# KEY FACTORS AFFECTING THE ADAPTATION OF PREFABRICATED PREFINISHED VOLUMETRIC CONSTRUCTION (PPVC) IN MALAYSIA INDUSTRY

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## DEDICATION

This project report is dedicated to my beloved family and friends for their endless support and encouragement.

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## ABSTRACT

Prefabricated Pre-finished Volumetric Construction (PPVC) is the advanced modular construction technology introduced by Singapore Building and Construction Authority (BCA) to promote a modern practices in construction sector which rectifying the fragmentation of construction industries towards higher productivity and more efficiency in project delivery. PPVC is an innovative approach to replace the traditional on-site construction method which construct a building using modular units away from the physical site but into a controlled factory environment. The adoption of PPVC has a significant solution to tackle the current level of quality, workmanship, productivity, non-environment construction, unaffordable housing, lacking on-site safety awareness, construction wastage and excessive reliance on unskilled foreign labors associated with conventional construction methods. In Malaysian, PPVC still lagging far behind in the development of Malaysian construction industry. The effectiveness of using PPVC can reduce the number of on-site contractors, increase the efficiencies in the use of resource and minimize the construction waste as well as reduce the overall of construction cost and durations. As a result, the aims of this study are to investigate the key factors affecting the adaptation of PPVC in Malaysia Construction Industry and thus recommend a criteria of feasible mitigation strategies in order to increase the possibility of using PPVC in the future development of Malaysian industry. To achieve these goals, questionnaire was administered by goggle survey form and distributed to industry experts who had working experience in the building industry. A total of 63 responses was received in this survey. Lastly, the results showed that highest number of respondents agreed that the effectiveness of using PPVC were “reduce the overall construction time”, “reduce on-site manpower and equipment requirement”, “better quality of workmanship, efficiency and productivity”. Results also implied that the top three important factors were “lacking experiences of current contractors, subcontractor on PPVC method”, “lacking PPVC of design experience, technical & installation” and “require high operation for capacities of heavy lift crane”. It also revealed the three effective mitigation strategies were “the use of Building Information Modelling (BIM) to tackle the building modular construction and coordination”, “intense coordination to ensure work sequence with minimal delays” and “early involvement of contractors and suppliers / manufacturers during the design phase of the project”. Moreover, there are significant risk on using PPVC as the reliability is much harder to guarantee than conventional construction method. PPVC can be very beneficial to a project, but only if everyone involved has the proper experience and ability to perform such activities. This study contributes to industry practitioners to enhance their understanding of PPVC in order to increase the affordability and sustainability of houses in the future development of Malaysian industry.

# ABSTRAK

Kaedah pembinaan volumetrik prafabrikasi prasiap (PPVC) merupakan teknologi pembinaan modular canggih yang diperkenalkan oleh Pihak Berkuasa Bangunan dan Pembinaan Singapura (BCA) untuk mempromosikan amalan moden dalam sektor pembinaan yang membetulkan pemecahan industri pembinaan ke arah produktiviti yang lebih tinggi dan kecekapan dalam penghantaran projek. PPVC adalah pendekatan inovatif yang menggantikan kaedah pembinaan unit modular secara tradisional di tapak kepada persekitaran kilang yang terkawal. Penerapan PPVC mempunyai penyelesaian yang penting untuk menangani tahap mutu, mutu kerja, produktiviti, pembinaan bukan persekitaran, perumahan yang tidak boleh dibiayai, kurang kesedaran keselamatan di tapak, pembaziran pembinaan dan pergantungan yang berlebihan terhadap tenaga kerja asing yang tidak mahir yang dikaitkan dengan kaedah pembinaan konvensional. Di Malaysia, PPVC masih jauh ketinggalan dalam pembangunan industri pembinaan di Malaysia. Keberkesanan penggunaan PPVC dapat mengurangkan jumlah kontraktor di tapak, meningkatkan kecekapan dalam penggunaan sumber dan meminimumkan sisa pembinaan serta mengurangkan keseluruhan kos pembinaan dan jangka masa. Oleh itu, matlamat kajian ini adalah untuk menyiasat faktor utama yang mempengaruhi penyesuaian PPVC di Industri Pembinaan Malaysia dan mencadangkan kriteria strategi mitigasi yang sesuai untuk meningkatkan kemungkinan penggunaan PPVC dalam pembangunan industri Malaysia pada masa akan datang. Untuk mencapai matlamat ini, soal selidik ditadbir oleh borang tinjauan goggle dan diedarkan kepada pakar industri yang mempunyai pengalaman kerja dalam industri pembinaan. Sebanyak 63 respons telah diterima dalam tinjauan ini. Akhir sekali, keputusan menunjukkan bahawa bilangan responden tertinggi bersetuju bahawa keberkesanan penggunaan PPVC "mengurangkan masa pembinaan keseluruhan", "mengurangkan keperluan tenaga kerja dan peralatan di tapak", "kualiti kerja, kecekapan dan produktiviti yang lebih baik". Hasilnya juga menyatakan bahawa tiga faktor utama yang dihadapi adalah "kurang pengalaman kontraktor semasa, subkontraktor dalam kaedah PPVC", "kurang pengalaman reka bentuk PPVC, teknikal dan pemasangan" dan "memerlukan operasi yang tinggi untuk kapasiti kren angkat berat". Ia juga mendedahkan bahawa tiga strategi mitigasi yang berkesan ialah "penggunaan Pemodelan Maklumat Bangunan (BIM) untuk menangani pembinaan dan penyelarasan modular bangunan", "penyelarasan sengit untuk memastikan urutan kerja dengan kelewatan yang minimum" dan "penglibatan awal kontraktor dan pembekal / pengeluar semasa fasa reka bentuk projek ". Selain itu, terdapat risiko yang signifikan untuk menggunakan PPVC kerana kebolehpercayaan lebih sukar untuk menjamin daripada kaedah pembinaan konvensional. PPVC boleh memberi manfaat kepada sesuatu projek, tetapi hanya jika semua orang yang terlibat mempunyai pengalaman dan keupayaan untuk melaksanakan aktiviti tersebut. Kajian ini menyumbang kepada para pengamal industri untuk meningkatkan pemahaman mereka terhadap PPVC dalam rangka meningkatkan kemampuan dan kelestarian rumah di masa depan pembangunan industri Malaysia.

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| | | |
|---|---|---|
| ANOVA | - | Analysis of Variance |
| BCA | - | Building and Construction Authority, Singapore |
| CIDB | - | Construction Industry Development Board Malaysia |
| CIMP | - | Construction Industry Master Plan |
| CITP | - | Construction Industry Transformation Programme |
| IBS | - | Industrialised Building System |
| PPVC | - | Prefabricated Pre-finished Volumetric Construction |
| QLASSIC | - | Quality Assessment System in Construction |
| SI | - | Severity Index |
| SPSS | - | Statistical Product of Service Solution |

## LIST OF SYMBOLS

| | | |
|---|---|---|
| n | - | Total Number of the completed questionnaires |
| f*i* | - | Total frequency of the score |
| n | - | Total Number of the completed questionnaires |
| w*i* | - | Weight of the assigned score |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Prefabricated Pre-finished Volumetric Construction (PPVC) is a new construction approach where building components are assembled into room-sized volumetric units off-site in a controlled factory environment (Jiang et al., 2018), and then transported on-site and stacked on top of each other to form a complete building. Modular components are characterized as a three dimensional object whereby its size is to provide utility space. Each modular component includes floor, walls, frame, ceiling and other accessories fitting (Kyjakova & Baskova, 2016). PPVC method is a fast evolving as an effective alternative compared to conventional construction method and it has been widely adopted in Japan, parts of Europe and North America.

Prefabricated Prefinished Volumetric Construction (PPVC) is known as Modular Construction technology in Malaysia which had been well-applicable in constructing commercial buildings around the world for decades (Ong Ying Rui & Khairulzan Yahya, 2016). Modular technology significantly speeds up construction, improves productivity in terms of manpower and time savings. In a nutshell, lower costs and shorter construction period with better quality are the core values implemented in every construction projects (Ong Ying Rui, Khairulzan Yahya, 2016). Building and Construction Authority, Singapore (BCA) is strongly promote off-site prefabricated for on-site assembly and encouraging more local corporates to focus on greater adoption of PPVC technology as well as productive technologies. Today, Singapore has developed the world's tallest of 40 storey PPVC condominium with concrete modular. In addition, Singapore is the most productive residential construction projects in the world due to its outcome-based regulation.

According to The Construction Industry Transformation Programme (CITP) 2016-2020 which envisions the Malaysian industry to become an advanced, continued growth of national collaborative, nurture international champions with the aim of success in Malaysian construction industry. To achieve these outcome, four strategic thrusts have been identified by CITP which were subsequently formed a clear key across each of the four strategic. The four (4) strategic thrusts are:

i. To deliver an industry culture which ingrained with professionalism, safety and quality.

ii. Malaysia will be a model for the emerging world in terms of sustainable infrastructure.

iii. The construction industry will more than double its productivity, and the increase in productivity will be matched by higher wages.

iv. Malaysian construction industry champions will be nurtured, and will lead the charge both locally and globally.

First strategic thrust of CITP aims to improve the quality standards of Malaysian construction industry. To achieve this vision, CITP emphasises on the implementation of the Quality Assessment System in Construction (QLASSIC). QLASSIC can be used to measure the quality of workmanship in building construction which serve as broader quality assurance based on the Standard of Building Requirement. However, to obtain high scores in QLASSIC through project that using conventional construction method are very difficult. To obtain higher QLASSIC scores, CITP encourage the adoption of new technology such as PPVC adoption to enhance precision of material and workmanship. Furthermore, CITP puts more effort on safety levels in the industry. There will be more stringent requirements on occupational safety and health implement in construction industry as well as standards and Codes of Practice which can governing construction safety and health. To achieve this mission, the PPVC adoption will enable to more control over the construction safety and health since building components are manufactured at the controlled factory. Workplace accidents and dangerous construction works can be minimized by transferring the main construction work to controlled factory environment.

Second strategic thrust of CITP that Malaysia's environmentally sustainable construction to be a model for the emerging world. To drive sustainable construction excellence in the industry, rating tools will be developed with incentive programmes to encourage sustainable projects. To achieve this mission, the PPVC adoption is mandatory to drive changes in current construction market to pursue long term environmentally sustainable practices to produce Malaysia as a low carbon and sustainable country. The adaptation of PPVC in the Malaysian Construction Industry is proven to improve productivity and promote sustainability of the construction industry (Musa M.F and Mohammad M.F, 2015). In addition, the adoption of PPVC produce less construction waste will be achieve in lower $CO_2$, more resilient, resource-efficient, and socially-inclusive manner.

Third strategic thrust of CITP that measures to raise productivity levels. In current of construction industry, low productivity level which reflect the construction participant's demand to adopt new technology and practice which results less high-skilled or construction experts in construction industry. However, for the new construction technology such as PPVC adoption, the construction workforce will be highly capable as well as the potential of increase skilled local workforce into the industry (CITP, 2016-2020).

Fourth strategic thrust of CITP aims for the performance of local construction participation to meet expected international standards. These visions are implement of internationalize practices and standards which includes the adoption of higher material standards and specifications. With the introduce Malaysian Standard for construction specifications will help to enhance and expand in facilitating the new technology such of PPVC. In addition, the create of nationwide standardization for PPVC method include the accreditation, quality check/assurance, modular coordination, standardized design components, codes and guidelines will allow fluently practice the PPVC adoption and its processes.

## 1.2 Problem Statement

Housing is the basic requirement of every human being. Due to the faster-growing population, and to fulfill the tremendous housing demand, a more affordable, faster, reliable, sustainable method of construction is deemed necessary in a developing countries such as in Malaysia construction industry. In current level of Malaysia industry, the issues of quality, workmanship, productivity, non-environment construction, unaffordable housing, lacking on-site safety awareness, construction wastage and excessive reliance on unskilled foreign labors which associated with conventional construction method. Although CIDB had introduced the Construction Industry Transformation Programme (CITP) 2016-2020 that measures to enhance and modernize the construction productivity by adopting of relevant technology such IBS technology / pre-fabrication in project planning. However, the adoption of improved construction technology such as PPVC still unexplored. To enhance the performance of the construction industry, Malaysian industry has to move towards industrialization by adopting PPVC, to replace from conventional construction method to the modern construction method as well as to improve the sustainability of the construction industry. Moreover, PPVC adoption will savings on the overall cost and on-site labor cost (Kamali and Hewage, 2016). In this direction, it could able to build more affordable residential houses in future development.

Despite there are many well-documented benefit that PPVC has an effective alternative to conventional construction method, and PPVC has widely gain acceptance into global construction community. However, it indeed a tough task for Malaysian Construction Industry in adopting a new technological innovation. Yet, much of the factors limiting the PPVC adoption in Malaysia. Country such as Singapore has successfully widely adoption of prefabricated pre-finished volumetric construction (PPVC), resulting in overall good performances compared to conventional on-site construction method (HDB, 2011). PPVC adoption also reducing compliance cost in the way of making more affordable housing project and realize cost effective. Therefore, this study is significant to improve the Malaysia industry move into positive transformation aimed to adopting PPVC construction method in order to increase the affordability and sustainability of houses in the near future development.

## 1.3 Aim and Objectives

The aim of this project report is to study the current gaps of adaptation of Prefabricated Prefinished Volumetric Construction (PPVC) in construction industry. The following objectives have been identified are:-

(a) To study on the effectiveness of using Prefabricated Prefinished Volumetric Construction (PPVC) method in Malaysia Construction Industry.

(b) To determine the factors affecting the adaptation of Prefabricated Prefinished Volumetric Construction (PPVC) method in Malaysia Construction Industry

(c) To recommend the mitigation strategies faced in adopting Prefabricated Prefinished Volumetric Construction (PPVC) method in Malaysia Construction Industry.

## 1.4 Scope of Work

The scope of this study is summarized as follow:

i. The data is collected by distribute survey questionnaire to the project participants who has experience involved in IBS or PPVC project

ii. The target respondents in this study are the key construction practitioners such as architects, engineers, quantity surveyors, suppliers / manufacturers and contractors in Malaysia.

iii. This study will focus on the adaptation of using Prefabricated Prefinished Volumetric Construction (PPVC) in Malaysia Construction Industry.

iv. This study will carry out survey questionnaire on industry experts who had experience in PPVC method.

## 1.5 Significance of Study

Through this study, the introduction of PPVC method will becoming widely used in future development which leading edge to construction industry. The cost and time performances, planning and measurement and the challenges to sustain in the adoption of Prefabricated Prefinished Volumetric Construction (PPVC) project will be recorded and analyzed. In addition, throughout of this study, PPVC can extensively introduced for many high-rise construction and perhaps can help interested participants find the ways to minimal the problems of constructing affordable and sustainable housing by using PPVC method in the future development of the Malaysia industry. PPVC method also significant helps housing to wide adoption of green material resources, eco-friendly production and the advance engineering equipment on a larger scale in order to enhance the project cost to be more effectiveness.

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