

**DETERMINING LEAN PRINCIPLE FACTORS TO ACHIEVE
SUSTAINABLE CONSTRUCTION WITH TIME REDUCTION EMPHASIS**

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ABSTRACT

Sustainable construction, which has been dubbed as green construction, describes the responsibility of the construction industry in achieving a sustainable environment. The aim of this research is to determine the Lean Principles factors to achieve sustainable construction with time reduction emphasis. The methodology of mix methods consists of literature review, interviews, questionnaire survey and scheduling simulation. From the literature review, it shows clearly the sustainable construction is not focusing on time factor. This gap needs to be addressed because time is an important element in the construction life cycle. The questionnaire survey was distributed to the construction players and the results show the respondents give a high score on the implementation of sustainable construction because of the environmental issues rather than time. From the questionnaire also, the correlation analysis shows there was a strong correlation between the sustainable construction and lean principles in the view of time reduction. The construction scheduling simulation using Microsoft Project were used to see the time impact of conventional tall buildings when using Industrialized Building System (IBS) as a practical approach of Lean Principles. The scheduling simulation shows the time reduction in project completion. The conceptual framework has been established using Lean Principles in sustainable construction and the validation process of the framework showed that there is time reduction element if the framework is being implemented in the sustainable project. The average estimation of time reduction is 20% and majority of time reduction gained from construction stage in the project lifecycle. As conclusion, there were a significance relationship between Lean Principles in sustainable construction to achieve time reduction.

ABSTRAK

Pembinaan mampan juga dikenali sebagai pembinaan hijau menunjukkan tanggungjawab industri pembinaan dalam mencapai pembinaan lestari. Tujuan penyelidikan ini adalah untuk menentukan faktor-faktor dalam prinsip *Lean* terhadap pembinaan mampan dan hubungannya dengan faktor pengurangan masa. Metodologi kaedah penyelidikan campuran (*mix method*) yang digunakan terdiri daripada kajian literatur, temuduga, tinjauan soal selidik dan simulasi perancangan kerja. Dari kajian literatur, pembinaan mampan kurang memfokuskan terhadap pengurangan masa, sedangkan masa merupakan faktor yang perlu diambilkira dalam kejayaan projek. Kajian soal selidik juga menunjukkan bahawa pemain industri pembinaan memberikan skor tertinggi terhadap implimentasi pembinaan mampan yang tertumpu kepada faktor penjagaan alam sekitar dan bukannya masa. Dari soal selidik juga, analisa korelasi dijalankan dan terdapat hubungan yang kuat antara pembinaan mampan dan prinsip *Lean* dalam pengurangan masa projek. Simulasi masa pembinaan menggunakan perisian *Microsoft Project* digunakan untuk melihat kesan masa terhadap bangunan-bangunan konvensional apabila menggunakan sistem binaan berindustri. Simulasi yang dilakukan ini menunjukkan terdapat pengurangan masa projek. Konsep kerangka kerja telah dihasilkan menggunakan prinsip *Lean* dalam pembinaan mampan dan proses validasi menunjukkan berlakunya purata pengurangan masa sebanyak 20% dengan sebahagian besar pengurangan masa berlaku dalam fasa pembinaan. Sebagai kesimpulan, terdapat hubungan yang ketara antara prinsip *Lean* dalam pengurangan masa untuk pembinaan mampan.

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APPROVAL

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CHAPTER 1

INTRODUCTION

1.1 Background

Sustainable construction has become one of the major focus on delivering construction project nowadays. This contemporary agenda has become the new approach for construction players to participate, either in real practice or research. Sustainable construction being the focus on the goals that are usually related with the problems of climate change, energy reduction and clean air also water (Ismael & Tripp, 2018).

According to Bruntland Report (1987) the main definition of sustainable construction is the development that meets the needs of the present without compromising the ability of the future generations with their own needs. Since then many progressive world events had taken place to increase the level of awareness on environment and sustainability agendas such as Rio Earth Summit (1992), Maastricht Treaty (1992), Kyoto Conference on Global Warming (1997),

Johannesburg Earth Summit (2002), Washington Earth Observation Summit 2003 and Malaysia Sustainable Development Goals Summit (2019).

The ideas and strategies initiated by these world events have prompted positive actions and plans by many countries to implement and absorb the philosophy within the construction context. Currently held judgements about sustainability, do not always represent reality (Shealy, 2017). The project prolonged until the sustainable elements are being put a side. The aim of the project delivery becomes more relevance as a project success element. Sustainable construction appears overly risky when the outcome value appears not to align with the stakeholder objectives (Yang, et. al., 2015).

The sustainable input really benefits the industry and it gives the best impact towards producing the output that benefits the future. The terminology of sustainable materials, sustainable development, sustainable neighbourhood and green buildings always come to mind when the issue of sustainable construction is being brought up.

In recent years, the sustainable construction is being debated as an important measure to assuage the green and environmental elements. Basically, this is due to degradation of global environment and the consent to future generation's living needs. At the local scale, the development is threatening by eroding infrastructure, congested of tall buildings and pollution. On the larger scale, it is affected by the climate change and weather related natural disasters.

The demand of the daily needs, such as the quality of life contributes to the sustainable needs and the trends appear to be more converging and more realistic. Parameters of quality, such as the economy, management of social and environmental resources as well as the inhabitant's quality of life, play a significant role as well. At the domestic demand, the development was threatening by eroding infrastructure, congested roadworks, poor air quality and lack of access to fresh water. On a larger scale, there are developments affected by climate change and other related environmental problems.

The perception of sustainable construction always being referred as environmental and green technology, but the focus is more than that. Sustainable construction involved the development in relation to the environment, economic, social and governance. As a summary, sustainable construction can be understood as self-preserved development.

Sustainable construction, which has been dubbed as green construction, describes the responsibility of the construction industry in achieving sustainable environment (Nazirah, 2009). It leads to aim the delivering of output without putting the time factor in the philosophy.

Sustainable construction should be a process whereby, over time, sustainability is achieved. The concept of sustainability must be applied into construction industry to influence the manner in project management to deliver the construction project within the time frame.

In managing the sustainable project, the issue of project delivery also has been a main aim of each development. In relation to budget, specification and duration, sustainability focus is to deliver the project according to a specification with less wastage and less pollution (Ofori, 2000). The diversion should investigate duration because the success of the project being counted when it is completed on time. In contemporary view, the element of time reduction gives the advantage in viewing the successful project delivery. It is more appreciated if the sustainable development is completed in a rapid way.

The government has emphasized a lot of efforts, such as putting the outline that green growth is no longer an option but a necessary game changer to transform the Malaysian economy and its infrastructure into one that is efficient, clean and sustainable. With reference to the 11th Malaysia Plan, many parties are involved to realise this dream. Construction players such as consultants and contractors collaborate with agencies such Public Work Department (JKR), Construction Industry Development Board (CIDB), Sustainable Construction Excellence Centre (MAMPAN) and academic agencies to develop and utilise the tools in achieving sustainable construction.

Malaysia as a developing country, it is pertinent that the construction industry plays a role in its economic growth whereby, the industry has been consistently contributing 3-5% of the national Gross Domestic Product (CIDB, 2000). The increase in value depends on the challenges in the areas of productivity, quality, safety, technology and unproductive practices. The new paradigm in

delivering the sustainable construction is rapidly increasing and should be an agenda in the project life cycle. It will be much appreciated if the environmentally friendly project is delivered in parallel with maximizing the profit of the economic development while maintaining services and quality of life. Project goals should include the items of time reduction while maintaining sustainability elements to produce a new dimension of rapid sustainable construction projects.

1.2 Problem Statement

Construction industry must inevitably change its historic methods of operating with little regard for environmental impacts to a new mode that makes environmental concerns a centrepiece of its efforts (Xueying et. al., 2019). Previously, the concern on environment is relatively a small part of most of construction development. However, with the growing awareness on environmental protection due to the depletion of non-renewable resources, global warming and extremity of destruction to ecology and biodiversity impact, this issue has gain wider attention by the construction practitioners worldwide.

Many efforts are being directed to build sustainably in construction world. The direction of the industry is now shifting from developing with environmental concern as a small part of the process into having the development process being integrated within the wider context of environmental agenda. Thus, the activities of construction industry must work and comply with the needs to protect and sustain the environment.

Sustainable construction focuses on delivering a project which meets the needs of the present without compromising the ability of the future generations to meet their own needs (Bruntland, 1987). Sustainable construction has shifted focus

in contemporary construction practice that intends to have an efficient process with the benefits to future generation. Understanding the environment and establishing better practices, utilizing continuous improvement principles will help to realise the aim of achieving sustainable construction. Figure 1.1 below shows the diagram of sustainability in construction.

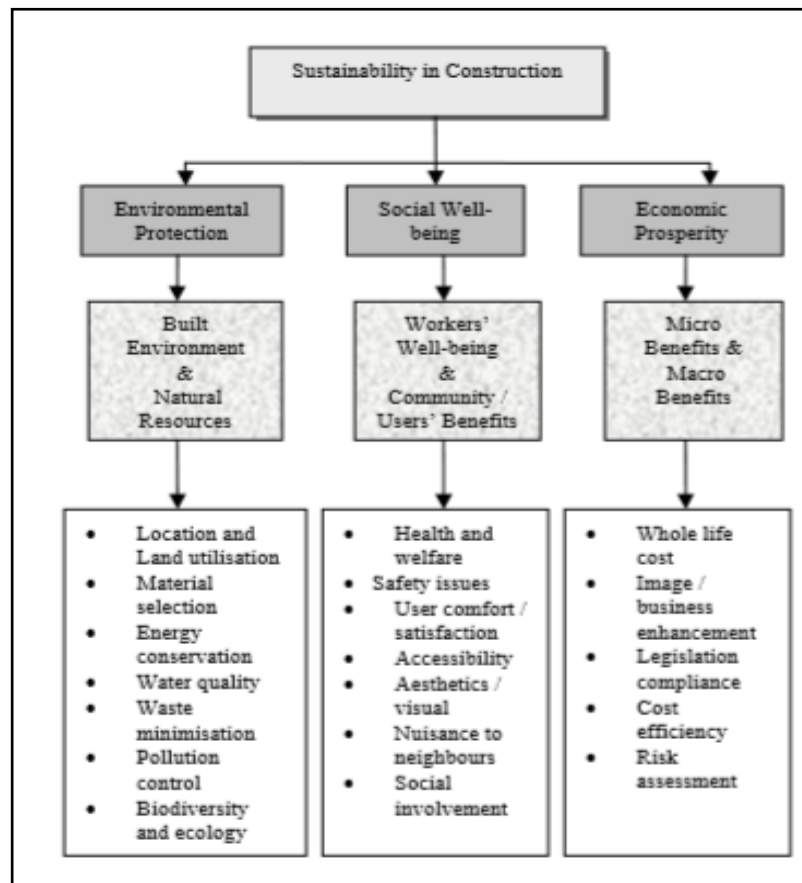


Figure 1.1 Elements of Sustainable in Construction (Nazirah, 2009)

Reference to Figure 1.1, the elements of sustainable construction less focus on duration and not looking at the elements of time reduction (Nazirah, 2009). The integration of time reduction in the sustainable construction will help to derive the added value of the development and minimize delay. Time is one of the factors in successful project delivery (Lok & Abdul, 2015). To ensure the sustainable project to be success, the element of time should be incorporated to the sustainable project life cycle.

This integration will give the added value of construction time in each element of economy, environment and society (Wu & Barnes, 2016). In the new paradigm shift, the sustainable construction should be delivered in the secured time frame to enhance the efficiency in the project life cycle. The area of sustainable construction will create the discerning of utilizing the environmental effort towards social, economy and environment.

1.3 Aim and Research Objectives

Sustainable construction has a strong impact and relationship with the development that has impact on the environment. Through this research, it was found that sustainable construction has less focuses on time reduction of construction process flow, while retaining the element of sustainability. Therefore, a suitable method must be designated to get the relationship between sustainable construction and time factor. Aim of this research is to determine the Lean

Principles factors to achieve sustainable construction with time reduction emphasis.

The following objectives are set within the design of this research:

1. To evaluate the fundamental concept of sustainable construction;
2. To explore the time reduction factor that contributes to sustainable construction;
3. To evaluate the potential application using Lean Principles to achieve sustainable construction with time reduction emphasis; and
4. To establish a conceptual framework with time reduction and Lean Principles in sustainable construction.

1.4 Research Scope

The focus of this study is confined to the West Malaysia only, excluding East Malaysia. The primary data collection will be collected through questionnaire survey which have been sent through directly to selective respondents mainly site personnel who have leading roles in the construction management such as project managers, general managers, resident engineers, site managers and site engineers collectively as the construction players. On site interviews were conducted with construction players to validate the factors that are related to this research. All the respondents should have experience involving in the constructions of tall buildings. This research does not focus on the non-price factor. Also, all case studies will be focused on time factor.

As the case studies related to the construction scenario, five (5) multi storey buildings project was selected, which included traditional and modern buildings. The project listed in this research is shown in Table 1.1. The scope of the study also focuses on exploring the new management philosophy, especially the Lean Construction Principles. The element of time reduction will also be covered for the whole sustainable project.

Table 1.1 Projects related to case studies

No.	Project Title	Start Date	Finish Date
1	Construction of 10 Storey PDRM's Quarters in Klang, Selangor, Malaysia	1 February 2015	31 January 2017
2	Construction of 18 Storey PDRM's Quarters in Subang Jaya, Selangor Malaysia	1 April 2015	31 March 2017
3	Construction of 7 Storey PDRM's Quarters in Tanah Rata, Cameron Highland, Pahang, Malaysia	1 April 2015	31 March 2017
4	Construction of 10 Storey Hostel at UiTM Permatang Pauh, Penang, Malaysia	1 June 2015	31 Mei 2017
5	Construction of 10 Storey Government Residential units in Putrajaya, Malaysia	1 August 2015	31 July 2017

1.5 Research Significance

The significance of this research is to contribute the new knowledge on the understanding for construction players by incorporating the time reduction and Lean construction principles in the sustainable construction project in Malaysia. This derivation will help the industry to produce the sustainable development with the element of time reduction. The lean construction principles will directly guide the construction players to achieve sustainable construction with the reduction of time factors.

1.6 Thesis Outline

This thesis consists of six chapters. A summary of each chapter is provided as follows:

Chapter 1: Comprises the introduction of the research, which develops the direction of the research. The identification of the crucial issues which leads to the formulation of the problems, objectives, significance and scope of the research as the limitation of the research.

Chapter 2: Explains the current state of knowledge by reviewing the existing literature on the sustainable construction, time factor in construction process flow and Lean Principles towards time reduction. The subjects covered includes, the

overview, current implementation, project lifecycle and the need for sustainable construction.

Chapter 3: This chapter explains the overall research methodology for this research. The data collection uses the analysis using mix method (qualitative and quantitative). The case study is also being analysed and simulated using Project Management Software to comprehend the impact of time reduction in construction process flow.

Chapter 4: This chapter discusses the analysis of the data and results of the interviews and questionnaires for the implementation of sustainable construction in Malaysia, time reduction elements and the relation between Lean principles and sustainable elements.

Chapter 5: This chapter derived the conceptual framework of sustainable construction with time reduction factor. The main findings are also being discussed and elaborated in this chapter.

Chapter 6: This chapter presents the conclusion and recommendations for the future research.

1.7 Chapter Conclusion

This chapter provides the research background and details the problems arising in the sustainable construction. The objectives of this study are clearly stated, based on the research design. The research design flow with the starting of getting the boundary of knowledge on three main items; Lean Principles, sustainable construction and elements of time in construction process. Then the mix methods which involved qualitative and quantitative method were used in analysis to achieve the objectives. The elements of sustainability may focus on the constructions that contribute to better environmental effects. It did not mention about the duration as the main aim while the project delivery aims for handing over the project within the timeframe. The integration of sustainable elements and duration will bring the concept of Sustainable Construction with the time reduction factor.