# RELATIONSHIP MODEL OF CONSTRUCTABILITY AND COST PERFORMANCE FOR INDONESIA STATE BUILDING PROJECT

PITO SUMARNO

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy

School of Civil Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

AUGUST 2020

## DEDICATION

This thesis is dedicated to Almighty Allah for sparing our lives to this day.

## ACKNOWLEDGEMENT

Alhamdulillah for everything, for all I was able to achieve and all I tried but was not able to achieve. I express my sincere appreciation to my main supervisor, Prof. Dr. Muhd. Zaimi Abdul Majid, for his guidance and support towards this research. My special gratitude goes to the panel of examiners of my Viva session; the Chairman, Prof. Dr. Azlan Bin Adnan, the assistant chairman Dr. Eeydzah Binti Aminudin, the External examiner from Institut Teknologi Bandung (ITB), Prof. Dr. Ir. Krishna S. Pribadi, the Internal Examiner from Universiti Teknologi malaysia (UTM), Prof. Ir. Dr. Rosli Bin Mohammad Zin. Dr. Ain Naadia Binti Mazlan for all their constructive reviews and criticism. I equally acknowledge the support of my individual-supervisors Dr. Ir. Hari G. Soeparto and Dr. Ir. Drs. Afrizal Nursin for their assistance, encouragement and valuable guidance during the years of my study. I would like also to thank Prof. Dr. Ir. Yusuf Latief from University of Indonesia for his honest encouragement.

Many thanks to the Contractors, Consultants, and Government owned companies and Universities for their invaluable advice and inspiration on how to find out the relationship model of constructability and cost performance for Indonesia state building project. Special appreciation to Dr. Eng. Ir. Erman Surya Bakti for his valuable guidance in writing this thesis, Dr. Ir. Rustam, for explaining how cost of Indonesia state building are implemented by standard and Associate Professor Dr. Bambang Trigunarsyah for his inspiration on how to implement constructability in a construction company in Indonesia.

My profound gratitude to IAMPI (Indonesian Society of Project Management Professionals), LPJKN (National Construction Services Development Board), the Ministry of Public Works and Public Housing Republik Indonesia for providing me with the internal project information, support on questionnaires and expert panel.

Finally, I am most thankful with deep sense appreciation to my beloved wife and my granddaughter for their love, great patience and understanding throughout this study.

## ABSTRACT

Constructability and cost are directly related to each other; when the complexity increase, the cost will also increase. Controlling the design, bid and build in terms of constructability helps to better manage the cost performance of projects. Hence, this study is to investigate the relationship model between constructability and cost performance of government building project in Indonesia at design, bid and build stage. Implementing constructability at the beginning of a design, bid and build could have an impact on cost performance results. By increasing the application of constructability innovations and managing its barriers can optimize the cost performance. The relationship model approach H1 is the relationship between constructability to the design stage, H2 is the relationship between the design to the bid and build stage, H3 is the relationship between the constructability to the bid and build stage, H4 is the relationship between the constructability guidelines and standards against cost performance. Data collection using questionnaire are obtained from design professional respondents, contractor/sub-contractor, supplier/vendor and government project owner or their representatives (construction management consultant). Hundred (100) respondents were selected from infrastructure projects and further hundred (100) respondents were chosen from building projects. From the survey, fifty (50) respondents of building projects and forty-six (46) respondents from infrastructure projects responded to the survey. The first stage of the survey is to attest the questions and variables, the second stage of survey is to obtain the data of the study. The Likert scale answers, and other forms were used. The data are then processed through the common perception of questions with homogeneity using SPSS. The data were also tested for reliability using SEM PLS, where they were then analysed in accordance to the objectives. From the results: H1 exhibits seventy-two (72) percent of respondent strongly agreed that constructability implemented at the design stage by the independent reviewer/Construction Management Consultant for projects more than four (4) floors of high rise building or more than 5000 Square meters of floor areas or more than one Designer involved. H2 exhibits sixty-five (65) percent of respondents strongly agree that during design stage the design consultant had incorporate the building standard, bidding/contract and consideration of easier method of construction. H3 exhibits eighty-one (81) percent of respondents agreed that the bidding process was conducted to select a contractor that has a cheaper and reasonable price which can be relied upon during construction. H4 exhibits seventy-four (74) percent of respondents strongly agree that constructability implemented by using the standards and guideline as well as compliance to the requirements, help the cost performance to meet by the project owners budget. In this study it was concluded that the relationship model between constructability and cost performance at design, bid and build stage as project delivery method can be used to control project cost performance.

# ABSTRAK

Kebolehbinaan dan kos berkaitan secara langsung antara satu sama lain apabila kerumitan meningkat, kos juga akan meningkat. Mengawal reka-bentuk, tender dan pembinaan dari segi kebolehlaksanaan membantu mengurus prestasi kos projek dengan lebih baik. Oleh itu kajian ini bertujuan untuk mengkaji model hubungan antara kebolehbinaan dan prestasi kos ke atas projek bangunan awam di Indonesia pada peringkat reka-bentuk, tender dan pembinaan. Melaksanakan kebolehbinaan pada peringkat awal reka-bentuk, tender dan pembinaan dapat memberi kesan pada prestasi kos. Dengan meningkatkan aplikasi inovasi kebolehbinaan dan mengurus halangannya dapat mengoptimumkan prestasi kos. Pendekatan model hubungan H1 adalah hubungan antara kebolehbinaan dengan tahap reka-bentuk, H2 adalah hubungan antara reka-bentuk dengan tahap tender dan pembinaan, H3 adalah hubungan antara kebolehbinaan dengan tahap tender dan pembinaan, H4 adalah hubungan antara garis panduan dan piawaian kebolehbinaan terhadap prestasi kos. Pengumpulan data menggunakan soal selidik diperolehi daripada responden profesional di bidang reka-bentuk, kontraktor/sub kontraktor, pembekal/vendor dan pemilik projek kerajaan atau wakilnya (perunding pengurusan pembinaan). Seratus (100) responden telah dipilih dari projek infrastruktur dan seratus (100) responden lagi adalah dari projek pembinaan bangunan. Dari soal selidik tersebut lima puluh (50) responden projek pembinaan dan empat puluh enam (46) responden dari projek infrastruktur telah memberi maklum balas. Tahap pertama soal selidik adalah untuk menguji soalan dalam soal selidik dan pemboleh-ubah, tahap kedua soal selidik adalah untuk mendapatkan data kajian. Jawapan skala Likert dan bentuk lain telah di-gunakan. Data kemudian diproses menggunakan SPSS melalui persepsi umum terhadap keseragaman soalan. Hasil proses kemudian diuji kebolehpercayaan menggunakan SEM PLS, hasilnya dianalisis berdasarkan objektif. Menurut hasil kajian: H1 menunjukan tujuh puluh dua (72) peratus responden sangat setuju bahawa kebolehbinaan dilaksanakan pada peringkat reka-bentuk oleh pemeriksa bebas/perunding pengurusan pembinaan ke atas projek bangunan tinggi yang melebihi 4 tingkat, atau keluasan lebih dari pada 5000 meter persegi atau lebih dari satu perunding reka-bentuk terlibat. H2 menunjukan enam puluh lima (65) peratus responden sangat setuju bahawa tahap perunding reka-bentuk yang telah menggabungkan piawaian bangunan, tender/kontrak dan kebolehlaksanaan kaedah pembinaan. H3 menunjukan lapan puluh satu (81) peratus responden bersetuju bahawa rancangan tender dilakukan untuk mencari kontraktor yang mempunyai harga yang lebih murah dan berpatutan tetapi boleh dipertanggungjawabkan semasa pembinaan. H4 menunjukan tujuh puluh empat (74) peratus responden sangat setuju bahawa kebolehbinaanyang dilaksanakan dengan menggunakan piawaian dan garis panduan serta mematuhi syarat, dimana prestasi kos projek dapat memenuhi anggaran pemilik. Daripada kajian ini dapat disimpulkan bahawa model hubungan antara kebolehbinaan dan prestasi kos pada tahap reka-bentuk, tender dan pembinaan melalui kaedah penyampaian projek dapat digunakan untuk pengawalan prestasi kos projek.

**TABLE OF CONTENTS**

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| AV | - | Actual Value |
| AC | - | Actual Cost |
| AACE | | American Association of Cost Engineering |
| ASCE | - | American Society of Civil Engineering |
| BC | - | Budget Ceiling |
| BofQ | - | Bill of Quantities |
| BUA | - | Budget User Authority |
| C | - | Constructability |
| CII | - | Construction Industry Institute |
| CR | - | Constructability review |
| CIIA | - | Construction Industry Institute, Australia |
| CIDB | - | Construction Industry Development Board |
| CIRIA | - | Construction Industry Research Information Association |
| CM | - | Construction Management |
| CPI | - | Cost Performance Index |
| CR | - | Constructability Review |
| D | - | Design |
| DGT | - | Directorate General of Treasury |
| EV | - | Earned Value |
| GIS | - | Geographic Information System |
| GDP | - | Gross domestic product |
| H | - | Relationship |
| HR | - | House of Representatives |
| HSSE | - | Health Safety Security and Environmental |
| IPE | - | Independent Price Estimated |
| IFC | - | Information For Construction |
| LCC | - | Life Cycle Costing |
| MFR | - | Minestry of Financial Republic of Indonesia |
| MPWH | - | The Ministry of Public Works and Public Housing of Republic of Indonesia |

| | | |
|---|---|---|
| PRI | - | Presidential Regulation Republic of Indonesia |
| PMI | - | Project Management Institute |
| PV | - | Plan Value |
| PMBOK | - | Project Management Body of Knowledge |
| RFP | - | Request For Proposal |
| RQ | - | Research Question |
| SEM | - | Structural Equation Modeling |
| PLS | - | Partial List Square |
| SPSS | - | **S**tatistical **P**ackage for the **S**ocial **S**ciences |
| SREB | | State Revenue and Expenditure Budget |
| UK | - | United Kingdom |
| US | - | United States |
| USD | - | United States Dollar |
| XBB | - | Variable of Bid and Build |
| XBD | - | Variable of Bid Design |
| XD | - | Variable of Design |
| XP | - | Variable of Project complexity |
| XC | - | Variable of Constructability |
| Y | - | Variable of Cost Performance |
| JCT | - | Joint Contract Tribunal |
| SA | - | Strongly Agree |
| A | - | Agree |
| D | - | Doubtful |
| DA | - | Disagree |
| SD | - | Strongly Disagree |

## LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of the Research

In any nation, the construction sector is regarded as one of the most important sectors due to government budgetary allocations and its contribution to the national gross domestic product (GDP). The GDP of Indonesia from construction has varied between 657 USD per head and 4284.70 USD per head in the last decade (Tradingeconomics.com, 2020). Thus, there remains a need to keep this figure high through the development of the Indonesian construction services industry which will in turn encourage more investments in novel building designs, materials and construction equipment, and project funding.

The budgeting process for a government project, particularly a state building construction project in Indonesia, begins with the preparation of the state revenue and expenditure budget as the annual government financial plan which is approved by the House of Representatives of Indonesia. State ministries, hereinafter referred to as Ministries are the government apparatus in charge of specific affairs in government of Indonesia. There are institutions which are are non-ministerial organizations and other budget users established to carry out certain tasks based on the provision of 1945 Constitution of the Republic of Indonesia or other laws and regulations. User Assistant Budget State Treasurer is an organizational unit within the Ministry of Finance that is constituted by the Minister of Finance which is responsible for managing the budget originating from User assistant budget state treasurer while the budget implementation entry list is a budget implementation document prepared by the Budget user/Budget user authority of Indonesia. Additionally, there is a budget ceiling of government of Indonesia which is a budget allocation determined to fund central government expenditure and/or for budget financing in the Annual state revenue and expenditure budget. A comprehensive

work plan with budget of State ministries/institutions and documents of the Ministry or institution's annual financial plan are compiled according to the Ministry/Institution's budget section.

The program is an elaboration of policies in accordance with the vision and mission of the Indonesian Ministry/Institution whose formulation reflects the duties and functions of Level I units or Ministry/Institution units that result in activities with measurable Performance indicators.

An outcome is the performance or target to be achieved from the mobilization of resources and budget for a program. An activity is the elaboration of a Program whose formulation reflects the duties and functions of Level II/Work Unit units or certain assignments of Ministries/ Institutions which contain components of activities that results in Outputs with measurable Performance indicators. Outputs, on the other hand, are goods and services that result from an activity carried out to support achievement of program goals and objectives and policies.

This target is what often brings about variations like insufficient, adequate and surplus budgets in cost performance. Thus, there is the need for an in-depth research on the stability of the budget and the reason behind the variation in cost performance.

The budget from the perspective of the project owner, in this case the government of Indonesia in relation to the construction of state buildings under the Indonesia Minister of Public Works and Housing regulations is determined on budget per unit cost basis. Then a budget ceiling which is a cap on the budget allocation that is set aside to fund central or state government spending and/or budget financing for the year. Based on this ceiling, the Indonesian government project manager auctions off work using self-calculated prices (Independent price estimation) which possibly falls under the budget ceiling for ease and fairness in price comparison. Finally, a definitive price is arrived at as the basis of contract implementation. Likewise, while implementing the contract, changes occur that result in variations in the cost performance of the owner (budget ceiling).

The principle of budget allocation depends on the scope defined by the form/shape of design while the principle of a design results in a project that is complete, usable and flexible such that it requires low maintenance with some degree of energy efficiency and constructed within a budget. Generally, design is divided into schematic design and design development phases which largely determines the budget. Budget itself needs to be controlled as it could be influenced by the parameters determining the level of difficulty of project implementation (Robert A. Youker, 2002), bid and build. Therefore, factors of design such as project complexity level and selection level of design professional and contractor are controlled by finding the most appropriate constructability method.

The execution of construction projects passes through many phases. These phases can be grouped into preconstruction phase which include Inception/initiation, strategizing, planning and designing, construction phase which include execution, monitoring, testing and commissioning) and in use phase when the project close. Inadequate or lack of proper integration of these stages leads to unfavourable conditions like increased cost, improper design, delay, loss of design enhancement opportunities or total abandon of the project. In addition, most decisions in the pre-construction phase affect the construction performance (Pulaski and Horman, 2005), and those impacts increase with the projects' size. The lack of construction knowledge during the design and planning stage has majorly contributed to these setbacks. In view of these problems encountered during construction, researchers and stakeholders have come up with the idea of incorporating construction knowledge (or constructor) at the early phases of projects, especially during the design stage.

Constructability concept which is also known as constructability has been defined by Nima et al. (2001) as the optimum use of construction knowledge and experience by the owner, engineer, contractor and construction manager in the conceptual planning, detailed engineering, procurement and field operations phases to achieve the overall project objectives. The concept denotes the ease with which the raw materials of the construction process (labour, production equipment and tools, and materials and installed equipment) can be brought together by a builder to complete a project in a timely and economic manner (Glavinich, 1995). The concept

first emerged in the United Kingdom and United State of America in the late 1970's following studies on how efficiency, productivity, cost effectiveness and quality could be achieved in the construction industry (Low, 2001; Wong et al., 2006; Hijazi, et al. 2009). Construction Industry Institute (CII) have also defined constructability "as the optimum use of construction knowledge and experience in planning, design, procurement and field operations to achieve overall project objectives". Furthermore, Kamari and Pimplikar (2012) defined constructability as a project management technique for reviewing construction processes from the conception to finished stage during the pre-construction phase. It is usually a means for identifying obstacles before a project is actually constructed to help reduce or prevent incidences of error, delays and cost overrun.

Constructability has an important role to play in the success of a project as it links the construction and the design phases together (Boktor et al., 2013). Many of the decisions made early in the design process affect the construction of the project and so construction expertise needs to be incorporated in the process to improve the design. Thus, according to the CII (1993), maximum benefits occur when individuals with construction knowledge and experience become involved in the early stages of a project life cycle. Constructability should be applied at the early stage and considered as an important objective in all the stages of the construction process. This is because of its ability to influence project cost and add better value for money (Wang et al., 2016).

The process of constructability can be applied throughout the project's life cycle; from feasibility studies, planning, procurement, construction, to post-construction. As long as there is involvement of Stakeholders related to the project in general, the role of Designer is vital in implementing constructability (Hassan, 1997). Planners/Designers are technically responsible at the planning/design stage in the construction phase as shown in Figure 1.1. Figure 1.1 illustrates the project life cycle in traditional contracts while Figure 1.2 shows the level of influence of planners/designers on costs which increases at the start of the project and decreases as it tend towards the end. However, spending generally increases according to the

time of project implementation. Figures 1.1 and 1.2 also show that the best time for constructability is at the planning.

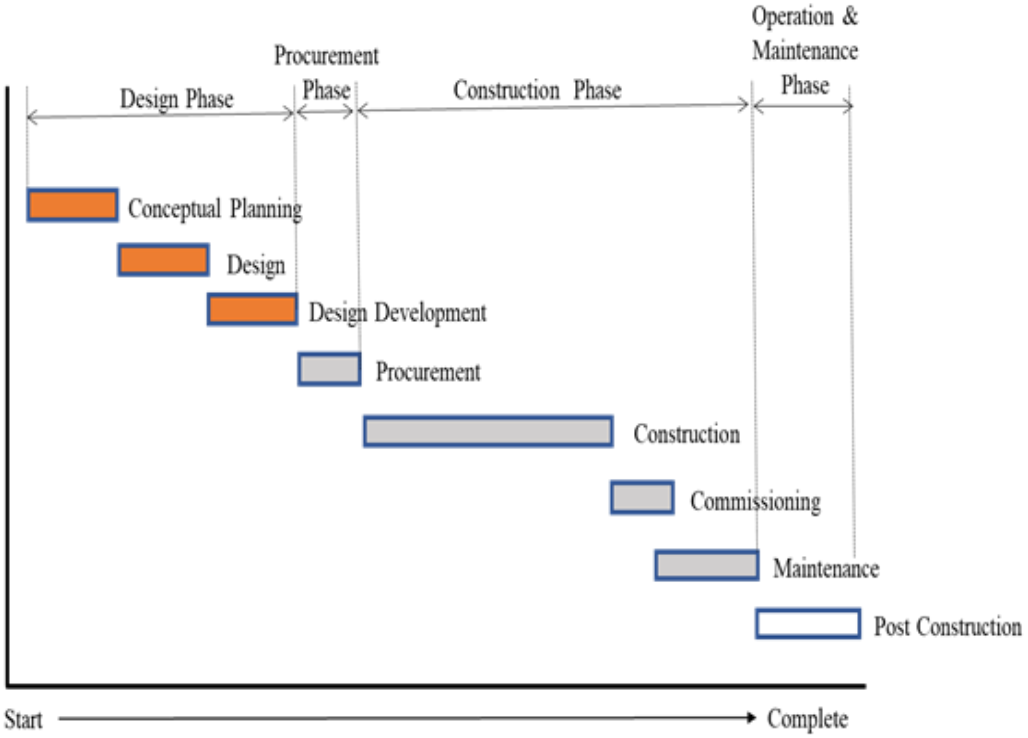


Figure 1.1 Project life cycle (Hassan,1997)

The Project Delivery Method consists of Traditional (Design-Bid-Build), Management (Management, Construction Management), Integrated (Design and Build, EPC/Engineering Procurement Construction) and Partnering approaches. the selected option depends on the respective project Owners.

Indonesia generally uses a traditional contract approach. In the traditional contract approach which is known as design-bid-build construction, players have less collaboration at the design process. The construction process in turn faces hindrances during construction and in the delivery methods of the project. Several studies (Jergeas, 2001; Alshawi and Underwood, 1994; Madelsohn, 1997; Griffith and Sidwell, 1995) have shown that many of the problems of inadequate design and production methods within both traditional and non-traditional construction contracts are caused by unclear and/or missing project information, inadequacies in the quality of information provided or lack of complete information as well as general lack of

co-ordination of design with construction. These problems can constitute as high as 75% of the total problems encountered during construction (Madelsohn, 1997). Effective utilisation of the concept of constructability to overcome these problems depends on the availability of the right information at the appropriate level of detail (Pulaski & Horman, 2005). This requires that designers and contractors improve the quality of information passed between stages, using the right people while doing so at the right time. Several studies have shown that lack of integration of construction knowledge into the design process hinders the ability to construct and has been cited as one reason why projects exceed budgets and schedule deadlines (Trigunarsyah, 2004b).

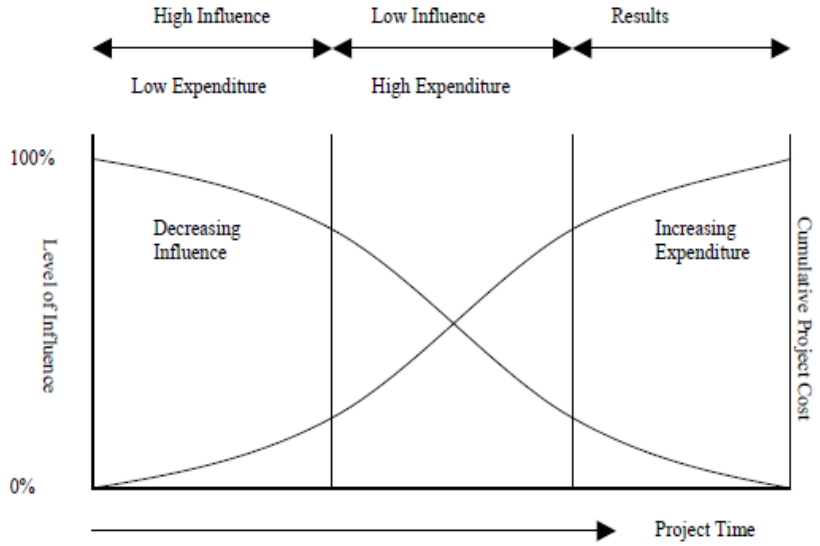


Figure 1.2 Designers Level of Influence (Hassan,1997)

Common sense and research in the field of knowledge management indicates that the majority of constructability knowledge that exists resides in the minds of construction experts. In order to use this knowledge effectively, the right information should be tapped at the right time and at the appropriate level of detail (Ari Muchtar, 1991; Pulaski and Horman, 2005). Thus, the goal of a system that introduces constructability information into design should be to enable decisions about project design and construction to be made right the first time (Christopher Jones, 1993). When this occurs, constructability knowledge can be most effectively utilized and the process becomes most efficient. Hijazi, et al. (2009) opined that construction

managers display the benefit of adopting constructability in terms of cost reduction within the range of one to fourteen percent of the total cost. Regardless of the stage of its implementation, constructability centres on the design.

Prior to the improvement of constructability during the planning and design stages, the key to achieving this during the construction phase of the project is normally through an effective feedback construction knowledge system (Kartam, et al. 1999). Furthermore, Kartam, et al. (1999) stated that when a project advances into the construction phase, the feedback system needed to take care of the task at hand is the construction knowledge in terms of methods, materials, equipment and coordination.

Despite the importance of constructability input, the means by which this knowledge is introduced in construction projects is still largely rudimentary. Current methods typically use design reviews by construction experts. Sometimes tools, such as checklists, are used to help systematize the process. These methods are relatively unsophisticated, inefficient, and often lead to rework. This, in turn, can result in animosity among team members. While these methods have led to project improvements, it is clear that there have been limited advances in introducing constructability information more effectively in design.

In Indonesia, construction projects under government are awarded on a competitive bid basis using combination (lump-sum and unit price) (Bakti, 2002). Ninety percent of construction projects especially government building in Indonesia are awarded through auction approach that uses traditional contracts on a competitive basis. The Ministry of Public Works and Housing of the Republic of Indonesia has established Implementing Agencies for Procurement of Government Goods and Services in all provinces in Indonesia 34 (thirty-four) Provinces (Tradingeconomics.com, 2020) to ensure the implementation of government goods and services procurement without any irregularities, corruption, mark ups and so on. In the traditional approach in project delivery method, design/planning and construction are carried out by a separate Design consultant and contractor respectively. Thus the designer must have construction competencies that can

facilitate the implementation of work, shorten the implementation time make economic construction implementation costs amongst others. Generally in Indonesia, Design consultants do not pay attention to environmental conditions which often lead to difficulties during construction; often leading to changes in scope, time, cost, and quality.

According to the regulation of the MPWH 22 (2018), the budget for the construction of government buildings should be predetermined. Thus, in order to have better control of project cost, starting from initial design stage up to the completion of a given project., the constructability method can be implemented to ensure project cost performance as predetermined. This approach requires better understanding of the relationship between constructability and cost performance. Cost performance is defined as the planned cost (contract) compared to the actual cost which must be equal of one (1) without any contract changes.

## 1.2 Problem Statement

Fifty percent of government building construction projects cost performance which the traditional contracting method had been used in Indonesia has not been satisfactory according to MPWH (2019) report. The problem with the traditional contract approach are the design consultant works separately from the construction contractor who works only after design is completely done. It is possible the design results might not be implemented during construction due to various unforeseen environmental situations that require changes in resources which results in increased cost and unsatisfactory quality. The constructability methods should be capable to control the project cost performance but constructability in Indonesia is not clearly implemented; especially in government building projects.

Given a case study of Malaysia, the construction industry constitutes an important element of Malaysian economy. It shows how important it is to control and manage cost performance as well as ensure that projects are in good quality and efficient. The four fundamental constraints that needs to be considered in order to

manage construction projects successfully are scope, cost, time, quality and health safety security and environmental. In Malaysia, the problem of cost overrun is considered significant in the construction industry. Several factors that contribute to cost overrun in Malaysian construction projects (A.S. Ali, and S.N. Kamaruzzaman, 2010) are calculated as follows: budget as specified in the plan compared to actual cost results in almost fifteen percent greater than the specified project budget.

In the case of Pakistan, the traditional project delivery method used for building construction projects is “design-bid-build", especially in government sectors. Most of the projects following traditional project delivery method do not meet the desired project performance in terms of cost, budget as specified in plan (PV) compared to actual cost (AC) results in almost Twenty-five percent greater than the specified project budget. The propose cost performance can be improved by adopting non-traditional project delivery methods (Amna Shaukat, 2001).

Traditional project delivery method is used in Indonesia for the purpose of preparing the preliminary budget and obtaining an independent price estimate before proceeding with a separate design for the construction work. The owner of the project determines the independent price estimate based on contract documents that have been made by the design consultant after which it is auctioned to get a price below the Independent price estimate. After being awarded the contract, the contractor starts working on construction and often leaves out drawing because it is not in accordance with the field conditions and to prevent the price from exceeding changes. Planning difficulties are due to very complex projects or very low budgets. It has been done looking for a professional designer, estimator, contractor, but the results still occur that the cost performance are still unsatisfactory.

Constructability is measured by the effectiveness of planning/designs, contracts, schedules, sequence construction, procurement, transportation, site layout in addition to a well-planned start-up and HSSE (Health Safety, Security, Environmental) elements.

Cost is the money spent in establishing (establishing, doing, etc.) something while performance refers to how well a person, machine, etc. does a certain activity or job. Cost measurement based on historical cost can be used as assets such as buildings, equipment and so on. Cost performance is a measure of the value of the work/contract completed (EV/earned value), compared to the actual cost (AC/actual cost) of the project. These two must be similar in value. (PMI, PMBOK ed 2016). The term of performance is a form of action that results in work has been achieved or carried out. A Model is representation of an object, objects, or ideas in a simplified form of conditions or natural phenomena.

Cost performance criteria can be classified as follows:

(a) A contract without any change (actually based on initial contract) and regarded as having a very high performance level of scale 4.

(b) A contract with minimum change with additional cost less than or equal of ten percent and regarded as having a high performance level of scale 3. (PRI number 16, 2018).

(c) A contract that changes significantly where additional cost exceed of ten percent and regarded as having a medium performance level of scale 2.

(d) A terminated contract with performance level of scale 1.

## 1.3 Aims and Objectives of the Study

This study aims to investigate the relationship between model of constructability and cost performance at the design bid and build stage. This aim wil be achieved through the following specific objectives;

(a) To identify critical factors that affect cost performance when implementing constructability at the design stage.

(b) To identify the influential factors that impacts cost performance when implementing constructability at bid and build stages.

(c) To investigate the relationship model of constructability and cost performance at the design, bid and build stages of contracts involving government building projects in Indonesia.

## 1.4 Research Scope and Limitations

This research is intended to investigate a relationship model of constructability and cost performance in the design, bid, and build delivery method of government building projects in Indonesia. The study aims to identify the critical and influential factors that affect the cost performance at the design, bid, and build stage while also investigating the relationships model of constructability and cost performance on the government building project in Indonesia.

A single and multi-years budget determination, using a unit price and lump sum combined contract. The government building is as specified by the Ministry of public works and housing of Indonesia.

The study involves Design professional, Contractors, Sub-contractors, Suppliers, Vendors, project Owners and their representatives. It is supported by the relevant stakeholders in the construction industry, regulations and applicable standards. The study was implemented through primary and secondary data collection from all government procurement goods and service centers across the 34 provinces in Indonesia where the data information is applicable. The study is carried out in line with the criteria of building cost that are used as a reference for government budget through survey, interview and questionnaire. This is to ensure that the data is valid and representative of the respondents in Indonesia. It entails a preliminary interview of the experts in related construction industry followed by questionnaire to obtain the various constructability methods and model as well as for the purpose of finding the real contract value of government buildings. Although

this study is focused on the state buildings, the literature review covers studies relating to other places. The tool applied to analyse the obtained survey data was SPSS (Statistical Package for the Social Sciences). The next questionnaire focuses on applying the project with the submission of traditional projects and loopholes from the application of constructability to obtain optimal costs. Case studies and expert judgments from interviews and surveys were used to investigate the relationship model of constructability and cost performance in the government building project.

This study is limited to the government building projects in Indonesia with traditional contracts delivery method. The nature of the combination of contracts is between unit price, lump sum in single years and multi years contract. This research is viewed from the perspective of the Owner of a government project, that is the person that uses the state budget or the regional budget, Regulations and standards adjusted

## 1.5 Significance of Research

The traditional contract system, through improper planning/design, is plaqued delays as a consequence of poor management. Constructability ensures cost saving and time optimization while maximizing design opportunity as well as project complexity. Contributions from the use of science and construction experience emphasize several aspects, among others.

First, this study identifies factors that affect the costs performance at the design stage, constructability problems in traditional contract systems likewise design processes that significantly improve savings and better cost performance.

Second, it provides identification of influential factors that have an impact on cost performance when implementing constructability at bid - build stage.

Third, this study investigates the relationships model of constructability and cost performance at the design, bid and build contract stages on the government

building project in Indonesia. The model will serve as a significant contribution in addressing the identified gaps from constructability process. Data can be obtained at the Ministry of public works and housing republic of Indonesia (Directorate of Construction) and other relevant sources.

## 1.6 Organization of the Thesis

This thesis consists of six chapters. To achieve the aim of this study, the thesis is organized as follows:

Chapter 1 presents the background of the study, the problem statements, the research objectives, the research scope and limitations, the significance of the study, and the outline of the thesis.

Chapter 2 presents a comprehensive review of pertinent literatures on design process, bid and build process, constructability standard and cost performance. It begins with a definition of latent and manifest, exogenous and endogenous variables that has been used internationally and in Indonesia. In addition, this chapter also provides details of design process, constructability process, bid & build process and cost performance which is the main goal of this research. This chapter ends with a summary highlighting the research gap.

Chapter 3 describes the methodology applied in accomplishing the problems summarized in the research aims and objectives. This chapter sets up the premise that leads to the establishment of the methodology that proffers answer to the questions raised by the aim and objectives of the study. Detail discussion of the methods for answering these questions is provided.

Chapter 4 gives details of the questionnaire used in the survey. This involves using questionnaire survey that were distributed amongst design professionals, contractors, sub-contractors, suppliers, vendors, project owners or their

## REFERENCES


AACE (2009) International Recommended Practice 30R-03, *ImplementingProject Constructability*, AACE International, Morgantown, WV.

Aapaoja, 2014. the success of constructability affecting the reducing of cost performance

Abd. Majid, Muhd. Zaimi (1997). *Non-execusable Delay in Constructions*. Loughborough University of Technology, UK: Ph.D. Thesis.

Abd. Majid, M. Z. and McCaffer R. (1997). Discussion of assessment of Work Performance of Maintenance Contractor in Saudi Arabia. *Journal of Management in Engineering. Vol 13 (5),* 91-95.

Abd. Ghani, Rosli (2007). *Asas Pengaturcaraan Pangkalan Data Web PhP and MySQL*. Venton Publishing, Selangor, Malaysia.

Abdelsayed M., and Navron M. (1999). An Information Sharing, Internet Based, System for Project Control. *Journal of System Engineering and Information System,* 16. 211-233.

Abeyegoonasekera, 1999, A case study on a condominium project in Singapore

Abudayyeh, O. (1997). Audio/ Visual Information in Construction Project Control. *Journal of Advance in Engineering Software*, 28, 97-101.

According to the Business Roundtable (1982), Several barriers that frequently restrict the integration of construction input with project planning and design

Adam, S. (1989). *Practical Buildability-CIRIA* (The Construction Industry Research and Information Association) Building Design Report. London: Butterworths.

Aibinu, A.A. and Jagboro, G.O. (2002) "The Effects of Construction Delays on Project Delivery in the Nigerian Construction Industry". *International Journal of Project Management*. Vol. 20 No. 8, pp 593-599.

Alfredo F. Serpell, 2005, The factors that influence the accuracy of the estimated cost at the Concept Design stage

Al-Hammad, A-Mohsen and Assaf,S. (1996). Assessment of Work Performance of Maintenance Contractors in Saudi Arabia. *Journal of Management in Engineering*. Vol 16(1), 44-49.

Al-Mahaidi R, Kalra R, Mikhael S. (2017) Design and Constructability Challenges of

Strengthening Existing Bridges. InAustroads Bridge Conference, 10th, 2017, Melbourne, Victoria, Australia

Al-Sedairy S.T. and Rutland P. (1994). Project management as a way forward in a developing country. *Global Project Management Handbook* (Cleland, D.I. and Gareis R. Eds.), USA: McGraw-Hill, Inc., 5-4 to 5-6.

Akpan, E.O.P., Amade, B., Okangba, S.E. and Ekweozor, C.O.(2014) Constructability Practice and Project Deliver Processes in the Nigerian Construction Industry. *Journal of Building Performance* 5, 1, pp 10-21.

Amade, B. (2014) Containing Failure and Abandonment of Public Sector Construction Projects in Nigeria. A PhD Seminar Paper of the Federal University of Technology, Owerri, Nigeria, December. pp 1-35.

Amor, R., and Ihsan Faraj (2001). Misconception about Integrated Project Databases. *IT Con Vol.6.,* 57-68.

Amna Shaukat (2001) , *Comparation of Project Delivery Method*, Department of Construction Engineering and Management, School of Civil and

Environmental Engineering (SCEE), National University of Sciences and Technology (NUST), Islamabad, Pakistan

Anastasopoulos, P.C., Florax, R.J., Labi, S. and Karlaftis, M.G.. (2010) Contracting in highway maintenance and rehabilitation: Are spatial effects important?. *Transportation Research Part A: Policy and Practice*. 44(3):136-46.

Aouad, G., (1995). The Conceptual Modelling of Construction Management Information. *Automation in Construction 3*, 267-282.

Arbabi, O., Saghatforoush, E., Nikouravan, H.A., Mahoud, M. (2017) Solutions to Overcome Barriers of Implementing Constructability, Operability, and Maintainability (COM) Concepts in Infrastructure Projects: A Meta-Synthesis Approach. Journal of Engineering, Project & Production Management. 7(2).

Argote, L. & McGrath, J. (1993). Group processes in organizations: continuity and change. *International review of industrial and organizational psychology*. New York: Wiley.

Ari Muchtar, 1991, the majority of constructability knowledge that exists resides in the minds of construction experts. In order to use this knowledge effectively, the right information should be tapped at the right time and at the appropriate level of detail

Assaf, S. A., AlKhalil, M., and Al_Hazm,M. (1995). Causes of Delay in Large

Building Construction Projects. *Journal of Management in Engineering,* Vol. 11, no 2. 45-50.

A.S. Ali, and S.N. Kamaruzzaman, (2010) *Cost performance for building construction projects in Klang Valley.* Journal of Building Performance, 1 (1). pp. 110 118. ISSN 2180-2106

Azman, M.N., Ahamad, M.S., Hussin, W.M. (2012) Comparative study on prefabrication construction process. International surveying research journal. 2(1):45-58.

Australia (1996) CI. Constructability manual. Construction Industry Institute Australia (CII Australia), Adelaide, Australia.

ASCE-American Society of Civil Engineering, 1988

ASCE, 1991; Construction Industry Institute Australia, 1996b

Bakti, Erman S., (2002). *Constructability at Project Level*. Master Thesis, University of Indonesia. Jakarta.

Bakti, Erman S., (2012). *Constructability database knowledge model and guidelines of industrial plant at construction stage,* . Doctorate Thesis, University teknologi Malaysia (UTM),.

Barrie, D. S. and B. C. Paulson (1992). *Professional Construction Management*. McGraw-Hill, Inc., New York.

Baccurini, 1996, second project complexity in construction project consisting of many varied interrelated parts and can be operated in terms of differentiation and interdependency

Baumeister RF, Vohs KD, Tice DM. The strength model of self-control. Current directions in psychological science. 2007 Dec;16(6):351-5.

BCA, 2005; (Building Construction Authority) Construction Industry Review Committee, 2001; Glavinich, 1995; Gray & Hughes, 2001; Nima., 2002; Uhlik & Lores, 1998. The integration of experienced construction personnel into the earliest stages of project planning as full-fledged members of the project team will greatly improve the chances of achieving a better quality project, completed in a safe manner, on schedule, for the least cost.

Bertelsen, 2003, defined project complexity, however there seems still to be no clear, universally accepted definition has been produced

Bowen, P.A., and Erwin, G.J., (1990). The Impact of Second- G e n e r a t i o n Expert System on Building Design Evaluation. *Proceeding of International*

*Symposium on Building Economics and Construction Management*, CIB, Sydney, Auatralia, 419-427.

Bohlander and Snell (2010). *Managing Human Resources*. South-Western Cengage Learning, 15th editions.

Boktor, J., Hanna, A., Menassa, C.C. (2013) State of practice of building information modeling in the mechanical construction industry. *Journal of management in engineering*. 30(1):78-85.

Boyce (1994), highlighted the importance of selecting simple structures in designs, as it will save cost while extra cost is anticipated when odd shaped buildings are designed

Bryman, A and Cramer D.,(1997). *Quantitative Data Analysis with SPSS for Windows: a Guide for Social Scientist*. Routledge, New York.

Budi Susilo Supanji, 1995, Experiences gained in the past will encourage to deepen their knowledge and abilities.

Building Magazine, 2010. *The role of traditional contracts,* Category Construction, Sarah Richardson. building, co. uk.

Busby, J. S. (1999). An assessment of post project reviews. *Project Management Journal*, *30* (3), 23–29.

Business Roundtable (1982). *Integrating Construction Resources and Technology into Engineering*, The Business Roundtable, New York.

Capone, P., Getuli, V., & Giusti, T. (2014, January). Constructability and safety performance-based design: a design and assessment tool for the building process. In *31st International Symposium on Automation and Robotics in Construction and Mining* (pp. 313-320).

Chan E.H., Suen H. and Chan S.L. (2005) An Integrated Extranet System: e-AEC for Architects, Engineers and Contractors in Hong Kong and China. *Journal of Construction Research. Vol. 6 No 2*. 253-271.

Chan, D.W., and Kumaraswamy, M. M. (1996). An Evaluation of Construction Time Performance in Buiding Industry. *Journal of Building and Environment*, Vol 31. No 6. 569-578

Christopher Jones, 1993, the goal of a system that introduces constructability information to design should be to enable decisions about project design and construction to be made right the first time

Construction Industry Institute Australia/ CIIA (1992). *Constructability Principles File*, Construction Industry Institute, Australia, Adelaide.

CII (1998), Constructability: *A Primer*. *Implementing Project Constructability*. Participant Handbook, Construction Industry Institute. Austin, Texas.

CII (1993). *Electronic Data Management Task Force*. RS-20-1,2 and 3. Austin, Texas.

CII (1996). *Constructability Guidelines*. The University of Texas, Austin.

CIIA (1992). *Constructability Principles File*, Construction Industry Institute, Australia, Adelaide.

CIRIA (1983). *Buildability: An Assessment*. Special Publication 26: CIRIA (The Construction Industry Research and Information Association). London.

Council on Tall Building and Urban Habitat (1995), *Architecture of Tall Building*, McGraw Hill, USA, 408.

Creswell, Vicki, & Clark, 2007. In general these strategies are called the research approach.

Dada, M.O. (2013) Client and Consultant Organisations Assessment of Design-Bid-Build Procurement Practice In Nigeria. *Journal of Building Performance*. 15;4(1).

Dallas, 2004, the risk component

De Silva, N., Rajakaruna, R.W., Bandara, K.A. (2008) Challenges faced by the construction industry in Sri Lanka: perspective of clients and contractors. *Building Resilience*. 158.

Djohanputro, 2004, Another understanding, and often used by most people, risk is uncertainty that can be quantified which can cause loss or loss, Comparison of Risk and Uncertainty

Easton, V.J., and J.H. McColl. (2007), *Non-parametric Method*. *Statistic Glossary*, VI.1. www.stats.gla.ac.uk/steps/glossary/nonparametric.html.

Edum-Fotwe, F. T., Egbu, C., & Gibb, A. G. F. (2003). Designing facilities management needs into infrastructure projects: case from a major hospital. *Journal of Performance of constructed Facilities*, *17*(1), 43-50.

Fayyad, U., Piatetsky-Shapiro, G. and Smyth, P. (1996), "The KDD process for extracting useful knowledge from volumes of data", *Communications of the ACM*, Vol. 39 No. 11, 27-34.

Fellow, R., and Liu, A (1997), *Research Method for Construction*. London: Blackwell Science.

Fisher, M. (1997), Characteristics of Design- Relevant Constructability Knowledge. *Journal of Construction Engineering & Management*, Vol. 123. No 3, 253-260.

Fisher Deborah. J., Stuart, D. Andersen and Suhel P. Rahman (2000), Integrating Constructability Tools into Constructability Review Process. *Journal of Construction Engineering and Management*, Vol 126 No 2, 89-96.

Fong, Patrick S.W. and Yip, Jimmy C.H. An Investigative Study of the Application of Lessons Learned Systems in Construction Projects. *Journal for Education in the Built Environment, Vol. 1, Issue 2, August 2006. 27-38*

Fox, S., Marsh, L., Cockerham, G. (2002) Constructability rules: guidelines for successful application to bespoke buildings. *Construction Management & Economics*. 20(8):689-96.

Francis, V. E. and A. C. Sidwell (1996). *Development of the Constructability Principles*, Construction Industry Institute, Australia, Adelaide.

Francis, V.E., Chen, S.E., Mehrtens, V.M., Sidwell, A.C., McGeorge, W.D. (1999) Constructability strategy for improved project performance. *Architectural Science Review*. 42(2):133-8.

Francis, V. E., A. C. Sidwell and S.E. Chen (1996). *Constructability Manual*. Construction Industry Institute, Australia, Adelaide.

Francis, V. E., A. C. Sidwell and S.E. Chen (1997). *Client Guide to Implementing Constructability.* Construction Industry Institute, Australia, Adelaide.

Galić, M., Dolaček-Alduk Z., Uremović B. (2013) Constructability-Buildability-Izgradivost. *E-GFOS*. 4(6):68-80.

Ganah et al., 2000, When visualisation tools are employed to visualise any possibility of physical interference during construction, it allows the investigations to iron out difficulties that may occur before construction commences on site

Gibson Jr, GE., (1996), Constructability In Public Sector, *Journal of Construction Engineering & Management*, Vol 122. No 3, 274-280.

Glavinich, T.E. (1995). Improving constructability during design phase. *Journal of*

*Architectural Engineering*, 1(2), p 73-76

Goodrum, Paul M., Mohammed F. Yasin and Donn E. Hancher (2003). *Lesson Learned System for Kentucky Transfortation Project*. Research Report. Transportation of Cabinet Centre Collage of Engineering, University of Kentucky.

Griffith, A. (1984). A Critical Investigation of Factors Influencing Buildability and Productivity. *Department of Building*, Heriot-Watt University.

Griffith, A. & Sidwell, A.C. (1995). Constructability in building and engineering projects. London, Macmillan Press Ltd.

Griffith, A, Sidwell, A.C. (1997) Development of constructability concepts, principles and practices. Engineering, *Construction and Architectural Management*. 4(4):295-310.

Gugel, J., (1994). Model for Constructability Approach Selection, *Journal of Construction Engineering & Management*, Vol 120 no 3, 509-521.

Haider T. (2009). Financial Management of Construction Contracts (Constructability and its relation with TQM, Cost Shifting Risk, and Cost/Benefits). *International of Research Journal of Finance and Economics*. Issue 28.

Hancher, D. E., Thozhal, J. J., & Goodrum, P. M. (2003). Constructibility Issues on KyTC Projects.

Harirchian, E. Constructability Comparison Between IBS and Conventional Construction (Doctoral dissertation, Universiti Teknologi Malaysia).

(Hassan, 1997), the involvement of Stakeholders related to the project in general the role of Designer is vital in implementing constructability

Henderson JR, Ruikar KD, Dainty AR. The need to improve double-loop learning and design-construction feedback loops: A survey of industry practice. Engineering, Construction and Architectural Management. 2013 Apr 26;20(3):290-306.

Hendrickson, 1989, While construction is the process of identifying activities and resources used to build a facility which is an advanced stage of planning and the result is the absorption of a design

Hijazi, W., Alkass, S. and Zayed, T.(2009) Constructability Assessment Using BIM/4D CAD Simulation Model. *International Transactions BIM* pp 1-14.

Hockey, G.R. (2011) A motivational control theory of cognitive fatigue. Cognitive

fatigue: Multidisciplinary perspectives on current research and future applications. 167-87.

Holroyd, 2003, Accessibility of a project is a key factor for efficient site progress

Hon, S.L., Gairns. D.A., and Wilson, O.D. (1988). *Buildability: A Review of Research and Practice.* Australian Institute of Building Papers:3.

Huang, X., & Hinze, J. (2006). Owner's role in construction safety. *Journal of construction engineering and management*, *132*(2), 164-173.

Iman Suharto, 1999, the budget for planning costs will be a vehicle for controlling the project at the implementation stage

Igwe C, Nasiri F, Hammad A. (2017) Evaluating the Impact of Buildability Assessment and Value Management on Construction Project Delivery. *Methodology*. 4;2:2.

Issac, S and Michael, B.W (1995). *Handbook in Research and Evaluation*, 2nd ed. San Diego, California. Edits Publisher.

Jackson, J.T. (1990). Technical Specification Effect on Construction. *Journal of Construction Engineering and Management,* 116 (3), 463-467.

Jadidoleslami, S., Saghatforoush, E., Zare Ravasan A. (2018) Constructability obstacles: an exploratory factor analysis approach. *International Journal of Construction Management*. 8:1-4.

Jagboro, 2002, the performance of engineering projects within the Nigerian Construction industry is below internationally accepted standards

Jarkas, A. M. (2010a). Buildability factors affecting formwork labour productivity of building floors. *Canadian Journal of Civil Engineering*, *37*(10), 1383-1394.

Jarkas, A. M. (2011). Buildability factors influencing concreting labor productivity. *Journal of construction engineering and management*, *138*(1), 89-97.

Jarkas, A. M. (2010b). The influence of buildability factors on rebar fixing labour productivity of beams. *Construction Management and Economics*, *28*(5), 527-543.

Jarkas, A. M. (2012). Analysis and measurement of buildability factors influencing rebar installation labor productivity of in situ reinforced concrete walls. *Journal of Architectural Engineering*, *18*(1), 52-60.

Jarkas, A. M. (2010c). The impacts of buildability factors on formwork labour

productivity of columns. *Journal of Civil Engineering and Management*, *16*(4), 471-483.

Jellinger, T.C. (1981). *Construction Contract Documents and Specifications*. Addison Wesley, Reading, Mass.

Jergeas, G., Van der Put, J. (2001) Benefits of constructability on construction projects. *J. Constr. Eng. Manage*., 127(4) 281–290.

Joppe, M. (2000). *The Research Process.* Retrieved February 25, 1998, from http://www.ryerson.ca/~mjoppe/rp.html.

Juliansyah Noor (2011). quantitative research is applied to test certain theories by examining relationships between variables

Kamari and Pimplikar (2012) defined constructability as a project management technique for reviewing construction processes from the conception to finished stage during the pre-construction phrase

Kaming P.F., Olomolaiye, P.O., Holt, G.D., Harris, F.C. (1997) Factors influencing construction time and cost overruns on high-rise projects in Indonesia. *Construction Management & Economics*. 15(1):83-94.

Karakhan, A.A., Rajendran, S., Gambatese, J., Nnaji, C. (2018) Measuring and Evaluating Safety Maturity of Construction Contractors: Multicriteria Decision-Making Approach. *Journal of Construction Engineering and Management.* 144(7):04018054.

Kari, Norge, & Stephen, 1997. The aim is to generalize populations, based on predetermined samples

Kartam, N., Al-Rashaid, K. and Askar, H. (1999) Constructability Knowledge-Intensive Database System. *Construction Informatics Digital Library*, Paper W78-199-2498, pp 1-9.

Kartam, Nabil A. (1996). Making Effective Use of Construction Lessons Learned in Project Life Cycle. *Journal of Construction Engineering and Management,* Vol 122 -1.

Kaspar, 1991, the design-related problems collected from various journal and research.

Keith Potts. (2013). The traditional system

Kerridge, A. E. (1993). Plan for Constructability. *Hydrocarbon Processing. Vol. 72*,

No. 1, 135.

Kim, W. (1979). “Relational Database Systems.” ACM Computing Surveys, 11(3), 185–211.

Koole, S.L., Tops, M., Strübin, S., Bouw, J., Schneider, I.K., Jostmann, N.B. (2014) The ego fixation hypothesis: Involuntary persistence of self-control. The control within: Motivation and its regulation.95-112.

Korytárová J, Hanák T, Kozik R, Radziszewska–Zielina E. (2015) Exploring the contractors’ qualification process in public works contracts. *Procedia Engineering*. 123:276-83.

Kuo, V. (2012). The role of knowledge management in improving constructability (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Kurzban, R., Duckworth, A., Kable, J.W., Myers, J. (2013) An opportunity cost model of subjective effort and task performance. Behavioral and Brain Sciences. 36(6):661-79.

Lam, Patrick T.I. (2006). Contribution of Designers to Improving Buildability and Constructability. *Journal of Design Studies*, Vol. 27, 457-479.

Lancaster, 2005, the designer (architects/engineers) is isolated from knowledge of actual construction costs and the costs of construction based upon alternative designs

Larsen, K.R. and Bloniarz, P.A. (2000) A cost and performance model for Web service investment. Communications of the ACM. 43(2):109-16.

Latimer, Dewitt and Chris Hendrickson (2002) “Digital Archival of Construction Project Information.” *Proceedings of the International Symposium on Automation and Robotics for Construction.*

Lawrence A, Machi Brenda T, Mc Evoy, (2009) “The Literatur Review”, Corwin Press A SAGE Company.

Lee, Y.W., Lee, S.K., Jang, W., Han, S.H. (2015) Constructability Assessment Model for International Construction Projects Using Structural Equation. *Journal of The Korean Society of Civil Engineers*. 35(4):941-51.

Li, Ji, Osama Moselhi and Sabah Alkass (2006). Internet-based Database Management System for Project Control. *Journal of Engineering, Construction and Architectural Management.* Vol 13 (3), 242-253

Li, Tian Rui. and Da Ruan (2007). An extended process model of

Knowledge Discovery in Database. *Journal of Enterprise Information Management* Vol. 20 No. 2, 169-177

Li, Z., Wang, L., & Ma, G. (2018). Method for the enhancement of buildability and bending resistance of 3D printable tailing mortar. International Journal of Concrete Structures and Materials, 12(1), 543–554.

Lin, Y.C., Yen, C.P., Hu, H.T., (2017) Applications of Civil Information Modeling (CIM) for Constructability Review in Railway Construction Projects. *InProceedings of the International Conference on Business and Information Management* (pp. 102-106).

Lipshitz, R., Popper, M. & Oz, S. (1996). Building learning organizations: the design and implementation of organizational learning mechanisms. *Journal of Applied Behavioral Sciences, 32*, 292–305.

Low, S.P. (2001). Quantifying the relationship between buildability, structural quality and productivity in construction. *Structural Survey*, 19(2), p106-112

Mak, S. (2001). A Model of Information Management for Construction Using Information Technology. *Automation in Construction*, 10. 257-263.

Manuel C, Macedo, 1977, Unnecessary Cost in the Design Phase

Mawhinney Mark. (2001) *International Construction*. Oxford ; Malden, MA : Blackwell Science.

Mendelsohn, R. (1997). The Constructability Review Process: a Constructor's Perspective. *Journal of Management in Engineering*. Vol 13 no 3, 17-19.

Meanwhile, Glavinich (1995) the buildability of a design as the ease with which the raw materials of the construction process (labour, production equipment and tools, materials and installed equipment) can be brought together by a builder to complete the project in a timely and economic manner

Miller, EK, Cosen JD. An integrative theory of prefrontal cortex function. Annual review of neuroscience. 2001 Mar; 24 (1): 167-202.

Mills, 2001, who describes the construction industry as one of the most dynamic, risky and challenging businesses and goes on to say however, that the industry has a very poor reputation for managing risk, with many major projects failing to meet deadlines and cost targets

MF 2004 (Ministry of Finance of the Republic of Indonesia. Minister of Finance Regulation No. 571/KMK.06/2004 concerning Technical Guidelines for

completion of the Budget Implementation List of the 2005 Budget years.

MPWH 2018, (Ministry of Public Work and housing Indonesia, Minister of Public Works Regulation No. 22/PRT/M/2018, concerning the Technical Guidelines for Building Construction of the government, Directorate of Building and Environmental management.

MPWH, 2019 (Ministry of Public Work and Housing, procurement agency report No. 01/LP/M/2019,

Mitchell, William J. (1977). *"Computer Aided Architectural Design*." Van Nostrand Reinhold Co., New York.

Miyake A, Friedman NP, Emerson MJ, Witzki AH, Howerter A, Wager TD. The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. Cognitive psychology. 2000 Aug 1;41(1):49-100.

Mohd. Zin, R. (2004). *Design Phase Constructability Assessment Model*. Universiti Teknologi Malaysia; Ph.D. Thesis.

Mohamed, S., (1999). Quantifiying Time and Cost Associated with the Request for Information (RFI) Processes in Construction. *The International Journal of Construction Information Technology, 7.* 35-50.

Mulholland and Christian, 1999,

Muller, Ralf (2003). *Communication of Information Technology Project Sponsor and Managers in Buyer-Seller releationships*. USA. www.dissertation.com.

Mydin, S. H., Zin, R. M., Majid, M. Z. A., Zahidi, M., & Memon, A. H. (2011). Buildability attributes at design phase in Malaysian building construction. *International Journal of Sustainable Construction Engineering and Technology*, *2*(1).

Naoum, S. G. (1998). *Dissertation Research and Writing dor Construction Students*. Butterworth-Hainemann, Oxford.

Nana Syaodih, 2010. The research strategy with quantitative design always involves a post-positivism view

Nawi, M.N., Kamar, K.A., Abdullah, M.R., Haron, A.T., Lee, A.N., Arif, M.O. (2009) Enhancement of constructability concept: An experience in offsite Malaysia construction industry. InProceeding Changing Roles, New Roles: New Challenge Conference, Noordwick Aan Zee, Nederland.

Nima, M.A. (2001). *Constructability Factor in the Malaysian Construction*

*Industry*. University Putra Malaysia: Ph.D. Thesis.

Nima, M.A., Abdul-Kadir, M.R., Jaafar, M.S., and Al Ghulami, G.R. (2001). Constructability Implementation: A Survey in the Malaysian Construction Industry. *Journal of Construction and Economics. Vol 19*: 404-410.

Nima, M.A., Abdul-Kadir, M.R., & Jaafar, M.S. (2001). Evaluation of the role of the contractor's personnel in enhancing project constructability, *Structural Survey*, 19(4), p193-200

Nima, M.A., Abdul-Kadir, M.R., Jaafar, M.S., Alghulami, R.G. (2004) Constructability concepts in kuala selangor cable-stayed bridge in Malaysia. *Journal of construction engineering and management*. (3):315-21.

Noor, 2011. These variables are measured (usually with research instruments) so that data consisting of numbers can be analyzed based on statistical procedures

O'Connor, J.T., (1986a), Collecting Constructability Improvement Ideas, *Journal of Construction Engineering*, Vol 112, No 4, 463-475.

O'Connor, J.T., Tucker, R.L. (1986b). Industrial Project Constructability Improvement. *Journal of Construction Engineering and Management*, Vol 112, No 1, 69-81.

O'Connor, J.T., (1987), Constructability Concepts for Engineering and Procurement. *Journal of Construction Engineering and Management*, Vol 113, No2, 253-248.

O'Connor, J., Victoria S.D. (1988), Constructability Improvement during Field Operations. *Journal of Construction Engineering and Management*, Vol 114, no 4, 548-564.

O'Connor J.T. (1991), Improving Highway Specifications for Constructability. *Journal of Construction Engineering and Management*, Vol 117, no 2, 242-258.

O'Connor, J, et al (1994), Constructability programs, Method for Assessment and Benchmarking, *Journal of Performance of Constructed Facilities*, Vol 8, no 1, 46-64.

O'Connor, J. T. and S. J. Miller (1995). "Overcoming Barriers to Successful Constructability Implementation Efforts." *ASCE Journal of Performance of Constructed Facilities* 9(2), 117-128.

Opfer, Neil (1999). Intranet Internet Applications for the Construction

Industry.*Journal of Construction Education, Associated School of Construction. Vol 4. No2*. 175-186.

O'Connor, T.J. & Miller, S.J. (1994). Barriers to constructability implementation, *Journal of Performance of Constructed Facilities*, 8(2), p 110-129.

Odeh, A.M., Battaineh, H.T. (2002) Causes of construction delay: traditional contracts. *International journal of project management*. 20(1):67-73.

Ogunsanmi, O.E. (2006) Comparisons of procurement characteristics of traditional and labour-only procurements in housing projects in Nigeria. *Covenant Journal of Research in the Built Environment*. 3(2).

Oh, E. H., Naderpajouh, N., Hastak, M., & Gokhale, S. (2015). Integration of the construction knowledge and expertise in front-end planning. *Journal of Construction Engineering and Management*, *142*(2), 04015067.

Othman E, Ahmed A. (2011), Improving building performance through integrating constructability in the design process. Organization, technology & management in construction: an international journal. 2011 Dec 1;3(2):333-47.

Oyedele and Tham, (2005), Examining architects'performance in Nigerian private and public sectors building project, *Journal of Engineering construction* & *architectural Management* 12 (1): 52-68 Feb 2005.

Pakkala P, Martin de Jong W, Aijo J. (2007) International overview of innovative contracting practices for roads.

Park, J. S., Hyun, C. T., Hong, T. H., Park, S. H., & Moon, H. S. (2009). Development of checklist for improving constructability in steel structure construction. *Journal of the Architectural Institute of Korea Planning & Design*, 25(12), 197–206

Park, C. S., & Park, H. T. (2010). Improving constructability analysis tasks by applying BIM technology. *Korean Journal of Construction Engineering and Management*, *11*(2), 137-146.

Parker, Hendry W., and Oglesby, Clarkston (1974). *Method Improvement for Construction Manager*. Mc Graw-Hill Book Company, New York.

Patrick, T.I.L (2006) Contributions of designers to Improving buildability and *Constructability. Journal of Design* Studies, Vol 27 no. 4, 457-479.

Paulson, B., Jr. (1976 ) Designing to reduce construction costs. *J. Constr. Div., Am. Soc. Civ. Eng*., 587–592.

Pepper, 1994, Case studies on two environmental capital projects in the US

Pheng, L.S. and Abeye, B. (1999). *Legislation of Buildability Requirement: Are We Ready?* Jurutera. IEM Malaysia. 5, 33-40.

Pocock, J.B., Kuennen, S.T., Gambatese, J., Rauschkolb, J. 2006) Constructability state of practice report. *Journal of construction engineering and management*. 132(4):373-83.

Poh, P. S. H., & Chen, J. (2010). The Singapore buildable design appraisal system: A preliminary review of the relationship between buildability, site productivity and cost. *Construction Management & Economics*, 16(6), 681–692.

PRI 2018 (Presidential regulation Republic of Indonesia number 16, 2018 *concerning government procurement.*

PMI 2016 (Project Management Institute), PMBOK (Project Management Body of Knowledge) ® guide, 2016 edition.

Pulaski, M. H., & Horman, M. J. (2005). Organizing constructability knowledge for design. *Journal of Construction Engineering and Management*, 131(8), 911–919.

Pulaski, M. H., Horman, M. J., & Riley, D. R. (2006). Constructability practices to manage sustainable building knowledge. *Journal of Architectural Engineering*, *12*(2), 83-92.

Michael W Radtke and Russell, 1993, the obstacles to improve constructability still prevail, *Project level model process for implementing constructability*, *Journal of Construction Engineering and Management* , technical papers, *119* .

Rahman, M., & Alhassan, A. (2012). A contractor's perception on early contractor involvement. *Built Environment Project and Asset Management*, *2*(2), 217-233.

Rahmani, F., Maqsood, T., Khalfan, M. (2017) An overview of construction procurement methods in Australia. *Engineering, Construction and Architectural Managemen*t. 24(4):593-609.

Rashvand, P., & Zaimi Abd Majid, M. (2013). Critical criteria on client and customer satisfaction for the issue of performance measurement. *Journal of management in engineering*, *30*(1), 10-18.

Regan, M., Love, P.E., Jim, J. (2015) Public infrastructure procurement: a review of

adversarial and non-adversarial contracting methods. *Journal of Public Procurement*. 15(4):405-38.

Resgui Y., and Cooper G. (1998). A Proposed Open Infrastructure for Construction Project Document Sharing. *Electronic Journal of Information Technology In Construction. ITcon, 3*. 11-24.

Robert K. Yin (2009). there are three conditions that will influence the type of research strategy. Research Startegy

Rojas E.M., and Songer A.D.(1999). Web Centric Systems: A New Paradigm for Collaborative Engineering. *Journal of Management in Engineering 15 (1),* Jan/Feb, 39-45.

Rowings, J.E., Federle, M.O., Rusk, J. (2000) Design/build methods for electrical contracting industry. *Journal of Construction Engineering and Management*. 126(1):15-21.

Russell, J.S., J. G. Gugel, (1992a*). Benefits and Costs of Constructability: Four Case Studies*, The Construction Industry Institute, Austin.

Russell, J. S., J. G. Gugel, (1992b). *Project-level Model and Approaches to Implement Constructability*, The Construction Industry Institute, Austin.

Russell, J.S., (1994b). Comparative Analysis of Three Construtability Approaches, *Journal of Construction Engineering & Management*, Vol 120. No 1, 180-195.

Russell, J.S., (1994c), Constructability related to TQM, Value Engineering & Cost/ Benefit, *Journal of Performance of Construction Facilities*, Vol 8, no 1, 31-45.

Russell, J.S., (1993). Documented Constructability Savings for Petrochemical-Facility Expansion, *Journal of Performance of Constructed Facilities* Vol 8, no 7, 27-45.

Rosli, 2004, collaboration between design consultant and contractors

Rwamamara, R., & Simonsson, P. (2012). Self-compacting concrete use for construction work environment sustainability. *Journal of Civil Engineering and Management, 18*(5), 724-734.

Saghatforoush, E., Hassim, S., Jaafar, S., Kadir, R.A. (2009) Constructability implementation among Malaysian building contractors. *European Journal of Scientific Research.* 29(4):518-32.

Salim, Amur H.A. (2006). *The Consultancy Fee for Structural Design Changes of*

*Reinforced Concrete Building in Oman.* PhD Thesis. University Teknologi Malaysia.

Scott, D., (2003). Web-based Construction Information Management Systems, *The Australian Journal of Construction Economics and Building* Vol 3 (1), 43-51.

Secchi, P., Ciaschi, R. & Spence, D. (1999). A concept for an ESA lessons learned system. *Proceedings of alerts and lessons learned: An effective way to prevent failures and problems* (Tech. Rep. WPP-167). Noordwijk, The Netherlands: ESTEC, 57-61.

Sharpe, R., (1995). IT In the Construction Engineering Future Directions. *IE Australia Forum*. Sydney 21 February and Melbourne 22 February.

Shih (2006). The Application of a Panorama Image Database Management System (PIDMSI for Information Integration on Construction Sites. *Electronic Journal of Information Technology In Construction. ITcon, 11*. 641.

Sidwell, A.C. and Francis V.E. (1996). The Application of Constructability Principles in The Australian Construction Industry. *The Organisation and Management of Construction Shaping Theory and Practice,* Vol 2, 264-272.

Siegel. S. (1998). *Nonparametric Statistics for Behavioral Sciense*. London: Mc Graw Hill.

Simonsson, P. (2011) Buildability of Concrete Structures: Processes, Methods and Material. Doctoral Thesis, Department of Civil, Environmental and Natural Resources Engineering, Luleå University of Technology, SE-971 87 Luleå, Sweden.

Skibniewski, M.J., Arciszewski, T., and Lueprasert, K. (1997), Constructability analysis: Machine learning approach, *Journal of Computing in Civil Engineering*, 11 (1), 8-16.

Slaughter, E.S. (2000), Implementation of construction Innovations, Journal of Building Research and Information. Vol 28, no 1, 2-17.

Smith, 1999, This understanding of risk implies that there is some knowledge about a risk, as opposed to uncertainty about which there is no knowledge.

Sholihin & Ratmono, 2013. Concepts are abstractions or ideas that are obtained from the results of summaries and organizing knowledge or observations of a fact or reality expressed in words

Sorensen L.S. (1998). *A Web Based Computer System Supporting InformationAccess, Exchange and Mangement during Building Processes, Life Cycle of*

*Construction IT Innovation, Technology Transfer from Research to Practice* (CIB Report) V, 226. Royal Institute of Technology, U.K, 397-408.

Song, L., Mohamed, Y., & AbouRizk, S. M. (2009). Early contractor involvement in design and its impact on construction schedule performance. *Journal of Management in Engineering*, *25*(1), 12-20.

Stockburger, David W., (2011). Introductory Statistics: Concepts, Models, and Applications, www.psychstat.missouristate.edu/introbook/sbk04m.htm (accessed Dec 2011)

Stukhart, G. (1987). "Construction Management Responsibilities during Design." *Journal of Construction Engineering and Management* 113(1): 90-98.

Stuss DT, Alexander MP. Executive functions and the frontal lobes: a conceptual view. Psychological research. 2000 Aug 1;63(3-4):289-98.

Suckarieh, G. (2004). Implementing a Web-based Knowledge Base for a Construction Company: Industria-Academia Collaboration. *Proceeding of the 2004 American Society for Engineering Education Annual Conference & Exposition. American Society for Engineering.*

Sukardi, Ibrahim, & Ariffin, 2014. The interrelationships between independent variables and independent variables, as well as between independent variables and independent variables have occurred naturally and not manipulated

Tatum, C. B., J. A. Vanegas and J.M. Williams. (1986). *Constructability Improvement During Conceptual Planning*, The Construction Industry Institute, The University of Texas of Austin.

Tatum,C.B., (1987a), Improving constructability during conceptual Planning, *Journal of Construction Engineering & Management*, Vol 113. No 2, 191-207.

Tatum CB. (1987b), Process of innovation in Construction Firm, Journal *of Construction Engineering and Management*, Vol 113, No 4, 648-663.

Tatum, C. B. (1989). Management Challenges of Integrating Construction Methods and Design approaches. *Journal of Management in Engineering, Vol 5.2*, 139-154.

The CM Committee, of ASCE Construction Division (1991), Constructability and Constructability programs: White Paper. *Journal of Construction Engineering & Management*, Vol 117, No 1, 67-89.

The Collins English Dictionary (2006), complexity as "the state or quality of being

intricate or complex", where complex is defined as "made up of many interconnecting parts"

Thomas, P.V. (2003). Best Practices for Process Plant Modifications (Fertilizer Plants). *Cost Engineering; May 2003; 45, 5.* 19-28.

Tong, 2004, the design-related problems collected from various journal and research

Tradingeconomics.com, 2020, national gross domestic product (GDP) Indonesia in the field of construction

Trigunarsyah, B. (2004a), Constructability Practices among Construction Contractors in Indonesia, *Journal of Construction Engineering and Management*. Vol 130, No 5, 656-669.

Trigunarsyah, B. (2001) *Implementation of Constructability Improvement into the Indonesian Construction Industry*. PhD Thesis, The University of Melbourne, Australia.

Trigunarsyah, B., (2007), Constructability Innovation in Pipe Rack Design for Refinary Project. *Proceedings Construction, Management an Economics: past, present and future,* Reading, UK.

Trigunarsyah B. (2007) Project designers' role in improving constructability of Indonesian construction projects. *Construction Management and Economics*. 25(2):207-15.

Trigunarsyah, B. (2004b). A review of current practice in constructability improvement case studies on construction projects in Indonesia, *Construction Management & Economic*s, 22(6), p 567-580

Trigunarsyah B. (2004c) Project owners' role in improving constructability of construction projects: an example analysis for Indonesia. *Construction Management and Economics.* 22(8):861-76.

Twort, A.C. (1972), Civil Engineering Supervision and Management, 2nd ed., Edward Arnold, London

Ubani, E.C. and Ononuju, C.N. (2013) A Study of Failure and Abandonment of Public Sector Driven Civil Engineering Projects in Nigeria: An Empirical Review. *American Journalof Scientific and Industrial Research*, pp 75-82

Uhlik, F.T., Lores, G.V. (1998) Assessment of constructability practices among general contractors. *Journal of Architectural Engineering*. 4(3):113-23.

van der Linden D. (2011) The urge to stop: The cognitive and biological nature of acute mental fatigue. Cognitive fatigue: Multidisciplinary perspectives on

current research and future applications. 149-64.

Wainer, H., & Braun, H. I. (1988). *Test validity*. Hilldale, NJ: Lawrence Earlbaum Associates.

Wang, J., Wang, X., Shou, W., Chong, H.Y., Guo, J. (2016) Building information modeling-based integration of MEP layout designs and constructability. *Automation in Construction*. 61:134-46.

Wells, J. (1986). *The Construction Industry in Developing Countries: Alternative Strategies for Development*. Croom Helm Ltd., London.

Weng.NG.S., Aminah Md Yusof (2006), The Success Factors of Design and Build Procurement Method: A Literature Visit, *Proceeding of 6th Asia-Pacific Structural Engineering and Construction Conference*, Kuala Lumpur, Malaysia.

William, Scott D. (2007). Construction Document Changes to Improve *Constructability*. *National Conference on Building Commissioning*. May 2-4. USA.

Winter, G. (2000). *A comparative discussion of the notion of validity in qualitative and quantitative research. The Qualitative Report, 4*(3&4). Retrieved February 25, 1998, from http://www.nova.edu/ssss/QR/QR4-3/winter.html.

Wong, F.W.H., Lam, P.T.I., Chan, A.P.C. and Chan, E.H.W. (2006) "A Review of Buildability Performance in Hong Kong and Strategies for Improvement" *Surveying and Built Environment*, Vol 17 No. 2, pp 37-48.

Wong, F. W., Lam, P. T., Chan, E. H. & Shen, L. (2007). A study of measures to improve constructability. *International Journal of Quality & Reliability Management*, 24, 586-601.

Wood H.L, 2013, the factors which make a project complex and the impact that they have upon a project are not widely understood

Yu, W. and Skibniewski, M. J. (1999). Quantitative constructability analysis with a neuro-fuzzy knowledgebased multi-criterion decision support system, *Automation in Construction, 8,* 553-565.

Yin, R.K. (1994), *Case Study Research Design and Methods*. Sage Publication, California, USA.

Youssefl, 2005, found out that most of the main construction methods were changed

by the contractor in order to cater for construction needs that were not identified and dealt with by the designer

Zaidi, M.A., Davies, H. (2011) Constructability: a model framework for knowledge transfer development, a three country comparison. *International proceedings of economics and development research*. 15:258-63.

Zen Achwar, 1989, construction cost efficiency

Zin, R. M. (2004). *Design phase constructability assessment model* (Doctoral dissertation, Universiti Teknologi Malaysia).

Zhang, C., Zayed, T., Hijazi, W., Alkass, S. (2018) Quantitative assessment of building constructability using BIM and 4D simulation. *Open Journal of Civil Engineering*. 6(03):442.

Zuber-Skerritt, O.(2002), A Model for Designing Action Learning and Action Research Programs. *Journal of The Learning Organization*, *Journal of The Learning Organization*, 9 4, 143-14.