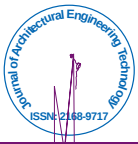

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Installation g) Maintenance [45]. Even though this methodology tends to be used frequently in construction due to its simplicity in the phases, it fails to adapt the communication and coordination for mega and complex projects [43].

In the literature, several proposed solutions focus on identifying the speci c phase during which these challenges can be addressed, such as the pre-construction or planning phase [12]. However, the literature predominantly emphasizes identifying cost overruns rather than pinpointing the precise phase when projects are most susceptible to these overruns. Another recommendation is the application of key performance indicators (KPIs); according to the Egan Report, it is crucial to measure project activities to gain insights into areas requiring improvement. Nevertheless, it is not explicitly outlined which speci c

Leyba ACG, Rana MQ, Salazar AM, Saini M, Oladinrin OT, et al. (2024) Deploying the Hybrid Project Management Methodology Framework in Major Transportation Projects in the United Kingdom. J Archit Eng Tech 13: 377.

PRISM. As per the ratings, the most commonly used methodology in the construction of MTPs, with a rate of 62.3%, is Lean. Following closely, the second highest rated methodology is Prince2 at 54.7%, followed by Agile and Waterfall at 41.5%, and PMBOK at 30.2%.

e nal question, 10b, aims to ascertain the phase during which project managers predominantly utilise PMM in MTPs. e hypothesis validation involves determining the phase where PMMs are most frequently applied. (Figure 4) presents the outcomes regarding the application of PMM across various life-cycle phases of MTPs. Respondents provided insights on the phases in which they applied PMM, ranked as follows:

- Planification/Design/Pre-construction phase received the highest response, with 24 respondents accounting for 45.3%.
- Execution/Construction phase emerged as the second most likely phase, with 37.7%.
- T e De nition of the phase as

and operational aspects within construction supply chains. While Lean principles contribute to enhanced e ciency and cost reduction, Agile methodologies facilitate organizational learning, adaptability, and e ective change management [58].

Numerous best practices and techniques were employed to optimise project outcomes, including modular assembly, ABC inventory analysis, ergonomic training for workers, substitution of manual labour with mechanical methods, waste management strategies, implementation of the Last Planner System (LPS), ergonomic workplace design, and provision of suitable tools for the workforce [61].

D c

e primary ndings derived from both the literature review and the questionnaire are as follows:

- T e literature highlights the top ve factors a ecting MTPs are design changes, risk and uncertainties, inaccurate assessment of project duration, work complexity, and non-performance of subcontractors [16]. e questionnaire results corroborate these ndings, ranking the following factors: 1) complexity of works, 2) risk and uncertainties, 3) design changes, 4) time delays, and 5) cost overruns. Additionally, other literature-based factors include lack of commitment from stakeholders, late delivery and lack of coordination and measurement of bene ts, and ine ective communication and relevant training [62]. MTPs are widely regarded as controversial, o en experiencing delays, exceeding budgets, and delivering less bene t than anticipated [9]. According to [7], the most common challenges in large infrastructure projects are cost overruns [10] and shortages in skills and labour. ese challenges result in schedule overruns [11], budget estimations increase [12], low productivity, and can impact performance management and stakeholder interests [13]. Consistent

guideline, PRINCE2, alongside PMI and APM methodologies.

In general, the UK Construction sector must embrace continuous improvement and strive to overcome fragmentation. Reports emphasise the need for the industry to adopt a more proactive and collaborative approach throughout its structure. Knowledge transfer is deemed essential and applicable to MTPs. e typical procurement process in UK civil engineering contracts follows a design-bid-build approach. However, it's crucial for the industry to assess the suitability of this method for large and complex projects, considering the trade-o s involved in physical design and construction methods [68]. Furthermore, the construction sector should prioritise addressing issues highlighted in various construction reports, including fragmentation, lack of trust, and unity [69-71], while striving to improve project delivery within organisational constraints. ere is a need for increased knowledge sharing within the industry, particularly regarding the performance of speci c PMMs applied in projects and their impact on project success. Organisations can further enhance project success by customising hybrid project management methodologies to align with their business processes.

e implementation steps for this framework involve the PM de ning the project's lifecycle. e framework currently consists of four phases (De nition of the project, Pre-construction or design phase, Construction or execution phase, Delivery, and close-out of the project), but it can vary depending on the project, with some MTPs including a maintenance phase. Following the project de nition, detailing its inputs becomes crucial, initiating the planning and de nition of activities, schedules, personnel, and budget.

From the outset of the project's life ycle, it's essential to integrate principles from hybrid methodologies such as Lean and Agile. Particularly, Lean methodology is recommended for waste reduction and process improvement during construction, while agile methodology allows for early identi cation of customer requirements and task division involving team collaboration. Various Lean and Agile techniques and tools should be applied in each phase. Essential Lean tools applicable to construction include Just-In-Time, Value Stream Mapping, Bottleneck Analysis, Plan-Do-Check-Act (PDCA), Last Planner System (LPS) [52], Root Cause Analysis (RCA), and Overall Equipment E ectiveness (OEE) [72]. Agile practices commonly involve project inspection, customer focus, waste elimination akin to Lean, planned events, team reviews, and supportive systems to optimise work [73]. ese elements can be utilized in conjunction with those outlined in section D of the framework.

roughout the project, the PM, along with the team, should continuously analyse and evaluate risks derived from internal and external factors, employing timely preventive or mitigating measures [16], and referring to guidelines and best practices outlined in PRINCE2, PMBOK, and APMBOK. e PM may incorporate additional elements and methodologies as deemed suitable and necessary for the MTP.

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