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LEAN CONSTRUCTION AND AWP: SIMILARITIES, DIFFERENCES, AND OPPORTUNITIES

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ABSTRACT

The registered levels of failure in construction projects encouraged searching for new concepts and methods to improve the performance of these projects. Lean construction and Advanced Work Packaging (AWP) are examples of these concepts. While lean construction has been practiced for three decades, AWP is still newer. Despite the growing interest in Advanced Work Packaging (AWP) and Lean Construction, there is currently no published research that explores the feasibility and effectiveness of applying AWP and Lean Construction in construction projects. The current study aims to provide a comparison between the two concepts based on the results from reviewing the literature. This study, which covered 29 studies, summarizes similarities and differences between lean and AWP based on four categories; context and principles, project specification, roles in the project, and work approach. Based on the results, the study recommends investing in ways to integrate the two concepts aiming at achieving better performance on all levels and decreasing the impact of uncertainty and complexity in construction projects.

KEYWORDS

Lean construction, Advanced Work Packaging (AWP), construction projects, Last Planner System (LPS), comparison, literature review.

INTRODUCTION

During the last few decades, the increased levels of complexity and rates of failure to deliver construction projects on time, with the planned cost, and with good quality have encouraged the movement toward the adoption of new concepts that are more related to thinking about construction as a production system (Farghaly & Soman, 2021). Unlike the traditional project management theory, understanding construction as a production system means that construction systems should be designed, controlled, and improved based on three goals improving the intended produced product, improving the production process and its characteristics (e.g. cost minimization), and meeting the needs and requirements of the customer (e.g. quality) (Koskela et al., 2002; Koskela & Howell, 2002).

Lean Construction and its related applications and tools such as the Last Planner System (LPS) and Integrated Project Delivery (IPD) and more recently, Advanced Work Packaging

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(AWP) are examples of the concepts to support the management and control of construction production systems (Farghaly & Soman, 2021). In many locations around the world, the implementation of lean construction has shown improvements on various levels including cost saving, project duration reduction, higher safety awareness and fewer accidents rates, sustainability, errors and rework reduction, wastes reduction, better inventory management, higher predictability of work, higher labor productivity and increasing customer satisfaction (Albalkhy & Sweis, 2021). The concept of AWP is still new compared to lean construction but shows positive signs about its ability to improve performance in construction projects. For instance, a study that included 20 construction projects in the United States and Canada showed that implementing AWP helped achieve better predictability and improved productivity, cost, safety, and quality (Hamdi & Lafhaj, 2021; O'Brien et al., 2016). Some estimates showed that AWP can help achieve around 25% gain in productivity and 10% installation cost savings in construction projects (CII & COAA, 2013; Rebai et al., 2022). Accordingly, research and interest in AWP are increasing.

Although Advanced Work Packaging (AWP) and Lean Construction have been shown to have significant benefits in enhancing construction productivity and efficiency, their feasibility and efficacy have yet to be examined in the scientific community via a research article. Although both concepts aim to improve performance and productivity in construction projects, the link between them to provide more chances for project success remains inadequately explored. An essential question to be asked is how the two concepts can complement each other. The present study investigates the similarities and differences between AWP and Lean Construction by reviewing the existing literature to address this inquiry.

DEFINITIONS

Lean Construction

Lean originated following the development of the Toyota Production System (TPS) in Japan. Since then, there have been many works that aimed to describe TPS and the principles and theory of lean (Liker, 2004; Ohno, 1988; Womack et al., 1990; Womack & Jones, 1996). In these works, lean principles were defined based on the identification of value based on the client's needs and requirements, value stream mapping, creating a flow of information and materials and waste elimination, establishing pull and producing only what is needed, achieving continuous improvement, and respect for partners and people.

The success of lean in Toyota encouraged its implementation in other fields; including the construction field. The first work about lean construction was the presentation of the "new production philosophy to construction" by Lauri Koskela (1992), which was then followed by the Transformation-Flow-Value theory (TFV) in 2000 (Koskela, 2000). Another important work was the presentation of the most famous lean tool, the Last Planner System (LPS) (Ballard, 2000). LPS can be understood as a planning and production control tool that integrates collaborative planning with all possible stakeholders especially the last planner (people who do the work), incorporates the pull concept and plan based on what "CAN" be done instead of the push mechanism that is based only on what "SHOULD" be done, identifies constraints to be removed, develops performance measures such as Planned-Percent-Completed (PPC), and integrates learning process based on the principles of continuous improvement and non-compliance to plan analysis (Porwal et al., 2010).

LPS and TFV together helped to construct a base for the theoretical and practical streams of the theory of lean in the construction sector (Albalkhy & Sweis, 2021). Over the years, there has been no agreement on a specific definition for lean construction, but one of the definitions that were raised following studying a list of existing literature about lean construction was *"a philosophy that aims to improve the collaboration between all project stakeholders to maximize*

value for all of them in general and the customer in particular, in addition to eliminating all kind of wastes, achieving continuous improvement, improving flow, reducing cost and enhancing safety and quality" (Albalkhy & Sweis, 2021).

AWP

AWP roots go back to the development of Workface Planning (WFP), which was one of the best practices to face the challenges facing the construction of oil and gas projects in Alberta according to the Construction Owners Association of Alberta (COAA) (Hamdi, 2013). WFP is "*the process of organizing and delivering all the elements necessary, before the work is started, to enable craft persons to perform quality work in a safe, effective, and efficient manner. This is accomplished by breaking down (planning) construction work by trade into discrete work packages that completely describe/cover the scope of work for a given project to efficiently use available resources and track progress"* (Hamdi, 2013). In 2011, a joint research work between COAA and the Construction Industry Institute (CII) started aiming at reviewing different methods (including WFP and LPS) and developing a project planning and execution model. The research was based on studying industry cases, literature review, interviews with experts, and team experience resulted in the development of the AWP approach (Halala & Fayek, 2019). According to the CII (CII - RR272-11, 2013), AWP is *"a planned, executable process that encompasses the work on an engineering, procurement, and construction, beginning with initial planning and continuing through detailed design and construction execution".*

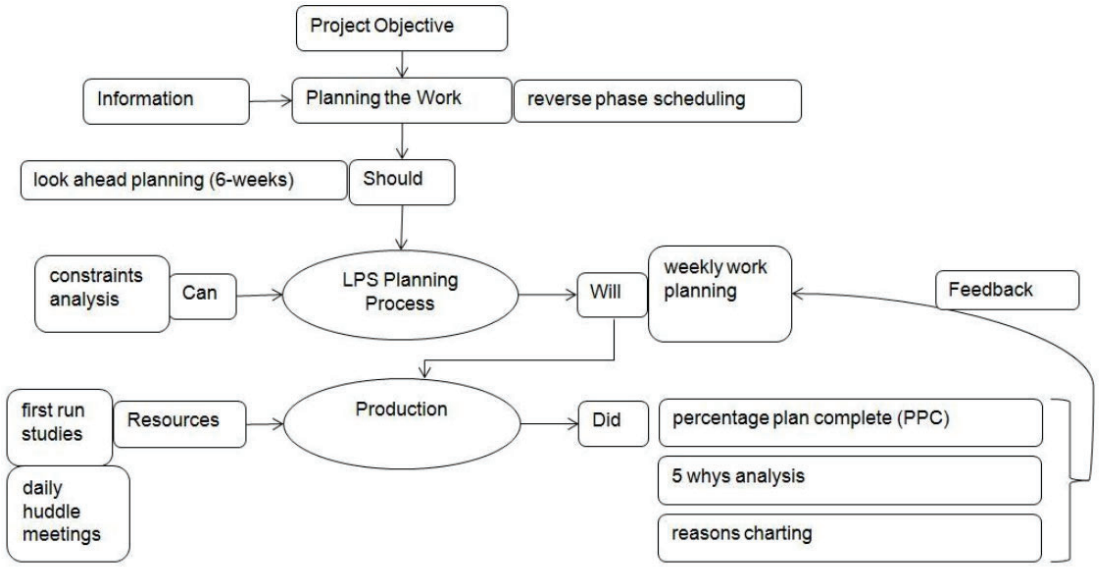

Figure 1: LPS planning process (Porwal et al., 2010).

AWP is a construction-driven project delivery process that begins with the end in mind, in which construction and engineering must collaborate during planning to create a constraint-free field environment (Wu et al., 2021). This collaboration ensures that the project is designed with a construction-friendly sequence and that the supply chain is sequenced accordingly by breaking down the project scope into Construction and Engineering Work Packages (Ponticelli et al., 2015). AWP was also designed to facilitate the planning process and reduce the burden while creating work packaging by removing any possible constraints as early as possible (Halala, 2018). Unlike traditional work packaging where planning is done only in the early phases of the project, AWP tries to provide a holistic approach to planning and execution of

work packaging along the whole project life cycle as follows (Olfa et al., 2013; Ponticelli et al., 2015):

- The first stage of a project involves identifying critical planning elements to define work packaging deliverables. The project is divided into Construction Work Packages (CWPs) which align with the execution plan and Engineering Work Packages (EWPs).
- The second stage is Detailed Engineering which refines the work from the first stage. Output includes detailed specifications for EWPs, a discipline-based schedule, and aligning plans to ensure consistency.
- The third stage is Construction, with detailed planning and execution of Installation Work Packages (IWPs). IWPs are issued 3 weeks before the start and are approved by frontline personnel. After execution, IWPs are controlled by owner representatives for quality checks and updates.

Despite receiving some criticism from the Lean community due to the expected impact on inventory growth, push orientation, and variability increase (Arbulu & Shenoy, 2021; Tommelein & Ballard, 2016), there have been several calls to integrate AWP and lean construction, especially by the CII and the Lean Construction Institute (LCI) (CII & LCI, 2022a, 2022b; CIIBuilds, 2022b, 2022a). Nevertheless, a scientific paper still has not addressed the possibility of applying AWP and LCI.

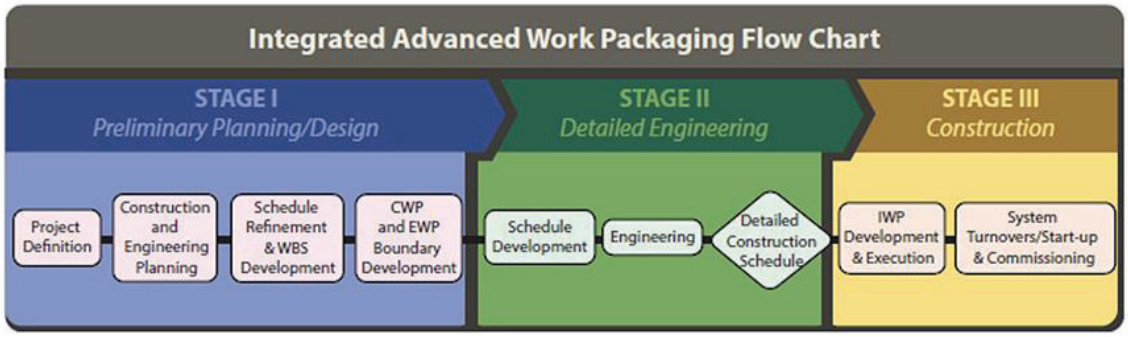

Figure 2: AWP flowchart (CII - RR272-11, 2013).

RESEARCH METHODOLOGY

This study aims to conduct a comparison between lean construction and AWP to identify similarities, differences, and possible opportunities. To do so, a literature review was conducted using a search for the keywords: ((“advanced work packaging” OR AWP) OR (“workface planning” OR WFP)) AND (construction or building). The focus on AWP is because of the low number of publications about it in comparison to lean. The search was done firstly on Google Scholar, Web of Science, and Scopus to cover the scientific articles about the studied topic. Then, it includes other resources; especially those published by CII.

The total number of studies included in the literature was 29. The charactersitcs of the studies are shown in Table 1. Following the analysis of these studies, four main categories were studied, which are context and culture, project specification, roles in the project, and work approach. The selection of these four main categories in this study was based on their relevance to the implementation of Advanced Work Packaging (AWP) and Lean Construction in construction projects. These categories were chosen to explore the factors that could affect the implementation and success of AWP and Lean Construction in various project contexts and organizational cultures.

Table 1: Literature characteristics.

Charactersitcs		Number of publications
Type of publication	Journal Article	11
	Conference	4
	Book	2
	Thesis	3
	Report	7
	White paper	2
Year of Publication	2013	3
	2014	-
	2015	2
	2016	2
	2017	1
	2018	2
	2019	2
	2020	6
	2021	4
	2022	8
	2023	1

The category of context and culture was included due to its broader organizational and cultural factors that can impact the implementation of AWP and Lean Construction. Project specification was identified as a category due to its critical role in determining the scope and objectives of the project, which could influence the selection of the appropriate work approach, roles, and responsibilities required for AWP and Lean Construction implementation. Roles in the project were selected as a category due to the need for clearly defined roles and responsibilities for the successful implementation of AWP and Lean Construction. Finally, the work approach was chosen as a category to analyze the implementation of AWP and Lean Construction in the context of the project management approach used, as well as the availability of technology and resources necessary for successful implementation. Due to the presence of different lean tools, the fourth part, which is about the work approach provides a comparison between AWP and LPS as LPS is the most known planning and control tool in lean thinking.

RESULTS

Context and principles

Context includes the type of each concept, origin, orientation, and purpose as explained in the literature. The comparison based on the context is shown in Table 2. Concerning the type, it is agreed that lean is not based on a specific tool or methodology; rather, it resulted from a set of principles that were first coined in the automotive industry and constitute what is called lean thinking. Accordingly, lean can be seen as a philosophy based on which different tools and methodologies were developed (Albalkhy & Sweis, 2021; CII & LCI, 2022a). On another hand, AWP is an approach or a methodology that was considered a best practice in work packaging to solve the problems facing construction in the oil and gas sector as explained by the (CII - RR272-11, 2013). In terms of orientation and purpose, AWP can be considered a task-oriented

approach that aims to improve task management to increase predictability and productivity in projects (Halala, 2018). While lean has evolved to be more of a human-centric approach that values workers' engagement and is based on collaboration to create value, flow, and continuous improvement (Santos et al., 2021). Orientation toward "respect for people" and collaboration made it possible for lean to go beyond time, cost, and quality improvement to cover other aspects such as innovation and integration of workers' ideas, sustainability, and safety (CII & LCI, 2022a). This does not mean that AWP neglects the human factor. For instance, Path of Construction (POC), which is an essential practice in AWP should be jointly developed and aligned with respect to all stakeholders (CII & LCI, 2022b). Additionally, according to CII and LCI, a key value for AWP and lean construction is integrating the safety, health, and well-being of workers in the process design (CII & LCI, 2022a).

Table 2: AWP vs Lean- context

Context		
Criteria	**AWP**	**Lean Construction**
Type	Methodology	Philosophy
Origin	Oil & Gas Industry	Automotive Industry
Orientation	Task-oriented	People-oriented
Main Purpose	Increase productivity, predictability, and efficiency	Value creation, flow, and continuous improvement

Project Specification

AWP method was developed to respond to the increased complexity of capital construction projects (Halala, 2018). According to Hamdi (Hamdi, 2022), the implementation of AWP in small projects is possible but not attractive as it fits more megaprojects. In contrast, lean can be implemented in all types of projects (Albalkhy & Sweis, 2022). Concerning the contractual relationships and project delivery types, AWP considers early contracting a priority, in which the requirements for AWP and AWP language (plans, procedures, strategies, and responsibilities) should be clearly stated and included in the contract (Halala & Fayek, 2019). For lean, lean can be used with different types of contracting and project delivery methods. However, the lean community has had a big role in the development and adoption of collaborative delivery methods such as lean project delivery system (LPDS), integrated project delivery (IPD), target value delivery (TVD), and others (CII & LCI, 2022a; Koskela et al., 2002). Referring to the costing strategy, the AWP requires defining the initial conceptual model and estimate based on the work packages and then conducting formal cost-saving ideas, which results in the locking of the estimate (CIIBuilds, 2022b). For lean, one of the most encouraged practices is the Target Value Design (TVD), which is based on keeping the design and costs aligned with the client's target cost defined in the early design phase (Ng & Hall, 2019). Regarding the project planning methods, AWP conducts interactive planning sessions, which include all key stakeholders and are driven by the construction, until the preparation of the CWP (Construction work packages) with a push aspect in the CWP release matrix, but once on the site, the workforce planner changed the concept dealing with the IWP (Installation work packages) release plan in a pull concept. The pull could also be promoted when a supplier needs to provide relevant information to Procurement Work Package(CII, 2020). All that is always conforming to the main plan and with the alignment to the POC (path of construction) and (CIIBuilds, 2022b). On another hand, lean construction strictly focuses on pull planning and builds its plans using a collaborative planning method in presence of all stakeholders and participants (CII & LCI, 2022a). The comparison based on project specification is shown in Table 3.

Table 3: AWP vs Lean- Project specifications.

Project Specifications		
Criteria	**AWP**	**Lean Construction**
Suitability	Capital Projects	All types of Projects
Contracting and project delivery	Contracting strategy is a priority and needs to be defined	Different types of delivery but encouraging IPD
Costing/value	Initial conceptual model and estimate Conducting formal cost-saving ideas	Target value design (TVD)
Planning Principle	Push and interactive planning Pull for supplier and PWP, and in the site	Pull and collaborative planning

Roles in the project

As AWP is a structured approach, it has clear definitions for various roles, which is not the case in lean. For instance, while in lean, clients are the main focus and their presence and participation is a key to success in all project phases (Albalkhy & Sweis, 2021), there is no strict definition of their representatives like that in AWP. AWP champions, who act as the voice of the client are responsible for the implementation of AWP procedures and standards throughout the project (Hamdi, 2022). Additionally, while the collaborative planning sessions require the attendance of all possible stakeholders in LPS, there is no strict requirement to make someone a facilitator. In contrast, AWP interactive sessions are usually led by the Construction Manager (1st to 3rd levels of planning) and then workface planners (4th and 5th levels of planning) (Hamdi, 2022). The workface planners are responsible for IWPs definition and management on site to ensure the removal of constraints and the proper execution of the work (CII & LCI, 2022a). A clear definition of lean roles can be found in the last planner which refers to the foreman or the frontline supervisor who has to engage in constraints management and removal (Porwal et al., 2010).

Work approach

AWP is a structured approach that has three main phases of work that are resulting in the CWPs, EWPs, and IWPs. The work in AWP usually starts with area-based decomposition by developing the construction work areas (CWAs) and then over the disciplines-based planning and control. As an approach with origins from the oil and gas sector, during the planning process, AWP focuses on aspects such as constructability, operability, maintainability, and constraint removal (CIIBuilds, 2022b). In turn, lean practices in LPS adopt the short-range production planning levels (i.e. master schedule, phase or pull planning, look-ahead planning, weekly work planning, and daily huddle meetings and learning). Aligned with some practices such as takt planning, short-range planning in LPS aims to ensure the avoidance of overlapping between trades and remove variability sources that may hinder the flow of the work (CII & LCI, 2022a).

Concerning performance measurement, AWP relies on productivity measures for the CWP, and EWP, in addition to safety and delay indicators. It also uses the installation cost of IWPs and their conformity with the planned budget (Halala & Fayek, 2019; Hamdi, 2013; Rebai et al., 2022). In lean, as stated earlier, the focus is on trying to achieve continuous improvement in all possible aspects (e.g. client satisfaction, safety, sustainability, time, cost, and quality). Specifically, in LPS, different measures are considered to cover different aspects including for instance the percent plan complete (PPC), which helps to identify the deviation between what was planned and what was executed (Ballard, 2000). In addition to other measures such as cost reporting (CR), schedule variation (SV), quality reporting (QA/QC), Root-cause Analysis (RA), and Reason Summary for non-competition (RS) (España et al., 2012).

Regarding the learning process, AWP refers to knowledge management related to the IWP process and value chain (Hamdi, 2022). In lean, the learning process is a fundamental concept that supports the continuous improvement goal. Therefore, many tools can be used to support

the learning process in LPS such as the analysis of the frequency of plan failures, 5 Whys, Plan–Do–Check–Act (PDCA), Detect–Correct–Analyze–Prevent, variance analysis and the reason for variance (Hannis Ansah et al., 2016). Table 4 summarizes the comparison between AWP and LPS in relation to the work approach.

Table 4: AWP vs Lean- Work approach.

	Work approach	
Criteria	**AWP**	**Lean Construction (LPS)**
Planning Structure	Milestone Planning L1 Planning (Areas) L2 Planning (Disciplines) L3 Planning (Work for a crew) CWA, CWP, EWP, IWP	Master Schedule Phase Scheduling Look-Ahead Planning Weekly Planning Daily huddle meetings and learning
Risk	Systemized risk analysis and constraints removal	Constraints removal throughout the whole project Error-proofing
Performance measurement	Productivity Safety Installation cost Delay	PPC, CR, SV, QA/QC, RA, RS, and others
Planning classification (colored stickers)	By areas and discipline	By trades
Learning	Knowledge management (IWP)	Analysis of Frequency of plan failures 5 Whys, Plan–Do–Check–Act, detect–Correct–Analyze–Prevent Variance analysis Reason for variance

The literature was used in this study to compare two concepts that aim to improve the performance of construction production systems, which are AWP and Lean Construction. The analysis of the found studies showed that despite the differences in the approach, context and principles, type of projects, and structure and roles, the two concepts have many things in common. Which shows room for mutual interaction and integration between the AWP and Lean Construction. Figure 3 shows the possible integration chart between AWP and lean construction.

More specifically, AWP and lean construction share the goals of creating improvements in productivity, quality, and efficiency in construction projects. Both focus as well on the removal of all constraints that may hinder the flow of work and affect efficiency. The safety of workers and stakeholder participation in the planning and control are also among the shared points between AWP and lean construction.

Concerning how AWP can benefit from lean construction, one of the primary focuses can be more oriented toward the human factor. In lean construction, respect for people is an essential principle that is reflected in most lean tools; especially in the LPS. This principle requires respecting the inputs of workers, building trust, creating effective communication strategies, and strengthening the team working environment. Additionally, AWP can benefit from other lean principles such as the focus on flow and waste elimination and pull planning. Moreover, while AWP has its tools to improve the learning process, there is still room to benefit from the continuous improvement experience in lean thinking. Concerning performance measuring and control, focusing on the value of the client may help to produce more key performance indicators (KPIs) that can help achieve better performance on different levels while implementing AWP. Finally, AWP can benefit from the integration with other concepts related to lean such as TVD, IPD, and LPDS.

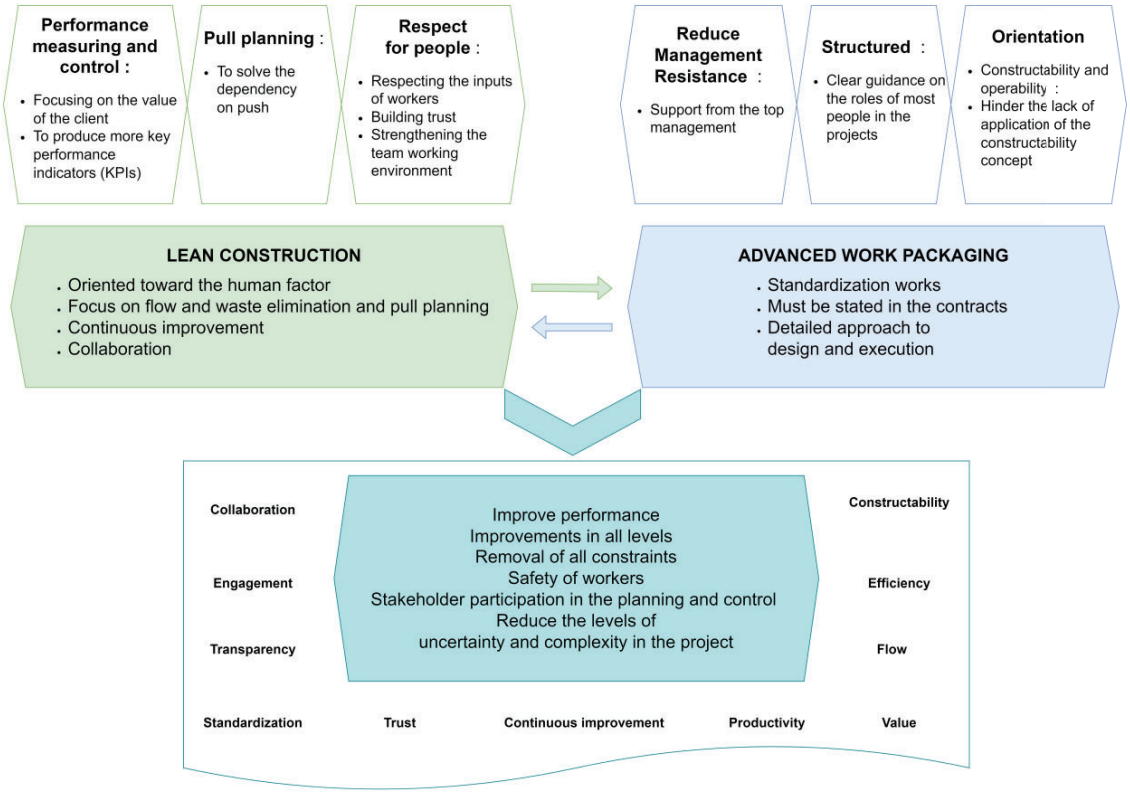

Figure 3: Possible integration chart between AWP and lean construction.

In turn, AWP can support the standardization works in lean. With its structured way, AWP offers opportunities for ease of implementation. This is supported by its clear guidance on the roles of most people in the projects. As a result, this might be helpful to face the challenges of the reluctance of people to adopt lean (Albalkhy et al., 2021; Albalkhy & Sweis, 2021). Additionally, as AWP has to be clearly stated in the contracts, its adoption with lean construction may help to reduce the management resistance to change and the lack of support from the top management, which was considered in many studies among the most serious barriers facing the adoption of lean (Albalkhy et al., 2021; Albalkhy & Sweis, 2021). Moreover, with its detailed approach to design and execution and its orientation toward constructability and operability, AWP adoption may hinder the lack of application of the constructability concept, which is another cited barrier that faces the adoption of lean (Albalkhy et al., 2021). Finally, as a method that was specifically developed for a large-scale project, the integration of AWP and lean construction can help to reduce the levels of uncertainty and complexity in the project.

DISCUSSION AND CONCLUSIONS

The integration of AWP and Lean Construction has the potential to create a more collaborative and efficient environment in construction projects, leading to improved project outcomes, reduced project delays, and cost overruns. The synergistic effect of integrating AWP and Lean Construction can promote standardization, constructability, and the adoption of best practices, leading to improved project outcomes. The integration can also promote the flow of work and value in the project and achieve continuous improvement through the use of lean tools and techniques.

However, the study has some limitations. The low number of publications about AWP in comparison to Lean Construction resulted in relying on non-peer-reviewed industry reports as

a primary source of information on AWP. Further investigations based on case studies analysis, content analysis of the reports and standards of AWP compared to lean literature, or collecting perspectives via interviews, surveys, or any other data collection method may be required to investigate the possibilities, impacts, or challenges facing this integration between AWP and Lean Construction. The study does not focus on the detailed approach in AWP and a specific Lean tool such as LPS, rather, it covers the main themes of the work. Future studies can provide a comparison on the base of details in each phase of the project.

In summary, the study helps practitioners and researchers to understand the links and differences between AWP and Lean Construction concepts and how to integrate them to make improvements in the construction environment. The integration of AWP and Lean Construction represents a promising avenue for improving construction project outcomes, but further research is required to validate the impact of the integration on these measures.

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