

Process improvement analysis in toll corridor development with lean six sigma approach: case in PT Jasamarga Related Business

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Abstract. Toll Corridor Development (TCD) is one of the businesses conducted by PT Jasamarga Related Business as a follow-up to the issuance of Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat (PUPR) No. 28 of 2021. In the development of its first TCD project, Jasamarga Related Business (JMRB) encountered issues that resulted in the delay of the project's completion. The purpose of this research is to analyze and make improvements to the causes of delays in the Taman Mini TCD project. In this research, the lean six sigma approach is used to analyze process improvements that can be carried out so that these problems can be minimized in the further development of TCD. To identify activities that cause delays in the implementation of this project, the critical path method (CPM) was used based on the results of interviews with those directly involved in the development of TCD project. From the activities that cause the delay, a causal analysis is carried out using a fishbone diagram, and then an analysis of possible improvements is carried out using a lean concept approach. Based on the analysis results, three main issues are identified, namely inadequate planning process, ineffective partner or consultant selection process and delays in construction completion. From the cause-and-effect analysis, it can be concluded that potential improvements can be made by implementing the concept of pull planning, improving the business process by reducing waste and enhancing value-added activities, establishing effective stakeholder management, and maximizing the use of technology-based applications to aid project control.

Keywords: project management, process improvement, lean, six sigma.

1. Introduction

To be able to survive in today's competitive market, it has become imperative for construction companies to improve the quality of work, increase work effectiveness, reduce waste and costs, and increase profits (Al-Aomar, 2012). Furthermore, in the construction industry there are several important factors that are of concern to reduce or eliminate waste, such as scope of work, time, cost, quality and also the environment (Demirkesen & Bayhan, 2022). Hence, it is essential to implement effective strategies in the construction industry to reduce the amount of waste and increase the level of competitiveness (Porter, 1985).

Furthermore, according to Al-Aomar (2012), the construction sector is prone to waste, delays, errors, and also inefficiency in carrying out work. According to Van der Aalst et al., (2003) the field of construction is known for its complexity and changes during the construction process, which results in a large number of resources, both human resources and materials being wasted every year as a result of inefficient or even ineffective quality management procedures. there is (Arditi & Gunaydin, 1997) . Therefore, efforts are needed to improve the management of a project.

One improvement method that can be used is Six Sigma. According to Stewart & Spencer (2006), a structured but flexible six sigma framework provides a solid procedure for gathering information about the sequence of construction processes that allows process and quality improvement, where the main goal of six sigma is to reduce variations and defects in the process. Furthermore, according to Sawant & Pataskar (2014) six sigma is easier to use because it can identify the necessary changes and the tools or techniques required to implement those changes. Six sigma, as defined by Antony & Banuelas (2002), is a philosophy that applies a well-structured methodology for continuous improvement to reduce process variability and eliminate waste in business processes using statistical tools and techniques. The use of statistical analysis and data-driven decision-making in six sigma also contributes to its effectiveness and ease of

implementation. In the construction industry, six sigma can be implemented to reduce defects, minimize variation, and assess existing performance, as stated by (Ullah et al., 2017) Based on the definition provided above, it can be concluded that this methodology provides a structured approach to problem-solving and process improvement, making it easier for organizations to identify areas for improvement, define specific goals, and apply the appropriate tools and techniques to achieve those goals

Another alternative for making improvements is to use the concept of lean construction, which is a system designed to minimize the wastage of materials, time, and effort to obtain maximum results (Koskela et al., 2002). However, according to Demirkesen & Bayhan (2022), currently not many companies have implemented the lean concept in their business. This is because many companies do not have sufficient information about the concept of lean and many people think that applying lean is expensive.

According to (Al-Aomar, 2012), these two improvement methods can be integrated into lean six sigma, to reduce various types of waste in construction projects. Furthermore, according to (Galli, 2018), lean six sigma is a structured methodology that primarily focuses on problem-solving and minimizing defects in overall processes. It combines the principles of Lean, which aim to eliminate waste and increase efficiency, with the statistical analysis and data-driven approach of six sigma. Especially for projects that have a time limit, such as a Pengembangan Tempat Istirahat dan Pelayanan (TIP) project that has a limited concession period in its operations. With the existence of limitations in the operational period, the company needs to carry out the planning and construction processes effectively and efficiently

The first TIP project development undertaken by Jasamarga Related Business (JMRB) also called Toll Corridor Development (TCD) was the TCD Taman Mini. TCD Taman Mini development is divided into three phases. Phase 1 is in the form of retail development that is directly connected to the LRT station and also the rest area. The planning process for Phase 1 will begin in mid-2020 in parallel with the permit process, and the construction process will begin in August 2021. For phases 2 and 3, the concept planned is retail and hospital development. The planning process for phases 2 and 3 begins at the same time as phase 1, while the construction process was originally planned for mid-2022 but until now it has not started because it is still awaiting the design and permit process.

Currently, the construction of phase 1 is experiencing delays, namely the initial plan for the completion of phase 1 construction in July 2022 which is targeted to be operational in August 2022. However, until now, phase 1 construction has not been completed, with construction progress of 92% (as of 31 January 2023) and is targeted to be able to operate in March – April 2023. The aim of this research is to analyze and recommend improvements to delays in the TCD Taman Mini project using the lean six sigma approach.

2. Method

This research is qualitative research. This research began by identifying the problems that occurred in the case of late completion of the Taman Mini TCD Project, then determine the purpose of this research and what limitations will be used, so that the research process can be more focused and directed. Then carry out a literature study related to theories related to operations management, project management, lean concept, six sigma in construction work and fishbone diagrams. The purpose of compiling this literature study is as a theoretical basis in conducting research. This research method uses the concept of lean six sigma, where an analysis is carried out using the DMAIC approach first and then an improvement process is carried out using the lean concept approach.

In the analysis with six sigma, there are five steps known as Define, Measure, Analyze, Improve, and Control (DMAIC) (Slack & Lewis, 2017). For the Define phase, based on the previous problem formulation that there is an issue of delayed completion of Taman Mini phase 1 TCD, an analysis will be conducted to determine what process improvements can be implemented to prevent this issue from recurring in future TCD developments. In the Measure phase, a Critical Path Method (CPM) analysis is conducted using Microsoft Project. The CPM is developed based on secondary data obtained from the project. In addition to the CPM analysis, this phase also involves analyzing

the actual duration of work completion and comparing it with the planned duration. This helps identify which activities are experiencing delays in their completion. In the Analyze phase, the processed secondary data is analyzed. To validate the results obtained from the secondary data analysis, primary data collection is also conducted through interviews with key stakeholders directly involved in the development of Taman Mini TCD. The analysis is performed using a fishbone diagram to identify the root causes of the issues that have occurred. Next, in the Improve phase, an analysis is conducted to identify potential improvements that can be made to address the identified issues. The improvement analysis in this phase utilizes a lean construction approach. As for the Control phase, due to the time limitations of this research, it cannot be carried out at this stage. The analysis for the Control phase can be included as part of future research.

This study used secondary data and primary data. Secondary data related to the technical development of Taman Mini TCD, while primary data was in the form of interviews with the team involved in the development of Taman Mini TCD. The secondary data used in this study is technical data related to the TCD Taman Mini Project, both data related to planning, licensing, procurement, and construction. Data related to permits is in the form of a list of required permits related to the TCD Taman Mini project, both permits to JMRB shareholders, area and building permits to the Government of DKI Jakarta, and other permits needed. Data related to planning, such as the master schedule for TCD Taman Mini completion, both the initial plan and current realization, and a list of drawing requirements needed for TCD Taman Mini. For data related to procurement in the form of the procurement process carried out in the TCD Taman Mini development for both the procurement of consultants and contractors. Data related to construction relates to implementation reports and TCD Taman Mini construction progress data. Apart from the internal data, there is also external data from various related literature and regulations.

To be able to answer the problems that occur, secondary data is needed in the form of the Taman Mini TCD project schedule to be processed using Microsoft Project assistance to find out which activities in this project are included in the critical path so that they have the potential to cause delays in the overall construction process.

The primary data in this study were obtained by conducting observations and interviews with the team directly involved in the development of TCD Taman Mini. The purpose of collecting primary data is to analyze and validate the results of secondary data processing. The profile of the respondents in this interview is as follows (Table 1).

Table 1 Respondents profile

Position	Company	Experience	Objective
Direktur Utama JMRB	JMRB (Internal)	3 Years in TCD Taman Mini Development	Find out management's expectations for the development of TCD
Direktur Pengembangan Kawasan JMRB	JMRB (Internal)	1 Year in TCD Taman Mini Development	Find out management's expectations for the development of TCD
GM Pengembangan Bisnis Properti	JMRB (Internal)	1 Year in TCD Taman Mini Development	Find out how the current process is and potential improvements that might be made, especially related to TCD business planning.
GM Teknik dan Pengendalian Proyek	JMRB (Internal)	6 Months in TCD Taman Mini Development	Find out how the current process is and potential improvements that might be made, especially related to technical planning and control of TCD projects
GM Pemasaran	JMRB (Internal)	1 Year in TCD Taman Mini Development	Find out how the current process is and potential improvements that might be made, especially related to TCD marketing strategy
Pimpinan Proyek TCD Taman Mini	JMRB (Internal)	2 Years in TCD Taman Mini Development	Find out how the current process is and potential improvements that might be made, especially related to the implementation and controlling of the TCD project
Site Engineer Manager (Contractor)	Adhi Karya (External)	2 Years in TCD Taman Mini Development	To identify the issues that have occurred and potential solutions that can be implemented.

3. Results and Discussion

For business-related data, the collected data includes the timeline for the analysis of the Highest and Best Use (HBU), business plan development, as well as permits and coordination required from the Shareholders. Technical data includes the timeline for permits, consultant procurement, and planning and construction implementation. Marketing team data includes the timeline for developing marketing strategies and operational targets for Taman Mini TCD.

Based on the obtained secondary data, the next step is to analyze the Critical Path Method (CPM) using the Microsoft Project application, in the context of Six Sigma, this process is the measurement phase. CPM is one of the methods used to analyze activities that fall within the critical path, that determines the duration of the project completion. (Heizer, Render & Munson, 2020). CPM is chosen because the time data used consists of a single value, without separate pessimistic or optimistic times. In CPM, the interdependencies between activities are established, ultimately determining the total completion time, and identifying the activities that are part of the critical path.

The data used in the Critical Path Method (CPM) is the planned data of the development of Taman Mini TCD Phase 1. This data is used to determine the sequence of activities, their durations, and dependencies in the project schedule. The planned data represents the initial project plan, including the estimated durations for each activity and the planned start and finish dates. Meanwhile, actual data is used as a comparison to determine which activities experience delays in their execution and how long the duration of those delays is.

The result of processing the secondary data, which includes a network diagram of activities that are part of the critical path, can be seen in [Appendix 1](#). The results of the CPM analysis, both for the planned and actual data, are as follows:

Table 2 Critical path based on CPM analysis

Planned Data	Actual Data
Business Planning	Business Planning
HBU Planning	HBU Planning
Preliminary Business Planning	Preliminary Business Planning
Procurement: Planning and Supervisory Consultant	Selection of Phase 1 Parking Building Strategic Partner
Architect Consultant	Technical Planning of Phase 1 Parking Building
MEP Consultant	Contractor Procurement of Phase 1 Parking Building
MEP Planning	Phase 1 Parking Building Construction
Concept Design	Marketing Phase 1
Schematic Design	Operational Phase 1
Design Development For Tender	
Construction Phase 1	
Architectural Construction	
MEP Construction	
Operational Phase 1	

From the analysis results, it is also known that there is a delay in completing TCD Taman Mini phase 1 for 270 days. Furthermore, here are the activities that are included in the critical path based on the planned data and experience delays according to the actual data namely:

Table 3 Delayed activities

No.	Delayed Activities	Delayed Duration (Days)
1	HBU Planning	60
2	Consultant Procurement	282
3	MEP Planning	15
4	Interior Planning	140
5	Construction Phase 1	142

As part of the analysis phase, primary data collection is required to validate the results of the previous secondary data analysis. In this research, primary data is collected by conducting interviews with the team directly involved in the development of Taman Mini TCD. Interviews are conducted with the General Manager Pengembangan Bisnis Properti, General Manager Teknik & Pengendalian Proyek, Pimpinan Proyek TCD Taman Mini and General Manager Pemasaran to understand the technical issues that have occurred and possible improvements according to their respective functions. Additionally, interviews are conducted with the Direktur Utama and Direktur Pengembangan Kawasan of PT JMRB to understand the management's perspective on TCD development. Interviews are also conducted with the Site Engineer Manager from the contractor's side to gain insights into the issues from the contractor's perspective.

Based on the interview results, it is known that one of the issues in the development of TCD Taman Mini is related to planning, as stated by the Direktur Utama of JMRB, that in the TCD planning, it needs to be aligned with the marketing concept. Furthermore, according to the Direktur Pengembangan Kawasan and General Manager Pengembangan Bisnis Properti, the planning of TCD Taman Mini should be done more comprehensively and agreed upon by all parties involved to avoid significant changes. Meanwhile, according to the General Manager Teknik dan Pengendalian Proyek, Project Manager, and representatives of the contractor of TCD Taman Mini, incomplete planning is one of the constraints that occurred and resulted in delays in the overall completion of TCD Taman Mini, where several changes occurred in its implementation, causing delays and repetitions in some activities.

Based on the data processing results, it is also known that there are issues related to the selection process of partners or consultants that have not been effective. This is consistent with the interview findings with the General Marketing Pemasaran, where there are internal constraints in appointing marketing consultants. In line with this, there were also challenges in selecting strategic partners for the parking building. Although initially hindered by concept changes, even after the concept was finalized, JMRB faced technical challenges in the selection process, which took a long time. This was mentioned by the Direktur Utama of JMRB, "... regarding partner selection, yes, initially we went through several concept changes, but even when we decided on the final concept, we still faced challenges in the technical appointment process related to GCG (Good Corporate Governance) and other regulations."

Another identified issue from the processing of primary and secondary data is the delay in the implementation of construction works. Based on the analysis of secondary data, it is known that the total delay in completing the TCD Taman Mini project is 142 days. This is also in line with the interview findings from the CEO, where one of the areas that needs improvement is project control. Meanwhile, according to the General Manager of Engineering and Project Control, although most of the delays were caused by incomplete planning, there is still a need for improvement in project control for future developments.

Based on the above information, the problems identified in the development of TCD Taman Mini can be summarized as follows:

- a. Problem 1: Inadequate planning
- b. Problem 2: Ineffective partner or consultant selection process.
- c. Problem 3: Delay in the implementation of construction work.

The two aforementioned issues are then analyzed using a cause-and-effect analysis with a fishbone diagram. This cause-and-effect analysis activity is included in the analysis phase of the Six Sigma process. The following categories are used in the fishbone diagram:

Table 4 Categories in fishbone diagrams

Categories	Journal
People	Huovila et al, 1997
Communication	Huovila et al, 1997
Process	Ballard & Koskela, 1998
External	Ballard & Koskela, 1998
Design	Ballard & Koskela, 1998

The results of the fishbone diagram for each problem can be seen in figure 1, figure 2 and figure 3 below. Furthermore the analysis findings from the fishbone diagram are as follows:

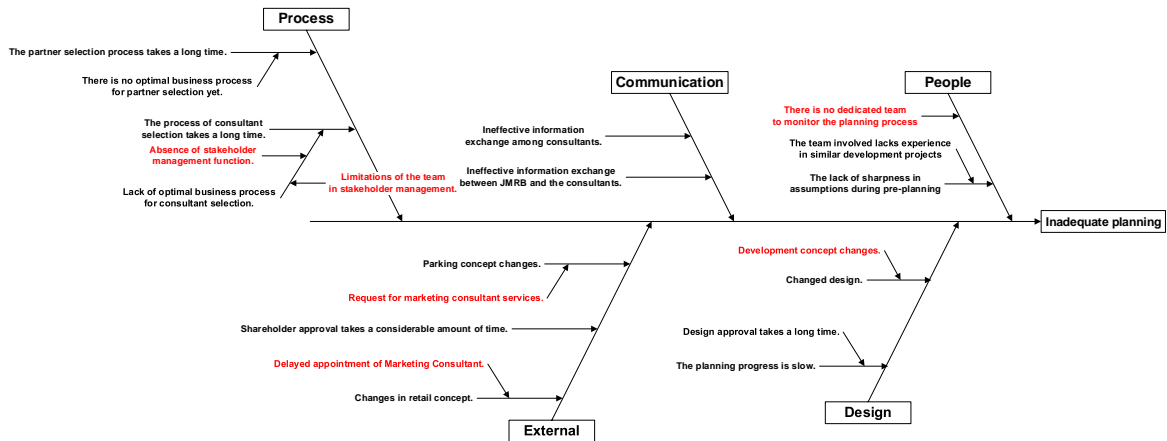


Figure 1 Fishbone diagram problem 1

Table 5 Fishbone analysis result problem 1

Problem 1 : Inadequate planning	
People	: Due to the lack of a dedicated team for the planning function, the planning process becomes ineffective. Additionally, another cause is the lack of sharpness in the initial assumptions during planning, which is attributed to the team's lack of experience in developing similar projects.
Communication	: The lack of effective communication between the planning consultants and between JMRB and the planning consultants results in the ineffectiveness of technical planning activities.
Process	: The partner selection process and the appointment of consultants take a significant amount of time. This is mainly due to the lack of an effective business process related to these activities. It is essential to address this issue since the selection of consultants and partners is a recurring activity in future TCD development.
External	: There is a change in the concept of retail development. Initially, all retail in Phase 1 was planned as general retail with bare conditions. However, based on the marketing consultant's concept, the retail on the 1st floor will be transformed into a Market Place Market Hall, requiring more detailed interior planning. This adjustment necessitates revisiting both the business planning and technical planning that have been previously done.
Design	: The slow progress of technical planning by the consultant can be attributed to the lengthy approval process from JMRB. Upon further analysis, this issue is also related to the absence of a dedicated team for monitoring the planning process.

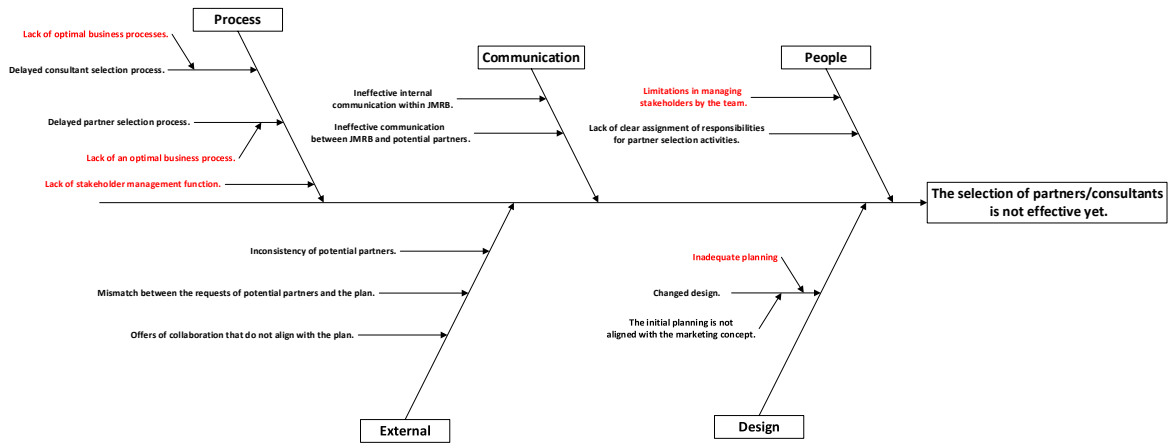


Figure 2 Fishbone diagram problem 2.

Table 6 Fishbone analysis result problem 2

Problem 2 : Ineffective partner or consultant selection process

People	: Limited team capacity in stakeholder management, and a lack of clear task allocation for partner selection activities
Communication	: Poor internal communication within JMRB regarding the partner selection process, as well as ineffective communication with potential partners, resulting in multiple instances of misperception between JMRB and potential partners, leading to repeated processes.
Process	: Lack of effective business processes for both consultant appointment and partner selection.
External	: Inconsistency among potential partners regarding collaboration plans, as well as some partnership proposals that do not align with the plan. Additionally, some stakeholders were not captured from the beginning, resulting in delayed discussions on collaboration with these stakeholders.
Design	: Immature concept planning, both in terms of business planning and technical planning.

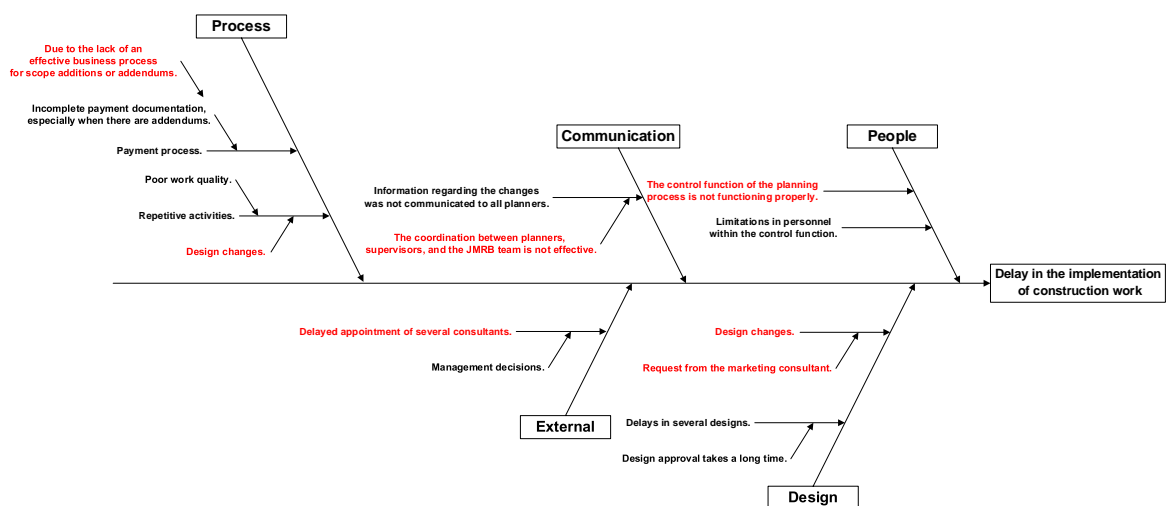


Figure 3 Fishbone diagram problem 3.

Table 7 Fishbone Analysis Result Problem 3

Problem 3 : Delay in the implementation of construction work	
People	: Suboptimal project control function at JMRB due to limited personnel resources
Communication	: Failure to communicate changes to all consultants due to ineffective communication between planning consultants, supervisors, and JMRB.
Process	: Repetitive activities, caused by poor work quality and design changes. Additionally, there is a delay in the payment process, which is analyzed to be due to incomplete payment documents, especially regarding contract addendums. This is attributed to the lack of an effective business process for scope additions or addendums in the project.
External	: The delay in appointing consultants, specifically the marketing consultant and the selection of a parking building partner, is due to the lengthy decision-making process by the management.
Design	: There were design changes and delays in completing some designs, resulting in delays in the construction process.

Based on the analysis of the problems and their causes using a fishbone diagram, the next step is to analyze potential improvements using the concept of lean, which falls under the "improve" phase in Six Sigma. According to (Diekmann et al., 2004), there are five principles in lean construction adapted from lean manufacturing: customer focus, culture/people, workplace organization & standardization, waste elimination, and continuous improvement/build-in quality.

Based on these lean principles, the following improvements can be made for the issues in the TCD Taman Mini project:

- a. In the planning phase, the concept of pull planning can be implemented, where activities are scheduled based on the downstream concept (Bajjou & Chafi, 2018). In the case of the TCD project, the downstream aspect of TCD Taman Mini's development is marketing activities. Therefore, in the planning process, it is important to align the plan with the concepts and strategies of the marketing team.
- b. It is evident in this case that there is currently no optimal business process in place, whether it's in the selection of consultants, partners, or in the process of addendums or scope changes. Effective business processes are critical in TCD development because the absence of effective processes can lead to waste in project execution. In analyzing the business processes, it is essential to ensure that each activity adds value (Ballard & Howell, 2003). This means that every step in the process should contribute to the overall value and success of the project, eliminating any non-value-added activities or inefficiencies.
- c. In the development of TCD, there are many external stakeholders involved, including regulatory bodies such as the Kementerian Pekerjaan Umum dan Perumahan Rakyat (PUPR), Kementerian Perhubungan, local governments, as well as strategic partners such as investors, and service providers such as consultants and contractors. In addition to these external stakeholders, there are also internal stakeholders from the Jasa Marga Group business group, considering that the development of TCD is carried out in the toll road corridor, which will inevitably interact with toll road operators. In relation to this, JMRB also feels the need to establish effective stakeholder management, so that control over each stakeholder can be properly implemented, and no stakeholders are overlooked in the planning process.
- d. In the current development of TCD, it is evident that the control function is not effectively implemented, both in planning and construction. JMRB needs to enhance its control function by utilizing various technology-based tools such as MS Project and Building Information Modeling (BIM). According to (Bryde et al., 2013), the use of BIM can optimize costs, control work cycles, and significantly save time. With the increasing number of projects to be undertaken by JMRB, effective control function becomes crucial in project execution.

- e. Additionally, the commitment of JMRB management in TCD development plays a vital role. This aligns with the findings of a study conducted by (Demirkesen & Bayhan, 2022), which states that management commitment is one of the most important factors in implementing lean concepts in construction. An example of management commitment in the development of TCD Taman Mini is related to organizational structure fulfillment. It has been identified that there are still some positions within the organizational structure that have not been filled, which is one of the causes of issues in the development of TCD Taman Mini. The lack of organizational structure fulfillment in JMRB directly impacts the current development of TCD Taman Mini and can have implications for JMRB's overall business development. This is because the company may fail to achieve one of its targets effectively or encounter challenges. This aligns with the theory presented by (Slack & Lewis, 2017), which states that companies can get trapped in a "vicious cycle" if they misapply strategies in meeting the required resource needs.

4. Conclusion and Recommendations

In the development of the Taman Mini Phase TCD by PT JMRB, it is known that there have been delays in its completion. Therefore, in this research, an analysis is conducted to identify the causes of these delays, as well as to analyze potential improvements that can be implemented to prevent the recurrence of such issues in future developments.

Based on the analysis of secondary data management, it is found that several activities are part of the critical path in the development of the Taman Mini TCD by JMRB, specifically the Taman Mini Phase TCD. Furthermore, based on the actual data, it is also known that several activities have experienced delays, including those related to business planning, technical planning, contractor procurement, strategic partner selection, construction, and operational preparations for Taman Mini Phase 1 TCD.

As a validation of the analysis of secondary data, primary data collection was conducted through interviews with the team directly involved in the development of Taman Mini Phase 1 TCD. From the analysis of the processed primary data, two main problems are identified in the Taman Mini Phase 1 TCD project, which are:

- a. Problem 1: Inadequate planning.
- b. Problem 2: Ineffective partner or consultant selection process.
- c. Problem 3: Delay in the implementation of construction work.

Next, a cause-and-effect analysis is conducted on the two main issues using a fishbone diagram. The fishbone diagram analysis includes five categories: people, communication, process, external factors, and design. Based on the analysis of cause and effect, an analysis of potential improvements is conducted for the development of Taman Mini TCD using the lean construction approach, with the following results:

- a. In the planning phase, the concept of pull planning can be implemented, where activities are scheduled based on the downstream concept.
- b. In the development of Taman Mini TCD, an effective business process is needed, both for procurement processes, partner selection, and project control, to ensure that each activity in the process adds value and minimizes waste.
- c. A good stakeholder management is also required as TCD development involves various parties, including consultants, contractors, relevant government authorities, strategic partners, shareholders, and other stakeholders directly impacted by the TCD development.
- d. Regarding project control, JMRB should consider maximizing the use of technology-based software such as Microsoft Project or Building Information Modeling (BIM) to optimize costs, control work cycles, and achieve significant time savings.
- e. A commitment from JMRB management is required for the further development of TCD, as management commitment is one of the most important factors in implementing lean concepts in construction. An example of management commitment in this case is related to providing the necessary resources for TCD development, including personnel and other resources.

Based on the above analysis and considering the limitations of this study, further research should be conducted to delve deeper into specific aspects, particularly regarding stakeholder management that needs to be implemented by JMRB. Additionally, a more detailed analysis of business process improvement that can be undertaken at JMRB is recommended. Furthermore, due to the time constraints of this study, future research can be conducted to analyze the control phase in relation to the implementation of the identified improvements at JMRB.

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Appendix 1

