ELEMENT OF WATERFALL MODEL IN CONSTRUCTION PROJECT

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FACULTY OF ENGINEERING
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ABSTRACT

Waterfall Model was implemented to examine the model in Sabah construction. A project management technique based on short feedback cycles, frequent change adaptation, real-time and continuous communication between all project stakeholders, post-project evaluations, and regular plan updates is required (Mohamed & Moselhi, 2019). The Waterfall Model is the oldest and the recognized SDLC model. It is widely used in government projects and in many major companies. The most influential elements in Malaysia include incorrect contractor planning, poor site management, and insufficient contractor experience (Shah, 2016). Financial issues, changes in the design and scope, delays in the owner's decisions and approvals, challenges in acquiring a construction permit, and coordination and communication issues are all major factors for delays to happen (Assaf, *et al*., 2006). Suitability and relevance of the Waterfall model being used in construction projects in Sabah would be discussed. Focusing on ongoing construction projects in Sabah, the implemented study would benefit in understanding more regarding the Waterfall Model. This study focuses on the implementation of Waterfall Model into the construction industry in Sabah with some discussions about to the project delays factor and any foreseen impact of other factors. The methodology used in this study is qualitative method, by doing secondary research and data collecting from previous studies, and document analysis from Sabah's construction project documents from *Jabatan Kerja Raya* (JKR) Sabah. There are three construction projects that has been analyzed which are the *Cadangan Pembinaan Kolam Renang, Balai Bomba dan Kuarters Kimanis* and *Cadangan Pembinaan Hospital (76 Katil).* The elements and application of Waterfall Model used in all three projects were specified and analyzed throughout this research. The limitations of this research are time and also not many open resources available for the application of Waterfall Model especially in construction projects. Further recommendations and suggestions are also specified in the final chapter of this study, to be used for the future study of the same field.

ABSTRAK

Waterfall Model metodologi diaplikasikan untuk menilai keberkesanan metodologi untuk projek-projek pembinaan di Sabah. Teknik pengurusan projek adalah berkisar tentang kitaran maklum balas, penerimaan dalam sesuatu perubahan yang berlaku, reality dan komunikasi yang berterusan dalam kalangan golongan-golongan yang berkepentingan, penilaian pasca projek dan kemaskini tentative harian adalah diperlukan (Mohamed & Moselhi, O, 2019). Waterfall Model adalah metode yang paling klasik dan salah satu model SDLC yang terkenal. Model ini digunakan secara meluas terutamanya dalam projek-projek kerajaan dan di kebanyakannya syarikat-syarikat perindustrian. Elemen yang berpengaruh dalam hal tarikh penangguhan dalam industri pembinaan termasuklah kesilapan dalam perancangan seorang kontraktor projek, pengurusan tapak projek yang kurang memberangsangkan, dan pengalaman yang tidak cukup dalam kalangan kontraktor projek (Shah, 2016). Masalah kewangan, perubahan dalam reka bentuk dan skop projek, penangguhan dalam keputusan dan kelulusan dari pihak pemilik, cabaran dalam memiliki permit pembinaan dan koordinasi dan komunikasi isu juga adalah faktor-faktor utama untuk penangguhan masa untuk berlaku (Assaf, et al., 2006). Sepanjang kertas kerja, kesesuaian dan kerelevenan dalam Waterfall Model untuk digunakan dalam projek pembinaan, khususnya di Sabah akan dibincangkan. Memfokuskan terhadap projek-projek yang masih dalam proses pembinaan di Sabah, sebuah kajian yang mengaplikasikan metode itu akan memberi hasil yang memberangsangkan dan lebih difahami oleh pembaca berkenaan Waterfall Model. Metodologi yang digunakan dalam kajian ini adalah kaedah kualitatif, dengan melakukan penyelidikan sekunder dan pengumpulan data daripada kajian lepas, dan analisis dokumen daripada dokumen projek pembinaan Sabah dari Jabatan Kerja Raya (JKR) Sabah. Terdapat tiga projek pembinaan yang telah dianalisis iaitu Cadangan Pembinaan Kolam Renang, Balai Bomba dan Kuarters Kimanis dan Cadangan Pembinaan Hospital (76 Katil). Aplikasi Waterfall Model yang digunakan dalam ketiga-tiga projek telah dinyatakan dan dianalisis sepanjang penyelidikan ini. Keterbatasan penyelidikan ini adalah masa dan juga tidak banyak sumber terbuka yang tersedia untuk aplikasi Model Air Terjun terutamanya dalam projek pembinaan juga dinyatakan dalam bab akhir kajian ini, untuk digunakan untuk kajian masa depan bidang yang sama.

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SDLC	**-**	Software Development Lifecycle
DBB	**-**	Design, Bid & Build
DB	**-**	Design & Build
EOT	**-**	Extension of Time

CHAPTER 1

INTRODUCTION

1.1 Overview

Before starting any project, project management help the project manager to see the larger picture. This is in the sense that project management includes project phases that can be used to track progress, take remedial action when errors are discovered, and assign resources to different phases (Charvat, 2003). The Waterfall Model is a well-known project management method. Due to the building business in Malaysia, particularly in Sabah, is sickening and worsening each year, the Waterfall Model was implemented to examine the model in Sabah construction. As a result, the Waterfall Model is highlighted as a control variable in this thesis to handle the delays problem.

Despite the fact that project management has proven to be a successful procurement strategy in the construction industry, there are still issues with poor project management that have resulted in venture postponements, cost overruns, and delays with low client satisfaction (Khalid, 2019). If no immediate action is taken, delays may become a taboo in the construction industry. These delays can be decreased or avoided by better pre-project planning and project management, which are two of the most important success elements for completing a construction project (Khalid, 2019).

1.2 Background of Study

The heart of what makes a construction project to execute is project management. While it deals with the technical aspects of budgeting and cement being removed, execution, it also demands project managers to interact with the builders', stakeholders', and community's specific needs. Following the traditional way in construction projects, each phase would be carried out in teams and each succession would be passed to the next team in line (Mohamed & Moselhi, 2019). As for example, starting with the planning phase that would be pushed onto the next team. This leads to disagreements between the contractor's companies during the execution phase. Obstacles can include things such as delayed goods, labour disruptions, equipment breakdowns, weather conditions, and fluctuations in onsite worker productivity rates. Not all of these issues may be attributed to missing or incorrect drawings and specifications. Some of these also occur as a result of the project team members' lack of communication and coordination which is caused by poor management of the team.

A project management technique based on short feedback cycles, frequent change adaptation, real-time and continuous communication between all project stakeholders, post-project evaluations, and regular plan updates is required (Mohamed & Moselhi, 2019). Waterfall Model is the oldest and the recognized SDLC model. It is widely used in government projects and in many major companies. Unique features that stand out is its sequential steps which briefly explained in Figure 1.1. It goes downward through the phases of requirements involved in analysis, design, coding, testing, and maintenance (Alshamran and Bahattab, 2015). It also ensures that design faults are identified prior to the development of a product. Due to its extensive documentation and planning, this model works well for projects where quality control is a primary priority (Munassar *et al.*, 2010).

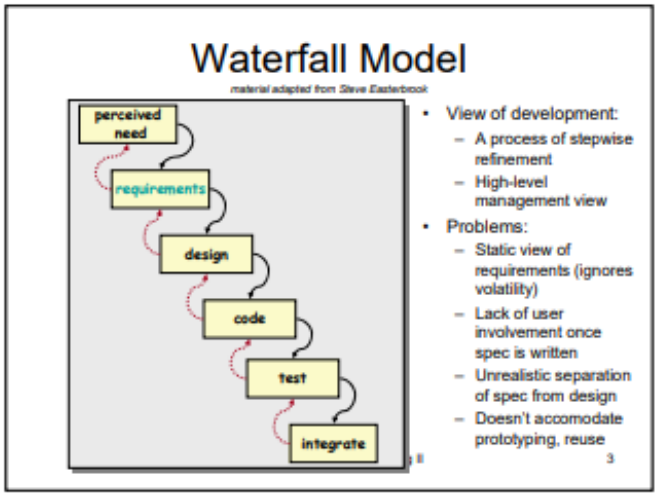

Figure 1.1: Brief Explanation on Waterfall Model

Source: Model, W, (2015)

"The major advantage of the Waterfall Model for the SDLC is that it provides a structure for organizing and controlling a software development project. The single most important methodological need in this approach, however, is to identify user requirements accurately" (Kramer, 2018), (Sage & Palmer, 1990). The Waterfall Model's depiction of ascendancy is practical, logical, and simple to comprehend as it is a linear model. It performs admirably and produces the desired outcomes. Because the steps are stiff and exact, each one is completed one at a time, causing the maintenance process to become easier. The start and finish dates are well established, which reduces tension. This comes from the stages that would only proceed to the next stage to guarantee the quality and ensure the milestones are met (Alshamran and Bahattab, 2015).

Waterfall project management has its origins in areas other than software, such as manufacturing and construction, where the approach emerged out of necessity (Rahayu, 2020). Complex projects are currently shifting towards Agile and Sprint Models, although the Waterfall Model still works effectively for smaller projects such as system process changes or where needs are simple and testable. Proved by the research by (Petersen, et al., 2009) that waterfall model is not suitable to be used in large scale development. Contrast with (Rahayu, 2020), that uses Waterfall

Model in the application report of Islamic School that suggested this model provides for a return to a previous stage; nevertheless, going back to a previous stage necessitates costly rewrites for both documentation and application development. If there are delays, the entire project and timeframe will be affected. Throughout the Software Development Life Cycle (SDLC), the Waterfall Model is straightforward to comprehend and administer (Rahayu, 2020).

1.3 Problem Statement

According to the National Audit Reports, there are 69 issues with the development of public projects (Jatarona *et al.*, 2016). Malaysia's construction industry has been criticized for its poor performance, particularly in the construction of public projects. In Malaysia, public projects are frequently reported as sick, delayed, and plentiful (Jatarona *et* al., 2016). The recurrence of comparable issues in public construction projects has piqued the public's interest. As mentioned by Senior Works Minister Datuk Seri Fadillah Yusof, there are 15 in total delayed and even cancelled construction projects in Sabah and Sarawak (Malay Mail, 2021). Projects that are expected to generate the locals' economy are extended in terms of time would be affecting the economic progression indirectly. Delays and ensuing cost consequences would be the penalty that particular company would suffer from.

The most influential elements in Malaysia include incorrect contractor planning, poor site management, and insufficient contractor experience (Shah, 2016). Financial issues, changes in the design and scope, delays in the owner's decisions and approvals, challenges in acquiring a construction permit, and coordination and communication issues are all major factors for delays to happen (Assaf, *et al.*, 2006). Poor site management and supervision, late progress payments by clients, change orders by clients during construction, ineffective planning and scheduling of project by contractor, slowness in decision-making by client, delays in producing design documents, poor contract management by consultant, and

problems with subcontractors were discovered to be the most common causes of delay (Mehdi, 2013). Roots of delays could safely be caused by improper planning in the organization. With a detailed and arranged planning in the management, problems occurring during the construction process could be handled in a great way and thus, avoiding delays.

Supported by (Jatarona *et al*, 2016), poor project schedule management remains to be the main causes for late completion in Malaysian projects. A six-dimensional (3D) stigma, inadequate site coordination and management, incompetency of construction players, sluggish technology adoption, chaotic decision-making, and inefficient administrative processes were shown by a principal component analysis (PCA) (Yap *et al*, 2019). Poor construction project planning and management have several negative consequences for project duration and completion. Construction delays and time constraints are typically to blame for turning profitable endeavours into losing undertakings. Increased pre-project planning and successful project management can decrease or eliminate these delays, as they are one of the most important success factors in the completion of a construction project (Khalid, 2019).

Additionally, documenting the lessons learnt from building challenges may be useful for future projects and even different stages within the same project. However, the lack of collaboration among team members obstructs this and may lead to the same mistakes being repeated. As a result, a project management technique based on short feedback cycles, frequent change adaptation, real-time and continuous communication between all project stakeholders, post-project evaluations, and regular plan updates is required (Mohamed & Moselhi, 2019).

1.4 Objectives

In this paper, there are 3 objectives that would be focused on which are: -

- To describe the Waterfall model principle.
- To distinguish the elements of the waterfall model in construction projects in Sabah.
- To analyse the applications of waterfall models in construction projects in Sabah.

1.5 Scope of Study

Throughout this study, the suitability and relevance of the Waterfall model being used in construction projects in Sabah would be discussed. Focusing on ongoing construction projects in Sabah, the implemented study would benefit in understanding more regarding the Waterfall Model. Applying the model on construction projects in Sabah would be discussed in detail in this study. Significance of establishing this issue would provide greater insights and understanding on problems that have been harassing the projects' progress and put the Waterfall Model on the spotlight. This would be achieved as the theoretical concepts discussed would be applied in real life projects in Sabah. Other than that, this study is expected to provide a better and simplified way in delivering construction projects by minimizing the major causes of delays.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter includes information gathered on including the Software Development Life Cycle (SDLC), the phases in Waterfall Model, advantages, and disadvantages of Waterfall Model factors that affecting project's successes and delays. Together with the applications of Waterfall Model in overseas, Malaysia and Sabah showing the relevancy of using Waterfall Model.

2.2 Software Development Life Cycle (SDLC)

In 1969, Meir "Manny" Lehman discussed one of the first approaches to the Software Development Life Cycle (SDLC). "The basic approach recognizes the futility of separating design, evaluation, and documentation processes in software-system design. As explained in Figure 2.1, SDLC is an expanding model seeded by a formal definition of the system, which provides a first, executable, functional model and structures the design process. It is tested and further expanded through a sequence of models that develop an increasing amount of function and an increasing amount of detail as to how that function is to be executed. Ultimately, the model becomes the system." (Kramer, 2018).

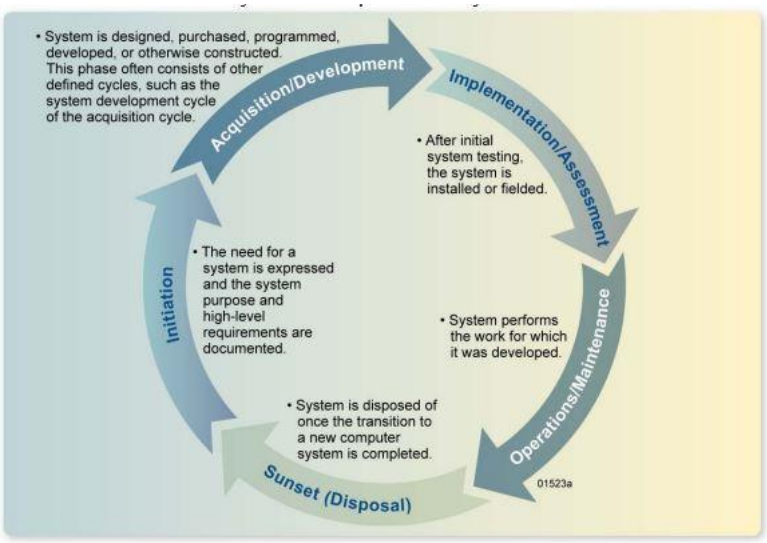

Figure 2.1: Software Development Life Cycle (SDLC) Phases

Source: Radack, S., (2009)

Under SDLC, there are several development methodologies other than Waterfall Model that are often used in the construction industry. This includes Agile, Lean, Iterative, Spiral, V-Model and DevOps Model. These approaches differ in certain respects, but all of them serve the same purpose which is to assist the construction team in an efficient and cost-effective manner. The predetermined time frame and cost should be included in the system development. The SDLC consists of a comprehensive plan that outlines how to organise, create, and maintain. Each stage of the SDLC life cycle has a distinct procedure and outputs that feed into the following stage. Briefly, the process would begin with the business understanding and requirements elicitation phase involving the business concepts and requirements into features and functionalities that could then be used to meet business demands.

In construction fields, financial institutions are focused on reducing human costs associated with process training and compliance audits, as well as boosting the effectiveness of system administration. Plan on creating a regulation knowledge using semantic markup platform and graph database technologies, which would be useful for model creation management and maintenance. The regulation knowledge would depict an easy and complete view of the entire system development life cycle, including all types of specification data (Wang, *et al.*, 2020).

Regulation knowledge is a rapid method that continuously integrates regulation knowledge information, significantly improves the efficiency of acquiring, sharing, and maintaining regulation knowledge, lower software labor costs, and improves enterprises' ability to analyze and apply regulation information and data, all of which have broad application value in the construction of enterprise internal control management. It also increases the efficiency, accuracy, and integrity of software development process requirements as well as the accompanying information query efficiency, accuracy, and integrity. For example, the "Internet plus" model has achieved deep integration in the financial industry, adapting to the rapid development of the financial market in the information technology era; all types of technological innovation have been utilized in various financial scenes.

With the growth of the firm, standardization, the standardization process, and the regulatory management model have become one of the most effective ways to run the business. Despite this, classic manual regulation management approaches are still commonly used in the enterprise to cope with massive regulation systems. This is incompatible with the desire for systematic and intelligent enterprise-wide sustainable development. Mainly there are two main information in regulation management: -

- Manual sorting of enormous system standards has a high cost, inefficient and difficult to maintain.
- Lack of systematic logical association, deep integration among information, and low efficiency of information search and acquisition in the natural organizational form of regulation information (Wang, et al., 2020).

In financial organizations, establishing and renewing internal control regulations is frequently a lag, and it frequently lacks overall strategy. In the context of project management, information in system specification files is more distributed and the relationships between them are opaque, resulting in poor data integration and query efficiency. Throughout the life cycle of a project, all team members should be guided by a defined project methodology (Charvat, 2003). The chosen technique

should be familiar to all members of a team and used throughout their projects. A few project management approaches focus on the administration of a single project, ignoring the fact that many other projects compete for the same resources and attention inside a corporation.

The project management methodology should also provide project managers the impression that the organization has a project management framework and processes in place. Construction regarding complete regulation methodologies include the following steps:

- Obtaining regulatory information and creating a structured entity relationship model of the regulatory graph based on the real work's business logic
- Collecting data sources and performing pre-processing;
- Creating a data structure model based on an entity relationship model;
- Graphing the regulation information extracted from the data source to the entity relationship group; transforming unstructured information into organized information; constructing appropriate algorithm logic; and completing the regulatory graph's technical layer creation;
- Developing the functional module of the system atlas and finishing the application layer building of the system atlas by combining the knowledge life cycle principle and practical application scenarios (Wang *et al.*, 2020).

Those steps above Digitalization of the manufacturing industry are constantly being driven forward under various terms such as Industry 4.0, Cloud Manufacturing (CM), and Smart Manufacturing (SM). Although the aim of these different approaches is different, they are identical in two respects:-

- the connectivity among all players and machines is increasing dramatically
- efficient data communication is a key acceptance factor.

Therefore, different standards for data storage and exchange have been developed, two of which have become widely accepted in this context. Data exchange between different tools of architectural software is an important factor for the digitization of the construction industry. The Building Information Modelling (BIM)