SUSTAINABILITY

Making the Case for Modular Construction

A RESEARCH REVIEW FROM THE MODULAR BUILDING INSTITUTE

WHO ARE WE?

Founded in 1983, the Modular Building Institute (MBI) is the international non-profit trade association serving modular construction. Our 550+ members represent two distinct segments of the modular industry:

- permanent modular construction, and
- relocatable buildings.

OUR MISSION

As the Voice of Commercial Modular Construction™, it is MBI's mission to expand the use of offsite construction through innovative construction practices, outreach and education to the construction community and customers, and recognition of high quality modular designs and facilities.

According to a March 2022 article by McKinsey & Company, the world will see a once-in-a-lifetime wave of capital spending on physical assets between now and 2027. This surge of investment—amounting to roughly $130 trillion —will flood into projects to decarbonize and renew critical infrastructure. Ninety-three percent of CEOs say that sustainability issues are important for the future success of their business, and 54 percent expect sustainability to be embedded within the core business strategies of most companies in the next decade.

From a sustainable and strategic perspective, modular construction has the potential to dramatically change how we build in four key areas:

- Significant waste reduction
- Lower carbon footprint/embodied carbon
- Relocate, renovate, and repurpose
- Greater energy efficiency/tighter building envelope

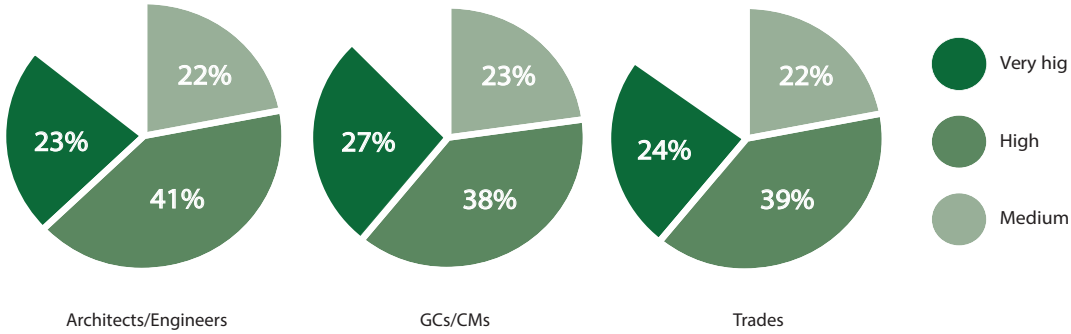
WASTE REDUCTION

The Environmental Protection Agency considers construction waste and debris is one of the largest contributors to landfills annually. While construction demolition of existing structures represents about 90 percent of this landfill waste, new construction activity accounts for nearly fifty-seven million tons of landfill waste.

But it doesn't have to be this way.

There have been several studies and reports conducted globally on the impact modular and prefabrication have on overall waste reduction. From the groundbreaking "Prefabrication and Modular Construction 2020" report by

Dodge Data and Analytics, eighty-six percent of architect, contractor, and developer respondents said that utilizing modular construction had a medium, high, or very high impact on reducing waste generated by construction activities.



Impact of Modular Construction on Construction Waste Reduction
(Percentages Reporting Medium, High, or Very High Contribution)
Dodge Data & Analytics, 2020

In terms of academic research, the results are also undeniable.

RESEARCH SPOTLIGHTS

Quantifying Advantages of Modular Construction: Waste Generation – L. Loizou, K. Barati, X. Shen ORCID, B. Li

This paper focuses on modular construction as an off-site production system, where a framework to compare waste generation of modular and conventional, in-situ construction methods is proposed. This paper aims to quantify these differences. The framework relies on a comprehensive literature review to estimate the waste rates of building materials, which are then applied to realistic case studies in order to determine the differences in waste generation. Overall, modular construction reduces the overall weight of waste by up to 83.2%, for the cases considered. This corresponds to a 47.9% decrease in the cost of waste for large structures.

Qualitative comparisons asserting that prefabrication reduces waste have also been verified. For quantitative comparisons, the results show greater waste reductions than most previous studies. Quale et al., Jaillon et al., Kim, Jaillon and Poon, and Hosseini et al., showed waste reductions of 20.1%, 52%, 60%, 65%, and 92%, respectively.

Overall, modular construction reduces the overall weight of waste by up to 83.2%

Quantifying Advantages of Modular Construction: Waste Generation – Loizou, et.al.

Homes constructed using modular were found to use about 20% less material overall

Onsite vs. Offsite: Comparing Environmental Impacts – Quale, et.al.

The average wastage reduction level was about 52%

Quantifying the Waste Reduction Potential of Using Prefabrication in Building Construction in Hong Kong – Jaillona, et.al.

Onsite vs. Offsite: Comparing Environmental Impacts - Quale, et. al.

The University of Virginia conducted a study (Quale, et.al.) using life cycle assessment to quantify the environmental impacts of constructing a typical residential home using two methods, based on data from several modular construction companies and conventional homebuilders. The study, peer-reviewed and published in the Journal of Industrial Ecology, included impacts from material production and transport, off-site and on-site energy use, worker transport, and waste management.

In terms of materials usage and waste, homes constructed using a modular process were found to use about 20 percent less material overall. This included greater material use for modular mate lines and transportation but significantly less material waste for modular. In fact, the modular homes sent about 75 percent less wood and drywall waste to the land fill per project (1,380 lbs. for modular vs 5,500 lbs. for conventional). Worker transport to the jobsite daily had a negative impact for conventional construction while energy use in the factory reduced the environmental impact of modular construction projects.

Quantifying the Waste Reduction Potential of Using Prefabrication in Building Construction in Hong Kong - L. Jaillona, C.S.Poon, Y.H. Chiang

As Hong Kong is a compact city with limited available land and high land prices, the construction of high-rise buildings is prevalent. The construction industry produces a significant amount of building waste. In 2005, about 21.5 million tonnes of construction waste were generated, of which 11% was disposed of in landfills and 89% in public filling areas. At the present rate, Hong Kong will run out of both public filling areas and landfill space within the next decade. The government is taking action to tackle the problem, such as by introducing a construction waste landfill charge, and promoting prefabrication to reduce on-site waste generation. This paper reports an ongoing study on the use of prefabrication in buildings and its impact on waste reduction in Hong Kong. A questionnaire survey was administered to experienced professionals, and case studies of recently completed building projects were conducted. The results revealed that construction waste reduction is one of the major benefits when using prefabrication compared with conventional construction. The average wastage reduction level was about 52%. This implies that a wider use of prefabrication could considerably reduce construction waste generation in Hong Kong and alleviate the burdens associated with its management.

LOWER CARBON FOOTPRINT / EMBODIED CARBON

While carbon footprint measurements have long been a popular way of

evaluating the carbon needed to operate a building, they can be misleading since they don't consider the structure's entire life cycle and the materials used to construct it. Embodied carbon measurements, on the other hand, look at the carbon usage inherent to the materials—and the project-related transportation and maintenance thereof—used in a building project. Still, both metrics provide valuable insights into the overall environmental impact of any given building, and modular construction techiniques have been shown to reduce both.

In fact, as mentioned in the Quale, et. al., research referenced above, the environmental impacts from modular construction are, on average, lower than those from on-site construction with total greenhouse gas emissions about 30 percent less by using modular construction.

RESEARCH SPOTLIGHTS

North Ridge CO2 Analysis Report - Comparison between Modular and On-Site Construction - M. Al-Hussein, J.D. Manrique, D. Mah

This study, conducted by the University of Alberta, comparing modular and on-site construction noted significant advantages for modular construction, specifically noting a compressed site schedule, minimized waste, fewer workers on-site (and for less time), fewer materials stored on-site, and a tighter building envelope. The research found that by using modular construction, the overall schedule was shortened by four months on an 11-month project and CO2 emissions were reduced by 43 percent.

Comparison of the Embodied Carbon Emissions and Direct Construction Costs for Modular and Conventional Residential Buildings in South Korea - H. Jang, Y. Ahn, S. Roh.

This study analyzed the embodied carbon emissions and direct construction costs incurred during the production phase of a modular residential building and provides comparison to an equivalent conventional residential building. Major drawings and design details for a modular residential building in South Korea were obtained, and the quantity take-off data for the major construction materials were analyzed for a modular construction method and a conventional construction method using a reinforced concrete structure under the same conditions. Focusing on major construction materials during the production phase, the embodied carbon emissions assessment revealed that adopting a modular construction approach reduced the environmental impact by approximately 36%, as compared to the conventional reinforced concrete method. This result was significantly affected by the large input of ready-mix concrete, with its high embodied carbon emissions, utilized in RC construction and not modular construction.

A modular construction approach reduced the environmental impact by [about] 36%

Comparison of the Embodied Carbon Emissions and Direct Construction Costs for Modular and Conventional Residential Buildings in South Korea – Jang, et. al.

Renovated Reuse Case Study

Company: Aries Building Systems, LLC
Location: San Jacinto, California
Building Use: Office Space
Gross Size of Project: 6672 Square Feet
Days to complete: 70

Aries Building Systems utilized five (5) 12x60 modular units and four (4) 12x64 units that were originally three (3) different buildings, all built by different manufacturers, with three (3) totally and uniquely different floor and roof systems. Taking three (3) buildings, for a total of nine (9) modules, Aries created a single 6,672 sf office space in just 70 days.

The interior of the building consists of tegular acoustic ceiling system to provide further depth and texture to the ceiling plane, commercial grade carpet tiles in all offices, and wood plank flooring in the conference room and common areas. The exterior of the building consists of a stucco roof facia and a stacked stone wainscot, separated by vertical wood siding. Architectural grade insulated windows and doors were used. Aries also installed an indoor fire suppression and alarm systems to bring the building up to 2019 code and local jurisdictional requirements.

This renovation also brought the structure to comply with 2019 Building codes, Cal Green and Title 24 energy conservation requirements including, high efficiency Heat Pumps and LED lighting. Light Harvesting was implemented and designed to collect/utilize natural daylight in the interior of the buildings, reducing the need for energy-consuming artificial lighting. The building also features a reflective white membrane roof system.

RELOCATE, RENOVATE, REPURPOSE

One opportunity that modular construction provides to reduce the negative environmental impact is the ability to design for the relocation of an entire building. As modular buildings are constructed in modules, the buildings can be more easily "deconstructed" and reused.

During the 2010 Vancouver Winter Olympics, city officials had the forethought to consider what would be done with the structures used to house athletes after the games ended. The Olympic Village was a mixed-use complex costing nearly $1 billion that housed athletes during the 2010 games. The village was built in an abandoned industrial area mostly covered in parking lots, had 1100 living units, of which almost one third were designated to be used again as affordable rental or for-purchase homes.

As a result of this forethought, seniors across British Columbia are now enjoying much needed affordable living accommodations. Following an agreement between the provincial government and the Vancouver Organizing Committee, 320 modular housing units from the Olympic Village were relocated and converted into permanent, affordable apartments in six communities across the province.

GREATER ENERGY EFFICIENCY / TIGHTER BUILDING ENVELOPE

According to the National Renewable Energy Lab (NREL) "Industrialized construction has immense potential to address the growing need globally to build and upgrade the building stock to be affordable, energy-efficient, and resilient. It can also help achieve the United States' goal of a 50% reduction in U.S. greenhouse gas (GHG) emissions by 2030. The industrialized construction of Net Zero Energy (NZE), low-carbon modular buildings is an essential step for developing a transformational pathway for our clean energy future."

RESEARCH SPOTLIGHT

Modular Construction: Energy-Efficiency Field Study in Commercial and Multifamily Buildings - July 9, 2020. University of Nebraska-Lincoln, Colorado State University, and New Buildings Institute.

A multiyear field study targeting four climate zones in three states {CA, PA and WA}, documenting energy performance of 45 modular projects with a focus on multifamily buildings. Prefabrication in a controlled, factory setting has the potential to improve energy efficiency and performance while streamlining related code-compliance processes and better enabling the integration of advanced technologies. When integrated, this approach may reduce total energy use by 50 percent when compared to comparable site-built construction.

[Modular] may reduce total energy use by 50%

Modular Construction: Energy-Efficiency Field Study in Commercial and Multifamily Buildings

CONCLUSION

Modular construction is a more environmentally-friendly building method than traditional on-site construction. By utilizing modular techniques, building developers can lower their projects' overall environmental impact through reduced emissions, reduced waste, material reusability, and increased energy efficiency.

LEARN MORE ABOUT ALL THE BENEFITS OF MODULAR CONSTRUCTION AT MODULAR.ORG OR CONTACT MBI DIRECTLY AT INFO@MODULAR.ORG