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이동 가능한 모듈식 건물의 탄소 배출 최적화
재배치 단계를 위한 BIM 기반 이론적 프레임워크

Optimizing the Carbon Emission in Relocatable Modular Buildings
A BIM-Based Theoretical Framework for the Relocation Phase

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Abstract

The construction industry is a major contributor to greenhouse gas emissions, demanding innovative solutions. Relocatable modular buildings (RMBs) offer promise due to their potential for reduced embodied carbon through prefabrication and reuse. However, the relocation phase itself can introduce operational carbon emissions. This study addresses this challenge by proposing a BIM-based framework to monitor and evaluate both embodied and operational carbon emissions within the RMB system during the relocation phase.The framework outlines the relocation process, considering carbon emissions at each step: dismantling, transportation, maintenance, and reassembly. BIM use cases are integrated to quantify these emissions:Identifying replaced components during maintenance using the RMB BIM model; Simulating on-site work and measuring operational emissions using construction site BIM models; and Utilizing databases on transportation and factory maintenance.By providing deeper insights into lifecycle carbon reduction for RMBs, especially during the relocation phase, this BIM-based framework can significantly contribute to sustainable construction practices.

키워드 : 탄소 배출, 재배치 가능한 모듈식 건물(RMB), 재배치 단계, 건축 정보 모델링(BIM), 프레임워크.
Keywords : carbon emission, relocatable modular building (RMB), relocation phase, building information modeling (BIM), framework.

1. Introduction

The global construction industry is a significant contributor to greenhouse gas emissions, accounting for a substantial portion of embodied and operational carbon. In response to this pressing environmental challenge, researchers worldwide are exploring low-carbon construction practices and innovative building materials. Among these advancements, relocatable modular buildings (RMBs) are emerging as a promising solution with the potential to significantly reduce the carbon footprint of the built environment.

Through prefabrication, reuse, recyclability, and refurbishment, RMB can significantly reduce embodied carbon emissions throughout their lifecycle [1]. The lifecycle in the modular construction field includes the design phase, production phase, construction phase, operation phase, and disposal phase. By avoiding new construction, RMB introduces the concept of the relocation phase within the construction lifecycle, emphasizing its significance in reducing embodied carbon. However, the relocation phase involves dismantling, transporting, maintaining, and reassembling these units to new construction sites, contributing to additional operational carbon emissions.

The trade-off relationship between embodied and operational carbon has not been fully addressed in terms of RMB [2]. In recent years, building information modeling (BIM) implementation has been actively promoted in the global construction industry, and it has been perceived as an efficient approach to facilitate dynamic carbon emission measurement [3]. Therefore, the purpose of this study is to propose a theoretical BIM-based framework to monitor and evaluate embodied and operational carbon during the relocation phase of RMBs, aiming to minimize the additional emissions and maximize the overall lifecycle of carbon reduction benefits.

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2. Proposed framework

This section presents a BIM-based methodological framework for monitoring and evaluating embodied and operational carbon within the RMB system during the relocation phase. The framework leverages insights identified in previous studies on modular construction and the limited research available on RMB [1, 4, 5].

As shown in Figure 1, the proposed framework outlines the relocation process for RMB units, considering the carbon emissions generated at each step. The process begins with dismantling and transporting RMB units to the factory for maintenance. Here, the components are assessed to determine if replacements are necessary. Upon completion of maintenance, the RMB units are transported to a new construction site.

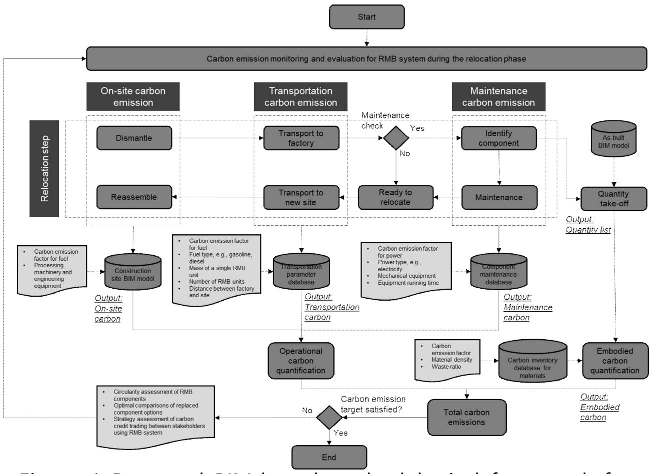

Figure 1 Proposed BIM-based methodological framework for carbon emission monitoring and evaluation in the RMB system

Several BIM use cases are integrated to support the quantification of embodied and operational carbon. During the maintenance step, quantity take-off is performed based on the RMB BIM model to identify and quantify replaced components. Construction site BIM models are also utilized to simulate the on-site work and measure the operational carbon emissions. Additionally, databases related to transportation and factory maintenance activities contribute to the quantification process. The data is then used to assess the overall carbon footprint of the relocation project.

The framework incorporates several promising future research directions suggested in [6] regarding BIM integration with modular construction for low-carbon evaluation. These directions include circularity assessment of RMB components, optimal comparisons of replacement component options, and strategies for carbon credit trading among stakeholders involved in the RMB system.

3. Conclusion

This paper proposes a theoretical framework, leveraging BIM for the integrated monitoring and evaluation of embodied and operational carbon within the RMB system during the relocation phase. This framework aims to synthesize the quantification of embodied and operational carbon, thereby providing deeper insights into lifecycle carbon reduction strategies for buildings.It is important to acknowledge, however, that the framework is currently in its initial stages of development. Further research will be dedicated to elaborating on its functionalities in greater detail.

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