries, particularly Malaysia. Therefore, a survey must be conducted to probe the findings from the literature review, as well as to explore new factors that contribute to the green cost premium in Malaysia.

5. CONCLUSION

This paper found that green cost premium is being widely associated with sustainable construction and is a crucial barrier toward sustainable construction practice implementation. The objective of this study was achieved, as it identified 27 green cost premium factors classified them into seven elements.

However, some limitations emerged that will be the basis for further study. First, most of the studies only identified the factors that contribute to green cost premium but did not address the interrelationship among the factors nor their significance levels. Second, the solutions to minimize the green cost premium were suggested without identifying the root causes. Therefore, future research must analyze the interaction between green cost premium factors and rank them according to their significance. Furthermore, future research must identify the root causes of green cost premium factors, as well as possible strategies to minimize the sustainable building construction project cost, with the expectation to improve sustainable construction implementation in Malaysia.

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