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Housekeeping in Construction: Key Drivers of Occupational Safety and Productivity in the Industry

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Abstract

Question: What are the underlying factors of construction housekeeping that contribute to occupational safety and work productivity in the Indonesian construction industry?

Purpose: The study aims to identify and categorize the key factors of construction housekeeping that influence safety and productivity, thereby elevating housekeeping from a routine task to a strategic lean management priority.

Research Method: A quantitative research design was employed, combining a comprehensive literature review with a structured questionnaire survey distributed to construction practitioners in Indonesia. The collected data were analyzed to extract common themes and groupings related to housekeeping impacts.

Findings: The findings show that housekeeping factors that affect occupational safety can be grouped into five main categories: Lean Worksite Management Practices, Lean Safety Culture and Workforce Support, Worksite Organization and Workflow Efficiency, Worker Welfare and Safety Facilities, and Waste Reduction and Hazard Control. Meanwhile, housekeeping factors that affect work productivity are divided into four main groups: Lean Workflow and Site Coordination, Material Flow and Waste Reduction, Equipment Operational Reliability, and Worksite Accessibility and Operational Control.

Limitations: The study is limited to responses from construction practitioners in Indonesia and may not reflect conditions in other countries or regions.

Implications: Construction managers should consider housekeeping as a core component of both safety and productivity frameworks. Incorporating housekeeping strategies into project planning and supervision can lead to more efficient operations and fewer

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accidents.

Value for authors: This research contributes to the body of knowledge by repositioning construction housekeeping as a strategic factor in project management. It provides a framework for integrating housekeeping into safety and productivity policies, particularly in developing country contexts like Indonesia.

Keywords: Construction housekeeping, Construction industry, Productivity, Occupational safety

Paper type: Technical Note

Introduction

Construction housekeeping, or managing cleanliness and tidiness on construction sites, is a crucial element often overlooked. In the context of construction projects, housekeeping includes activities such as arranging materials, cleaning work areas, and managing construction waste properly. Good housekeeping practices create a more organized work environment and may reduce the risk of work accidents (Hettiarachchi and Coomasaru 2019, Lawani et al. 2019). A clean and orderly work environment facilitates worker movement, increases operational efficiency, and minimizes potential hazards such as slipping, being hit by materials, or other accidents (Johari and Jha 2019). In addition, tidiness at the work site also plays an important role in increasing productivity because workers can easily find the necessary tools and materials, reducing wasted time (Choudhry 2017). Thus, the relationship between housekeeping, occupational safety, and work productivity is a unity that influences each other in supporting the success of a construction project.

Despite its importance, housekeeping practices in the construction industry are often under-appreciated. Many construction projects, especially in developing countries, including Indonesia, face challenges in implementing effective housekeeping (Ratman et al. 2020). One of the challenges is the lack of awareness among project team management and workers about the impact of construction housekeeping on workplace safety and productivity. Worksite conditions characterized by scattered materials, inadequate storage space, and slow waste management are clear examples of poor housekeeping practices (Susanto et al. 2021, Ratman et al. 2020). In addition, the pressure to complete projects on schedule often makes management more focused on meeting time and cost targets, thereby ignoring the importance of the cleanliness and tidiness of the worksite (Susanto et al. 2021, Othman et al. 2020). As a result, the risk of accidents increases and work productivity decreases, ultimately affecting the project's efficiency and sustainability.

Construction housekeeping is an important aspect in construction projects because it is closely associated with both safety and productivity performance. Poor housekeeping conditions, such as scattered materials, unmanaged waste, and obstructed work areas, may increase accident risks and disrupt construction activities. In contrast, effective housekeeping practices can create safer and more organized work environments by reducing potential hazards, improving accessibility, and supporting smoother workflows (Lawani et al. 2019). In addition, better housekeeping implementation may minimize unnecessary movement, reduce

time loss, and improve operational efficiency on construction sites (Ghani and Fadzil 2026). Therefore, safety and productivity are two critical aspects that are associated with construction housekeeping practices and are essential indicators of construction project performance.

The purpose of this research is to explore the latent construction housekeeping factors that significantly influence occupational safety and productivity in construction projects. By exploring these factors, this study aims to understand how practices such as waste management, material organization, work area cleanliness, and accessibility planning contribute to creating safer, more efficient work environments. The findings are expected to provide valuable insights for construction managers and stakeholders in optimizing housekeeping strategies to improve overall safety standards and productivity in the industry.

Literature Review

Construction Housekeeping

Housekeeping in construction refers to a set of practices aimed at maintaining cleanliness, tidiness, and orderliness on a construction site. According to several studies, housekeeping includes important elements such as construction waste management, material arrangement, providing a clean work area, and managing safe access routes (Hwang et al. 2020, Lestari et al. 2020, Othman et al. 2020, Mollo et al. 2019, Johari and Jha 2019). These elements help create a comfortable working environment and prevent potential hazards that can harm workers (Jazayeri and Dadi 2017). Effective housekeeping is the basis for proper construction site management and contributes to the project's smooth operation. It concerns maintaining the ideal working environment on a project site (Othman et al. 2020).

Occupational safety is one of the most crucial aspects in the construction industry, given the high rate of work accidents that often occur in this sector. Safety risk factors include an unorganized work environment, lack of safety equipment, and substandard site conditions (Mishra et al. 2022, Shazwan et al. 2017, WSHC 2016). Poor housekeeping can increase the risk of accidents such as slips, being struck by materials, or injuries from heavy equipment (Susanto et al. 2021, Lawani et al. 2019, Mollo et al. 2019). For instance, Silalahi (2019) found a relationship between housekeeping practices and work accidents in a housing project in Medan, Indonesia. Studies have shown that organized work conditions through good housekeeping can significantly reduce work accidents, because an organized work environment minimizes the potential for unexpected hazards (Lestari et al. 2020, Ratman et al. 2020, Aboagye-Nimo and Emuze 2017).

On the other hand, productivity in construction projects is measured through indicators such as time efficiency, achievement of project targets, and work output levels (Fauzan and Sunindijo 2021, Shazwan 2017). Poor working conditions, such as messy areas or obstructed access, can slow worker movement and work processes (Aboagye-Nimo and Emuze 2017, Mollo et al. 2019). In contrast, good housekeeping practices enable workers to work more efficiently, as all tools, materials, and access routes are readily available and easily accessible

(Othman et al. 2020). Thus, a tidy working environment improves work comfort and accelerates the achievement of productivity targets (Mollo et al. 2020, Choudhry 2017, WSHC 2016).

Previous studies have consistently shown a close relationship between housekeeping, occupational safety, and productivity in construction projects. These studies found that projects with good housekeeping practices tend to have lower occupational accident rates and higher productivity achievements (Fauzan and Sunindijo 2021, Ratman et al. 2020). For example, construction projects that implement a planned housekeeping management system have improved productivity by 24.64% (Ostos-Sánchez and Livia-Chuzón 2023). Ardhani et al. (2022) found that 70% of construction workers with poor knowledge and practice of housekeeping are at risk of a work-related accident. Based on the literature, effective housekeeping not only provides potential benefits, such as increased occupational safety, but also the overall efficiency and productivity of construction projects.

Lean Construction and Its Relevance to Housekeeping

Housekeeping Lean Construction is a modern way of managing construction projects. Unlike traditional construction management, which focuses mostly on finishing projects on time and within budget, Lean Construction aims to deliver more value for the customer while reducing waste (Mossman 2018, Abdelhamid & Copeland 2022). It also encourages continuous improvement by involving everyone on the project (managers, workers, suppliers, and clients) in a collaborative process (Elfing & Seppänen 2022, Asadian et al. 2023, Malvik 2024). In Lean Construction, success is not just about finishing fast, but about creating an efficient, safe, and respectful work environment where people work smarter, not harder.

From a Lean Construction perspective, the relationship between housekeeping and lean can be understood at the level of project management philosophy and principles. Lean Construction emphasizes the importance of value creation and waste minimization in all construction project activities (Francis & Thomas 2020). Waste in construction extends beyond wasted materials to waiting time, unnecessary movement, workflow disruptions, and unsafe working conditions. In this context, housekeeping plays a crucial role in supporting a more organized, safe, and efficient work environment, allowing the construction process to run more smoothly with minimal disruption.

Furthermore, housekeeping practices support Lean Construction principles of increasing workflow efficiency and promoting continuous improvement. A clean and organized work area can reduce time lost searching for tools or materials, facilitate the mobility of workers and equipment, and minimize the potential for workplace accidents that can hamper project productivity (Villanueva et al. 2022). Therefore, housekeeping is viewed not only as a cleaning activity but also as part of a project management strategy to support operational performance, safety, and productivity in implementing Lean Construction.

In practice, however, many construction projects still overlook simple yet essential tasks such as housekeeping, site cleanliness, and worker welfare (Shazwan et al. 2017, Hansen 2025). These activities are often seen as minor issues rather than part of the core construction

process. But poor housekeeping leads to scattered materials, blocked access routes, and unsafe conditions, may contribute to accidents and reduce productivity. According to Lean Construction principles, keeping the site clean, organized, and safe is not just a support task. It is part of delivering value and minimizing waste.

This study supports the Lean Construction philosophy by focusing on housekeeping as a strategic management activity. These include not only traditional activities like cleaning the work area and organizing materials, but also providing clean dormitories, personal protective equipment (PPE), first-aid facilities, and access to clean water. These factors ensure that workers are healthy, safe, and able to perform their tasks efficiently. Treating housekeeping as part of Lean management can lead to safer, cleaner, and more productive construction projects. This is especially important in developing countries where project sites often lack structured health and safety practices.

Construction Housekeeping and the 5S/6S Framework in Construction

Housekeeping in the construction industry is often closely linked to the implementation of the 5S or 6S framework, which originated in Japanese manufacturing practices and has since been adapted across various sectors, including construction. The 5S methodology consists of *Seiri* (Sort), *Seiton* (Set in Order), *Seiso* (Shine), *Seiketsu* (Standardize), and *Shitsuke* (Sustain), focusing on workplace organization, cleanliness, and standardization to improve efficiency and reduce waste (Moro 2020). In some adaptations, a sixth 'S' for Safety is added, forming the 6S framework to address safety concerns alongside efficiency and orderliness (Jiménez et al. 2019, Jiménez et al. 2021, Škůrkova 2022). In the construction context, the application of 5S/6S usually involves organizing tools, ensuring clean workspaces, labeling materials, and promoting discipline in daily site management (Kotwal et al. 2025).

Several studies have demonstrated that 5S/6S contributes to improved safety and productivity in construction projects. For example, Misiurek and Misiurek (2019) developed a standard approach to improve construction workplace quality and safety. Through a case study, Dan (2015) assessed the applicability of the 6S framework to improve the arrangement of a construction site. Similarly, Menezes et al. (2020) highlighted the positive effect of implementing the 6S framework on workers' morale while reducing project cost and time. These studies confirm that implementing 5S/6S in construction can lead to safer, more organized project environments.

Despite its benefits, the 5S/6S approach has limitations when applied to construction, especially in developing countries where project conditions are highly dynamic and diverse. Traditional 5S/6S focuses primarily on material arrangement, workspace cleanliness, and process standardization, often overlooking broader aspects of worker welfare and site-specific constraints (Soekresno et al. 2016, Hiwale et al. 2018). Construction sites are not static factories; they involve temporary setups, mobile workforces, and constantly changing site layouts (Hansen 2024). As a result, project complexity, work habits and culture, as well as a lack of motivation and knowledge, hinder the implementation of 5S/6S in construction projects (Darwan 2020, Nwaki et al. 2021).

The 5S concept originates from the Japanese lean manufacturing approach, which has a broader scope than housekeeping (Moro 2020). This concept focuses not only on work area cleanliness (*Seiso*) but also encompasses sorting (*Seiri*), organizing (*Seiton*), standardization (*Seiketsu*), and establishing discipline and a sustainable work culture (*Shitsuke*). Thus, 5S is a more comprehensive and structured workplace management system, while housekeeping is more specific, focusing on the organization, cleanliness, orderliness, and safety of the work environment.

In the Indonesian construction industry, the term "construction housekeeping" is considered more relevant than "5S" because it better reflects operational practices commonly used in the field (Kurniawan et al. 2017). In construction projects, housekeeping is often associated with maintaining work area cleanliness, organizing materials, managing construction waste, ensuring smooth access to work areas, and controlling potential hazards that could impact worker safety and productivity (Kirani et al. 2023). This term is more familiar to contractors, construction practitioners, and HSE personnel in Indonesia (Silalahi 2019, Ardhani et al. 2022). Therefore, it is more widely used in daily project operations, particularly for occupational safety and controlling project environmental conditions.

Methods

This study uses a quantitative research design to identify and analyze the underlying construction housekeeping factors affecting occupational safety and productivity. The quantitative approach was chosen because it enables objective, systematic measurement. This study focuses on collecting numerical data for analysis to reveal patterns, relationships, and key factors underlying housekeeping practices in construction projects. This study is designed to provide generalizable, relevant results for the construction industry at large, especially in the management of occupational safety and productivity.

The study population consists of construction practitioners in Indonesia, such as project managers, site managers, and safety supervisors with actual experience managing housekeeping at project sites. The research sample was selected using a purposive sampling method, in which respondents who meet certain criteria, including a minimum of 2 years of experience in construction projects and a role as a project manager/site manager/safety officer/supervisor, were included in the study. This specific sample selection is expected to provide relevant and valid data to identify key construction housekeeping factors.

Data collection was carried out in three main stages. First, a literature review was conducted to identify housekeeping factors recognized in previous studies. Table 1 presents the review results showing construction housekeeping factors influencing safety (coded X) and productivity (coded Z). Next, a pilot study was conducted involving five construction practitioners with a minimum of ten years of working experience to test the feasibility and clarity of the research instrument. After revisions based on the results of the pilot study, the questionnaire was distributed to collect primary data.

Table 1: Identified Construction Housekeeping Factors

Code	Factor	References
X1	Regular cleaning	Aboagye & Emuze (2017), Othman et al. (2020), Gurmu (2019), Nordin et al. (2020), Choudry (2017), Emuze et al. (2016), Lawani et al. (2019), Hwang et al. (2020), Shazwan (2017)
X2	Cleanliness of project access	Aboagye & Emuze (2017), Othman et al. (2020), Goh et al. (2016), Vishnu & Riyana (2018), Emuze et al. (2016), Mosly (2022), Lestari et al. (2020)
X3	Storage facilities	Aboagye & Emuze (2017), Akroush & El-adaway (2017), Emuze et al. (2016), Mosly (2022), Shazwan (2017)
X4	Efficient working space	Aboagye & Emuze (2017), Choudry (2017), Mollo et al. (2019), Mosly (2022), WSHC (2016)
X5	Construction waste treatment	Aboagye & Emuze (2017), Othman et al. (2020), Gurmu (2019), Akroush & El-adaway (2017), Williams et al. (2018), Emuze et al. (2016), Mollo et al. (2019), Shazwan (2017), Johari & Jha (2019)
X6	Supervision and control	Aboagye & Emuze (2017), Othman et al. (2020), Akroush & El-adaway (2017),
X7	Regular inspections	Othman et al. (2020), Shazwan (2017)
X8	Material and equipment organization	Goh et al. (2016), Mollo et al. (2019), Shazwan (2017), Johari & Jha (2019), WSHC (2016)
X9	Housekeeping awareness and knowledge	Ahmad et al. (2016)
X10	Hazard identification	Akroush & El-adaway (2017), Mishra et al. (2022), WSHC (2016)
X11	5s technique implementation	Jazayeri & Dadi (2017), Akram et al. (2023), Kirani et al. (2023)
X12	Equipment maintenance and inspection	Choudry (2017), Hettiarachchi & Coomasaru (2019)
X13	PPE and clinic availability	Lestari et al. (2020)
X14	Cleaning of workers' dormitory	Lestari et al. (2020)
X15	Clean water for workers	Lestari et al. (2020)

Code	Factor	References
Z1	Regular cleaning	Aboagye & Emuze (2017), Othman et al. (2020), Gurmu (2019), Nordin et al. (2020), Choudry (2017), Emuze et al. (2016), Lawani et al. (2019), Hwang et al. (2020), Shazwan (2017)
Z2	Cleanliness of project access	Aboagye & Emuze (2017), Othman et al. (2020), Goh et al. (2016), Emuze et al. (2016), Mosly (2022), Lestari et al. (2020)
Z3	Storage facilities	Aboagye & Emuze (2017), Akroush & El-adaway (2017), Emuze et al. (2016), Mosly (2022), Shazwan (2017)
Z4	Efficient working space	Aboagye & Emuze (2017), Choudry (2017), Mollo et al. (2019), Mosly (2022), WSHC (2016)
Z5	Construction waste treatment	Aboagye & Emuze (2017), Othman et al. (2020), Gurmu (2019), Akroush & El-adaway (2017), Williams et al. (2018), Emuze et al. (2016), Mollo et al. (2019), Shazwan (2017), Johari & Jha (2019)
Z6	Supervision and control	Aboagye & Emuze (2017), Othman et al. (2020), Akroush & El-adaway (2017),
Z7	Regular inspections	Othman et al. (2020), Shazwan (2017)
Z8	Material and equipment organization	Goh et al. (2016), Mollo et al. (2019), Shazwan (2017), Johari & Jha (2019), WSHC (2016), Choudry (2017), Hwang et al. (2020)
Z9	Hazard identification	Akroush & El-adaway (2017), WSHC (2016)
Z10	Material logistic	Lawani et al. (2019), Qi et al. (2024)
Z11	Equipment maintenance and inspection	Choudry (2017), Hettiarachchi & Coomasaru (2019)
Z12	Proper site layout	WSHC (2016), Hansen (2024)

The data collection in this study was conducted using a structured questionnaire survey distributed to construction practitioners. The questionnaire consisted of three main sections. The first section collected respondents' demographic and professional information, including position, gender, years of experience, and affiliation. The second section focused on construction housekeeping factors related to safety performance, while the third section examined construction housekeeping factors influencing productivity performance on construction projects.

The questionnaire was distributed using both online and offline methods. Online distribution was conducted via Google Forms, while offline distribution was conducted by directly approaching respondents at construction project sites. A six-point Likert scale was used to measure respondents' perceptions of each variable, ranging from 1 = strongly disagree to 6 = strongly agree. The use of an even-numbered Likert scale was intended to minimize

neutral responses and encourage respondents to provide clearer opinions regarding the influence of construction housekeeping practices on safety and productivity performance.

Prior to analysis, all collected questionnaire responses were screened and reviewed for completeness and consistency. Only fully completed questionnaires were included in the final analysis dataset. As a result, no missing data imputation or replacement procedure was required in this study. Responses that were incomplete or contained substantial missing information were excluded during the data screening process to maintain the consistency and reliability of the statistical analysis. Out of 62 responses gathered, two were invalid. Table 2 displays the profile of survey respondents.

The collected data will be analyzed using exploratory factor analysis (EFA) to identify the underlying factors influencing occupational safety and productivity using SPSS. This process involves evaluating correlations among variables and grouping those with strong relationships. The factor extraction process was conducted using Principal Component Analysis (PCA). Factor retention was primarily determined based on the eigenvalue-greater-than-one criterion (eigenvalue > 1.0).

Table 2: Respondents' Profile

Profile	Number	Percentage
Gender		
Male	49	82%
Female	11	18%
Total	60	100%
Working experience		
2-5 years	35	58%
5-10 years	14	23%
10-15 years	9	15%
15-20 years	0	0%
>20 years	2	3%
Total	60	100%
Affiliation		
Owner/developer	11	18%
Consultant	20	33%
Contractor	29	48%

Profile	Number	Percentage
Total	60	100%
	Position	
Project manager	8	13%
Site manager	3	5%
Site supervisor	26	43%
Spv consultant	14	23%
HSE officer	9	15%
Total	60	100%

Results and Discussion

Construction Housekeeping and Work Safety

EFA with SPSS software yielded a reliability value of 0.814 for construction housekeeping factors influencing occupational safety. The Kaiser-Meyer-Olkin value was 0.696, which is a significant value. Furthermore, a communality analysis was carried out with the Principal Component Analysis extraction method, which showed that all factors had an extraction value above 0.40. Table 3 displays the total variance explained (TVE), which shows the formation of five groupings that are the underlying factors for construction housekeeping factors influencing occupational safety. Table 4 presents a structure matrix containing the correlations between the observed variables and the underlying factors.

Table 3: TVE for Construction Housekeeping Factors to Work Safety

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	4.288	28.590	28.590	4.288	28.590	28.590	3.169
2	1.806	12.040	40.630	1.806	12.040	40.630	2.415
3	1.358	9.054	49.684	1.358	9.054	49.684	2.093
4	1.248	8.317	58.001	1.248	8.317	58.001	1.562

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
5	1.110	7.402	65.403	1.110	7.402	65.403	2.458
6	0.993	6.618	72.021				
7	0.860	5.735	77.755				
8	0.645	4.302	82.057				
9	0.603	4.019	86.076				
10	0.525	3.502	89.578				
11	0.408	2.719	92.297				
12	0.349	2.326	94.623				
13	0.321	2.140	96.764				
14	0.286	1.909	98.673				
15	0.199	1.327	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Table 4: Matrix for Construction Housekeeping Factors to Work Safety

	1	2	3	4	5
X1 (regular cleaning)	0.586		0.611		
X2 (cleanliness of project access)	0.730				
X3 (storage facilities)			0.765		
X4 (efficient working space)			0.740		
X5 (construction waste treatment)					0.713
X6 (supervision and control)		0.624			
X7 (regular inspection)	0.769				

	1	2	3	4	5
X8 (material and equipment organization)					0.601
X9 (housekeeping awareness and knowledge)		0.791			
X10 (hazard identification)					0.795
X11 (5S technique implementation)	0.721				
X12 (equipment maintenance and inspection)	0.596				
X13 (PPE and clinic availability)				0.736	
X14 (cleaning of workers' dormitory)		0.83			
X15 (clean water for workers)				0.599	

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Based on Table 4, five groups of construction housekeeping factors affecting occupational safety were obtained. The first group (Lean Worksite Management Practices) consists of four factors, namely Access Cleanliness (X2), Regular Inspections (X7), 5S Technique Implementation (X11), and Equipment Maintenance and Inspection (X12). This group is associated to Lean Construction principles related to operational control, continuous improvement, and workflow reliability. Factors such as access cleanliness, regular inspections, 5S implementation, and equipment maintenance support smoother construction operations by reducing unnecessary disruptions, improving site organization, and minimizing delays caused by unsafe or inefficient worksite conditions (Akram et al. 2023, Kirani et al. 2023). The project team can ensure the safety of construction workers through regular inspections of the condition of the work environment and tools (Othman et al. 2020). The project team can also prevent hazards arising from dirty areas, obstructed access, or the use of unmaintained equipment (Choudry 2017).

The second group (Lean Safety Culture and Workforce Support) consists of three factors, namely Supervision and Control (X6), Housekeeping Awareness and Knowledge (X9), and Cleaning of Workers' Dormitory (X14). This group focuses on increasing awareness, supervision, and compliance with housekeeping practices in the workplace and workers' residences. The factors in this group emphasize the role of supervision in building a good housekeeping culture in construction projects, encouraging workers to actively maintain cleanliness and understand the importance of housekeeping for their safety (Othman et al. 2020). In addition, this group also emphasizes the importance of housekeeping not only in the project site but also in workers' dormitories to ensure the cleanliness, comfort, and health of construction workers (Lestari et al. 2020). These factors contribute to improving worker

wellbeing, promoting safety culture, and encouraging continuous participation in maintaining efficient and organized construction site conditions.

The third group (Worksite Organization and Workflow Efficiency) includes three factors, namely Regular Cleaning (X1), Storage Facilities (X3), and Efficient Working Space (X4). The factors in this group focus on regular cleaning and efficient workspace management to improve work safety. The characteristics of this group are reducing clutter by arranging good storage facilities and keeping the work area tidy, increasing work efficiency by ensuring tools and materials are stored properly and easily accessible, and ensuring regular cleaning to prevent the risk of accidents due to debris or scattered objects (Aboagye and Emuze 2017, Kurniawan et al. 2017, Mosly 2022).

The fourth group (Worker Welfare and Safety Facilities) consists of two factors, namely PPE and Clinic Availability (X13) and Clean Water for Workers (X15). This group is oriented towards protecting the health and safety of workers through personal protective equipment (PPE), medical facilities, and access to clean water. This group focuses on the health aspects of workers, not just the cleanliness of the workplace. This is done by providing personal protective equipment (PPE) and medical services to protect workers from accidents or deteriorating health conditions; and ensuring clean water is available for workers' consumption and personal hygiene, which is very important for their health and productivity (Dodo 2014, Lestari et al. 2020, Sukamani and Wang 2020).

The fifth group (Waste Reduction and Hazard Control) includes three factors, namely Construction Waste Management (X5), Material and Equipment Organization (X8), and Hazard Identification (X10). These factors focus on risk prevention through hazard identification, material organization, and construction waste management. This group emphasizes risk management with early hazard identification and implementation of risk mitigation measures, ensuring that materials and equipment are stored properly so as not to pose a threat to workers. In addition, effective construction waste management can minimize the potential for hazards due to scattered construction waste (Islam et al. 2017, Mishra et al. 2022). Hence, this group is linked to operational procedures such as waste segregation, hazard identification routines, material organization systems, and monitoring of worksite accessibility to support cleaner and safer work environments while reducing inefficiencies, material loss, and operational disruptions that may negatively affect project performance.

Construction Housekeeping and Productivity

Like the above, the EFA yielded a reliability value 0.790 for construction housekeeping factors influencing productivity. The Kaiser-Meyer-Olkin value was 0.604 with a significant value. A communality analysis with the Principal Component Analysis extraction method showed that all factors had an extraction value above 0.40. Table 5 displays TVE and Table 6 presents the structure matrix showing the four groups of underlying factors for construction housekeeping factors influencing productivity.

Table 5: TVE for Construction Housekeeping Factors to Productivity

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	3.797	31.639	31.639	3.797	31.639	31.639	3.167
2	1.631	13.595	45.234	1.631	13.595	45.234	2.116
3	1.303	10.861	56.096	1.303	10.861	56.096	1.312
4	1.061	8.840	64.936	1.061	8.840	64.936	2.425
5	0.918	7.650	72.586				
6	0.824	6.863	79.449				
7	0.733	6.105	85.553				
8	0.545	4.538	90.091				
9	0.446	3.717	93.808				
10	0.372	3.097	96.904				
11	0.194	1.615	98.519				
12	0.178	1.481	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Table 6: Matrix for Construction Housekeeping Factors to Productivity

	1	2	3	4
Z1 (regular cleaning)	0.597			
Z2 (cleanliness of project access)				0.789
Z3 (storage facilities)	0.582	0.561		
Z4 (efficient working space)				0.648
Z5 (construction waste treatment)		0.768		

	1	2	3	4
Z6 (supervision and control)				0.844
Z7 (regular inspections)	0.687			
Z8 (material and equipment organization)		0.843		
Z9 (hazard identification)	0.740			
Z10 (material logistic)	0.774			
Z11 (equipment maintenance and inspection)			0.793	
Z12 (proper site layout)	0.704			

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Table 6 shows four groups of construction housekeeping factors affecting productivity. The first group (Lean Workflow and Site Coordination) reflects Lean Construction principles related to workflow reliability, operational coordination, and continuous process improvement. It consists of six factors, namely Regular Cleaning (Z1), Storage Facilities (Z3), Regular Inspections (Z7), Hazard Identification (Z9), Material Logistic (Z10), and Proper Site Layout (Z12). This group may improve work efficiency by ensuring that materials and equipment are easily accessible and the work environment remains neat and safe. Productivity disruptions can be caused by irregular layouts, poorly managed material storage, or unidentified hazards (Islam et al. 2017, WSHC 2016). In addition, regular inspections and regular cleaning can improve productivity due to the organized environment on site (Qi et al. 2024).

The second group (Material Flow and Waste Reduction) includes two factors, namely Construction Waste Treatment (Z5) and Material and Equipment Organization (Z8). This group focuses on waste management and material/equipment organization to improve work orders and efficiency. Construction waste treatment and proper organization of materials and equipment help reduce material loss, improve accessibility, and support more efficient work processes. Effective management of material flow also contributes to reducing delays and unnecessary handling activities that may negatively affect productivity performance (Othman et al. 2020, Hwang et al. 2020).

The third group (Equipment Operational Reliability) consists only of one factor, namely equipment maintenance and inspection (Z11). Although single-item groupings are generally not considered strong latent constructs in factor analysis, this variable emerged independently due to its distinct statistical loading pattern. In the context of Lean Construction, equipment reliability remains an important operational aspect because proper maintenance and inspection may reduce equipment breakdowns, minimize work stoppages, and support continuous workflow performance on construction sites (Hettiarachchi and Coomasaru 2019).

Therefore, this variable is interpreted as an independent indicative factor rather than a comprehensive latent dimension.

The fourth group (Worksite Accessibility and Operational Control) reflects Lean Construction principles associated with workflow efficiency, operational control, and safe worksite organization. It consists of three factors, namely Access Cleanliness (Z2), Efficient Working Space (Z4), and Supervision and Control (Z6). These factors contribute to creating a more controlled and accessible work environment that supports higher productivity and reduced operational disruption. This is realized by maintaining access to the work site clean and free of obstacles, so workers and heavy equipment can move smoothly (Goh et al. 2016). In addition, the project team can increase work efficiency by ensuring optimal workspace and minimal interference (Mosly 2022). All workers must follow the established housekeeping standards, and the project team can provide a special task force to carry out supervision and control to ensure that workers remain disciplined (Akroush and El-adaway 2017).

Discussion and Implications

This study aims to identify latent construction housekeeping factors that significantly influence occupational safety and productivity. The results found five groups of construction housekeeping factors affecting occupational safety. These five groups have different but complementary roles in creating a safer, more efficient, and healthier construction work environment. Group 1 (Lean Worksite Management Practices) and 3 (Worksite Organization and Workflow Efficiency) emphasize cleanliness and orderliness of the work area. Group 2 (Lean Safety Culture and Workforce Support) emphasizes a culture of discipline and housekeeping supervision. Group 4 (Worker Welfare and Safety Facilities) focuses on worker health through PPE, medical services, and access to clean water. Group 5 (Waste Reduction and Hazard Control) is more oriented towards risk prevention and hazard management. These five groups are latent housekeeping factors that may affect work safety in construction projects.

In addition, this study identified four groups of construction housekeeping factors that, taken together, may increase construction productivity through different approaches. Group 1 (Lean Workflow and Site Coordination) has the broadest scope in managing housekeeping, including logistics and safety inspections. Group 2 (Material Flow and Waste Reduction) focuses more on waste and material management, ensuring the workspace is organized. Group 3 (Equipment Operational Reliability) emphasizes tool maintenance, which is important to avoid disruptions in project operations. while Group 4 (Worksite Accessibility and Operational Control) is oriented towards access cleanliness, and worker supervision, ensuring a smooth workflow.

The findings of this study suggest that construction housekeeping practices may support several core principles of Lean Construction, particularly in relation to workflow reliability, waste reduction, production stability, and respect for people. Factors related to worksite organization, material arrangement, inspections, accessibility, and hazard control may help reduce operational interruptions, unnecessary movement, waiting time, and unsafe conditions

that commonly affect construction project performance (Aboagye-Nimo and Emuze 2017, Gurmu 2019, Malvik et al. 2024). In this context, housekeeping practices can be viewed as supporting mechanisms that help maintain smoother construction workflows and more stable site operations.

Furthermore, factors associated with worker welfare, supervision, and workplace cleanliness align with the Lean principle of creating safer, more supportive work environments (Ahmad et al. 2016, Fauzan and Sunindijo 2021). The findings provide exploratory empirical support showing that housekeeping-related practices remain relevant to Lean-oriented construction management, particularly in developing-country project environments where site organization and safety practices may still face implementation challenges.

The findings related to worker welfare and safety facilities suggest that housekeeping practices should also be integrated into routine construction safety management systems. Elements such as PPE availability, clean water access, clinic facilities, and worker welfare support should not only be provided as physical facilities, but also incorporated into daily operational monitoring and safety management activities on construction sites. Integrating these aspects into regular site operations may help improve compliance, maintain worker wellbeing, and support safer working environments.

These housekeeping-related safety elements may be embedded into existing safety management activities such as toolbox meetings, routine safety inspections, safety audits, and permit-to-work procedures. For example, supervisors may include housekeeping conditions, PPE compliance, and worker welfare facilities in daily inspection checklists and pre-work safety briefings. Similarly, site audits and permit-to-work evaluations may incorporate cleanliness, accessibility, and worker support conditions as part of operational safety assessment criteria. Such integration may help strengthen the implementation of construction housekeeping practices within broader project safety management systems.

Based on the above findings, a conceptual framework was developed (Figure 1). This framework illustrates the relationship between Lean Construction principles, construction housekeeping practices, 5S/6S implementation, and their impact on construction project safety and productivity. In general, this framework suggests that housekeeping is not viewed solely as a cleaning activity but as part of a project management strategy that supports operational efficiency, occupational safety, and continuous improvement.

At the beginning of the framework, there are two main components: Construction Context and Lean Construction Principles. The Construction Context component illustrates that housekeeping implementation is influenced by project conditions, work complexity, workforce characteristics, management commitment, and project regulations. Meanwhile, Lean Construction principles such as waste minimization, workflow improvement, respect for people, and continuous improvement serve as the conceptual foundation for implementing housekeeping on construction projects. This demonstrates that housekeeping is linked to efforts to reduce waste, improve workflows, and create a safer, more efficient work environment.

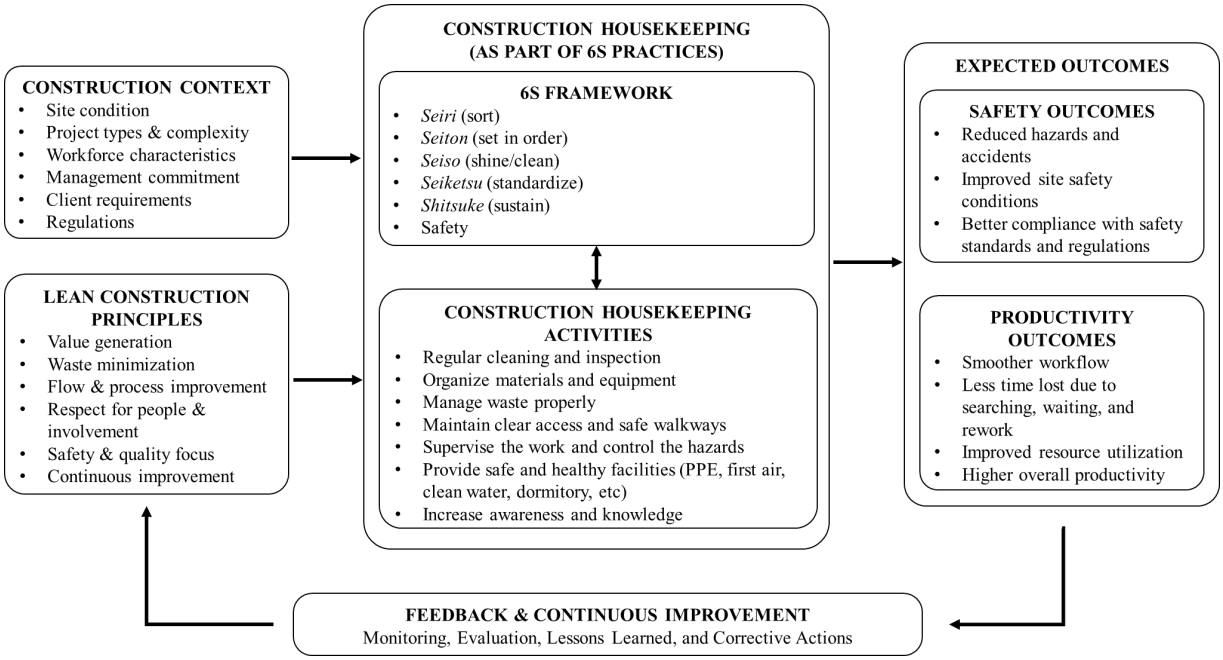

Figure 1: Lean Construction Housekeeping Framework for Safety and Productivity Improvement

The core of the framework states that Construction Housekeeping comprises two main elements: the 5S/6S Framework and Construction Housekeeping Activities. On the 6S side, the concepts of *Seiri, Seiton, Seiso, Seiketsu, Shitsuke*, and Safety serve as a systematic basis for creating an organized and efficient work area. Meanwhile, housekeeping activities include construction waste management, material and equipment organization, work area cleanliness, safe access to work areas, and the provision of safety and welfare facilities for workers. This aligns with the results of the factor groupings, specifically the Worksite Organization and Workflow Efficiency, Material Flow and Waste Reduction, and Worksite Accessibility and Operational Control groups, which emphasize the importance of work area organization, material flow control, and smooth project activities.

Furthermore, this framework also shows that housekeeping aspects are related to the human dimension and occupational safety. This is evident in the elements of providing PPE, clean water, health facilities, supervision, and increasing worker awareness of housekeeping. This supports factor groups such as Lean Safety Culture and Workforce Support and Worker Welfare and Safety Facilities, which demonstrate that a clean, safe, and organized work environment can support worker well-being while enhancing project operational stability.

The final section of the framework demonstrates that housekeeping and 6S implementation contribute to two key outcomes: Safety Outcomes and Productivity Outcomes. From a safety perspective, housekeeping may reduce potential hazards, improve project safety conditions, and support compliance with occupational safety standards. From a productivity perspective, housekeeping supports smooth workflows, reduces time wasted on material searches or access constraints, and increases the efficiency of project resource use.

These processes are further reinforced through feedback and continuous improvement mechanisms, which emphasize the importance of continuous evaluation, monitoring, and corrective action in accordance with Lean Construction principles.

Theoretically, this study confirms that housekeeping is not just a supporting activity but is a key element that may contribute to occupational safety (Ghani and Fadzil 2026). By identifying key factors such as Worksite Organization and Workflow Efficiency, and Waste Reduction and Hazard Control, this study enriches the theoretical framework of construction site management. Practically, this study suggests valuable insights for project managers, safety engineers, and construction site managers to integrate housekeeping practices into site and occupational safety management strategically. By understanding the factors that affect safety and productivity, project teams can develop more effective housekeeping policies and procedures, such as proper material placement, regular cleaning schedules, and safe access route designs. Hence, construction housekeeping is part of proactive safety and risk management practices in construction projects.

Given the exploratory nature of this study, Exploratory Factor Analysis (EFA) was employed to identify potential latent groupings among construction housekeeping variables related to safety and productivity performance. The study involved 60 respondents for 15 safety-related variables and 12 productivity-related variables. Although the sample size may be considered relatively modest compared to commonly recommended subject-to-variable ratios in factor analysis, the respondents were purposively selected based on their direct experience and involvement in construction project activities. Therefore, the findings of this study should be interpreted as exploratory and preliminary rather than conclusive.

Meanwhile, the Kaiser-Meyer-Olkin (KMO) values obtained were 0.696 for safety variables and 0.604 for productivity variables, indicating moderate sampling adequacy for factor analysis. While these values satisfied the minimum acceptable threshold for conducting EFA, they also suggest that the extracted factor structures should be interpreted with caution. In addition, several extracted factors were relatively weakly defined, including the productivity grouping containing only variable Z11. Therefore, these groupings were not interpreted as definitive latent constructs, but rather as indicative patterns that may provide preliminary insights into the relationships between construction housekeeping practices, safety, and productivity. Future studies with larger sample sizes and broader respondent representation are recommended to further validate and strengthen the factor structures identified in this study.

Conclusions

This study identifies latent factors in construction housekeeping that affect occupational safety and work productivity. The findings show that factors that affect occupational safety can be grouped into five main categories: Lean Worksite Management Practices, Lean Safety Culture and Workforce Support, Worksite Organization and Workflow Efficiency, Worker Welfare and Safety Facilities, and Waste Reduction and Hazard Control. Meanwhile, factors that affect work productivity are divided into four main groups: Lean Workflow and Site

Coordination, Material Flow and Waste Reduction, Equipment Operational Reliability, and Worksite Accessibility and Operational Control. These differences indicate that although safety and productivity are closely related, the approaches to optimizing them may require different yet complementary strategies.

The results of this study suggest that a holistic approach to construction housekeeping may improve workplace safety and productivity of construction projects. Some effective strategies may include a combination of good workplace hygiene and management practices, regular inspections and maintenance, and high levels of worker supervision and awareness. By understanding the latent factors that contribute to safety and productivity, construction managers can design more targeted housekeeping policies and procedures. Consistent implementation of these factors may not only reduce the risk of accidents and work disorders but also create a more organized, safe, and productive work environment in the long run.

In addition, these findings also suggest insights for stakeholders in the construction industry regarding the importance of integrating housekeeping into project planning from the early stages. A more systematic approach to managing the cleanliness and orderliness of the work site may reduce time lost to operational disruptions, improve employee morale, and create a safer, more efficient work environment. By implementing policies based on the identified latent factors, construction companies may improve safety and productivity standards sustainably, while meeting regulations and increasing industry competitiveness. This research may inform future works on the development of more comprehensive housekeeping guidelines or standards to improve the performance of construction projects.

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