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The Way Forward in Sustainable Construction: Issues and Challenges

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ABSTRACT

Construction industry is one of the most significant industries that contribute toward socio-economic growth especially to developing countries. The nature of the industry are fragmented, unique and complex which always face chronic problems like time overrun (70% of projects), cost overrun (average 14% of contract cost), and waste generation (approximately 10% of material cost). It is also regarded as one of the largest polluters to our environment. Traditional practices of construction process and management are found unable to control unprecedented challenges including the carbon emission issue. These challenges accent the need for practitioners to rethink and improve the construction process and technology. This shows that the construction industry has a major potential in the advancement of sustainable development by addressing issues related to the economic, social, and environment. By adopting sustainable construction, it can reduce the overall energy use and maximize potential for renewable energy supply, minimize waste, conserve water resources, enhance water quality, incorporate water sensitive design and minimize vulnerability to flooding, minimize polluting emissions to water, air and soil and minimize noise and light pollution.

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1. ISSUES IN CONSTRUCTION INDUSTRY

Construction industry plays a vital role in the economic growth of a country. It helps in improving the quality of life of its citizens by providing the necessary socio-economic infrastructure such as roads, hospitals, schools and other basic & enhanced facilities. Besides these the construction industry is a main contributor to a country's economy. Despite of the global economic downfall, construction industry contributes significantly to the Gross Domestic Product (GDP) of Malaysia's economy. As reported by CIDB, the construction sector had been consistently contributing an average of 3.8% over the last 30 years. Furthermore, the Malaysian construction industry is rapidly growing and improving significantly. This sector has registered a strong growth of 5.8% in 2009, and subsequently 8.7% for the first quarter of 2010 as against the overall GDP growth of 10.1% during the first quarter of the year. Hence, a lot of money is invested to sustain the growth of the construction industry [1].

Under the 10th Malaysian Plan, RM230 billion have been allocated to the development sector. Out of this development expenditure, 60% or RM138 billion will be expended in physical development which will be undertaken by the construction sector [1]. In 2011 alone, a total of 5,555 projects valued at RM 77,270 million had been awarded. These include residential projects costing RM 18,271 million, non-residential building projects costing RM 29,021 million, social amenities projects worth of RM 4,901 million and infrastructure projects worth of RM 24,625 million [2].

These developments has brought substantial and significant impacts to the country's economy and also resulted in other implications especially to the environment and social aspect of the country. Naturally, construction industry is fragmented and complex where it's on site basis & one-of-a-kind production and resource & schedule driven nature. The industry always faced serious and chronic problems likes time overrun, cost overrun, waste generation, imposing negative impacts to the environment and excessive resource consumption.

1.1. Time Overrun

Achieving completion of construction projects on time is a basic requirement. However, it seems seldom for projects to be completed on time. This has become a worldwide problem. A study showed that the Vietnamese government has acknowledged this issue as a big headache, especially with government-related funded projects [3]. In Nigeria, out of 3,407 projects only 24 projects were completed on time, while 1517 were delayed and 1812 were abandoned [4]. Omoregie & Radford [5] reported that the minimum average percentage escalation period of projects in Nigeria was found to be 188%. A similar research was conducted in Bosnia and Herzegovina on 177 projects and found that the contracted date was not met in 51.40 % of the projects [6]. Al-Momani [7] conducted a survey on 130 public projects in Jordan and found delays occurred in 106 (82%) of the projects. Frimpong et al. [8] found 33(70%) out of 47 projects in Ghana were delayed. Whilst, in Saudi Arabia 70% of projects faced time delay with average time delay of 10% to 30% of the original duration of the project [9]. Likewise, in Malaysia the construction industry is also facing the same critical problem of time overrun [10]-[12]. Abdullah Razzaki [13] reported that more than 90% of large MARA construction projects experienced delay since 1984. Endut et al [14] studied on time performance of 359 projects (301 new constructions while 58 refurbishment projects) in Malaysia. Of these 301 were public projects and 51 private projects. The study found that only 18.2% of the public sector projects and 29.45% of private sector projects had 0% time deviation (no delays) while the average percentage of time overrun for other projects was 49.71%.

Time Delay can be due to one or more reasons including problems of financing and payment for completed works [8],[10],[15],[16], poor contract management [17], changes in site conditions [7],[18], shortage of materials [17], design changes [18], weather condition [8], among others. As an example, Yogeswaran et al. [19] scrutinized 67 civil engineering projects in Hong Kong and found at least 15–20% of time overrun was due to inclement weather.

1.2. Cost Overrun

Cost is one of the major considerations throughout the lifecycle of a project. Unfortunately, most of the projects failed to achieve project completion with the estimated cost. Besides time overrun, cost overrun is also a serious problem in the construction industry. This is a major problem both in developed and developing countries. The trend is more severe in developing countries where these overruns sometimes exceeds 100% of the anticipated cost of the project [20].

A study by Omoregie & Radford [5] reported that the minimum average percentage escalation cost of projects in Nigeria was 14%. Other study in Slovenia on 92 traffic structures built showed that 51 % of contracted construction projects faced price overrun [21]. While in Uganda, the Northern-by-pass project at Kampala, faced cost overrun of more than 100% of the contract price. Zujo et al [6] pointed out that in Croatia 81% of 333 analyzed projects were suffering from price overrun while in Bosnia and Herzegovina, a study on 177 structural projects found that the contracted price was not met in 41.23% of the projects. In United Kingdom's (UK) construction industry, it was found that nearly one third of the clients' complaint that their projects generally overran the allocated budget [22]. One comprehensive research conducted by Flyvbjerg [23] regarding cost overruns in the global construction industry, found that 9 out of 10 projects had the overrun. The common overruns are between 50 to 100%.

Like other countries, Malaysian construction industry is also facing a lot of challenges in completing the construction projects within the estimated cost [12],[24],[25]. Endut et al. [14] conducted a study on 308 public projects and 51 private projects and they discovered that only 46.8% and 37.2% of public and private sector projects completed within the budget respectively.

There are various factors that contribute to cost overrun including lack of contractor's experience [26]-[28], poor site management and supervision [3],[29], inaccurate time and cost estimates [8],[30],[31], schedule delay [5],[32], frequent design changes [26],[33], fluctuation of prices of materials [20],[25],[27] cash flow and financial difficulties faced by contractors [3],[34].

1.3. Construction Waste

Waste is another serious problem in construction projects. Waste has direct impact on the productivity, material loss and completion time of project resulting in loss of a significant amount of revenue.

Forsberg et al [35] stated that the amount of waste contributed is around 30-35% of a project's production cost. The amount of construction materials wasted on the site is relatively high and equals 9% by weight of the purchased materials [36]. They investigated material waste generated in a Dutch construction project and found that the average waste per house was 6,860 kg which consisted of 4,480 kg of construction debris and 2,380 kg of other types of solid waste.

Construction wastes were generated because of one or more reasons including frequent design changes [37]-[40], poor quality of materials [36],[41]-[44], workers' mistakes during construction [45]-[47], poor planning [40],[48]-[50], poor site management [40],[41],[49], ordering errors [41],[47],[51],[52], material not in compliance with specification [49],[53], effect of weather [43],[44],[50],[54] and others.

In Malaysia, construction waste generation is becoming an important issue [55]. The high quantity of construction waste generated in the country is due to the rapid development of the construction industry. Demand of houses and major infrastructure projects contributed to the increase of construction waste [51],[56]. Begum et al [57] studied the economic feasibility of waste minimization in Malaysian construction project and concluded that by adopting waste minimization strategy like recycling and reusing material can save 2.5% of the total budget.

The major impact of increased construction waste generation has caused illegal dumping and has swelled rapidly in Malaysia [58]. A study done in Johor district alone indicated that 42% of 46 illegal dumping sites are of construction waste [59]. Furthermore, a study in Seberang Perai, Pulau Pinang also discovered more illegal dump site along the roadside [60]. Recent news had highlighted that almost 30 tons of construction wastes was dumped illegally in tropical mangrove swamp near Bandar Hilir, Malacca and construction debris problem near roadside at Section 17, Petaling Jaya, Selangor as shown in figures 1 and 2 [61],[62].

Figure 1: Construction waste illegally dumped in mangrove swamp [Source: The Star Newspaper 61]

Figure 2: Construction debris along roadside [Source: The Star Newspaper 62]

These illegal dumping has caused a risk to human health and environment [59],[60]. The issues of illegal dumping arise according to [63], is due to the cost and location of the project. The contractors intended to maximise profit by avoiding transportation cost and payment charge to the gazetted landfill. Distance between the project location and the landfill site also hinders the contractor to dispose in legal landfill. A study conducted at 30 construction sites in Malaysia identified six types of waste materials which includes concrete (12.32%), metals (9.62%), bricks (6.54%), plastics (0.43%), timber (69.10%) and other wastes (2%) [60]. Hence, it is timely for Malaysia to adopt a systematic and efficient waste management strategy which would minimise the generation of waste at different level. Advanced techniques such as lean construction can help in reducing waste at source and can minimised the waste produced during the operation by re-using and re-cycling.

1.4. Excessive Resource Consumption

Built environment has significant impact on resources where it accounts for one-sixth of the world's freshwater withdrawals, one-quarter of its wood harvest and two-fifths of its material and energy flows. The structures also have impact areas beyond their immediate location, affecting the watersheds, air quality, and transportation patterns of communities [64]. Buildings built without due consideration to energy, environmental impact and natural resources conservation will result in detrimental wastage affecting our ecological integrity [65].

Excessive resource and energy use and a growing demand for raw materials are largely responsible for the depletion of natural resources worldwide and the acceleration of global warming. About 40% of the world's resource and energy used is linked to the construction and maintenance of buildings (Global Green, USA). This contributes to one-tenth of the global economy [64].

Other statistic states that more than half of all resources consumed globally are used in construction, and 45 per cent of energy generated across the world is used to heat, light and ventilate our buildings, with a further 5 per cent arising from constructing those [66]. As an example, in the European Union, buildings are responsible for more than 40% of the total energy consumption and the construction sector is estimated to generate approximately 40% of all man-made wastes. In addition, the construction sector is the Union's largest industrial sector, contributing approximately 11% to the GNP and having more than 25 million people directly and indirectly engaged [67].

1.5. Threat to Environment

Built environment is considered the most environmental unfriendly human activity because it consumes large amounts of natural resources and produces a great deal of pollutants. The environmental impact of the construction industry is extensive and readily identifiable [64]. Most people are not serious about environmental protection in construction sites. They assume that a construction site is only a temporary setup lasting for two to three years. In fact, the industry is a major source of urban air pollutants [68].

The emission of CO2 by buildings contributed to the global warming and extreme weather change all over the world. The harvest of timber leads to the lost of natural forests. Other impacts of constructing a new building include quarrying to provide aggregates, production of cement, the wasteful use of water and the widespread use of toxic chemicals in materials [69].

2. TOWARDS SUSTAINABLE CONSTRUCTION

In November 1994, the First International Conference on Sustainable Construction held in Tampa, Florida, USA, the conference convener Kibert [70] defined sustainable construction as, "Creating a healthy built environment using resource-efficient, ecologically-based principles". Sustainable construction involves a commitment to:

i) Economic sustainability – increasing profitability by making more efficient use of resources, including labour, materials, water and energy.

ii) Environmental sustainability – preventing harmful and potential irreversible effects on the environment by careful use of natural resources, minimizing waste, protecting and where possible enhancing the environment.

iii) Social sustainability – responding to the needs of people at whatever stage of involvement in the construction process (from commissioning to demolition), providing high customer satisfaction and working closely with clients, suppliers, employees and local communities.

2.1. Challenges in Sustainable Construction

Traditional design and construction focuses on cost, performance and quality objectives but sustainable design and construction adds minimization of resource depletion, minimization of environmental degradation, and creating a healthy built environment to these criteria [71]. The shift to sustainability can be seen as a new paradigm [72] where sustainable objectives are within the building design and construction industry. It is considered for decision making at all stages of the life cycle of the facility. Figure 3 outlines the evolution and challenges of the sustainable construction concept in a global context.

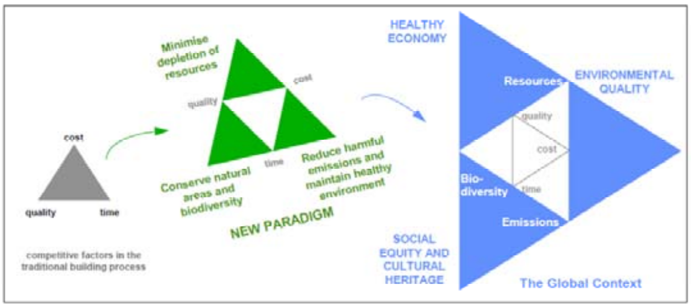

Figure 3: Challenges of sustainable construction in a global context [Huovila & Koskela, [73]]

2.2. Principles of Sustainable Construction

Sustainability is a dynamic concept. It requires decision makers to be flexible and willing to modify their approaches. To achieve sustainable construction, it is very important to balance the basic principles of sustainability i.e. environment, economic and social aspect together.

i. Environment Aspect

In environmental dimension the sustainable approaches are as follow:

- Increase material efficiency by reducing the material demand of non-renewable goods
- Reduce the material intensity via substitution technologies
- Enhance material recyclability

- Reduce and control the use and dispersion of toxic materials
- Reduce the energy required for transforming goods and supplying services
- Support the instruments of international conventions and agreements
- Maximize the sustainable use of biological and renewable resources
- Consider the impact of planned projects on air, soil, water, flora, and fauna.

ii. Economic Aspect

In economic dimension the sustainable approaches are as follow:

- Consider life-cycle costs
- Internalize external costs
- Consider alternative financing mechanisms
- Develop appropriate economic instruments to promote sustainable consumption
- Consider the economic impact on local structures

iii. Social Aspect

In social dimension the sustainable approaches are as follow:

- Enhance a participatory approach by involving stakeholders
- Promote public participation
- Promote the development of appropriate institutional frameworks
- Consider the influence on the existing social framework
- Assess the impact on health and the quality of life.

3. GREEN BUILDINGS

The construction industry is one of the biggest contributors to pollution and waste through its life cycle [74]. About 40% of the world's resource and energy use is linked to the construction and maintenance of buildings. Over 30% of conventional buildings have poor indoor air quality and we spend about 90% of our time indoors. These issues can be addressed by the Green building approach, which is more sustainable than current practices [75]. Green building practices are environmentally responsible and resource-efficient throughout a building's life-cycle. Green building relates to sustainable development, as it promotes building practices that conserve energy and water resources, preserve open spaces [76].

Green buildings minimise the emission of toxic substances throughout its life cycle, harmonise with the local climate, traditions, culture and the surrounding environment. Green buildings are able to sustain and improve the quality of human life whilst maintaining the capacity of the ecosystem at local and global levels. Green buildings have many benefits, such as better use of building resources, significant operational savings, and increased workplace productivity.

Green building practices can be introduced at any stage in construction, from design to deconstruction. Ideally, the impact of the built environment should be addressed on a life cycle basis, from the origins of the building material, through the manufacture and installation of these materials, to their eventual demolition of the building [77]. Also, considering that construction waste comprises of a significant portion of landfill material, green building principles are a good starting point, by guiding builders to realize the kinds of waste that are generated during the construction stage and how to reduce them [77]. The potential benefits of green building are summarized in figure 4 below:

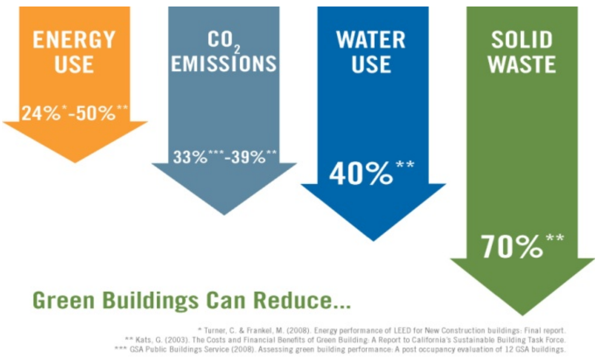

Figure 4: Benefits of Green Buildings

3.1. Green Building Standards

Various countries have developed Green building standards in accordance with their environment. Some of the green building standards in the world are:

- UK – BREEAM (BRE Environmental Assessment Method), launched in 1990, is a widely used means of reviewing and improving the environmental performance of buildings.

- Japan – CASBEE (Comprehensive Assessment System for Building Environmental Efficiency), was developed by the Japan Sustainable Building Consortium and introduced in 2004.
- USA - LEED (Leadership in Energy and Environment Design), owned by the U.S. Green building Council, promotes a whole-building approach by recognizing performance in the sustainable site development, water savings, energy efficiency, materials selection, and indoor environment quality.
- Canada – R-2000 is a voluntary national standard whose technical requirements involve three main areas of construction: energy performance, indoor air quality and environmental responsibility.
- Sweden - EcoEffect is a national environmental assessment system focusing on the environmental effects of the use of energy and materials, indoor and outdoor environment and life cycle costs.
- Hong Kong - BEAM (Building Environmental Assessment Method), defines over 100 best practice criteria to prevent pollution and reduce resource consumption across the whole life of a building, whilst providing a healthy environment inside and outdoors.
- Hong Kong - CEPAS (Comprehensive Environmental Performance Assessment Scheme), is a holistic assessment tool for various building types with clear demarcation of the entire building life-cycle, which covers the pre-design, design, construction & demolition and operation stages. The element of sustainability has been built into this assessment scheme. Issues of broader sense of sustainability as well as extending environmental sustainability to social and economic aspects are also integrated into all CEPAS categories and indicators.
- Malaysia - GBI (Green Building Index) was launched in 2009 and it comprises of 6 key criteria for rating the green building in Malaysia. The criteria are based on Energy Efficiency, Indoor Environmental Quality, Sustainable Site Planning and Management, Material and Resources, Water Efficiency and Innovation.

3.2. Examples of Green Building Projects Worldwide

Numerous projects have been carried out worldwide to achieve the benefits of sustainable and green development. Some of the examples are as follows:

- **Hong Kong Science Park** uses solar glass of photovoltaic panels to reduce energy consumption. The park is able to save approximately 250MWh of electricity consumption annually as shown in figure 5.

(a) (b)

Figure 5: Hong Kong Science Park – Solar Glass (Source: www.google.com)

- **German Parliament** as shown in figure 6 is designed to use 100% renewable energy. The renewable energies are passive use of solar power and natural light and also bio-fuel generators. This leads to a 94% cut in its carbon emissions.

Figure 6: German Parliament (Source: www.google.com)

- **Singapore - Punggol Eco-town** as shown in figure 7 is designed with incorporating elements of nature and "green living by water". Its features includes integrated public transport system, charging stations for electric cars, cycling lanes and 3.2 megawatt solar farm pumping straight into the grid and eliminates the use of batteries

Figure 7: Punggol Eco-town (Source: www.google.com)

- **ZEO Building in Bangi** as shown in figure 8 was built with a targeted building energy index [BEI] of as low as 50kWh/m2 per year by using renewable energy to bring the building to a zero energy status.

Figure 8: ZEO Building (Source: www.google.com)

4. TOOLS AND TECHNIQUES TO ACHIEVE SUSTAINABLE AND GREEN CONSTRUCTION

Traditional approach in construction is facing a lot of challenges such as the delay to complete the project in time, the expenditure exceeding the budget, the building defects and over dependent of foreign workers [13]. Thus, it needs serious attention to re-think construction for improvement. A significant improvement can be achieved by using advanced technological methods Like Lean techniques, Industrialized Building System (IBS), Building Information Modeling (BIM), Value Engineering (VE), Sustainable Supply Chain Management (SSCM) etc.

As an example in improving the traditional construction approach is by adopting lean technique. Lean acts from the project definition to the construction phase in achieving sustainable facility. Lean construction identifies sustainable values including economic, environmental and social values as critical factors in implementing sustainable construction as shown in figure 9 below.

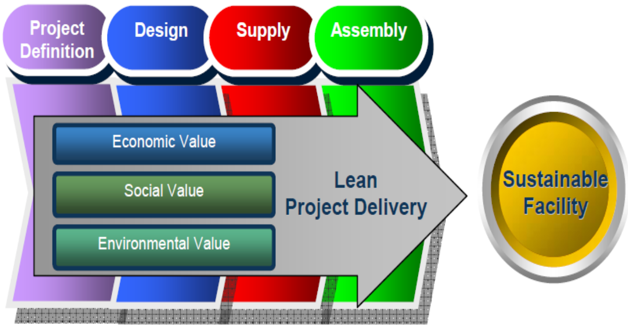

Figure 9: The relationship between Lean and Sustainability [Source: Bae & Kim 78]

5. CONCLUSION

Construction industry has been growing rapidly and plays a vital role in the economic growth of a country. It helps in improving the quality of life of its citizens by providing the necessary socio-economic infrastructure such as roads, hospitals, schools and other basic & enhanced facilities. However, it also generates implications to the environment and social aspect of the country. Most of the projects are designed in a traditional manner without consideration to energy & environmental impacts and natural resources conservation which resulted in detrimental wastage affecting our ecological integrity.

Wastes and pollutions are generated by the construction industry through its life cycle and excessive resource consumption. The emission of CO2 by buildings contributed to the global warming and extreme weather change all over the world. About 40% of the world's resource and energy use is linked to the construction and maintenance of buildings. These issues can be addressed by the Green building approach, which is more sustainable than current practices. Green building practices are environmentally responsible and resource-efficient throughout a building's life-cycle. The practices relate to sustainable development, as it promotes building practices that conserve energy and water resources, preserve open spaces. Green building practices can reduce energy consumption up to 50%, CO2 emission up to 39%, water used up to 40% and finally reduction in solid waste up to 70%. These significant improvements can be achieved by using advanced technological methods Like Lean techniques, Industrialized Building System (IBS), Building Information Modeling (BIM), Value Engineering (VE), Sustainable Supply Chain Managemnet (SSCM) etc.

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