EVALUATION OF MODULAR CONSTRUCTION METHODS VERSUS TRADITIONAL CONSTRUCTION METHODS FOR ARMY CONSTRUCTION PROJECTS

Matthew Milliron¹, Keith A. Rahn²

¹ Auburn University, Auburn, USA
² Auburn University, Auburn, USA

Abstract
This research study focuses on examining the Army's facility construction program during the fiscal years 2006 through 2013, known as Military Construction Transformation. For this program, the Army had goals to build better facilities, constructed faster and at less cost. To accomplish this, the Army gave contractors additional consideration for contract awards if the contractors proposed innovative design solutions, such as modular construction. This research examines construction costs, construction schedules, and maintenance records to determine if the Army's goals were met. There were more than 7,000 maintenance records available, covering more than ten years for the facilities evaluated. The results of the data revealed that modular construction is not providing the durability and maintainability that the Army paid for when compared to conventional construction through comparative case studies. A recommendation was provided as well as considerations for future research.

© 2023 The Authors. Published by Diamond Congress Ltd.

Keywords: construction, cost, facility, modular, traditional

1. Introduction
Billions of dollars are spent on Army facilities for both new construction and maintenance. In 2006 the United States Army, through the United States Army Corps of Engineers (USACE), implemented a construction buildout of $44.6 Billion that was required to be completed within the Fiscal Year (FY) 2006 to FY 2013 timeframe. To accomplish the construction on a highly accelerated schedule and massive scale, the Army relaxed several requirements that included allowing Type V Construction, such as modular buildings, and allowing industry criteria to be used instead of all Unified Facility Criteria (UFC) requirements that are highly prescriptive. This initiative also emphasized using Design-Build (D-B) instead of Design-Bid-Build (D-B-B) procurements. The Army called this endeavor MILCON Transformation, abbreviated as MT. MILCON stands for Military Construction.

By adopting performance-based criteria and industry best practices, contractors could utilize Type V (combustible) construction, which was previously not permitted in Military Construction. Type V construction enables the use of "modular units" – pre-manufactured sections constructed in workshops and delivered and installed onsite. Type V construction is built from combustible light wood framing-the least fire-resistant of all construction types. Fire ratings fall to zero for Type V-B construction (Allen & Lano, 2013). Realizing the need for fast construction, the Army placed incentives in D-B Requests for Proposals (RFP), stating contractors that proposed innovative design solutions, such as modular construction, would receive additional consideration from the source selection evaluation board. The Army was aware that the modular facilities would not provide the same longevity when compared to a concrete structure. The MILCON Transformation program specifically sought a 25-year rehabilitation/repurpose cycle instead of the 50-year cycle typical of previous construction requirements. Through onsite post-occupancy evaluations of the constructed facilities, many installation facility managers stated concerns that the buildings constructed using modular methods are inferior and perform poorly compared to buildings constructed using more robust and restrictive methods.
2. Research Background

In 2006, the United States Army Corps of Engineers (USACE) was responsible for executing six major Army initiatives that required the complete construction of facilities totaling approximately $44.6 Billion (FY 06 – FY 13) in a short timeframe. This requirement necessitated changing the current design, construction, and acquisition processes. Corps of Engineers leadership issued orders to update design and construction processes, titled, USACE Policy on Applicability and Use of the Military Construction Transformation Model Request for Proposal. This order stated: The Army faces a significant resource shortfall in providing permanent facilities to support a transforming Army at war. The Vice Chief of Staff of the Army (VCSA) has directed that standard facilities will be constructed to meet Warfighter functional and operational capabilities. This includes providing facilities that meet the quality-of-life features based on non-military considerations, such as equivalent living conditions in academia, and working facilities that meet requirements for current and future use, such as tactical equipment maintenance facilities that can service existing vehicles and vehicles the Army intends to field in the next five to ten years.

The Department of Defense budget request for the construction of new facilities and sustainment, restoration, and modernization is $21 Billion for FY 21. Even with this funding, it, on average, funds 80 percent of DOD facility sustainment requirements across the enterprise [5]. A backlog of $134 Billion in Renovation and Modernization (R&M) projects and low overall funding levels continue to cause the degradation of Army infrastructure [4]. Existing research has analyzed how the DOD and Army best utilize their construction funding. There is well-researched information focusing on decision-making when various construction methods can be used, as well as the cost and schedule impacts of different construction methods. For example, Modularization has the potential to address many recurring industry challenges, including a shortage of skilled workforce, tight budgets, schedule compression, and reduced site risk by reducing onsite labor [2]. Average construction costs per square foot are lower for facilities constructed with combustible materials than for facilities with higher levels of fire protection [7]. The Army appears to have achieved some savings in selected construction projects by expanding the use of wood materials and modular construction methods for some of its facilities. Still, the Government Accountability Office found little quantitative data on whether the use of these materials and methods will result in savings over the long term compared to the traditional use of steel, concrete, and masonry materials and onsite building methods [9]. Research on the overall Department of Defense facility spending between 2010-2016 shows $4.2 Billion in savings [1].

3. Research Aim

The scope of the research will look at unaccompanied personnel housing and administrative facilities constructed at Fort Bliss, TX, and Fort Carson, CO, as these facilities were constructed for the same purpose using both conventional and modular construction. This will allow for the most relevant analysis possible. The research will include maintenance records for the buildings from the first available record to 2022. Those buildings erected before MT are considered “legacy” facilities and were subjected to all applicable UFCs, establishing stringent construction requirements. These facilities required Type II construction [3]. Type II requires that building elements be of noncombustible materials [6]. As such, legacy facilities were not considered for evaluation.

The objective of this study is to explore whether the Army’s modular buildings are inferior in quality and do not provide efficient lifecycle facilities. The study focused on Unaccompanied Enlisted Personnel Housing (UEPH), also known as barracks and Administrative Facilities.

Archival data will provide information on the following themes:

1. Did modular construction hold up over time compared to conventional construction?
2. Are building systems in modular facilities performing as well as systems in conventional construction?
3. Did the Army get what it paid for in modular construction regarding durability and maintainability?

4. Literature Review
Modular construction in the context of this research is the method of assembling as much of a facility as possible, including structure, building systems, and finishes in a factory setting, as well as transporting the modular unit to a construction site for final assembly and completion. MT demonstrated that facilities could be constructed quickly and cheaper than before MT [1]. The compromise was the overall useful life of the facility before a major renovation, which was reduced to 25 years from 50 years. Before MT, the average construction duration of a $25 Million barracks was approximately two years or 720 calendar days. MT required that the total number of proposed calendar days for design and construction through completion, ready for turnover, shall not exceed 540 calendar days [11]. Since the projects were first initiated, many Army Installation Departments of Public Works (DPW) were concerned that the facilities would be poorly constructed and cause a significant resource drain on limited maintenance funds. The U.S. Army Corps of Engineers Inspector General developed a report that stated: Installation officials feared that the less-stringent commercial specifications and construction standards allowable under MT would result in increased Operations and Maintenance (O&M) costs in the future – additional expenses that already stressed DPW budgets might not be able to afford.

Senior Army leadership was committed to providing equitable delivery of projects within the Army's Total Obligation Authority to meet both mission and quality of life requirements. (Temple, 2006). USACE leadership further stated that in order to meet these challenges, the Army is implementing MT. A key component to successfully implementing MT was the Model RFP. The Model RFP, also known as the RFP Wizard, provided a web-based tool to develop D-B RFPs for standard Army facility types quickly. The technical performance requirements suitable for a D-B RFP, such as the architecture, mechanical, electrical, and structural elements, were developed in advance of projects for standard facility types. Minimal input was required from the technical team developing the D-B RFP; only the site, infrastructure and aesthetics of the building exterior required significant technical resources.

Many with a professional background indicated during post-occupancy reviews that the potential increased cost in the future to maintain facilities constructed using commercial construction standards outweighed any perceived cost savings claimed during the project delivery process. Almost all admitted that it was too early to conclude; however, no data was available to support their contentions at this point [10]. This research will look at the data collected and see if there is data-driven validity to the concern that Type V and modular construction are an inferior product. Given the significant dollars in the program, providing Type V facilities that meet service life and quality standards can save taxpayer money versus going back to more restrictive construction.

Modular buildings are manufactured facilities that provide factory-controlled environments in an assembly line configuration. Completing as many of the building components in a controlled environment allows the manufacturer to minimize inclement weather impacts, manage supply lines of individual components, and control quality through the assembly line method. Recent academic research in the last ten years, as well as older research, has referenced the following for a consistent definition of the term module, “A module is a product resulting from a series of remote assembly operations. It is usually the largest transportable unit or component of a facility. A module consists of a volume fitted with all structural elements, finishes, and process components, which regardless of system, function, or installing craft, are designed to occupy that space. Modules may contain prefabricated components or preassemblies and are frequently constructed away from the job site” [8].

It is noted that the Types of Construction (Type II and Type V) discussed in this research are fire-resistance ratings for exterior walls based on fire separation distance [6]. This fire resistance rating was frequently used to convey the quality of materials and is at the heart of the research. The use of “Type II” and “Type V” is used synonymously with quality in the Army vernacular. This is partly because, in Type II buildings, the materials and components are required to be non-combustible. As such, all the components that go into building assemblies must be rated as non-combustible. Electrical wiring in a Type II facility must be run in conduit, whereas a Type V facility may use non-metallic cable such as Romex. Light fixtures and outlet boxes may also be rated. Also, HVAC penetrations can be more sophisticated in Type II Construction, and finishes may have a higher rating. Substantial research has been conducted on modular construction, including the categories of modular construction and research on exactly how much academic literature has been developed on the modular construction industry.

Much of the existing literature discusses the use of modular construction in the industry and how it benefits project completion. One academic journal provided a succinct description of why modular is not
used. An Investigation of Critical Factors and Constraints for Selecting Modular Construction Over Conventional Stick-Built Technique. This journal discusses that more coordination in the planning and procurement process is required, and there is less flexibility to make changes late in the project. The journal provides an excellent evaluation of why modular is not used in two different sections. The first states, “In most cases, the decisions are made based on the experience and gut-feelings of senior project managers and modularization experts” [2]. This is followed up with the following conclusion, “Some of the barriers preventing the widespread use of modularization for commercial building projects include lack of modularization provisions in typical project design, lack of awareness of the benefits of modular construction among owners, the non-availability of prefabrication units in the project vicinity, restricted site layout, and modular design rigidity” [2].

Few academic journals or articles go into detail, specifically discussing the Army’s use of modular construction during the 2006-2013 timeframe and comparing the results to traditional construction. The most relevant data is a Government Accountability Office (GAO) report to the House of Representatives Armed Services Committee. This report published in 2010 and did not have the opportunity to evaluate the buildings in a long-term manner to assess their lifecycle performance. Acknowledging this, the GAO report stated, “Without long-term or life-cycle analyses that consider not only initial construction costs but also possible differences in facility service lives and annual operating and maintenance costs between the construction alternatives, it is not clear that the Army’s expanded use of wood materials and modular building methods will achieve the Army’s intended purpose of reduced facility costs over the long term” [9].

Army Corps of Engineers personnel visited several different modular manufacturers during the initial stages of the MT buildout. The modular manufacturers indicated through in-person interviews at the time that the Army’s requirements for the facilities were more robust than the traditional manufacturing of commercial facilities and residential buildings. The increased robustness was based on Anti-Terrorism and Force Protection (ATFP) requirements and the prevention of progressive collapse requirements when the constructed facility would be three stories or higher. These requirements required the manufacturers to increase overall structure rigidity and add considerations for glazing for blast resistance, as well as other building system considerations not present in commercial or residential construction. The modular manufacturers would have to set up the assembly lines specific to the Army’s projects. They would run the entire order through the plant at once, so the assembly line could be converted back to standard lines of business.

5. Research Methodology

Research was conducted using a quantitative method of analyzing archival data from initial construction award documentation and maintenance records for a specially selected number of facilities. Eight facilities across two locations will be utilized for the research, because the facilities provide the opportunity to examine similar buildings constructed at the same time. Four buildings used modular construction and four buildings used traditional methods.

Four buildings are located at Ft. Bliss, TX and include two barracks (one modular and one traditional construction) and two administrative facilities (one modular and one traditional construction). The second set of four buildings are located at Ft. Carson, CO and include the same make up and construction types as Ft. Bliss. Between the eight buildings, there are more than 7,300 maintenance call records to analyze spanning more than ten years.

6. Results and Discussion

Out of the 7,370 maintenance calls, there were more calls for modular facilities than those constructed via conventional methods. The four modular facilities received a total of 4,804 maintenance calls compared to the 2,566 that were recorded for the four conventional facilities which is depicted in Table 10 below.
An interesting result of the data analysis is that all the facilities receive a similar percentage of building system issues and normal maintenance. The average percentage across all facilities for building system issues is 61%. The average percentage across all facilities for normal maintenance issues is 36%. The most noticeable difference is the total number of service calls received for the facility types. The modular facilities received many more maintenance calls. For the Barracks, maintenance calls to modular facilities represents 65% percent of the total. Conventional facility maintenance calls are only 35% of the total. For the Admin Facilities, maintenance calls to modular facilities represents 65% percent of the total. Conventional facility maintenance calls are only 35% of the total.

All modular facilities analyzed had more maintenance calls than the comparable facility using conventional construction. This is a strong indicator that the modular facilities are not holding up over time compared to conventional construction and that the building systems in modular facilities are not performing as well as the conventionally constructed counterpart. “The Army set goals to reduce its estimated construction costs by 15 percent and building timelines by 30 percent” [9]. Based on the projects analyzed, the average cost savings were 13%, but on average, it took 16% longer to construct the facilities. It is interesting to note, that modular construction took longer to complete for both installations, the modular barracks at Ft. Bliss and the Admin Facility at Ft. Carson.

A significant limitation is the small sample size of Army facilities constructed at the same time that include both modular and conventional construction. The selection of facilities was made to evaluate the differences most accurately in first costs, construction duration and total maintenance calls. However,
the number of maintenance calls, more than 7000, provides a large sample size to evaluate across the facility types selected. Additionally, there was bias in the fact that the author was involved with the MILCON Transformation program attempting to achieve all the goals stated. Results of the data were not favourable to continuing modular construction.

6. Conclusion

The goal of MILCON Transformation was to provide facilities that could be built better, faster, and cheaper. The modular facilities analysed experienced 87% more maintenance calls than the conventionally constructed counterparts. This is almost twice as many service calls to maintain the facility. An interesting data point is that the type of calls are similar between routine maintenance and a building system issue for both types of construction; however, there are almost twice as many maintenance requests to the modular facilities. The Army’s goal was to reduce construction timelines by 30% when compared to conventional construction methods. The data analyzed indicates it took on average 16% more days to complete the construction of modular facilities when compared to the conventionally constructed counterpart. Another goal was to reduce cost by 15%. The data indicates the costs savings was less than 15%.

Modular facilities require almost twice as many maintenance calls to reach the 25-year rehabilitation/repurpose cycle, it does not appear modular construction is holding up over time compared to conventional construction and that modular facilities are not performing as well as conventional construction regarding durability and maintainability. In addition, the cost savings indicate the Army’s goals were not achieved. Based on the fact that none of the MILCON Transformation goals appear to be met, modular cannot be recommended in future Army construction projects. Based on the data available, catastrophic failure of building systems is rare. With the limited data available, the Army would need to do determine if fiscal programming requirements need to be allocated based on housing soldiers on the normal occurrence of service calls, or what happens when a catastrophic failure occurs. Future research can evaluate the potential impact of catastrophic conditions.
References


