Assessment on Construction Companies in the City of San Fernando, Pampanga Regarding the Adoption of Modular Construction as an Alternative to Traditional Construction for Housing Challenges

JOHN RANIEL N. BACSA[1], AARON S. MALONZO[2], DERICHK T. DIJAMCO[3], MA. KATHRINE P. FLORES[4], CHRISTOPHER C. FORMENTIRA[5], EDGAR BRIAN M. BINGCANG[6], DANIEL IAN A. PABUSTAN[7], ARIEL G. PABALATE[8]

[1, 2, 3, 4, 5, 6, 7, 8] *Department of Civil Engineering, Don Honorio Ventura State University*

Abstract- ***In the Philippines, Filipinos are affected by natural calamities (E.g. earthquakes, typhoons, etc.) all year round. Studies have shown that these calamities result in the destruction of residences, and the increase in housing shortage in the country. With the rise of modular construction as an alternative to traditional construction, it has gained popularity with its on-site construction speed, due to its parallel construction process. This research aimed to assess the awareness of the construction companies in the City of San Fernando, Pampanga regarding the adoption of modular construction as an alternative to traditional construction for housing challenges, with the purpose of assessing the level of awareness and willingness of the construction companies to adopt modular construction, identifying the most significant barriers in adopting modular construction, and the comparison between modular and traditional construction in terms of cost-effectiveness. This research employed the use of questionnaires distributed to the companies, and related literature to obtain necessary information. The awareness of the companies to employ and find the important factors affecting the adoption of modular construction were analyzed by enumerating the various aspects of modular construction in the questionnaire in a 4-scale format ranging from Strongly Not Aware to Strongly Aware and came to a conclusion that the companies were aware of modular construction with a grand mean of 3.17. The respondents were presented with a list of established barriers in modular construction and were instructed to rank their significance, and resulted in Transportation/Logistics as the most significant barrier, followed by Cost vs. Value, and Distance from Factory to Site. In obtaining their willingness to adopt modular construction, the respondents were given various possible scenarios in adopting modular construction; they were tasked to answer whether they are still willing to adopt modular construction despite the scenarios presented, resulting in an overwhelming agreement from the respondents. And in comparing modular and traditional construction methods, locally collected data was utilized to determine the cost-effectiveness of both methods, which concluded that modular construction is more cost-effective than the traditional method.***

Indexed Terms- ***Modular Construction, Traditional Construction, Housing Shortage***

I. THE PROBLEM AND A REVIEW OF RELATED LITERATURES AND STUDIES

1.1 Introduction:

Sustainability, inclusivity, resiliency, and safety in human settlements are one of the Sustainable Development Goals (SDG 11) of the United Nations. The rate of urbanization has outpaced many emerging cities' ability to meet the demands of a growing population; thus, the need to provide appropriate housing for everyone, especially the less fortunate, is one of the most critical issues. According to Jamaludin et al, when home prices are consistently high, it become a challenge for people with low to middle incomes to purchase real estate. To improve the quality of life, homes should be created with all the necessities for a healthy lifestyle, be cost effective, and

be located in an area with good transportation options. From an economic, socio-psychological, and environmental standpoint, it is crucial to incorporate sustainability principles into housing building.

In the Philippines, Bilkenn Corporation asserts that many Filipinos are affected by natural calamities. For instance, the Philippines experiences 20 typhoons on average each year. Additionally, the nation occasionally experiences earthquakes and volcanic activities, which is one element in the loss of homes, disruption of livelihoods, and destruction of life. Before some could reconstruct their damaged homes and means of support, it would likely take many months or even years. According to research published by the Philippine Institute for Development Studies (PIDS), housing remains unavailable for millions of Filipinos because they cannot afford it, particularly low-income and big families as well as those who reside in heavily urbanized cities.

The House Developer's Group said that shortage of housing is not only caused by natural calamities; the rising of prices and population increase could also be the cause of the scarcity. As stated by George Siy, chairman of the Subdivision and Housing Developers Association, Inc. on the interview of CNN Philippines, “From a production viewpoint, we have another problem and that is the growing housing shortage,". Siy clarified that surveys conducted three years ago indicated a three million house backlog, a much smaller number than the 6.5 million at present. He pointed out that the rate of population growth is outpacing the rate of home development.

Modular construction, also known as prefabrication or off-site construction, involves the manufacturing of building components in a controlled factory environment before they are transported to the construction site for assembly. This method has gained popularity in recent years as an alternative to traditional construction methods due to its potential to improve efficiency, reduce waste, and lower costs.

Navaratnam S. et al. (2019) discovered that prefabricated building construction structural performance data is limited, however modular constructions can be earthquake resistant if well-constructed. Load sharing and transfer in prefabricated building systems can be complicated by installation tolerances, second-order effects owing to sway stability, force transfer of horizontal loads, resilience to unexpected actions, and minimum horizontal force in any tie between modules. However, despite these potential benefits, the construction companies who adopts modular construction for housing projects remains limited..

This assessment aims to determine the current level of awareness and understanding of modular construction among construction companies, identify the barriers and challenges faced by construction companies in the adoption of modular construction as an alternative to traditional construction, and assess the level of interest and willingness of construction companies to adopt modular construction for housing projects.

The results of this assessment will provide valuable insights for construction companies, housing developers, and other stakeholders in the construction industry on the potential benefits and challenges of adopting modular construction for housing projects. Additionally, it will identify areas for improvement and potential solutions to overcome the barriers and challenges faced by construction companies in the adoption of modular construction.

1.2 Review of Related Studies

Modular construction has evolved rapidly as an alternate way of construction in recent years. The building sector is suffering a housing crisis, and modular construction has been recommended as a solution. The purpose of this literature study is to investigate the perceptions of construction businesses in the City of San Fernando on the use of modular building as an alternative to traditional construction for housing challenges.

- *Housing Challenges*

According to Bilkenn Corporation (2022), the Philippines is experiencing a homelessness issue, with 4.5 million Filipinos now homeless and 1.5 million informal settlers. These informal settlers suffer several sanitary and safety challenges, such as living near streams and natural catastrophes. They also suffer health hazards owing to a lack of clean water and sanitary services. They also confront challenges with forced eviction and having their homes razed without

a viable strategy for relocation. Many Filipinos relocate to cities in search of work or to escape disaster-prone areas. An increase in housing demand leads to an increase in land value and higher home costs. Housing is a serious issue in the Philippines, impacting everyone, particularly those regarded to be below the poverty line and middle-income families. Increasing goods costs and a lack of pay growth have pushed professionals to settle for renting rather than buying, resulting in more informal settlers. Red tape, excessive bureaucracy, and natural disasters also affect Filipinos, with 20 annual typhoons and seismic and volcanic activities hitting the country every once in a while. The prevalence of calamity is another factor contributing to people being displaced and homeless, resulted to taking months or even years for them to recover their homes and livelihoods.

The Philippine Institute for Development Studies (PIDS) (2021), says most households can only afford socialized housing, which is frequently located distant from places of employment or livelihood. The threshold of 30% of income used to determine home affordability may be too high for low-income households, but only 8% of urban households would face housing difficulties. As published by CNN Philippines Staff (2022), the proposal of Housing Secretary Jose Acuzar to build one million residences in specified locations of the country will necessitate "interest rate control," changes in production, and modifications in regulatory processes.

According to the Philippine Housing and Household Statistics (2021), Rodrigo Duterte, the President of the Philippines, has advocated for greatly better welfare via housing, particularly for the underprivileged and especially the poor. Despite rising demand for suitable housing, output and budget allocation for residential developments and accompanying services remain insufficient. The Philippine Statistics Authority (PSA) conducted the most recent housing and population census on 2015, which indicated a growing population. The Philippine government estimates that the country's housing needs would exceed 6.8 million units by 2022, with an emphasis on housing projects for homeless Filipinos and informal settlers. The number of families living in rent-free housing has declined significantly, and the total number of permitted house and lot units fell by 25.6% in 2018. The total amount borrowed from Philippine home financing institutions has increased from P74.6 billion in 2013 to P210.9 billion in 2018, with the Pag-IBIG Fund (HDMF) and Home Guaranty Corp. (HGC) providing 36.4% and 35.0 billion, respectively, of the funding. The Philippine house price index (RREPI) has seen year-over-year price hikes of at least 11% in the previous five years, except for condominiums which experienced a 5.8% increase.

- *Modular Construction*

Based on Industrial Quick Search (2022), modular buildings are structures composed of standardized pieces known as "modules" that are constructed in a controlled environment of a factory located far from the building's intended site. Standard modular pieces are constructed using the same materials and to the same principles and regulations as traditionally assembled structures.

According to Muhamad et al. (2016), modular construction is a way of constructing using three-dimensional or modular parts created in a factory. It is a breakthrough building approach that combines prefabricated volumetric modules made in a factory and assembled on-site, as described in the Journal of Building Engineering (2022). Most materials may be used to make three-dimensional units, which are most efficient when utilized for many identical units. Because each three-dimensional item is constructed individually to endure the rigors of shipping and to be hoisted into foundations, modular structures are stronger than conventional construction. A modular building's project turnaround time may be as much as half that of traditionally erected structures, resulting in time savings. Despite their shorter building time, modular structures are extremely durable.

- *Types of Modular Buildings*

Permanent Modular Construction (PMC) is a type of modular construction that uses offsite advanced manufacturing methods to prefabricate building sections. It is used in the construction of multi-story residential complexes, government buildings, health care facilities, schools, hotels, and any other building type seen in traditional on-site construction.

Relocatable structures, also known as temporary modular construction (TMC) or non-permanent

construction, are designed to be mobile, so they can be repurposed and transferred to different areas as needed.

Modular building is a cost-effective alternative to traditional construction and generates healthy income for builders while producing products with competitive property prices. It is a long-lasting and growing trend, with permanent modular buildings and non-permanent, relocatable modular constructions having comparable property values to site-built structures.

- *Characteristics of Modular Construction*

Muhamad et al. (2016) did research on modular construction, which is a building method that includes prefabricated modules being assembled in a factory and then transported to the construction site for final assembly. The study revealed various modular construction attributes which make it an appealing alternative for the construction sector, including better productivity, cost savings, and improved quality control. Moreover, modular building is seen as a sustainable alternative because of its low waste and energy usage. Overall, Muhamad et al. (2016) present a thorough examination of the advantages of modular building and its potential to modernize the construction sector.

Modular construction is characterized by high-quality, identical three-dimensional or room size volumetric units. These modules are mass-produced in a regulated factory or manufacturing facility, resulting in reduced waste and higher-quality modules. Factory-produced modular modules generate less waste at every stage of the manufacturing process, leading to a faster project schedule. On the other hand, Faster Project Schedule, modular construction moves the majority of the construction phase away from the construction site, allowing projects to be finished in half the time of traditional techniques. Figure 1.1 shows a comparison between modular and traditional building schedules.

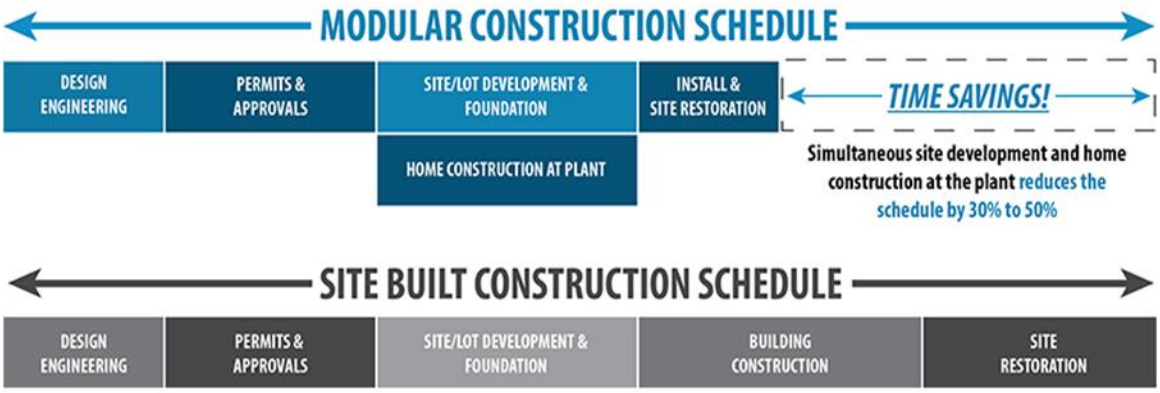

Figure 1.1 Comparison between Modular and Traditional building schedules.

Modular construction also promotes sustainability in the construction environment by reducing environmental impact, waste, on-site activities and disruption, and promoting sustainability. It also minimizes the demand for raw materials and the quantity of energy required to construct a building. Logistics and storage must be considered early and the units must be erected immediately at the authorized area. Coordination, planning, and communication are necessary for all stakeholders involved, as well as the design of services, mechanical and electrical (M&E), and adequate foundations. Ease renovation work is simplified by choosing and adding appropriate three-dimensional or modular modules for the remodeling project.

- *Benefits of Modular Construction*

Modular building projects may be finished 30-50% faster than traditional construction, and 60-90% of the work is done in a factory. Three-dimensional or modular modules are constructed using high-quality materials and are subjected to factory QA/QC management and control. Modular buildings are built to satisfy the same construction requirements as traditional structures and may service remote sites. They are moveable and flexible, and may be relocated

by simply removing joints and connections. They also make maintenance and refurbishment work easier while lowering the danger of accidents and associated liability for personnel. (Muhamad et al., 2016)

As previously stated, the project turnaround time for modular construction can be as little as half that of traditional building. This is because foundation work on-site and prefabricated section manufacture in the factory may be done consecutively, which speedsup the building process. Delays caused by inclement weather, which might compromise building quality and worker safety, can be almost eliminated. The completed modular sections that are typically delivered to the job site are ready to install, which saves time and effort. (Industrial Quick Search, 2022) Due to the high-quality materials and factory QA/QC management and control, modular construction is cost-effective and affordable. It also saves money on commissioning, defect, and repair expenses caused by poor craftsmanship and inferior materials. It also decreases waste due to the regulated industrial settings and atmosphere.

Modular construction is a sustainable and environmentally friendly construction approach that increases the construction process's sustainability and the performance of completed modular structures. It minimizes raw material consumption, eliminates waste, improves air quality, and delivers improved safety and fewer accidents. Modular structures may be dismantled, transported, or reconditioned for a new purpose, and they can be built with pre-attached barriers or protective cages as part of the lifting system.

Paliwal, S. did an identical investigation. (2019), to measure the expectations of industry experts eager to apply modular techniques, as well as the actual advantages gained when those modular methods are implemented. The findings reveals that the first four projects and actual advantages in the Las Vegas and Hong Kong construction sectors were identical, with the most significant benefit being better schedule. The top five anticipated advantages were enough labor, fewer site-based permits, less waste, less site interruption, and greater safety. Figure 1.2 compares the expected advantages to the actual benefits in Las Vegas.

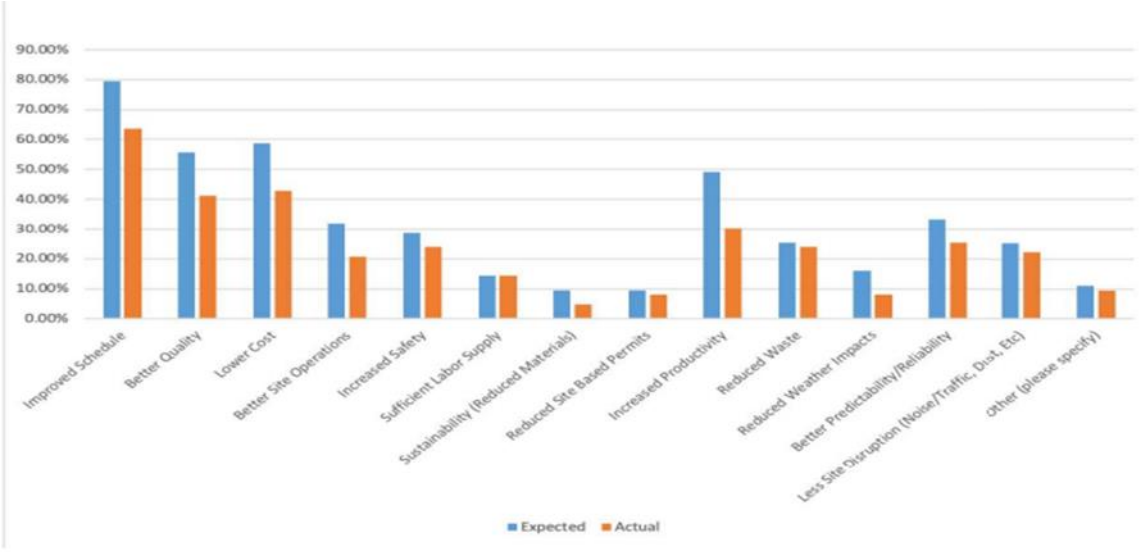

Figure 1.2 Benefits (Expected vs. Actual)

As per the study results of Kharo et al. (2019), respondents were asked to give their thoughts based on their work experience in the construction business. Participants were given a 4-point Likert scale and asked to rank the elements that favor prefabrication in the construction sector for small-scale residential building projects. Figure 1.3 displays the ranking of variables based on their AI score.

Sr. No.	Advantages of Prefabrication	AI Score	Rank
1	Shorten construction time	3.57	1
2	Low site waste	3.48	2
3	Better supervision	3.46	3

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4	Sustainable product (reusable, reinstalled)	3.46	3
5	Environmentally friendly	3.23	4
6	Reduce overall construction cost	3.12	5
7	Better quality	3.12	6
8	Improved aesthetic	3.05	7
9	Low design problems	3.03	8
10	Work is not affected by weather delays (related to excessive cold, heat, rain, snow, etc.)	3.03	8
11	Less theft of material/equipment (and less property damage due to vandalism)	3.00	9
12	Reduction of energy and water consumption	3.00	9
13	Enriched durability	2.92	10
14	Precise conformity to building code standards	2.91	11
15	Better occupational health and safety	2.91	11
16	Worker comfort level is higher than in site-built construction	2.87	12
17	Computerization of the production process permits a high degree of customization	2.70	13
18	Allows for year-round construction during any climate	2.70	13

Figure 1.3 Ranking of Prefabrication Advantages

Shortening construction time and reducing building site waste are placed top and second, with average mean values of 3.57 and 3.48, respectively. It implies that using prefabrication in construction will result in a reduction of overall project time owing to the manufacture of components at a specific site or at a factory.

As a result, there will be less trash on the building site. Furthermore, greater supervision, sustainable products, and ecologically friendly are ranked third and fourth, respectively, and are followed by others, as indicated.

Navaratnam S. et al. (2019), did a similar investigation, that prefabricated building construction structural performance data is limited when compared to traditional structures such as steel, concrete, and timber-frames. Modular structures, on the other hand, can be earthquake resistant if properly designed. Load sharing and transfer in prefabricated building systems may be complicated and impacted by installation tolerances. The influence of installation eccentricities and manufacturing tolerances, second-order effects due to sway stability, mechanism of force transfer of horizontal loads, robustness to accidental actions, and minimum horizontal force in any tie between modules are all important factors to consider in the design of modular buildings. Many countries, including Australia, have adopted performance-based design approaches, and standards such as AS 1170.2, AS 1170.4, AS 1530.4, AS 5113, and the National

Construction Code are used to ensure the stability of modular buildings under natural and manmade loads, including earthquakes.

- *Barriers of Modular Construction*

According to Zurbrugg, H., (2021), the distance between the facility and the location and size of the modular components makes transportation and handling modular parts problematic. Mishandling, carelessness, and accidents can all lead to module damage. Distribution needs a receiving location within a 10-mile radius, allowing installers to supervise the perfect travel to the project site and assure a seamless and speedy installation. Satellite Shelters, Inc. (2021), job site accessibility for equipment requires space and authorization to operate, and some building sites near heavily populated business areas may not be ideal for modular construction.

Moreover, Satellite Shelters, Inc. (2021), government licenses and zoning laws may be unfriendly to modular building. Meanwhile Zurbrugg (2021), instructed clients that during the early planning phase, consultation with modular building supplier is a must to determine if modular construction is the right alternative. Modular buildings are mass-produced, have a consistent form, style, shape, and design, and are not user-specific. This hindrance, if it exists, may be rapidly overcome with a good attitude and a desire to engage with officials. Off-site building encompasses a wide range of methods, from pre-cast wall panels to structural systems to completely functional structures. There is presently a need on large population centers to create thousands of low-cost, secure, and modern housing units in every media. In accordance to the research of Paliwal, S. (2019), the five most common impediments in utilizing modular systems in Las Vegas were contractor capability/leadership/experience, construction program, owner proclivity, transportation/logistics, and distance from factory to site. In Las Vegas, the barrier of urban site was ranked top, whereas in Hong Kong, it was placed second. The site laydown area was judged as ample, tight, acceptable, or inadequate by survey respondents. Concerns about quality, funding, and insurance were the least recognized hurdles. Figure 1.4 illustrates a thorough analysis of the acknowledged obstacles to modular building in Las Vegas.

Rank	Barrier	Score
1	Contractor Capability/Leadership/Experience	2.65
2	Program of the building	2.65
3	Owner Tendency	2.64
4	Transportation/Logistics	2.61
5	Distance from factory to site	2.58
6	Industry Knowledge	2.55
7	A/E's Tendency	2.52
8	Cost vs. Value	2.52
9	Fabricator Capability/Leadership/Experience	2.51
10	Regulations + Codes + Approval from Authorities	2.48
11	Design + Construction Culture	2.43
12	Supply Chain + Procurement	2.41
13	Labor Union	2.39
14	Design Freeze	2.29
15	Coordination	2.29
16	Urban Site (Site Access and on-site storage area)	2.1
17	Initial Investment	2.1
18	Manufacturing Technology	1.97
19	Site Operations	1.97
20	Concern for Quality	1.92
21	Financing + Insurance	1.77

Figure 1.4 Barriers

Trade coordination, Building Information Modeling (BIM), lack of information, quality of construction, cost, coordination, knowledge, limited local suppliers, trade perception of the pre-fab, jurisdiction acceptance and code compliance, fabrication facilities carries the correct certifications for local building officials while labor mindset, and the cost of locking in a subcontractor before design are the barriers in implementing modular construction in Las Vegas. Building codes in Las Vegas are tighter than in other areas of the country, and typical design evolution in Las Vegas follows a linear path from core/shell to finish trades. Modular building components, such as pre-fab bathrooms, need more comprehensive design and ownership choices on finishing and amenities be made early on and are not subject to change (Paliwal, S. 2019).

Sr. No	Disadvantages of Prefabrication	AII Score	Rank
1	Higher initial construction cost	3.25	1
2	Strict & difficult design changes	3.12	2
3	Time consuming in initial design	2.91	3
4	Leakage problem while joining prefabricated components	2.87	4
5	Lack of availability of prefabricated industries	2.85	5
6	Lack of skilled labour	2.85	5
7	Lack & expensive equipment	2.83	6
8	Limited site space	2.78	7
9	Lack of materials used in prefabrication	2.75	8
10	Fewer demand by clients	2.67	9
11	Government legislations and Guidelines	2.66	10
12	Transport requirements and may limit its scope	2.62	11
13	Limited trained labour	2.62	11
14	Lack of experiences	2.55	12
15	Increased production volume is required to ensure affordability through prefabrication	2.45	13
16	New process and unfamiliarity of process	2.45	13

Figure 1.5 Ranking of Prefabrication Disadvantages

Based on the collected data of Kharo et al. (2019), when used to building construction projects, prefabrication offers both advantages and disadvantages. Figure 1.5 displays the replies to the disadvantages (barriers) of using prefabrication.

Higher beginning cost and Tight & difficult design adjustments rank top and second, with average mean values of 3.25 and 3.12, respectively. When the prefabricated components are built early in the process, changing the design of the project in the future is rigid and costly. Moreover, time consuming in original design and leakage concerns while assembling prefabricated components are the third and fourth factors, respectively, as illustrated.

- *Adoption to Modular Construction*

According to a case study done in Malaysian Construction Industry (2016), the main crucial elements in this study are that shipping containers are the most ideal option or material to be utilized for modular building. The shipping container is primarily a material or solution to modular building since it meets the main criteria of modular construction, which is a three-dimensional unit with added value elements on strength and endurance. The disadvantage of utilizing a shipping container for modular building or construction is that it is prefabricated and has a fixed standard size, such as 20'x8'x81/2'.

The second issue is heat, because shipping containers are composed of steel, it absorbs heat, and living in a shipping container without any active or passive cooling system can bring discomfort to the occupants in tropical or hot temperature places. The third issue is the majority of renovated shipping containers for building are used or secondhand, and the items transported in the containers may be toxic to any human or living things. Malaysia lacks the expertise, technology, and experience to build a modular unit, but it can produce cabins that meet the main characteristic of modular construction.

In addition, study analyzes the Philippines' housing problems, such as homelessness and a shortage of affordable homes. It outlines modular building and shows how it is a more cost-effective and long-lasting alternative to traditional construction. There are two types of modular buildings introduced: permanent modular construction and relocatable constructions. Muhamad et al.'s research reveals various benefits of modular construction, including increased productivity, cost savings, and greater quality control.

1.3 Statement of the Problem

This study aims to answer the following questions:

- Are the construction companies aware of what is modular construction?

- Among the established barriers on the adoption of modular construction, which is the most significant?
- Considering the different barriers and challenges, is the construction company willing to adopt modular construction for housing projects instead of traditional construction?
- Which construction method is more cost-effective, modular or traditional?

1.4 Objectives of the Study

General Objective:

Generally, the aim of this study is to introduce the modular construction and assess the constructions companies regarding the adoption of this method as an alternative to conventional method for housing challenges.

Specific Objective:

- To determine the current level of awareness of modular construction among construction companies.
- To identify the most significant barriers in the adoption of modular construction.
- To assess the level of interest and willingness of construction companies to adopt modular construction for housing projects despite the barriers and challenges associated with using modular construction as an alternative to traditional construction.
- To compare the modular and traditional construction in terms of cost-effectiveness.

1.5 Significance of the Study

This study is significant to the following sectors:

Construction Industry

This study will lead to new ideas for the construction industry in terms of building a faster and high-quality structures that can help to mitigate the housing challenges. It can also help those in the construction industry to understand and have an idea about the fundamentals of modular construction.

City of San Fernando

The results of this study is beneficial to the community. The locality can adopt and apply modular construction to further improve, grow and make the community more competent.

School

The results of this study will aid Don Honorio Ventura State University and will serve as the basis for future studies of a similar nature. It can be an additional piece of information that will help the students especially Civil Engineering students and faculty to expand their knowledge about this research.

Future Researchers

This study will serve as the foundation and literature for future studies that will be related to Modular Construction. This can also deepen their knowledge and expand their information about modular construction.

1.6 Scope and Limitation

This study is focused on assessing construction companies about modular construction as an alternative for traditional construction for housing challenges. The assessment includes the awareness and understanding of the construction company with regards to modular construction. The proponents decides to assess the willingness of construction companies regarding the adoption of modular construction as a solution for housing crisis. This research was conducted around the City of San Fernando, Pampanga and it was delimited to construction companies around the vicinity. The study also focuses on the problems and challenges on adopting modular construction. The study is delimited to determining which of the two construction methods is more cost-effective and has better overall benefits and to a cost analysis between a residential modular building and a residential one-story building.

1.7 Conceptual Framework

Phase	Procedure	Product
Qualitative Data Collection	Data gathering from RRL's	Text and image data
Qualitative Data Analysis	Data screening Cost Comparison	Descriptive results from cost comparison
Survey Questionnaire	Purposefully selecting 1 participant from each company Validating the questionnaire from inline experts	Validated questionnaires
	Conducting f2f survey to the selected construction companies	Numeric Data
Quantitative Data Collection	Percentage and mean Relative Importance Index (RII)	Descriptive statistics Ranking of the most significant barriers
Quantitative Data Analysis	Interpretation and explanation of the qualitative and quantitative results	Discussion Implications Future research
Integration of the Qualitative and Quantitative		

1.8 Definition of Terms

Controlled environment. In this paper, it refers to the factory where the modules are built.

Housing challenges. This term refers to the problems that arises in the housing sector, and serves as a variable of this research.

Modular construction. Modular construction is a building method in which a building is constructed using pre-fabricated units, or modules, that are manufactured off-site in a factory setting, transported to the building site, and assembled on-site. In this paper, it refers as the main topic and one of the variables.

Traditional Construction. In this study, this term serves as one the variable and main topic.

Prefabrication. In this paper, it refers to the manufacturing in sections to enable the assembly of the modular units on site.

Stakeholders. It refers to the individuals or group that has an interest in the business venture of the construction companies in this study.

II. METHODOLOGY

This chapter presents the research procedures used in the study. It describes the design of the study, the respondents of the study, the instrument used, the sampling method, the data gathering procedure, and the statistical treatment employed in the analysis of data.

2.1 Research Design

This study uses mixed methods design to assess the construction companies regarding the adoption of modular construction as an alternative to traditional construction for housing challenges. This research utilizes Convergent Parallel Design to combine the qualitative and quantitative data that were collected from the respondents. This design helps the proponents to analyze the gathered data separately and interpret the results in an organized manner.

2.2 Respondents of the Study

The City of San Fernando has 188 registered construction companies based on the list granted by its municipality. The researchers used convenience sampling in selecting the respondents from the construction companies. The sampling method was adopted in order to acquire the necessary number of respondents imperative to the study in accordance with the respondent's availability. The determination for the total number of respondents or the sample size was based on the total number of the target population.

The research respondents were conveniently selected among the employees to gather essential information and insights regarding their understanding, and perception of modular construction as a solution to housing challenges in the Philippines. The data collected, was analyzed and evaluated to determine their level of familiarity and willingness to adopt modular construction as an alternative to traditional construction.

2.2.1 Sampling Method

In selecting the respondents, the primary step of the researchers is to randomly select construction companies within the vicinity of City of San Fernando, Pampanga. After that, researchers used convenience sampling to choose the participants for the survey. The criteria on selecting the respondents are the Civil Engineers, Project Managers, Architects, and Designers of the company.

Using Cochran's sample size determination for infinite population, this formula was used.

$$n_O = \frac{1}{4}\left(\frac{Z}{e}\right)^2$$

Where:

e = margin of error= 10.00%

Z= z-score corresponding to 90% confidence level= 1.645

Cochran's sample size determination for finite population

$$n = \frac{n_O}{1+\frac{(n_O-1)}{N}}.$$

Raosoft's sample size calculator was utilized by the researchers to verify the results gained by using Cochran's Formula in determining the total sample size of the study.

Out of the 188 registered construction companies, 50 companies were determined as the sample size using Cochran's Formula and Raosoft's sample size calculator, with one respondent each as the representative of their respective companies.

2.3 Research Instrument

The research consists of two instruments: the Printed Questionnaire and Related Literature. The first part of the printed questionnaire gathered the profile of the respondents. The second part is composed of questions prepared and formulated by the respondents with relation to the awareness of construction companies regarding modular construction. The third part lists down the barriers adopted from a study entitled "Opportunities and Challenges of Modular Construction in a Hospitality Centric Environment" by Shreyansh Paliwal, which was used to determine the significance of each barrier. And the fourth part is concerned with the assessment on the willingness of the construction companies to adopt modular construction despite the barriers presented in the questionnaire, which was referenced to a study by Wajiha Mohsin Shahzad entitled "Off-site Manufacturing as a Means of Improving Productivity in New Zealand Construction Industry: Key Barriers to Adopt and Improvement Measures". This study also required a Review of Related Literature as its second instrument to collect information about the market price of residential housing for both modular and traditional construction.

The questionnaire which aims to extract information on the construction companies, was reviewed and validated by a line of professionals: one statistician, one engineer from the construction field, and one expert on modular construction.

2.4 Data Collection Method

The researchers collected information regarding the use of modular construction as an alternative to traditional construction for housing challenges using a written questionnaire that was distributed to the selected representative from the construction companies in the City of San Fernando, Pampanga. The questionnaire was evaluated by experts to assure their reliability and accuracy, which provides credibility and support to the research and its findings. After the data collection, the researchers tallied the information and applied the required statistical procedures to analyze and assess the findings. The statistical analysis supports the presentation of the data in an accurate and relevant manner, as well as give insights into the construction businesses' experiences and perspectives towards the adoption of modular construction. Other data and information were also gathered from various related literature regarding the costs and overall benefits for both modular and traditional construction.

2.5 Data Analysis Method

The entirety of this study utilized both the quantitative and qualitative approach. Quantitative approach was used to analyze the data gathered from the survey questionnaires answered by the respondents of this study, while qualitative approach was used to describe the information gathered from the related literature. Statistical analysis was also used by the proponents to present and further describe the gathered data. Gathered data from the survey were focused on the determination of the construction companies' level of awareness and understanding about the modular construction. In addition, it also included the companies' willingness to adopt modular construction as an alternative to conventional construction for housing challenges. Data gathered from the related literature focused on the cost for the modular and traditional residential building, and which of the method is more cost-effective in the study's goal.

2.5.1 Statistical Treatment

The information acquired is crucial in reaching the right decision. At the conclusion of this treatment, researchers aimed for a productive inquiry. In order to evaluate the profile of the respondents in terms of positions, and years of experience, researchers utilized the formula of frequency % distribution for the first part of the questionnaire, and the formula is presented below:

2.5.1.1 Percentage and Mean

To determine how many construction companies are aware about modular construction, the proponents used percentage and frequency distribution and mean. The formula is given below:

- *Percentage* Formula:

$$P = \frac{f}{N} \; x \; 100$$

Where:
P = Percentage
F = Frequency
N = Number of Respondents

- *Mean*Formula:

$$\text{mean} = \frac{No.\ of\ the\ comapnies\ that\ are\ aware}{Number\ of\ all\ selected\ companies}$$

2.5.1.3 Relative Importance Index (RII)

Relative Importance Index was to the relative importance of the various barriers in the adoption of Modular Construction. The four-point scale importance indices (RII) for each factor as follows:

RII = ΣW / (A*N)

Where, W is the weighting given to each factor by the respondents (ranging from 1 to 4), A is the highest weight (i.e., 4 in this case), and N is the total number of respondents. Higher the value of RII, more significant the barrier is.

2.5.2 Cost Comparison

This cost comparison served as one of the supporting literatures for the results of the study. The goal of this cost comparison is to identify the most cost-effective option without compromising quality or performance between modular and conventional construction. In this comparison, researchers only considered the total cost of a building per square meter for both modular and traditional building. A three-bedroom house with a total floor space of 272 m^2 with its total cost was used as the reference for the traditional. In contrast, modular unit of approximate 18 m^2 with its total cost from Zhong Jian Steel Structure Co. Ltd. was utilized for the modular construction. Both sample projects for modular and traditional is a single-story residential building and the comparison focuses on the materials.

III. RESULTS AND DISCUSSION

This part of the paper shows the results gathered from the questionnaire that was disseminated throughout various construction companies in the City of San Fernando, Pampanga, and the interpretations of the said results. A total of 67 responses were collected out of the 188 registered construction companies, which was presented through charts and tables.

3.1 Socio-demographic Profile

This part of the paper determines the socio-demographic profile of the respondents from the construction companies in the City of San Fernando, Pampanga, particularly their position, and to investigate how this factor influence in the adoption of modular construction as an alternative to traditional construction for housing challenges. Out of the 188 registered construction companies, 67 of them were chosen to participate in the study, with one representative for each and differing job descriptions (i.e. Engineers, Architects, Project Managers, and Designers).

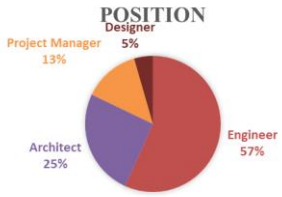

Figure 3.1 Position of the Respondents

Figure 3.1 shows engineer was the most favored occupation among the respondents, accounting has 38 responses (57% of the total). With 14 replies or 25%, architect was the second most popular pick. Project Manager was chosen by 9 respondents (13%), whereas Designer was chosen by just 3 respondents (5%).

3.2 Assessment on the Awareness of Modular Construction

Figure 3.2 under "Process" 33% (22) respondents answered that they are strongly aware, 54% (36) respondents answered that they are aware, 7% (5) respondents answered that they are not aware and 6% (4) respondents answered that they are strongly not aware. Most of the respondents answered aware with about 54% of 67 respondents.

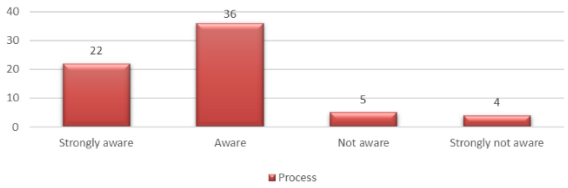

Figure 3.2 Process

Figure 3.3 under "Duration of Construction" 36% (24) respondents answered that they're strongly aware, 61% (41) respondents answered that they're aware, 3% (2) respondents answered that they're not aware and no respondent answer strongly not aware. Most of the respondents answered aware with about 61% of 67 respondents.

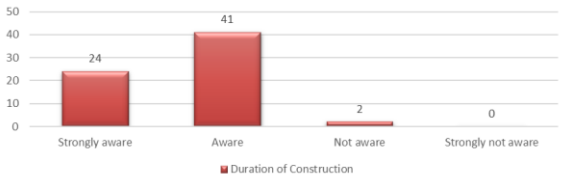

Figure 3.3 Duration of Construction

Figure 3.4 under "Budget" 31% (21) respondents answered that they're strongly aware, 54% (36) respondents answered that they're aware, 15% (10) respondents answered that they're not aware and no respondent answer strongly not aware. Most of the respondents answered aware with about 54% of 67 respondents.

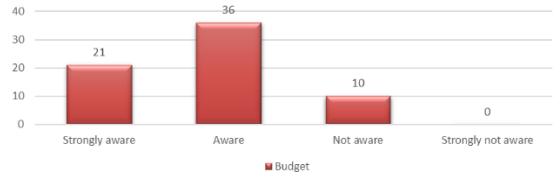

Figure 3.4 Budget

Figure 3.5 under "Safety" 39% (26) respondents answered that they're strongly aware, 42% (28) respondents answered that they're aware, 18% (12) respondents answered that they're not aware and 1% (1) respondent answer strongly not aware. Most of the respondents answered aware with about 42% of 67 respondents.

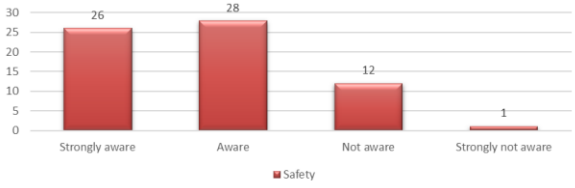

Figure 3.5 Safety

Figure 3.6 under "Vulnerability to Bad Weather" 36% (24) respondents answered that they're strongly aware, 48% (32) respondents answered that they're aware, 16% (11) respondents answered that they're not aware and no respondent answer strongly not aware. Most of the respondents answered aware with about 48% of 67 respondents.

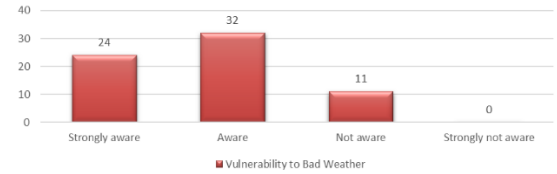

Figure 3.6 Vulnerability to Bad Weather

Figure 3.7 under "Quality" 26% (17) respondents answered that they're strongly aware, 59% (39) respondents answered that they're aware, 15% (10) respondents answered that they're not aware and 1 respondent answer strongly not aware. Most of the respondents answered aware with about 59% of 67 respondents

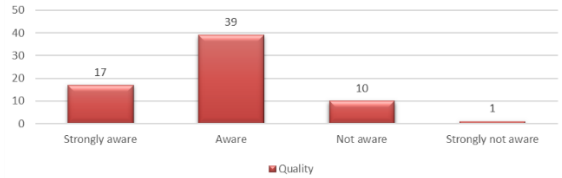

Figure 3.7 Quality

Figure 3.8 under "Environmentally Friendly" 29% (19) respondents answered that they're strongly aware, 58% (39) respondents answered that they're aware, 13% (9) respondents answered that they're not aware and no respondent answer strongly not aware. Most of the respondents answered aware with about 58% of 67 respondents.

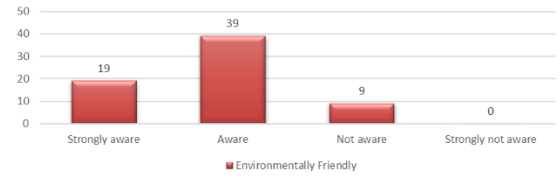

Figure 3.8 Environmentally Friendly

Figure 3.9 under "Community Friendly" 32% (21) respondents answered that they're strongly aware, 53% (35) respondents answered that they're aware, 15% (10) respondents answered that they're not aware

and 1 respondent answer strongly not aware. Most of the respondents answered aware with about 53% of 67 respondents.

Figure 3.9 Community Friendly

Figure 10 under “Noise Reduction” 36% (24) respondents answered that they’re strongly aware, 39% (26) respondents answered that they’re aware, 23% (15) respondents answered that they’re not aware and 2% (1) respondent answer strongly not aware. Most of the respondents answered aware with about 39% of 67 respondents.

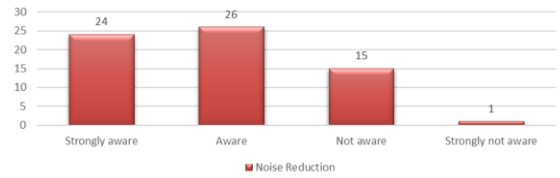

Figure 3.10 Noise Reduction

Figure 3.11 under “Late Changes to Design” 33% (22) respondents answered that they’re strongly aware, 50% (33) respondents answered that they’re aware, 15% (10) respondents answered that they’re not aware and 2% (1) respondent answer strongly not aware. Most of the respondents answered aware with about 49% of 67 respondents.

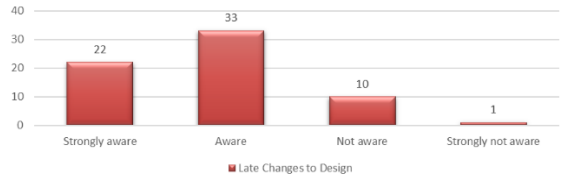

Figure 3.11 Late Changes to Design

Table 3.1 presents the respondents' level of awareness on various aspects of modular construction. The mean scores for all items were above 3, indicating that the respondents were generally aware of what modular construction is. The grand mean score was 3.17, which also falls under the "aware" category.

	Mean	Interpretation
Process	3.27	Aware
Duration of construction	3.33	Aware
Budget	3.16	Aware
Safety	3.18	Aware
Vulnerability to bad weather	3.19	Aware
Quality	3.06	Aware
Environmentally friendly	3.16	Aware
Community friendly	3.13	Aware
Noise reduction	3.07	Aware
Late changes to design	3.15	Aware
Grand Mean:	3.17	Aware

Table 3.1 Mean Score of the various aspects of modular construction

Legend:

3.51 – 4.00	-	Strongly Aware
2.51 – 3.50	-	Aware
2.50 – 1.51	-	Not Aware
1.00 – 1.50	-	Strongly Not Aware

3.3 Identification of the Most Significant Barriers in the Adoption of Modular Construction

Figure 3.12 shows the responses of the respondents about the identification of the most significant barriers. A total of 67 responses were recorded and analyzed to identify the most significant barriers.

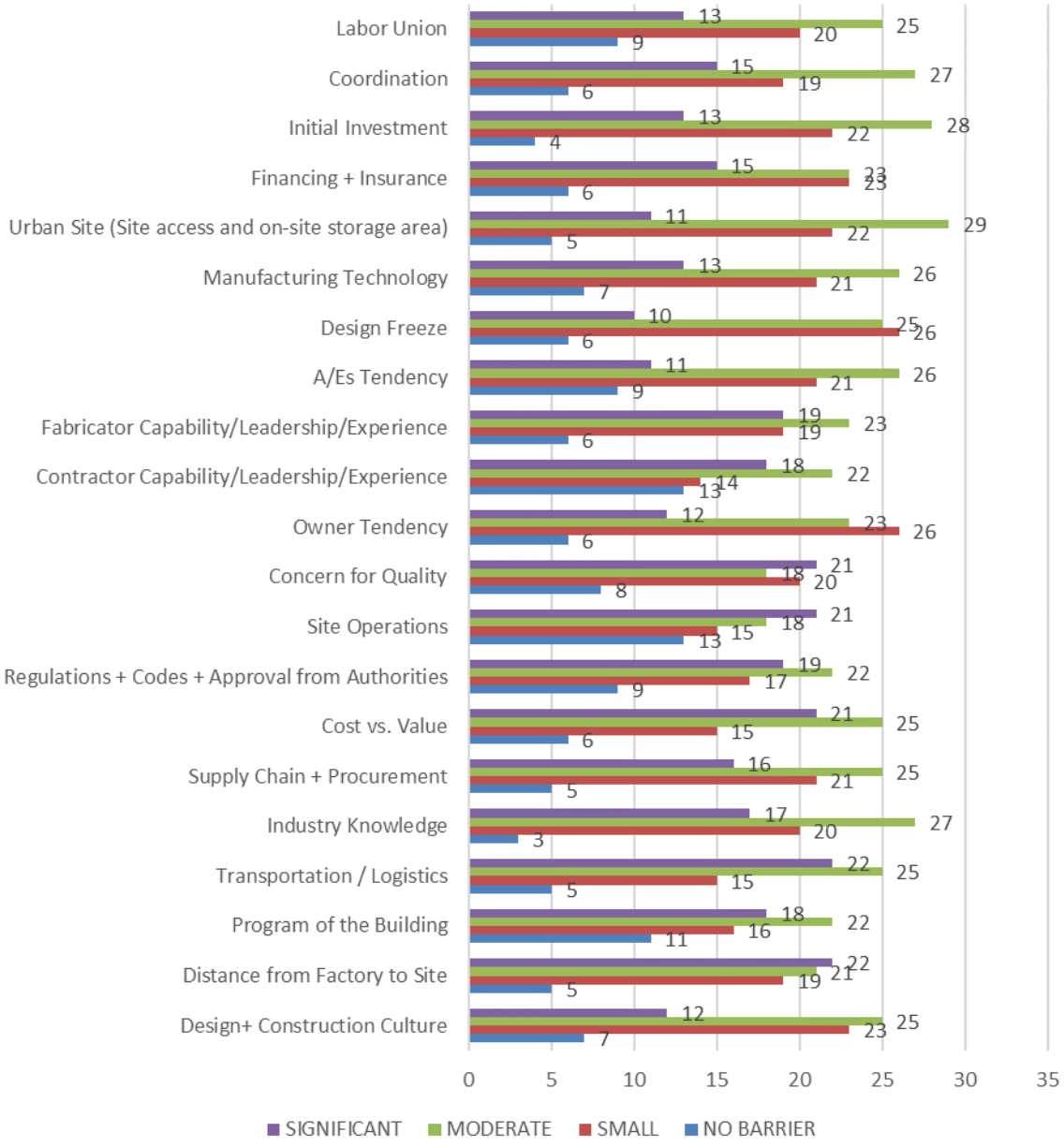

Figure 3.12 Most Significant Barriers

The research's results indicate the barriers to modular building adoption in the City of San Fernando, Pampanga. To measure the relative relevance of the different barriers, the study employed the Relative Importance Index (RII).

Barriers	RII	Ranking
Design+ Construction Culture	0.657	
Distance from Factory to Site	0.724	3rd
Program of the Building	0.675	
Transportation / Logistics	0.739	1st
Industry Knowledge	0.716	
Supply Chain + Procurement	0.694	
Cost vs. Value	0.728	2nd
Regulations + Codes + Approval from Authorities	0.690	
Site Operations	0.675	
Concern for Quality	0.694	
Owner Tendency	0.653	
Contractor Capability/Leadership/Experience	0.668	
Fabricator Capability/Leadership/Experience	0.705	
A/Es Tendency	0.646	
Design Freeze	0.646	
Manufacturing Technology	0.668	
Urban Site (Site access and on-site storage area)	0.672	
Financing + Insurance	0.675	
Initial Investment	0.687	
Coordination	0.690	
Labor Union	0.657	

Table 3.2 Relative Importance Index of the Established Barriers

Based on the findings, the most significant barrier is Transportation/Logistics, with an RII of 0.739, followed by Cost vs. Value, with a RII of 0.728, and Distance from Factory Site, with a RII of 0.724. The least significant barriers were, Owner Tendency with an RII value of 0.653, followed by A/Es Tendency and Design Freeze, both of which scored an RII value of 0.6456. The remaining barriers fall in between RII values ranging from 0.657 to 0.716. The findings of this study might help construction businesses in San Fernando, Pampanga, and other areas encountering similar obstacles in the adoption of modular building. Companies can boost the possibility of successful adoption of modular building as an alternative to traditional construction for housing challenges by addressing the significant barriers.

Listed below are the three most significant established barriers:

- *Transportation/Logistics*

The results show that 22 (32.84%) of the respondents find transportation/logistics as a significant barrier, 25 (37.31%) of the respondents answered moderate, 15 (22.39%) answered small, and the remaining 5 (7.46%) respondents answered no barrier. With an RII score of 0.739, transportation/logistics were identified as the biggest obstacle to the adoption of modular building.

Transportation/Logistics was identified as the most significant barrier due to the City of San Fernando's transportation problems. According to Arcellaz (2022), during rush hours, key highways such as the McArthur Highway, Jose Abad Santos Avenue, and Capital Boulevard face significant traffic congestion. Mayor Vilma Caluag stated that the local government has already taken many steps to solve the issue, that is by opening alternate routes to amend traffic congestions using private subdivision roads. The local government's efforts, however, are hardly felt due to a succession of road projects undertaken throughout the city, according to Caluag.

- *Cost vs. Value*

21 (31.34%) of the respondents answered significant, 25 (37.31%) of the respondents answered moderate, 15 (22.39%) regards cost vs. value as a small barrier, and a small number of the respondents answered no barrier numbered 6 (8.96%). Cost vs. Value came in second with an RII score of 0.728.

Cost vs. Value resulted as one of the most significant barriers in modular construction, this may be due to the people's doubt about whether or not a modular construction's value is worth its cost. As discussed by Salama et al (2018), there is a negative connotation associated with modular construction; this is due to the misconception that modular construction is only meant for temporary, single-story applications.

- *Distance from Factory to Site*

Regarding the distance from factory to site, 22 (32.84%) out of 67 respondents identifies it as a significant barrier, 21 (31.34%) of the respondents answered moderate, 19 (28.36%) regards it as a small barrier, while 5 (7.46%) answered no barrier. With an RII score of 0.724 came as the third most significant barrier.

This barrier became one of the key barriers in adopting modular construction, quite possibly caused by the limited number of modular suppliers in the City of San

Fernando, making the geographical distance between the factory and site more extensive, which results in the laborious delivering of modular units.

Listed below are the three least significant established barriers:

- *Owner Tendency*

Out of 67 responses, 12 (17.91%), respondents answered significant, 23 (34.33%) of the responses went to moderate, 26 (38.81%) answered small, while the remaining 6 (8.96%) went to no barrier. With an RII value of 0.653, owner tendency was identified as the least significant barrier.

The RII value of 0.6530 indicates that Owner Tendency has a very minor influence on the total barriers to the project. Owner Tendency refers to the project owner's preferences, inclinations, or decisions that may interfere with or delay the project. A lower RII score implies that, while it may be a factor, it is not as significant as other barriers in the study's findings. This might be because the project owner's preferences are more aligned with the project objectives, or there is excellent collaboration and communication between the owner and the project team.

- *A/E's Tendency*

11 (16.42%) of the respondents answered significant, 26 (38.81%) answered moderate, 21 (31.34%) identified A/E's tendency as a small barrier, and 9 (13.43%) of the respondents answered no barrier. With an RII value of 0.646, it suggests that the impact of A/Es Tendency on the barrier is relatively lower.

A/Es (Architects/Engineers) Tendency refers to the preferences or inclinations of the design professionals involved in the project. A combination of effective coordination and collaboration between the architects, engineers, and other project stakeholders, the A/Es Tendency is relatively lower, resulting in a smoother design process with fewer conflicts or delays caused by individual tendencies.

- *Design Freeze*

Under design freeze, 10 (14.93%) of the respondents consider the barrier as significant, 25 (37.31%) of the respondents identified it as a moderate barrier, 26 (38.81%) of the respondents answered small, and 6 (8.96%) of the respondents regards it as no barrier.

The term "Design Freeze" refers to the moment in a project where the design has been finalized and no more alterations are permitted. Although it scored an RII value of 0.646, indicating a relatively lower significance, this might be due to the well-managed and implemented design freeze procedure in the project. Effective communication, careful planning, and strong change management practices may have reduced the negative impact of design modifications or revisions that might have delayed the project.

3.4 Assessment on the Willingness to Adopt Modular Construction Despite the Barriers

Figure 3.13 under "Process and Programme",76% (51) respondents answered yes, and 24% (17) respondents answered no, in the use of modular construction limits the possibility of changes and alterations in the later stages of the construction. Most of the respondents answered yes with about 76% of 67 respondents. In the statement of time in the design phase respondents has an equal answer for yes and no.

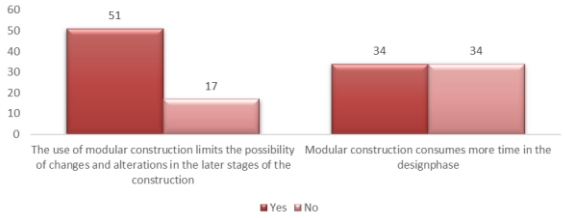

Figure 3.13 Process and Programme

Figure 3.14 under "Cost/Value/Productivity", 72% (48) of the respondents answered yes and 28% (19) of the respondents answered no. Most of the respondents answered yes with about 72% of 67 respondents. Under Figure 2.3 and 2.4, 85% (57) of the respondents answered yes and 10 of the respondents answered no. Most of the respondents answered yes with about 85% of 67 respondents.

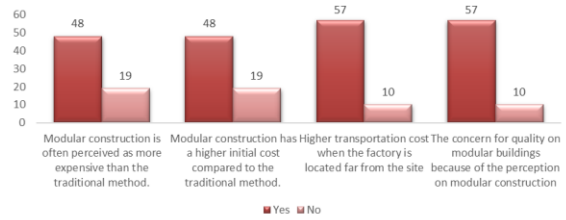

Figure 3.14 Cost/Value/Productivity

Figure 3.15 under "Regulatory", 93% (62) of the respondents answered yes and 7% (5) of the respondents answered no. Most of the respondents answered yes with about 93% of 67 respondents. For figure 3.2, 86% (58) of the respondents answered yes and 14% (9) of the respondents answered no. Most of the respondents answered yes with about 86% of 67 respondents.

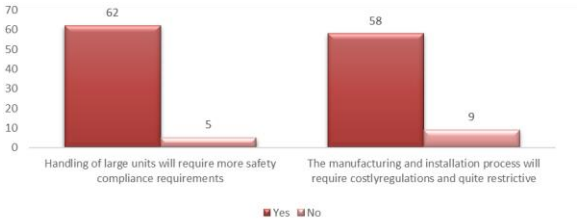

Figure 3.15 Regulatory

Figure 3.16 under "Industry/Market Culture", 53% (35) of the respondents answered yes and 47% (33) of the respondents answered no. Most of the respondents answered yes with about 52% of 67 respondents. For figure 4.2, 63% (42) of the respondents answered yes and 37% (25) of the respondents answered no. Most of the respondents answered yes with about 63% of 67 respondents.

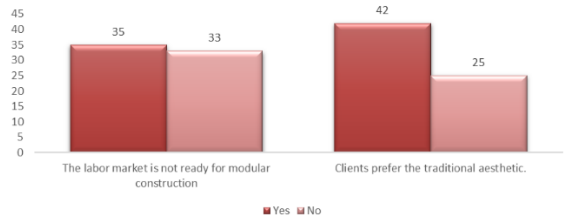

Figure 3.16 Industry/Market Culture

Figure 3.17 under "Supply Chain & Procurement", 82% (55) of the respondents answered yes and 18% (12) of the respondents answered no. Most of the respondents answered yes with about 82% out of 67 respondents. Under Figure 5.2, 67% (45) of the respondents answered yes and 33% (22) of the respondents answered no. Most of the respondents answered yes with about 67% of 67 respondents. Under Figure 5.3, 50 of the respondents answered yes and 18 of the respondents answered no. Most of the respondents answered yes with about 75% of 67 respondents.

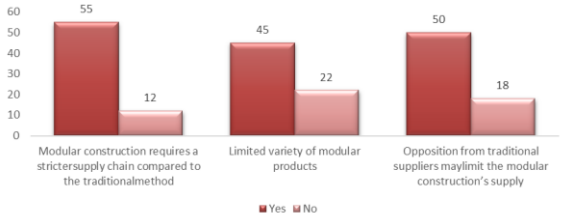

Figure 3.17 Supply Chain & Procurement

Figure 3.18 under "Skill & Shortage", 78% (52) of the respondents answered yes and 22% (17) of the respondents answered no. Most of the respondents answered yes with about 78% of 67 respondents. 73% (49) of the respondents answered yes and 27% (19) of the respondents answered no. Most of the respondents answered yes with about 73% of 67 respondents. 82% (55) of the respondents answered yes and 18% (12) of the respondents answered no. Most of the respondents answered yes with about 82% of 67 respondents. Under Figure 6.4, 73% (49) of the respondents answered yes and 17% (18) of the respondents answered no. Most of the respondents answered yes with about 73% of 67 respondents. 72% (48) of the respondents answered yes and 18% (21) of the respondents answered no. Most of the respondents answered yes with about 72% of 67 respondents.

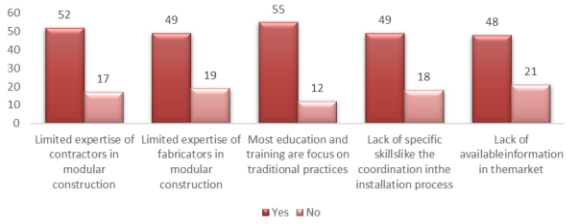

Figure 3.18 Skill & Shortage

Figure 3.19 under "Logistics & Site Operations", 79% (53) of the respondents answered yes and 21% (14) of the respondents answered no. Most of the respondents answered yes with about 79% of 67 respondents. Under Figure 7.2, 78% (52) of the

respondents answered yes and 22% (15) of the respondents answered no. Most of the respondents answered yes with about 78% of 67 respondents. Under Figure 7.3, 85% (57) of the respondents answered yes and 15% (10) of the respondents answered no. Most of the respondents answered yes with about 85% of 67 respondents. Under Figure 7.4, 76% (51) of the respondents answered yes and 14% (16) of the respondents answered no. Most of the respondents answered yes with about 76% of 67 respondents.

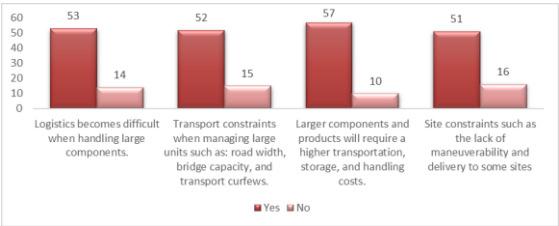

Figure 3.19 Logistics & Site Operations

Based on the figures 3.13 to 3.19, the data shows "yes" as the governing answer of the respondents, which indicates that the construction companies are willing to adopt modular construction as an alternative to traditional construction despite the different scenarios presented. This may be due to the fact that under these the fast-tracked nature of modular construction is able to keep up with the demand in housing despite having obvious downsides and challenges, followed by modular construction's ability to provide a safer housing alternative, including its capability to reduce site costs and delays, increased productivity and consistent quality, makes it a possible alternative to traditional construction (Buro Happold 2020). Furthermore RealProjectives (2019) states that producing the modules in a controlled environment, concerns about the weather delaying modular unit production are completely avoided. Building the modules at a factory allows construction sites to be cleaner and safer, while also providing more space to work and move around freely. Labor savings can vary greatly, but there is the possibility for up to a 25% reduction in construction expenses, allowing those highly skilled personnel to remain in stable sites with controlled and safer circumstances. And with the environment becoming a significant issue in the building sector, modular construction becomes a solution to reduce waste on each project and good alternative for traditional construction.

Barriers	Yes		No		Both		Total
	F	%	F	%	F	%	
Process and Programmed							
Statement 1							
Statement 2	50	74.63%	16	23.88%	1	1.49%	100%
	33	49.25%	33	49.25%	1	1.49%	100%
Total:	41.50	61.94%	24.50	36.67%	1	1.49%	100%
Cost/Value/Productivity							
Statement 1	48	71.64%	19	28.36%	0	0%	100%
Statement 2	48	71.64%	19	28.36%	0	0%	100%
Statement 3	57	85.07%	10	14.93%	0	0%	100%
Statement 4	57	85.07%	10	14.93%	0	0%	100%
Total:	52.50	78.36%	14.50	21.64%	0	0%	100%
Regulatory							
Statement 1	62	92.54%	5	7.46%	0	0%	100%
Statement 2	58	86.57%	9	13.43%	0	0%	100%
Total:	60	89.55%	7	10.45%	0	0%	100%
Industry/Market Culture							
Statement 1	34	50.75%	32	47.76%	1	1.49%	100%
Statement 2	42	62.69%	25	37.31%	0	0%	100%
Total:	38	56.72%	28.50	42.54%	0.5	0.75%	100%
Supply Chain and Procurement							

Statement 1							
Statement 2	55	82.09%	12	17.91%	0	0%	100%
Statement 3	45	67.16%	22	32.84%	0	0%	100%
	49	73.13%	17	25.37%	1	1.49%	100%
Total:	49.67	74.13%	17	25.37%	0.5	0.75%	100%
Skill and Shortage							
Statement 1	50	74.63%	15	22.39%	2	2.99%	100%
Statement 2	48	71.64%	18	26.87%	1	1.49%	100%
Statement 3	55	82.09%	12	17.91%	0	0%	100%
Statement 4	49	73.13%	18	26.87%	0	0%	100%
Statement 5	46	68.66%	19	28.36%	2	2.99%	100%
Total	49.60	74.03%	16.40	24.48%	1	1.49%	100%
Logistics and Site Operations							
Statement 1							
Statement 2	53	79.10%	14	20.90%	0	0%	100%
Statement 3	52	77.61%	15	22.39%	0	0%	100%
Statement 4	57	85.07%	10	14.93%	0	0%	100%
	51	76.12%	16	23.88%	0	0%	100%
Total:	53.25	79.48%	13.75	20.52%	0	0%	100%

Table 3.3 Percentage of the Willingness to Adopt Modular Construction Despite the Barriers

3.5 Cost Comparison of Modular and Traditional Construction

According to Trading Economics (2022), on average, you must spend 23,000 php to 35,000 php per sq.m in building a standard house. The construction cost per sq.m depends on the location. Based on the list of estimated residential construction cost per sq.m of different regions updated on December, 2022, the cost of construction in Central Luzon is 27, 625.14 php per sq.m. Furthermore, as stated by Bueno, F. (2021) from Pinoy Builders, the cost per sq.m for a prefab house is only 10,000 php to 15,000 php.

NUMBER	TYPE	FLOOR AREA (m^2)	NUMBER OF FLOORS	OCCUPANCY CATEGORY	INCLUSIONS	TOTAL COST	ESTIMATED COST PER m^2
1	MODULAR BUILDING	18	1	RESIDENTIAL	PREFAB CONATINER TOILET AND BATH ROOM PARTITION FLOOR ENHANCEMENT BASIC ELECTRICAL	289,000	16,055.56
2	TRADITIONAL BUILDING	272	1	RESIDENTIAL	CONCRETE AND MASONRY WALLS CEILING FORMWORKS REINFORCEMENT STEEL BARS KITCHEN & TOILET FIXTURES ELECTRICAL WORKS LIGHTINGS PLUMBING WORKS SEPTIC TANK TILEWORKS ROOFING/TINSMITHRY TRUSSES DOORS WINDOWS	3,655,750	13,440.26

Table 3.4 Technical parameters of modular building and traditional building

	INCLUSIONS	Prices (php)
Modular Building	PREFAB CONATINER	170,000.00
	TOILET AND BATH	65,000.00
	ROOM PARTITION	33,000.00
	FLOOR ENHANCEMENT	10,000.00
	BASIC ELECTRICAL	11,000.00
Traditional Building	CONCRETE AND MASONRY WALLS	710,000.00
	CEILING	165,000.00
	FORMWORKS	60,000.00
	REINFORCEMENT STEEL BARS	379,750.00
	KITCHEN & TOILET FIXTURES	141,000.00
	ELECTRICAL WORKS	225,000.00
	LIGHTINGS	95,000.00
	PLUMBING WORKS	140,000.00
	SEPTIC TANK	25,000.00
	TILEWORKS	250,000.00
	ROOFING/TINSMITHRY	410,000.00
	TRUSSES	315,000.00
	DOORS	140,000.00
	WINDOWS	600,000.00

Table 3.5 Prices for each inclusion for both modular and traditional building

Based on the data of the modular unit, the prefab container itself with an approximate 18 m^2 has a total cost of 170,000 PHP. This modular building has many optional add-ons, but the main components of the container are: from frame it is made from wall panel steel sheet with a thickness of 0.4 mm; Sandwich wall panels are made from proper eps insulation with a density of 25 kg/m^3; the fire rating of the unit is A2; ceiling is made from PVC ceiling panels; flooring is 18 mm fireproof cement-mixed fiberglass floor boards; door is fire resistant steel door with European standard door lock and; 2 windows with 925x1200 mm PVC frame and a double layered glass. All add-ons are optional and each add-ons have different varieties: for the toilet and bath it includes here the toilet bowl, sink, shower and fiberglass flooring; room partition include sandwich panel partition with steel door; for the floor enhancement it is intended for joint containers and for continuous flooring placement; for the basic electrical each set includes 2 led, 2 outlets, 1 airconditioned outlet and 1 main breaker. To sum up, the total cost of purchasing a modular unit is 289,000.00 PHP and the estimated cost per sq.m is 16,055.56 PHP.

For the traditional building, a three-bedroom residence with a total floor area of 272m^2 has a total project cost of 3,655,750.00 PHP. This total cost includes all the: concrete and masonry walls; ceiling; formworks; reinforcement steel bars, kitchen and toilet fixtures, electrical works; lightings; plumbing works; tile works; roofing/ tinsmith; trusses; doors; windows.

In general, modular construction can be a more cost-effective option than traditional construction, especially for simpler building designs and projects with a tight timeframe. However, for more complex projects, traditional construction may offer more flexibility and customization options, which can be worth the extra cost. Based on the table 3.4, which gives the findings of the cost comparison of the two separate example projects, conventional construction is more cost-effective than modular construction, with an estimated cost per sq.m of Php 13,440.26. As stated by Shu Wang et al (2020), in terms of building structure, prefabricated structure cost higher than the traditional construction. In the decoration and installation engineering, prefabricated building is lower than the traditional construction. As a result, they are essentially flat when compared to traditional building engineering but the main cost difference between these two methods comes from precast concrete components

IV. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

4.1 Summary of Findings

The aim of this paper is to assess the construction companies in the City of San Fernando, Pampanga regarding the adoption of modular construction as an alternative to traditional construction for housing challenges, determine their level of awareness, and to compare the costs between the two methods.

In conducting the data collection process, the researchers employed the use of survey questionnaires and related literature to gather the necessary information from the respondents, and to achieve the objectives of this study. The analysis method for the gathered results required the use of the Frequency Distribution method, Relative Importance Index, the Analysis of Variance (ANOVA), and Cost-Comparative Analysis

Listed below are the major findings in the study in terms of:

- *Respondents' awareness regarding modular construction:*

Table 3.1 overviews the results gathered from the respondents corresponding to their level of awareness regarding modular construction. The mean scores of

the various aspects were all higher than 2.51 but lower than 3.50, and resulted in a grand mean of 3.17, which indicates that the construction companies were "aware" of modular construction.

- *Most significant established barriers according to the respondents:*

The researchers employed the use of Relative Importance Index to determine the most significant established barriers based on the gathered data. The responses were categorized in a four-point scale ranging from No Barrier (1) to Significant (4). Taking into account the findings in table 3.2, Transportation/Logistics was established as the most significant barrier in adopting modular construction with an RII score of 0.7388, closely followed by in second place was Cost vs. Value with an RII score of 0.7276, and in third place was the Distance from Factory to Site with an RII score of 0.7239.

- *Respondents' willingness to adopt modular construction:*

According to the data in tables 3.13-3.19, all of the construction companies are willing to adopt despite the situations listed at the last part of the questionnaire. This part of the questionnaire received an overwhelming response from the respondents, wherein all of the recorded responses were *yes* except for figure 3.13, wherein 67 responses from "Modular construction consumes more time in the design phase" was split in half.

- *Modular construction and traditional construction's effectiveness*:

Based on the findings, the researchers identified that traditional construction is more cost-effective than traditional construction with an estimated cost difference 2,615.30 pesos per sq.m. The estimated cost per sq.m for traditional is Php 16,0555.56 while for the modular is Php 13,440.26.

4.2 Conclusions

The assessment on construction companies in the City of San Fernando, Pampanga concluded that the respondents were indeed aware of modular construction, its process, its significant barriers. They are willing to adopt modular construction despite its numerous established barriers, and modular construction's overall benefits and cost-effectiveness.

On the basis of the study's findings, the following conclusions were made:

- The study shows that construction companies are aware of modular construction, with a grand mean of 3.17 indicating an average level of awareness.
- As per the results of the study, the most significant established barriers to adopting modular construction was identified as Transportation/Logistics with an RII score of 0.7388, followed by Cost vs. Value with an RII score of 0.7276, and Distance from Factory to Site with an RII score of 0.7239.
- Despite the identified barriers, all of the construction companies surveyed were willing to adopt modular construction for housing projects instead of traditional construction.
- Based on the findings, the researchers concluded that in terms of estimated cost per square meter, traditional construction is more cost-effective than modular construction.

4.3 Recommendations

The proponents of this study suggest the following:

- Expand the study's scope, the thesis paper focuses primarily on the use of modular building as an alternative to traditional construction for housing challenges. Future studies should explore a broader variety of construction projects, such as commercial or industrial structures, to solve the problems connected to the scope. This would give a more thorough knowledge on modular construction's possible benefits and constraints.
- Conduct a detailed cost analysis, while the budget was cited in the thesis paper as one of the elements influencing modular building adoption, a more comprehensive cost study could contribute to offer a greater understanding of the possible cost savings associated with modular construction. Additional studies could assess the costs of modular construction to traditional construction for various building types, such as two-story or multi-story structures, to establish the financial benefits of using modular construction.
- Consider the local situation, when considering the possibilities of modular building as an alternative

to traditional construction, it is critical to consider the local context. Local building codes, zoning regulations, and labor prices might differ greatly between areas, affecting the feasibility and cost-effectiveness of modular construction. As a result, future research may investigate the local environment and how it can influence the adoption of modular building in San Fernando, Pampanga.

- While the thesis paper focuses on the possible benefits of modular building, it is also essential to evaluate the potential obstacles connected with using this construction method. Future research may explore at the logistics, shipping, and installation of modular components, as well as possible concerns with quality control and the endurance of modular buildings.
- To incorporate stakeholder feedback, future studies might include suggestions from construction firms, politicians, and local people to ensure that the proposals for implementing modular building are attainable and acceptable to key stakeholders. This could help in identifying potential adoption problems and providing insights into the most efficient strategies for promoting modular building adoption in the City of San Fernando, Pampanga.

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