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Integrating Agile Practices in Waterfall Methodology During Construction Phase: A Hybrid Approach in Construction Project Management

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***Abstract*—The purpose of this study was to explore the hybrid approach in construction project management by integrating Agile practices into the Waterfall methodology that will address the inherent challenges faced during the construction phase. A mixed-methods approach was employed, gathering both quantitative and qualitative data from a purposive sample of 15 construction project managers. The quantitative data were analyzed using descriptive statistics, including frequency distributions for categorical variables, while Fisher's Exact Test with Monte Carlo simulations was applied to assess the significance of relationships between variables. Findings revealed that common Waterfall-related challenges include delayed feedback (73%), lack of flexibility (54%), and poor collaboration (40%). While 60% of respondents were unfamiliar with Scrum, 53% had basic knowledge of Kanban, and 33% had intermediate knowledge. Agile practices such as Daily Scrum (100%), collaboration tools (80%), and Sprint Reviews were seen as effective strategies for enhancing communication, progress updates, and project alignment. The majority of respondents (93%) viewed the integration of Agile into Waterfall as feasible, with 67% interested in adopting a hybrid approach. Benefits included reduced delays (87%), increased flexibility (73%), and faster project delivery (60%), though challenges such as resistance to change (87%), lack of training (73%), and implementation complexity (60%) were noted. The study suggests that adopting a hybrid Agile-Waterfall approach can improve construction project management by addressing the limitations of Waterfall and enhancing flexibility, communication, and efficiency during the construction phase.**

Keywords—Waterfall Methodology, Agile Framework, Hybrid, Mixed-Methods, Purposive Sampling, Fisher's Exact Test.

I. INTRODUCTION

The construction industry plays a crucial role in boosting the economy of the Philippines, contributing significantly to the country's GDP [1]. Effective project management is essential to navigate the complexities of construction projects, as traditional methodologies like the Waterfall approach often face challenges such as inflexibility, delayed feedback, lack of client involvement, and poor collaboration [2]. The Waterfall methodology, commonly used in the Philippines, follows a linear, structured approach that emphasizes detailed planning and clear milestones, which is beneficial for safety and regulatory compliance [3]. However, its rigid nature makes it difficult to accommodate changes and unexpected risks [4]. Moreover, delayed feedback and limited client engagement during later phases can result in misalignment with client expectations and dissatisfaction [5]. Additionally, the Waterfall approach often leads to siloed teamwork, reducing collaboration between stakeholders, such as architects, engineers, and contractors [6].

In response to these challenges, agile methodologies, originally developed for software development, have been explored for their potential to enhance flexibility and responsiveness in construction project management. Agile frameworks, like Scrum, promote collaboration, iterative progress, and adaptability, which can address the evolving demands of construction projects. Various studies have demonstrated the effectiveness of integrating agile practices in construction, including Scrum implementations that increased productivity and reduced workload [7]. For instance, McCarthy Building Companies reported a 200% increase in productivity through Scrum, while a hard-bid construction project saw output rise from one to three change orders per week to 20 in just 10 days [8]. Moreover, the application of Scrum principles in a large-scale construction project, such as the $300 million Amazon fulfillment center, demonstrated how breaking tasks into manageable sprints improved collaboration and ensured continuous progress [9].

Given the dynamic nature of the construction industry and increasing client demands, adopting a hybrid project management approach that combines agile and traditional methodologies can optimize project delivery [10]. This study aims to explore the integration of agile frameworks, like Scrum, into the conventional Waterfall methodology to address challenges faced during the construction phase, promoting a more adaptive and efficient approach to construction project management.

II. METHODS

A. Research Design

This study utilized a mixed methods research design, integrating both quantitative and qualitative data to comprehensively address the research problem. Data was collected through an online survey distributed via email and

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LinkedIn, targeting Construction Project Managers in the Philippines. The survey included close-ended questions for quantitative data and open-ended questions for qualitative insights. A sequential explanatory approach was used, collecting and analyzing quantitative data first, followed by qualitative data for deeper interpretation.

B. Respondents

Due to the lack of available data on the population of construction project managers in the Philippines, the study employed purposive sampling, targeting 15 experienced professionals actively involved in managing construction projects using the Waterfall methodology.

C. Data Analysis

Quantitative analysis was conducted using Microsoft Excel for data management and visualization, including frequency distributions and stacked bar charts. Statistical analyses were performed in RStudio, utilizing Fisher's Exact Test with Monte Carlo simulation (10,000 replicates) to assess relationships between variables, accounting for small sample sizes and enhancing reliability. For qualitative data, thematic analysis was conducted to identify recurring patterns in open-ended responses. Themes were categorized, and frequencies were calculated to highlight key challenges and perceptions regarding the integration of Agile practices into Waterfall methodology.

III. RESULTS AND DISCUSSION

A. Reliability Test

To ensure the study's reliability, Cronbach's alpha was used to assess the internal consistency of survey items. The calculated coefficient was 0.80 for 14 items, indicating strong consistency and confirming the survey's effectiveness as a reliable data collection tool.

Table 1. Cronbach's Alpha

Cronbach's Alpha	Number of Items
0.80	14

B. Demographics

The study gathered responses from 15 construction project managers across 14 companies, including two from Design Coordinates, Inc., ensuring diverse perspectives.

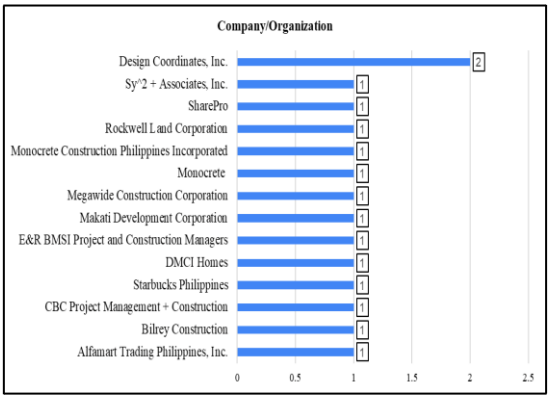

Fig. 1. Bar Chart of Company/Organization of Respondents

Most respondents have mid to senior-level experience, with 40% having 7–10 years of experience, 27% with 4–6 years, 20% with more than 10 years, and 13% with 1–3 years. Additionally, 47% have over a decade of experience with the Waterfall methodology, while 27% have 4–6 years, and 13% each have 7–10 years and 1–3 years of experience.

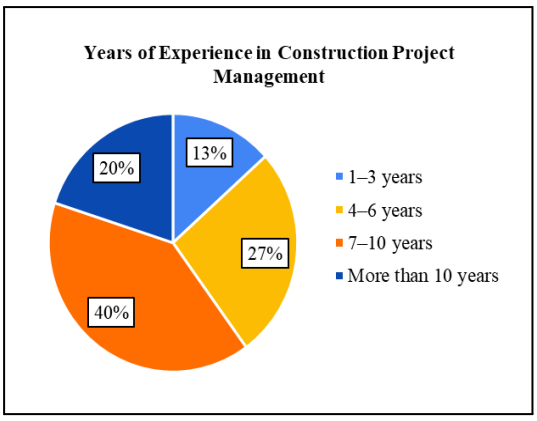

Fig. 2. Pie Chart of Years of Experience in Construction Project Management

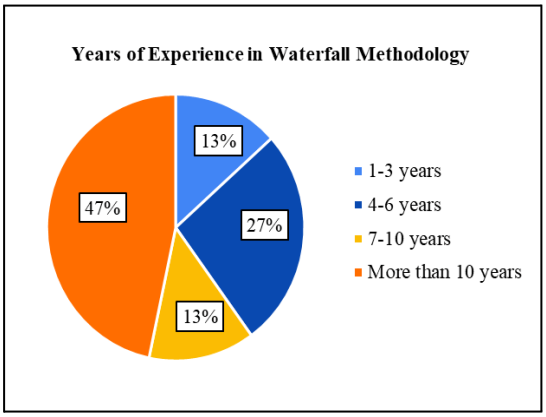

Fig. 3. Pie Chart of Years of Experience in Waterfall Methodology

Regarding project types, 47% of respondents work on commercial projects, 40% on residential projects, and 13% on infrastructure projects, indicating a strong focus on commercial construction.

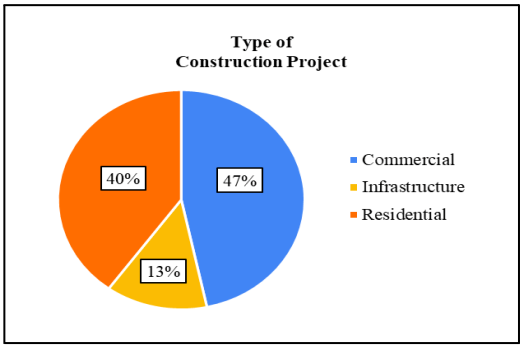

Fig. 4. Pie Chart of Construction Project Types

C. *Challenges Associated with Using Waterfall Methodology during Construction Phase*

Construction project managers face several challenges when using the Waterfall methodology during the construction phase. The most significant is delayed feedback, cited by 73% of respondents, as the linear approach limits timely communication and issue resolution. Lack of flexibility was identified as the second major challenge by 54% of respondents, as construction often requires quick adjustments that the rigid structure of Waterfall cannot accommodate. Poor collaboration among stakeholders ranked third, with 40% citing it as very significant, as the segmented phases hinder continuous coordination between architects, engineers, and contractors.

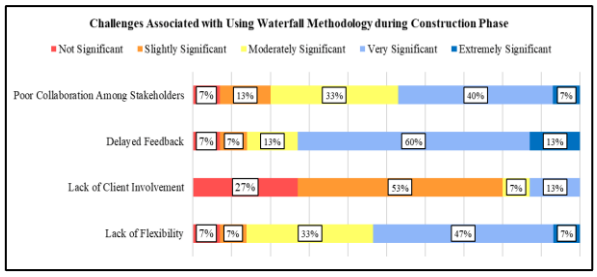

Fig. 5. Stacked Bar Chart of Challenges Associated with Using Waterfall Methodology during Construction Phase

Additional challenges include inadequate risk management, absence of digital collaboration tools, inconsistent documentation, and resource allocation issues. Delays in feedback and rigid processes often result in project delays and cost overruns, while poor collaboration leads to disrupted schedules and manpower shortages. Case examples highlight how delayed material approvals, insufficient client involvement, scattered communications, and unanticipated risks have directly contributed to project setbacks and budget overruns.

D. *Agile Level of Knowledge*

Construction project managers have limited familiarity with Agile frameworks, especially Scrum—60% report no knowledge, while 40% have basic knowledge, with no respondents at intermediate or higher proficiency. In contrast, Kanban is more recognized, with 53% having basic knowledge, 33% at an intermediate level, and 13% with no knowledge, likely due to its visual workflow management suited for project tracking.

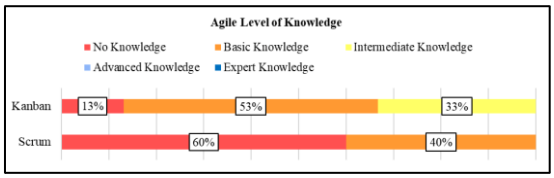

Fig. 6. Stacked Bar Chart of Agile Level of Knowledge

E. *Integration of Agile in Waterfall Methodology during Construction Phase*

Daily Scrum emerged as the most effective Agile practice, with 100% of respondents rating it as effective (60%) or very effective (40%), highlighting its role in facilitating daily updates and on-site coordination. Collaboration tools also ranked highly, with 80% finding them effective or very effective, supporting real-time communication and minimizing delays.

Sprint Reviews were rated effective by 60% and very effective by 20%, emphasizing their value in maintaining alignment and addressing risks. While Kanban boards and Sprint Retrospectives were seen as moderately beneficial, practices like Backlog Refinement, Sprint Planning, and Limiting Work in Progress received mixed or neutral feedback, indicating varying perceptions of their relevance in construction.

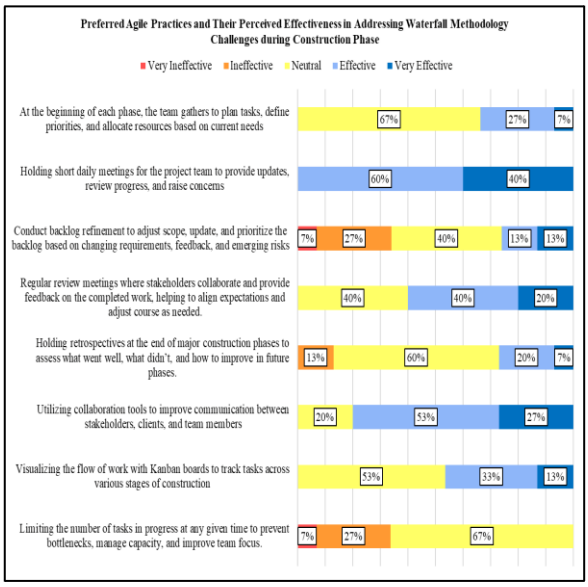

Fig. 7. Stacked Bar Chart of Preferred Agile Practices and Their Perceived Effectiveness in Addressing Waterfall Methodology Challenges during the Construction Phase

F. *Perception on the Integration of Agile in Waterfall Methodology during Construction Phase*

A survey revealed that 93% of respondents find integrating Agile into the Waterfall methodology during the construction phase feasible, indicating strong support for a hybrid approach despite potential challenges. Additionally, 74% of respondents are likely or very likely to adopt this approach, while 27% remain neutral, reflecting some uncertainty.

The most anticipated benefits of integration include reduced delays (87%), increased flexibility (73%), faster project delivery (60%), improved collaboration (53%), faster issue resolution (40%), and increased client satisfaction (20%).

However, key challenges include resistance to change (87%), lack of training (73%), complexity of implementation (60%), and potential confusion with mixed methodologies (40%). These insights highlight the need for targeted training

and change management to facilitate hybrid adoption in construction projects.

G. Relationship between Level of Knowledge of Agile Frameworks and the Years of Experience in Construction Project Management

A Fisher's Exact Test with Monte Carlo simulation found no significant relationship between Agile knowledge and years of experience in construction project management ($p = 0.411$), suggesting that knowledge acquisition is influenced more by targeted learning than tenure. Professionals with 7–10 years of experience had the highest Agile knowledge, while those with 1–3 years had the least. This highlights the need for structured Agile training regardless of experience level.

H. Relationship between Level of Knowledge of Agile Frameworks and the Likelihood to Adopt a Hybrid Agile-Waterfall Approach

The test revealed a significant relationship between Agile knowledge and the likelihood of adopting a hybrid Agile-Waterfall approach ($p = 0.0098$). Respondents with basic knowledge of Scrum or Kanban showed a higher likelihood of adoption compared to those with no knowledge, indicating that familiarity positively impacts willingness to integrate hybrid methods.

I. Relationship between Challenges Associated with Using Waterfall Methodology during Construction Phase and Construction Project Types

Analysis showed no significant association between construction project types and challenges with the Waterfall methodology ($p = 0.4225$), indicating that issues are consistently experienced across different project types. Delayed feedback was identified as the most significant challenge for both commercial and industrial projects, while poor stakeholder collaboration was most critical in residential projects. Improving communication and collaboration is essential to enhancing project efficiency.

IV. Conclusion

This study examined the challenges of using the Waterfall methodology during the construction phase, the knowledge level of construction project managers about Agile frameworks, potential Agile practices for integration, and perceptions of a hybrid Agile-Waterfall approach. The primary challenges identified were delayed feedback (73%), lack of flexibility (54%), and poor collaboration (40%), often leading to project delays and budget overruns. Despite no significant relationship between challenges and project types, it was clear that communication and adaptability are crucial to addressing these issues.

The study revealed limited knowledge of Agile frameworks among construction project managers, with 60% reporting no knowledge of Scrum and 40% having only basic knowledge. In contrast, Kanban was slightly more familiar, with 53% possessing basic knowledge and 33% at an intermediate level. Importantly, Agile familiarity correlated with a higher inclination to adopt hybrid approaches, indicating that enhancing Agile knowledge could encourage its integration.

Agile practices perceived as suitable for integration include Daily Scrum (100% effectiveness), collaboration tools (80% effectiveness), and Sprint Reviews for maintaining project alignment. Other practices, like Kanban boards and Sprint Retrospectives, received moderate support, while Limiting Work in Progress was considered ineffective in construction. Notably, 93% of respondents found integrating Agile practices into the Waterfall methodology feasible, with 67% likely to adopt a hybrid model. Key perceived benefits include reduced delays (87%), increased flexibility (73%), and faster project delivery (60%). However, resistance to change (87%), lack of training (73%), and implementation complexity (60%) were recognized as significant barriers.

To facilitate Agile integration, the study recommends a gradual approach, starting with minimally disruptive practices like Daily Scrum and digital collaboration tools. Leadership buy-in and stakeholder engagement are essential, as executive support greatly influences adoption success. Training tailored to construction professionals should be introduced to address knowledge gaps, focusing on practical Agile applications within construction workflows. Additionally, digital collaboration tools like Procore should be utilized to enhance communication and coordination throughout project phases.

Future research should investigate the long-term impact of a hybrid Agile-Waterfall approach on construction project outcomes, particularly concerning timelines, costs, and stakeholder collaboration. Expanding the study to include diverse and large-scale projects would provide more comprehensive insights into the effectiveness of Agile integration.

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