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Enhancing Project Management Performance in Prefabricated Building Construction under Uncertainty: A Comprehensive Approach

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Abstract : Prefabricated building construction is a pioneering approach that combines design, production, and assembly to attain energy efficiency, environmental sustainability, and economic feasibility. Despite continuous development in the industry in China, the low technical maturity of standardized design, factory production, and construction assembly introduces uncertainties affecting prefabricated component production and on-site assembly processes. This research focuses on enhancing project management performance under uncertainty to help enterprises navigate these challenges and optimize project resources. The study introduces a perspective on how uncertain factors influence the implementation of prefabricated building construction projects. It proposes a theoretical model considering project process management ability, adaptability to uncertain environments, and collaboration ability of project participants. The impact of uncertain factors is demonstrated through case studies and quantitative analysis, revealing constraints on implementation time, cost, quality, and safety. To address uncertainties in prefabricated component production scheduling, a fuzzy model is presented, expressing processing times in interval values. The model utilizes a cooperative co-evolution evolution algorithm (CCEA) to optimize scheduling, demonstrated through a real case study showcasing reduced project duration and minimized effects of processing time disturbances. Additionally, the research addresses on-site assembly construction scheduling, considering the relationship between task processing times and assigned resources. A multi-objective model with fuzzy activity durations is proposed, employing a hybrid cooperative co-evolution evolution algorithm (HCCEA) to optimize project scheduling. Results from real case studies indicate improved project performance in terms of duration, cost, and resilience to processing time delays and resource changes. The study also introduces a multistage dynamic process control model, utilizing IoT technology for real-time monitoring during component production and construction assembly. This approach dynamically adjusts schedules when constraints arise, leading to enhanced project management performance, as demonstrated in a real prefabricated housing project. Key contributions include a fuzzy prefabricated components production scheduling model, a multi-objective multi-mode resource-constrained construction project scheduling model with fuzzy activity durations, a multi-stage dynamic process control model, and a cooperative co-evolution evolution algorithm. The integrated mathematical model addresses the complexity of prefabricated building construction project management, providing a theoretical foundation for practical decision-making in the field.

Keywords : prefabricated construction, project management performance, uncertainty, fuzzy scheduling
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