International Journal of Innovative Research and Scientific Studies, 8(1) 2025, pages: 2285-2294

IJIRSS
International Journal of Innovative Research & Scientific Studies

ISSN: 2617-6548

URL: www.ijirss.com

A comparation: Implementation lean construction between design & build and design bid build government project in Indonesia

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Abstract

The purpose of implementing lean construction in construction projects is to reduce waste and increase project productivity, ensuring that the project achieves high performance sustainably. Projects that exhibit high performance in terms of cost, quality, time, safety, and environment are the aspirations of all parties involved, including owners, contractors, and other entities. This study aims to provide a comparison of lean construction implementation using Key Performance Indicators (KPIs) developed based on a matrix, to evaluate the performance between Design & Build (DB) and Design Bid Build (DBB) projects in Indonesian government projects. Through questionnaires and in-depth interviews distributed to DB and DBB project participants in government projects, this study reveals different patterns in the implementation of lean construction between DB and DBB projects. The results of this comparison indicate differences in interaction from the initiation phase, which affects the design and implementation phases of the project. Ultimately, distinct quadrants can be described as the outcomes of lean construction implementation in government projects between DB and DBB. This study is beneficial for all parties seeking to develop lean construction in projects to achieve sustainable project performance by continuously reducing waste and increasing productivity.

Keywords: Design & build, Design-bid-build, Key performance indicators, Lean construction, Project performance, Waste, productivity.

DOI: 10.53894/ijirss.v8i1.4954
Funding: This research is supported by PT. Brantas Abipraya Persero,Tbk (Number Grant : 0011/BAP-Grant/1/2025).
History: Received: 6 January 2025 **/ Revised:** 7 February 2025 **/ Accepted:** 14 February 2025 **/ Published:** 26 February 2025

Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Publisher: Innovative Research Publishing

1. Introduction

Lean construction is a principle of waste reduction and productivity improvement for all processes in the project life cycle [1-4]. This principle is believed to be effective in improving project performance in every project delivery system implemented [5-10]. Implementing lean construction on a project will provide added value to the project [9, 11], ensuring that project performance is achieved in terms of cost, quality, time, safety, and environment [12-17]. From a case study conducted at 30 project locations from 2018 to 2024, both Design and Build (DB) and Design Bid Build (DBB), it was shown that several projects, specifically 5 projects (17%), experienced losses, with 4 of them having a value above 100 billion. There were 10 projects (34%) that experienced a surplus but did not meet the expected target. This phenomenon needs to be studied and evaluated further to understand how this performance can occur. Overall, from the data studied, at least 50% of government projects in the case study had performance that was not as desired.

The development of key performance indicators is very important to measure project performance, as noted by Chan and Chan [18] and Lindhard and Larsen [19]. Bigwanto, et al. [11] have developed key performance indicators (KPIs) based on lean construction to measure project performance at each phase of the project life cycle. The developed KPIs can monitor project performance from the initiation, design, project implementation, and closing phases based on a matrix, making them very easy to implement on both ongoing and completed projects for evaluation purposes for subsequent projects. A comparison of project performance will be carried out according to the delivery system on 12 projects used as case studies, consisting of DB and DBB project deliveries.

Previous research on project performance has discussed many factors that influence project performance. Earlier studies on lean construction have focused on factors that influence lean construction implementation, barriers to implementation, and challenges of lean construction implementation in organizations. This research will strengthen the studies conducted by Bigwanto, et al. [9] and Bigwanto, et al. [11] previously, which have proven that lean construction implemented consistently on a project will provide added value to improving project performance. This research will provide a more in-depth study of the implementation of KPIs based on lean construction on project delivery systems, both DB and DBB.

2. Literature Review

2.1. Lean Construction

Sarhan, et al. [20] the general benefits of implementing lean construction in the construction industry include (1) customer satisfaction; (2) quality improvement; (3) increased productivity; (4) reduced construction time; (5) improved construction processes; (6) better health and safety records; (7) improved supplier relationships; (8) better inventory control/reduction; (9) increased market share; and (10) employee satisfaction.

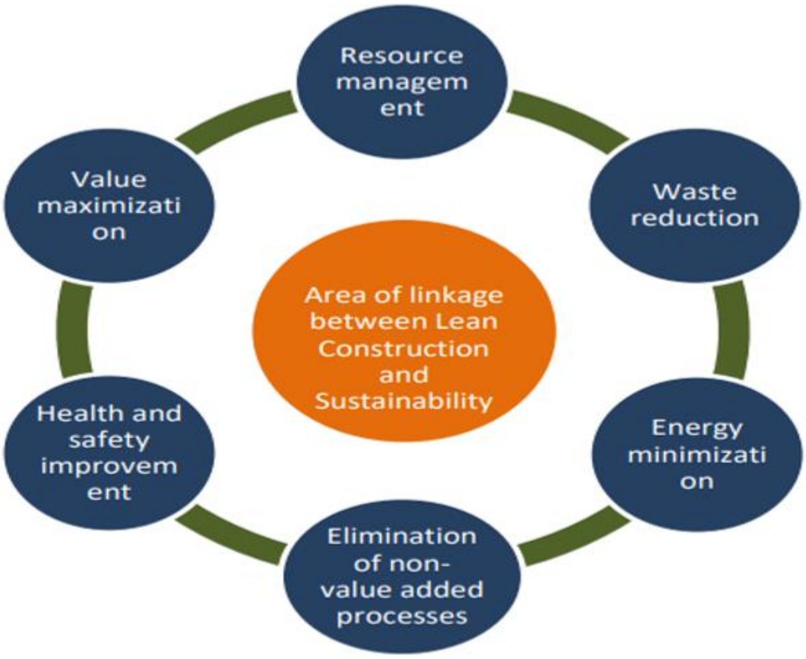

Figure 1.
Area linkage, lean construction, and sustainability project. [21]

Figure 1 illustrates the relationship between lean construction and long-term project sustainability.

Lean Construction is renowned for eliminating non-value-added activities and seeking to improve value delivery during the construction process. It is considered to have great potential to facilitate effective resource utilization. The first view states that Lean Construction is the application of lean production methods in the construction sector, while the second view posits that, as a theory, lean production is introduced into the construction sector to form a new model related to the construction industry itself [22]. Lean Construction is very effective at managing the construction process and achieving goals by eliminating waste. It has been found that there is a need for a more holistic approach to be adopted in the implementation of Lean Construction, such as health and safety and Six Sigma. Systematic training and research are also important to provide good interaction and collaboration with stakeholders. Lean Construction is also capable of improving sustainability in construction, thereby enhancing the quality of life for the construction industry in the future [23].

2.2. Key Performance Indicators (KPIs)

Key Performance Indicators (KPI) [24] can be described as follows:

1. The initiation phase is influenced by factors such as the mission, objectives, and consultation on critical matters noted by the owner.
2. The planning phase is influenced by several factors: mission, management support, client acceptance, and urgency.
3. The execution phase is influenced by several factors: mission, leadership, troubleshooting, schedule/plan, technical tasks, and client consultation.
4. The closing phase is influenced by factors: technical task, mission, client consultation.

Shenhar, et al. [25] divide project success into four dimensions. The first dimension is meeting design objectives, which applies to contracts signed by customers. The second dimension is the benefit to end users, referring to the advantages customers gain from the final product. The third dimension is the benefit to the organization, which pertains to the advantages obtained by the organization due to project implementation. The last dimension is the benefit to the country's technological infrastructure and the company involved in the development process. The combination of all these dimensions provides an overall assessment of project success. Meanwhile, Lim and Mohamed [26] divide projects into two perspectives when assessing their success: macro and micro.

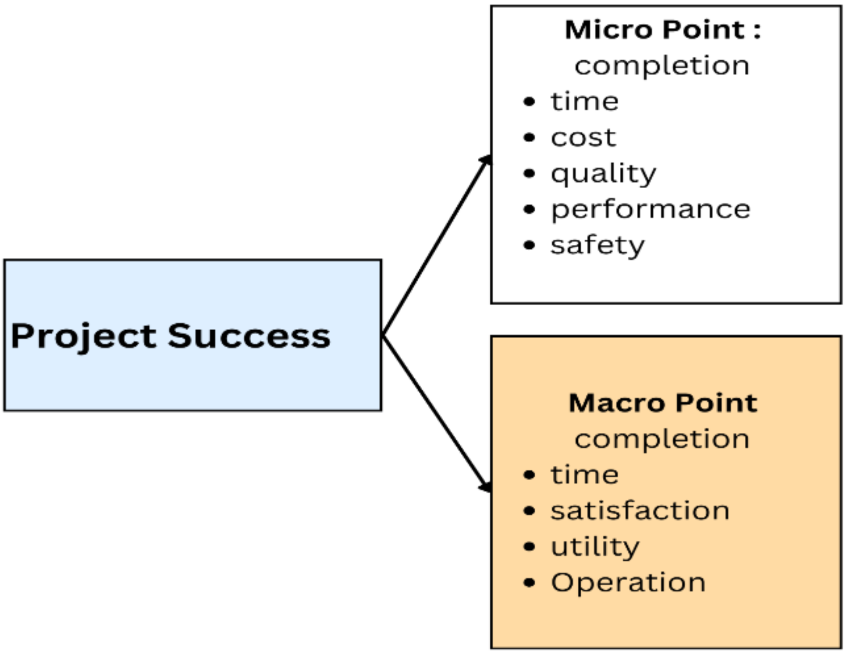

Figure 2.
Project Success Criteria [26].

Figure 2 presents the criteria for a successful project based on macro and micro indicators.

The purpose of KPIs is to enable the measurement of project and organizational performance on construction projects. Chan and Chan [18] recommend that the KPI development process involves consideration of the following factors:

a. KPIs are general indicators of performance that focus on critical aspects of outputs or outcomes.
b. KPIs are limited in number and manageable, and they can be maintained regularly.
c. Having too many (and too complex) KPIs can be time-consuming and resource-intensive.
d. The systematic use of KPIs is essential because the values in KPIs must be implemented consistently.
e. Data collection should be kept as simple as possible. Large sample sizes are required to reduce project-specific impacts.
f. KPIs should be designed for use on each building project. For performance measurement to be effective, measures or indicators must be accepted, understood, and owned throughout the organization.
g. KPIs need to be developed, and it is likely that several KPIs will change dynamically as changes and improvements occur.
h. KPI graphical displays should be simple in design, easy to update, and accessible.

2.3. Project Delivery System DB and DBB

Nikou Goftar, et al. [27] state that new delivery methods have emerged that allow flexibility in how projects are designed, bid, and ultimately built. Largely due to the requirement to select the lowest bidder in public projects, many construction projects are still limited to the Design-Bid-Build (DBB) project delivery method. Over time, this has allowed for a shift in the project delivery system and procurement process, specifically allowing the Design & Build (DB) method to be used on some projects [28]. The main changes in how projects are delivered using alternative delivery methods relate to the type of relationship between project stakeholders and the timing of their involvement in the project [29]. In traditional projects, design is typically completed before contractor selection [30]. With DB, design does not need to be completed before a contractor is selected, resulting in overlap between the construction and design phases [30, 31].

Several empirical studies have been conducted on the performance of Design-Build (DB) and compared it with other delivery methods [32-35]. In general, DB was found to be superior to traditional delivery systems in terms of time and cost performance [29]. DB projects reduced overall costs and duration by an average of 3% and 14% when compared to Design-Bid-Build (DBB) projects. However, cost growth for DB was 3.8% higher, while schedule growth for DB was 9% lower [34].

Okere [36] found that 76% of design-build (DB) projects were completed ahead of schedule, and the average cost growth for DB projects was less than 4%. The DB method offers a better time and cost alternative. Some disadvantages of DB include:

a. Mistakes made by designers can be concealed by contractors.
b. The selection of qualified design-build firms requires more effort than Design-Bid-Build (DBB) due to the two-stage selection process, which includes a request for qualifications and a request for proposals.
c. The database does not provide the owner with adequate control over the design and construction process.

El Asmar, et al. [29] stated that different design readiness levels are needed in each project delivery system, where Design-Bid-Build (DBB) requires 100% design readiness, while Design-Build (DB) requires 20% design readiness. Sari, et al. [37] noted that there is different partnering in each project delivery system, where DBB has a depth of competitive partnering [38, 39], while DB has a depth of cooperative, collaborative, and coalition partnering [39].

3. Materials and Method

This study uses a quantitative method involving project actors, both DB and DBB, to measure their perceptions of the success of lean construction implementation on projects currently being handled [40, 41]. The questionnaire was distributed to projects that had been completed, with 12 project locations divided into DB and DBB. The respondents whose perceptions were explored in this study held at least the position of project supervisor, whether in engineering, procurement, design, or operations. In summary, the methodology used in this study is as follows:

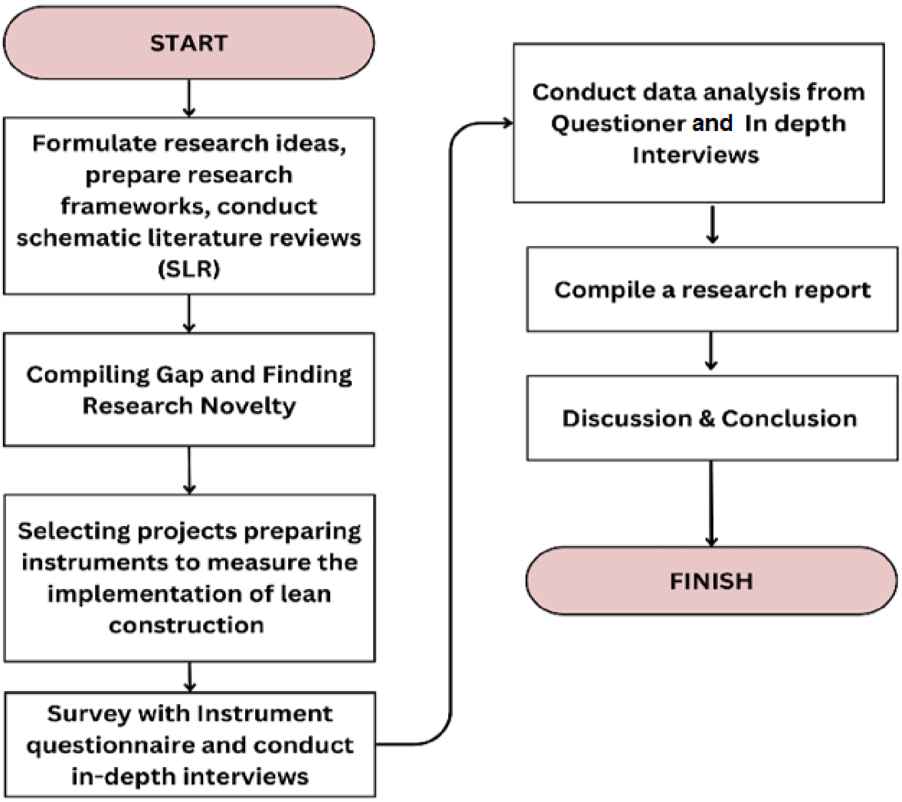

Figure 3.
Research design.

Figure 3 illustrates the stages of research conducted. Each stage will be carried out to produce a comparison of lean construction implementation on DB and DBB projects [42-44]. The locations of the 12 projects are presented in detail in the table below:

Table 1.
List of projects.

No	Project classification	Amount (IDR Billion)	Duration (Month)
1	DB A	266	18
2	DB B	405	60
3	DB C	159	24
4	DB D	179	26
5	DB E	159	30
6	DB F	200	36
7	DBB A	200	10
8	DBB B	101	18
9	DBB C	212	36
10	DBB D	100	28
11	DBB E	157	36
12	DBB F	192	18

Table 1 above presents the project location that will be used as a case study for implementing lean construction using matrix-based instruments [11, 45].

4. Results

The Key Performance Indicators (KPIs) measurement instrument for lean construction implementation is arranged based on the phases in the project life cycle, where 40 indicators are developed and divided into the initiation phase (8 factors), design (11 factors), project implementation (18 factors), and closing (3 factors). Each indicator's details are presented in the following table:

Table 2.
Indicators of lean construction [11].

Initiation Phase	Design Phase	Construction Phase	Closing Phase
• Have a shared perspective on completing the project. • Intensive Communication • Establish partnerships to enhance value. • Design collaboration among contractors and stakeholders. • Very fast decision-making. • Good knowledge transfer in the project. • Innovation and openness increase. • Ownership of the project.	• Design collaboration between contractors and suppliers or subcontractors. • Design maturity > 20% • Clear material specifications. • Very good design details. • Design is built through collaboration among all stakeholders, creating added value for customers. • Value engineering focuses on achieving the best value. • Competent designers. • No repetitive design; waste is reduced. • Environmentally friendly design (green building) • Designing lean procurement. • Design implementing BIM	• Work Culture (Trustworthy, competent, harmonious, loyal, adaptive, collaborative) • Projects are carried out according to the specified time frame • Work results meet the specified specifications and criteria • Work results meet quality control standards • No work accidents in the work environment • No errors in carrying out work • No wrong work/repair/making do • No unused materials (no waste) • Competent managerial team • Effective cost of labor • Competent subcontractors/suppliers • Planning and realization of schedules according to planning • Percent complete according to provisions • There is a project schedule that is understood by all stakeholders • There is no pending approval due to work approval and test results • There are no sudden material changes • Routine training related to lean principles • There is no job variability	• Payment and settlement were not problematic during the project. • SLF was submitted on time. • Output and asset submission; the final project report was well received.

Table 2 above describes lean construction-based indicators that will be used to assess their implementation in DB and DBB projects. This instrument employs a score of 0-4 to measure the depth of lean construction implementation based on Pinto's findings [46], where each assessment score can be interpreted as follows:

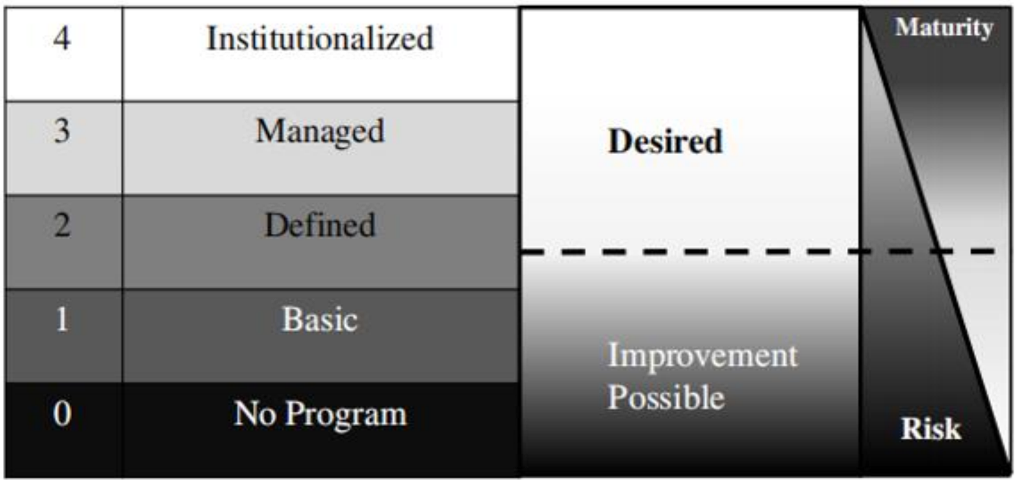

Figure 4.
Lean construction implementation assessment scale [46].

Figure 4 illustrates the assessment criteria for implementing lean construction, which consists of a scale from 0 to 4, along with an explanation as shown in the figure above [46].

In the assessment of the implementation of lean construction across 12 project locations, using instruments developed based on lean construction principles, the results obtained are presented in the form of graphs for each project as follows:

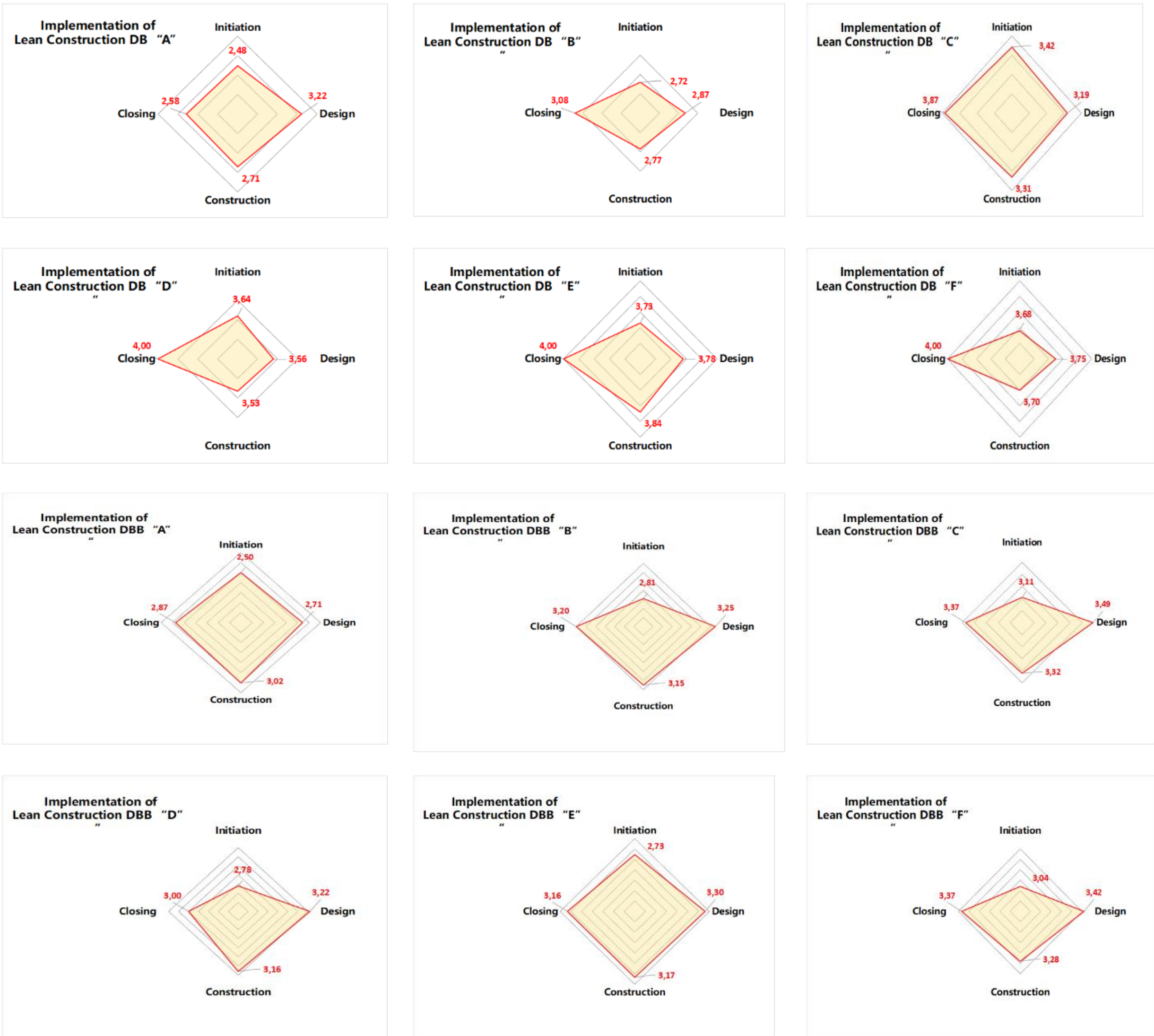

Figure 5.
Results of implementation lean construction in project.

Figure 5 illustrates the results of lean construction implementation at 12 project locations, consisting of 6 DB projects and 6 DBB projects. Each implementation is described in each phase of the project life cycle, namely the initiation, design, construction, and closing phases [47-51]. There are different characteristics in the project life cycle phases between DB and DBB projects [52-55]. This is because, in the DB project, the design and construction entities become one entity [34, 39] (design & build), so the strength in the initiation phase will drive the success of the project [37].

5. Discussion

From the implementation results above, several aspects can be discussed regarding the performance of 12 projects used as case studies in this study, as follows:

5.1. DB A

DB A has a low score in the initiation phase, namely 2.48. This indicates that the performance of the alignment of vision and mission between the DB contractor and its stakeholders (contractors, suppliers, etc.) is very low, as evidenced by the performance of DB A, which experienced delays and failed to achieve closure on time. The performance of the DB A project also incurred financial losses. This aligns with what was conveyed by Katar [34] and El Asmar, et al. [29] that in the DB project, the most important aspect is interaction and collaboration to align the vision and mission [28, 45, 56] to produce higher design maturity. High design maturity will encourage in-depth collaboration in implementing the project, resulting in high performance [12, 13].

5.2. DB B

The DB B project has weaknesses in the design process, which is always changing, resulting in low project performance, delays, and financial losses. In the design and construction implementation process of the DB B project, there is repetitive work that causes a prolonged project duration [8, 20]. This is contrary to the principles of lean construction, where repetitive work is considered waste that must be avoided. Sarhan and Fox [57] stated that in lean implementation, it is essential to build awareness related to understanding lean so that all parties comprehend and can actively participate in carrying out lean-based tasks.

5.3. DB C, DB D, DB E, DB F

DB C, DB D, DB E, and DB F projects have good initiation, design, project implementation, and closing performance, as indicated by scores above 3. This means that the implementation of lean construction is well managed and has become a culture in executing projects at each phase. Since the initiation phase, there has been effective collaboration and communication between stakeholders [58-61]. The success of lean construction implementation is marked by a financial surplus and timely project delivery [13, 62]. These four projects demonstrate that collaboration with stakeholders from the initiation phase drives the long-term success of the project [63-66].

5.4. DBB A, DBB B, DBB D, DBB E

The characteristics of the DBB project include the separation of the design and builder entities [34, 36, 52-54]. A weakness of this project delivery system is the competition between designers and builders professionally [38, 39]. In the DBB A, DBB B, DBB D, and DBB E projects, the scores in the initiation phase were very low (below 3) because the owner only involved a design consultant to prepare project documents. As a result, in the project implementation phase, the contractor was unable to innovate in a way that could accelerate the project and be financially profitable. The implementation of lean construction in the DBB project should be undertaken by the owner as a shared value by aligning the vision and mission related to the project to be implemented. The foundation of good governance is important to ensure a shared perspective in completing the project and achieving the desired targets. In the DBB project delivery, intensive communication between the contractor and designer is also necessary so that the speed of approval for the work implementation can be carried out quickly.

5.5. DBB C and DBB F

In DBB C and DBB F, the owner engaged in in-depth collaboration with the designer and contractor to prepare project documents. Although the DBB project delivery system at these two project locations successfully implemented lean construction, the project performance on both projects also met the targets, and the project was handed over to the owner on time. When considering the surplus obtained by the contractor on the DBB C and DBB F projects, the contractor achieved a profit exceeding 11% of the targeted 10%. Change orders did not occur because the project was collaboratively designed by stakeholders from the outset.

6. Conclusions

From the research presentation above, the following conclusions can be drawn:

1. Implementation of lean construction can be applied in all project delivery systems, both Design-Build (DB) and Design-Bid-Build (DBB). Measurement of implementation must be conducted at every phase of the project life cycle, including initiation, design, implementation, and closing phases. This implementation must utilize transparent and well-measured instruments to avoid subjectivity. The instrument developed by Bigwanto, et al. [11] can linearly demonstrate that the success of lean construction implementation and project performance are directly proportional, making this instrument suitable for further development in efforts to implement lean construction, particularly in government projects.

2. The success of lean construction implementation cannot be separated from the entire project life cycle, starting from the initiation, design, construction, and closing phases, which are a complete unit. Since the initiation phase, a common view of the same project is needed to avoid high waste in other phases. Repetitive work must also be avoided, as it is waste on the project that will result in a long duration of project implementation.

3. The success of lean construction implementation can occur in every project delivery system with the prerequisite of deep collaboration and partnering since the initiation phase. Design collaboration between stakeholders will ensure that procurement is handled well, and the construction phase will produce cost, quality, time, safety, and environmental performance according to the set targets. Another prerequisite is having human resources with superior competence in project design and implementation. Other prerequisites that must be met are the principles of good governance in project implementation because it is a government project that must be maintained in the long term to benefit the community.

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