

# 볼류메트릭 모듈 양중 및 인양 대안에 관한 연구

## Economic Alternative for Volumetric Module Lifting/Offloading

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**Abstract** : The construction industry's lack of experience and expertise makes it difficult for projects to realize the full benefits of implementing modular construction. Such project performance-hindering elements are often labeled as modular challenges. The added requirement for the transportation of the finished volumetric module is one aspect of the 'module transportation logistics,' the under-researched modular challenge that can prevent projects from incurring maximum cost and productivity benefits. The typical module transportation phases include lifting, transporting, and offloading. From conducting a literature review, this paper aims to investigate the equipment commonly adopted to lift and offload the module and validate its economic efficiency by comparing it with the alternative lifting/offloading equipment used in the two case projects. The results showed that hydraulic jacks are an economic alternative to the crane for lifting/offloading the module. The increase in single-module projects with smaller budgets made crane usage economically undesirable, and this study suggested a viable option for a more economical alternative.

**키워드** : 모듈러 공법, 볼류메트릭 모듈, 모듈 운반

**Keywords** : modular construction, volumetric module, module transportation

## 1. Introduction

Modular construction, unlike the traditional stick-built method, utilizes sophisticated off-site manufacturing facilities for the fabrication of volumetric modules, thus only the minimum necessary site works, such as foundation work, are carried out on-site. Accordingly, most of the unpredictable on-site variables affecting the project schedule and performance are minimized if not eliminated. However, since modular construction is still considered a relatively foreign method, some challenges arise when the current stick-built accustomed construction industry adopts this relatively 'new' method. Among the challenges, the typical lifting and offloading equipment used for finished volumetric modules poses a meaningful economic burden, yet the research regarding this topic is lacking. Therefore, this research reviews the existing literature to identify and validate the use of more economical alternative equipment to carry out the lifting and offloading tasks.

## 2. Alternative Validation

Volumetric modules are primarily lifted/hoisted and offloaded using a crane with a lifting beam or a frame that mitigate inward force due to inclined cables. Different forms of lifting systems are employed depending on the types, dimensions, and weights of the modules, and modules' designs include diverse types and numbers of ceiling or bottom points accordingly to the lifting system chosen [1]. For lifting and offloading multi-module structures, it is optimal to use the crane. The cost of crane operation is \$3,500 to \$4,500 per day, and it is the most expensive part of module installation. For single housing module projects using a crane might overturn the economic benefits of going modular, thus, other more economical substitutions can be more desirable [2].

This study reviewed two case projects where hydraulic jacks were used as alternatives for lifting/offloading the volumetric modules[3]. examined the behavior of a prefabricated modular house under load during lifting/offloading and transportation. Three switch-activated electro-hydraulic jacks were used on either side of the mini home to and from the temporary supports to the flatbed trailer. Similarly, four hydraulic jacks were used to lift and offload the Mojave Bloom, a modular house constructed for the Solar Decathlon 2020 design competition. The lifting process of the two case projects is shown in Figure 1.

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Figure 1. Module Lifting via Hydraulic Jacks: Mini-Home (left)[3], Mojave Bloom (right)

As depicted in Figure 1 (right), the extension capacity of the hydraulic jacks was insufficient, and lumber stacks were utilized after each rotation of full extension until the module was lifted to the desired height. Other than that, the use of hydraulic jacks for lifting/offloading the volumetric modules was validated as there were no other anomalies that might hinder its future adoption.

### 3. Conclusion

The current trend in the construction industry suggests an inevitable transition towards modular construction from the traditional stick-built method due to its inherent benefits, and it was evident from reviewing the literature that the demand for single housing modules is increasing. For such relatively smaller projects, using a crane, a commonly adopted module lifting and offloading equipment might be economically burdensome. Consequently, this study reviewed two case projects that adopted hydraulic jacks as economical alternative equipment to the crane and validated its use as there were no anomalies identified. However, it seems desirable to carefully consider the extension capacity of the hydraulic jacks subjected for use, as it may require additional height enhancements through other means.

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