



Modular Construction: An Alternative Building in a Tough Economy

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ABSTRACT

Modular construction is an innovative, sustainable construction delivery method utilizing off-site lean manufacturing techniques to prefabricate single or multi-storey while building structures in deliverable module sections. Modular construction can be permanent and temporary and ensures timely completion projects, jobsite improvement, waste reduction, quality control, sustainability with building design stronger than traditional home. Offsite construction can service a variety of building and construction type such as education buildings, housing, health care, office, dormitory and hospitality. The study was a survey research. The responses of one hundred and fifty (150) modular builders and another one hundred and fifty (150) traditional building contractors were randomly selected as samples for the investigation, making a sample of a total of 300 respondents. The data collected were analyzed using means, while t-test statistic was used to test the hypothesis. The finding shows that modular method of building construction assist in the realization of alternative buildings in tough economy more than traditional method. There is significant difference between modular construction and the traditional construction method towards the realization of alternative buildings in tough economy. Therefore, Modular construction provides alternative buildings in tough economy. Workshops and seminars on modular construction should be organized for contractors to enable them introduce the latest trend (Modular buildings) to the society. Client should be sanitized by the builders on the positive impacts of modular buildings.

Keywords: Modular construction, modular building strength, core benefits of modular buildings.

INTRODUCTION

Modular Construction is a term used to describe the use of factory produce pre-engineered building units that are delivered to site and assembled as large volumetric components or as substantial elements of a building. Off-site construction, also called prefabricated or modular construction, allow various building elements from bathrooms to pre-wired light fixtures to exterior walls to be built in a factory and transported to a construction site (Bunch, 2017). According to Morton (2011), Modular construction can reduce build time by 30 – 50% and provide an alternative solution in today's tough market. Morton further highlighted that, in a market where construction costs is of great concern, permanent modular construction (PMC) as a way to acquire a new building in a tough economy should be considered. This alternative construction technique yields faster completion time, improved efficiency, cleaner materials and better quality control. According to Modular Building Institute (n.d.), modular construction is a process in which a building is constructed off-site, under controlled plant conditions, using the same materials and designing to the same codes and standard as conventionally build facilities but in about half the time. Buildings are produced in modules that when put together on site, reflect the identical design intent and specifications of the most sophisticated site-built without compromise. Ikechukwu (2016) mention that, modular is a construction method that involves constructing sections away from the building site, then delivery them to the intended site. Ikechukwu maintained that, installation of the prefabricated sections are sometimes placed using a crane. The modules can be placed side-by-side, end-to-ends, or



stacked, allowing a variety of configurations and styles. According to Smith (2011), the off-site industry has grown from primarily a re-locatable modular manufacturing sector to a building delivery sector. This presents difficulty for both manufacturers of panels and units and the traditional building industry that do not understand off-site, its delivery process, and how to engage effectively in that process. An ideological and structural shift in the construction industry is occurring with abandonment of traditional design-bid-build contracts toward design-build and integrates project deliveries that rely on performance contracting and shared risk and reward. Off-site construction is a synonymous concept with integrated delivery. Research shows that projects that decide to utilize off-site after the design development phase have demonstrated a negative impact on both schedule and budget as a result of employing modular too late in the process of building delivery (Smith, 2011).

Features of Modular Building

Modular building can be an outdoor standalone structure, or can be assembled inside of a large building, such as a warehouse, factory, or office building. There is no project either too big or too small that a modular building is not well-suited for. A modular building typically has windows, doors, finished walls, lighting, flooring of your choice, and can be pre-wired for specific usage of the building. Modular buildings have HVAC and air filtration system and can be ordered in any colour or style. There are many options available to fit almost anyone's budget (Colleend, 2018).

Construction Process

Construction is offsite, using lean manufacturing techniques to prefabricate single or multi-storage buildings in deliverable module sections. Permanent modular construction (PMC) buildings are manufactured in a controlled setting and can be constructed of wood, steel, or concrete. Modular components are typically constructed indoors on assembly lines. Modular components may take as little as ten days but more often one to three months. PMC modules can be integrated into site built projects or stand alone and can be delivered with MEP, fixtures and interior finishes. The buildings are 60% to 90% completed offsite in a factory-controlled environment, and transported and assembled at the final building site. This can comprise the entire building or components or sub-assemblies of large structures. In many cases, modular contractors work with traditional general contracts to exploit the resources and advantages of each type of construction. Completed modules are transported to the building site and assembled by a crane. Placement of the modules may take from several hours to several days. Permanent modular buildings are built to meet or exceed the same building codes and standards as site-built structures and the same building codes and standards as site-built structures and the same architect-specified materials used in conventionally constructed buildings are used in modular construction projects. PMC can have as many stories as building codes allow. Unlike re-locatable buildings, PMC structures are intended to remain in one location for the duration of their useful life. The entire process of modular construction places significance on the design stage. This is where practices such as design for manufacture and assembly are used to ensure that assembly tolerances are controlled



throughout manufacture and assembly on site. It is vital that there is enough allowance in the design to allow the assembly to take up any slack or misalignment of components. The use of advanced CAD systems, 3D printing and manufacturing control systems are important for modular construction to be successful. This is quite unlike to on-site construction where the tradesmen can often make the part to suit any particular installation.

The Core Benefits of Modular Construction

Morton (2011) highlighted some attractive range of advantages of modular construction as follows:

Scheduling

One of the greatest benefits is the ability to dramatically reduce the time needed for construction. Factory efficiencies allow building components to be completed quickly and without weather delays. No more contracting with multiple building requirements. This makes modular construction suitable for owners who need buildings quickly, properties hard dates for occupancy, and areas where seasonal weather restricts or even halts construction.

Jobsite Improvement

Nearly completed modules ease the need for site equipment and staging areas, making them ideal for completed sites. A property in a remote location or has accessibility difficulties. Modular construction is likewise a great alternative for areas where an experienced or affordable labour force is difficult to come by. Modular construction affords a cleaner worksite with fewer disruptions. With the majority of the work completed off-site, issues such as noise, dust, debris, and weather complications are greatly reduced.

Waste Reduction

The factory process decreases the potential for errors, material use is more carefully monitored. An assembly line also offers more opportunities for recycling throughout the process.

Quality Control

Prefabricated building module has built-in quality checks. Modular building factories are dedicated to crafting highly effective buildings with inspections at each station, iminating on-the-fly decisions or unexpected complications that can occur in the field.

Sustainability

Modular construction easily incorporates sustainability. Specify the risk of recycled materials, LED lighting, high-efficiency mechanical systems, and sustainably harvested wood and low-flow fixtures.



According to Modular Building Institute (n.d.), modular construction offers the following benefits:

Greener

The factory – controlled process generates less waste, creates fewer site disturbances and allows for tighter construction. Modular buildings can be disassembled and the modules relocate or refurbished for new use, reducing the demand for raw materials and minimizing the amount of energy expended to create a building to meet the new need. When building in a factory, waste is eliminated by recycling and protecting building materials. Modular structure is substantially completed in a factory controlled setting using dry materials; the potential for high levels of moisture being trapped in the new construction is eliminated.

Faster

Construction of modular buildings occurs simultaneously with site work, allowing projects to be completed in half the time of traditional construction. Modular buildings can occur simultaneously with the site and foundation work, projects can be completed 30% to 50% sooner than traditional construction. 60 – 90% of the construction is completed inside factory, which mitigates the risk of weather delays. Buildings are occupied sooner, creating a faster return on investment.

Smarter

Modular buildings are built with the same materials and to the same building codes and architectural specifications as traditional construction. Once assembled, they are virtually indistinguishable from their site-built counterparts. The indoor construction environment reduces the risks of accidents and related liabilities for workers. PMC relies on advanced BIM for visualization to assess the energy performance and identify the most cost-effective efficiency measures. PMC is ideal for the use of this technology where the construction process is already a collaboration of systems, materials and people-much like the software itself. Modular units may be designed to fit in with external aesthetics of any existing building and modular units, once assembled, are virtually indistinguishable from their site-built counterparts.

Limitations of Modular Construction

Volumetric: Transporting the completed modular building sections take up a lot of space.
Flexibility: Due to transporting and sometimes manufacturing restrictions, module size can be limited affecting room sizes.

Some financial institutions may be hesitant to offer a loan for a modular home.

REQUIRED PERIOD/TIME FOR MODULAR CONSTRUCTION

The intention here is not to say that offsite generally is an appropriate solution to every building problem. Off-site has performed better on some building types, with certain building teams and in certain locations. These guidelines are not meant to be definitive but suggestive of consideration that should be taken when deciding if off-site is



appropriate. The required time for off-site construction according to Ihenketu (2017) include: Projects that are restricted by schedule such as schools and dormitories that must open for new school year or semester, embassies that must be built for operations in foreign country quickly, or retail units that must open doors to gain an increased return on revenue. It is hard to think of any building type today that does not demand a shorter construction schedule. Repetitious projects such as identical classroom units, dormitory units, office units, laboratories, high-tech facilities, communication structures, and bathroom pods. Projects that employ unique forms, unique sustainability requirements, or a higher degree of control in the end product also stand to benefit from off-site construction. The factory provides space for prototyping, quality control and ability to integrate complex systems. As such, off-site is restricted to box forms, and unique projects may in fact demand geometric forms that off-site construction cannot provide. The delivery method by the owner can have a large impact in determining if off-site is used or not. Although off-site can be used in any contract form, design-bid-build contracts without consideration to means and methods by the contractor during the design process or construction manager contracts by the contracts that make decisions concerning construction method without input from owners can work against off-site delivery. This can be mitigated by selecting design-build or integrated contracts that allow for early fabrication decision making by owners, designers and builders partnership with dealers and/or off-site product manufacturers direct through design assist during the planning and schematic phase of development.

MODULAR BUILDING STRENGTH

Modular homes are design to be stronger than traditional homes by, for example replacing nails with screws, adding glue to joints, and using 8 – 10% more lumber, than conventional housing. This is to help the modules maintain their structural integrity as they are transported on trucks to the construction site; however, it is difficult to predict the final building strength since the modules need to experience transportation stresses that traditional homes never experienced. The insulated forms are modular units that are dry-stacked (without mortar) and filled with concrete. Insulating concrete forms has an accepted ductility of used in high seismic risk zones.

RESEARCH QUESTION

To what extent does a modular building assist in the realization of alternative buildings in tough economy?

HYPOTHESIS

H₀: There is no significant difference between modular construction and the traditional construction method towards the realization of alternative buildings in tough economy.

METHODOLOGY

The study was a survey research. The responses of one hundred and fifty (150) modular builders and another one hundred and fifty (150) traditional building contractors were randomly selected as samples for the investigation, making a sample of a total of 300



respondents. The data collected were analyzed using means, while t-test statistic was used to test the hypothesis. The decision was that any mean from 2.50 and above was regarded as "Agree" while those with less than 2.50 were regarded as "Disagree".

Table 1: Responses of Builders on ways Modular and Traditional Buildings Assist in the Realization of Alternative Buildings in Tough Economy.

S/N	ITEMS	MODULAR		TRADITIONAL	
The following are ways modular/traditional building construction assist in realizing alternative buildings in tough economy					
		X	Decision	X	Decision
1	Scheduling	2.61	Agree	2.11	Disagree
2	Jobsite Improvement	2.70	Agree	2.30	Disagree
3	Waste Reduction	2.50	Disagree	2.41	Disagree
4	Quality Control	2.67	Agree	2.51	Agree
5	Sustainability	2.60	Agree	2.00	Disagree
6	Greener	2.11	Disagree	2.41	Disagree
7	Faster	2.50	Agree	2.50	Agree
8	Smarter	2.61	Agree	2.81	Agree
9	Easily constructed	2.13	Disagree	2.22	Disagree
10	moveable	2.51	Agree	2.44	Disagree

Field Survey (2019).

Table 2: T-test analysis of no significant difference exist between modular construction and the traditional construction method towards the realization of alternative buildings in tough economy.

Groups	N	X	df	t-cal	t-crit	Decision
Modular method	150	2.88	2			
	298	2.43	1.96	Reject H ₀		
Traditional method	150	2.10	300			

DECISION

From table 1, the respondents' responses shows that modular method of building construction assist in the realization of alternative buildings in tough economy more than traditional method. In table 2, the value of the t_{CAL} of 2.43 was greater than the t_{CRI} value of 1.96. Hence, the H_0 is rejected. This shows that there is significant difference between modular construction and the traditional construction method towards the realization of alternative buildings in tough economy.

CONCLUSION

Structurally, modular buildings are generally stronger than site-built construction because each module is engineered to independently withstand the rigors of transportation and craning onto foundations. Once together and sealed, the modules become one integrated wall, floors, and roof assembly. Buildings off-site ensure better construction quality management. Manufacturing plants have stringent quality assurance (QA) and quality control (QC) programs with independent inspection and testing protocols that promote superior quality of construction. As owners and designs look for more sustainable design for improved environmental impact, modular construction is inherently a naturally fit. Building in a controlled environment reduces waste through avoidance upstream rather than diversion downstream. This, along with improved quality management throughout



the construction process and significantly less on-site activity and disturbance inherently promotes sustainability. Modular construction ensures high quality, sustainable, innovative, efficient, cost-effective, and shorter time to completion.

RECOMMENDATIONS

Workshops and seminars on modular construction should be organized for contractors to enable them introduce the latest trend (Modular buildings) to the society.

Government should make soft-loan available to young graduates who have intention for modular construction to ensure self-employment.

Client should be sanitized by the builders on the positive impacts of modular buildings.

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