

**STUDY OF SHIPPING CONTAINER HOUSING AS AN
ALTERNATIVE TO SANDCRETE BLOCK AND
REINFORCED CONCRETE IN LAGOS**

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of the Requirements for the Degree of
Bachelor of Science in Architecture (B.Sc. Arch)

By

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JANUARY, 2020.

DECLARATION

I, Onuorah Uchechukwu John, a graduating student of the Department of Architecture, College of Environmental Sciences, Bells University of Technology, Ota hereby declares that this dissertation titled “study of modular shipping container homes as an alternative to sandcrete block and reinforced concrete Lagos” submitted by me in partial fulfillment of the requirements for the Degree of Bachelor of Science in Architecture (B.Sc. Arch) is my original work. It has never been previously submitted in part or in whole for the award of a degree. Wherever contribution of other are involved, efforts have been made to indicate them clearly with due reference to the literatures.

Signature

Date

CERTIFICATION

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DEDICATION

This project is dedicated to every single person whose support has been vital to my progress, to God almighty and to the hardworking staff of the department of architecture and Bell university of technology.

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I would like to express my thanks to the people who have helped me most throughout my project and to God for making it all a success. I am deeply grateful to my project supervisor, DR. Y.R. OKEYINKA – Ag. HOD for her unrelenting support for the project.

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LIST OF ABBREVIATIONS

ABBREVIATIONS

1. LEED – Leadership in Energy and Environmental Design
2. ICERT – International Conference on Environmental Research and Technology
3. ISO – International Organization of Standardization
4. ABT – Alternative Building Technologies
5. THN – Tempo Housing Nigeria
6. CAGR – Compound Annual Growth Rate

DEFINITION OF TERMS

Bane; a cause of great distress

Intermodal; transportation involving more than one form of carrier, as truck ship and rail

Drayage; transport of goods over a short distance

Prefabricated; practice of assembling components of a structure in a factory

Modular; constructed with standardized dimension for flexibility

Cargotecture; using shipping containers to create fully functional buildings

Typology; a classification according to general type

ABSTRACT

The paper reviews the use of ISO shipping containers as an alternative building technology to provide portable and quick housing in Lagos state. Housing has long been a bane of the lower class residents of Lagos as many people migrate from rural areas on a yearly basis with no means of support just so they can have the opportunity to work their way to wealth and riches in the commercial city of Lagos.

The current system of housing supply with the use of labour intensive reinforced concrete and masonry while it has provided housing for some of the those that can afford it, has however not been effective for getting the poor a roof over their heads and as a result, such individuals and their families have been left to drift into slums. The paper seeks to unearth the viability of the shipping container house to solve the state housing needs, by casting light on the emerging shipping container buildings around the world and locally, it highlights the many advantages and few drawbacks of this architectural typology over current practices. Technological advancements today have made it possible for people to convert small camper vans into comfortable homes and it is on this premise that this study argues that a shipping container will make for a comfortable home without compromises. It is hoped that this study will inform policy and space makers in Lagos state to endorse this typology in the conversation for a more affordable housing delivery.

CHAPTER ONE:

INTRODUCTION

1.1 Introduction

The need for investigating alternative building materials for housing is important as the city of Lagos is rapidly urbanizing and having to adapt to accommodate population growth through increasing densities. Interrogating ISO shipping containers is also essential since the manner in which state housing is provided lacks creativity and innovation – the government continues to offer housing through traditional approaches and with the use of conventional materials. The primary aim of the research is to examine the perceptions of the general public with regards to shipping container housing. The relevance of this study lies in the fact that the state remains challenged by an accumulating social housing backlog. There is a need for a different model for the provision of housing and ISO shipping containers hold some potentials that can be exploited to meet the needs of city dwellers and encourage a more sustainable urban fabric.

This chapter introduces the rationale and needs for investigating shipping container developments, outlines the challenges that relate to housing in the city in its problem statement, it then discusses the objective of the research study. Thereafter it outlines the research question that guides this research report and then will conclude with the research scope to define the boundaries of this research.

1.2 Background of Study

The quest to provide affordable buildings in Lagos state has been subject to a lot of discussion in recent years, however, the solution is one which has eluded the government, developers and other players in the Lagos state real estate landscape due to the numerous challenges mostly associated with our reliance on reinforced concrete and Sandcrete blocks and the high labor rate which comes along with it. This sparked a thought as to what could be the possible alternatives to provide affordable housing for Lagosians in the 21st century, hence the initial inspiration for this research.

Shipping containers are a widely available, relatively affordable resource that Nigerian architects, developers and builders are not using, the reason why may be related to the non-availability of building codes, the scarcity of pioneer projects, dimensional limitation of ISO shipping containers, and unwillingness to divert from the known conventions in the Nigerian building industry. However, the ISO shipping container has been designed to not only withstand the most extreme of weather conditions on sea voyage, but to withstand stacking of 9 fully loaded containers, making them an ideal structural component. The standard dimension of the containers means that they are an excellent modular unit and their inherent strength, weather proof nature and availability makes them ideal habitable structures. The availability of shipping containers in Lagos

is as a result of its role as Nigeria's port city and Nigeria's trade deficit - Nigeria imports more than she exports - this ensures the sustained surplus of shipping containers in Lagos. This potential reuse of shipping containers to address the city's housing needs which this research seeks to analyze, is a sustainable building practice which should be encouraged, and nurtured in order to provide mass housing quickly and with greater efficiency.

1.3 Statement of the Research Problem

Shelter or housing is not just a human right; it is a human need. Abraham Maslow's hierarchy of needs identifies shelter as a physiological basic need, alongside food and clothing, this implies that without housing we as humans cannot function properly or cannot function at all. "About 108 million Nigerians are estimated to be homeless, based on an average family of six people per housing unit. While Nigeria needs to build about 700,000 housing units every year to bridge the housing gap, the country barely builds 100,000 such units per year" **The Sun** newspaper, January 2018. About 86.9 million Nigerians are living in extreme poverty, the most in any single country in the world. This statistic released in June 2018 by the **World Poverty Clock** shows that there is a need to provide affordable housing and not just low-cost housing solution as the government has since attempted. The current model employed for the provision of low income housing leaves a lot of room for innovation and creativity and the adoption of shipping container homes as an alternative gets us closer to this housing delivery goal while creating a sustainable urban fabric for the city of Lagos.

However, it along with it comes some unique problems including;

- i. Where to source shipping containers
- ii. Cost comparison to conventional building methods
- iii. Acceptability of modular container living
- iv. Establishment of state building code

1.4 Research Aim & Objectives

The study aims to analyze the potentials of using ISO shipping containers to provide modular housing types as an affordable housing alternative which can be adopted by average to below average income individuals to provide stable, low cost and durable housing for simple habitation. It can also be employed by developers and government organizations to address the housing deficit in Lagos state and other parts of the country by extension. The system can further be used in various other scenarios where temporary housing needs to be provided for a reasonable period of time, this includes IDP camps, construction site, offices, humanitarian workers' temporary or permanent accommodation and so on.

1.5 Research Questions

In order to accomplish the objectives of the study, the research questions generated from the aim are as follows:

- i. What are the challenges or threats posed by conventional building methods?
- ii. What are the challenges/issues to using shipping containers for housing in Lagos?
- iii. How do shipping container housing units relate to preconceived ideas/perceptions about housing and ideas about home and how can it achieve high acceptability?
- iv. What potentials does modular shipping container housing possess if properly implemented and integrated

1.6 Justification of the Study

Homelessness is a global pandemic, a major headache, even in the most advanced economies where wealth is vertically accessible in relative doses. In New York and California, you see homeless men on the streets despite the presence of homeless shelters for people in these advanced climes. It just proves that no matter the global standing of any country, there will always be homeless people, probably due to choice, grit to make it or insufficient affordable housing, homelessness is sadly a scourge we might never be able to eradicate as a people. In Lagos, the term ‘sleep under a bridge’ was coined in the ‘60s and ‘70s, at the start of Nigerian industrialization, when Lagos made its earliest claim to becoming Nigeria’s commercial hub, harboring scores of migrants from smaller, less-commercial Nigerian cities who made a staple that represented the struggle. Some of these people come to Lagos for opportunity and a chance at making it without a support system, so they sleep under bridges and in unholy places till they can afford homes. The issue is still ongoing, as score of people still migrate to Lagos in yearly droves. Over the years, the Lagos state government through the Lagos state Development and Property Corporation (herein further referred to as LSDPC) and the Lagos state ministry of housing have come up with numerous low-cost housing schemes such as the Lagos HOMS (Lagos Home Ownership Mortgage Scheme), Igbogbo Low cost housing scheme in Ikorodu,

Lagos Rent-To-Own scheme, Illupeju gardens, have all failed in their attempts to capture low income earners who make up the 2.55 million housing deficit, and this failure is evidenced by the growth of slums across the state.

Although container housing is by no means a new idea, it is gaining popularity in advanced countries of the world such as USA where their severe trade deficit which leaves an abundance of unused shipping containers, it is a viable system of quick cheap and safe housing which is yet to be adopted in Nigeria. A good portion of Northern Nigeria is currently in a state of humanitarian crisis and southern Nigeria is not spared from the poverty and lack of basic amenities, it is imperative in the year 2019 that we look beyond known systems and housing conventions to newer methods for practical solutions.

1.7 Scope of the Study

This study focuses on how shipping containers can be converted to housing units in Lagos Nigeria, without compromising the essentials of a dwelling. Globally there is a growing trend of young couples choosing to downsize and live in tiny (toll-able) mobile homes and medium-sized motor vehicles (van), this trend demonstrates the limits of what is a home and more importantly, what is the minimum square area tolerable for habitation. Van living and tiny home trend is made possible by advances in technology that allows all homely appliances to be run off of a solar recharged battery and so people can live in a van without sacrificing the comforts of a regular home. Having established that living in a van is not just possible but also practical, container housing might be perceived as a luxury as a result of its much bigger size. This study also breathes life to the potentials that can be achieved if shipping container living is properly planed and implemented in Lagos state. Many of such potential include its unarguable sustainability, low cost and efficiency of building supply over a short period of time as is needed in Lagos state with some urgency.

1.8 Limitation of the Study

This research is limited to the city of Lagos Nigeria. One of the first challenges encountered in the course of this research was the fact that there is still a limited amount of academic research on the reuse of containers for housing and even more rare is with reference to Lagos Nigeria. There are only a few shipping container residential developments in the city and this narrowed down the case study options. Another impediment encountered during the study was the lack of access to resident in the case study building this posed as an obstacle in acquiring first-hand account from people living in container house.

CHAPTER TWO:

LITERATURE REVIEW

2.1 History of Shipping Container

Modern container shipping celebrated its 50th anniversary in 2006. Almost from the first voyage, use of this method of transport for goods grew steadily and in just five decades, container ships would carry about 60% of the value of goods shipped abroad. Before 1956, the most common mode of transporting goods between ports and piers used across the world was the traditional system in which goods were being loaded and unloaded individually. This system was expensive, inefficient and unsafe and time consuming. However, on April 1956, a vessel loaded with fifty-eight shipping containers set out from the port of Newark to Houston. This simple loading system was the beginning of the history of ISO shipping Container.

Mc Lean, known as the father of containerization had an idea to make the traditional shipping methods become easier. His idea was to hook the trailers from truck and lift them straight onto the vessels, this principle provides more flexibility in term of transportation of container compared to freight cargo and cost much more cheaply. He was right. According to **Colin Davies**

“...Mc Lean started by simply loading the trailers of his trucks onto the decks of ships instead of unloading small boxes one at a time from truck to hold. There were a lot of advantages to the new method. It was faster, more secure and required much less labor. But to get the most out of it, to achieve real transport “intermodality”, investment was required in new handling equipment and bigger ships. In 1956 the first true container ship, the ideal-x, sailed from Newark, New Jersey, and the tooling-up of Port Elizabeth, the first true container port, began.”

According to **Levinson M.** “...Containers were quickly adopted for land transportation, and the reduction in loading time and transshipment cost lowered rates for goods that moved entirely by land. As shipping lines built huge vessels specially designed to handle containers, ocean freight rates plummeted as container shipping became intermodal, with a seamless shifting of containers among ships and trucks and trains.”

It is then widely accepted and adopted by major transport hubs across worldwide. The international standard for container size agreed to in 1961 paved the way for container ships to be used to transport goods between countries.

2.2 The Birth of Intermodalism

Intermodalism is a system that is based on the theory that efficiency will be vastly improved when the same container, with the same cargo, can be transported with minimum interruption via different transport modes from an initial place of receipt to a final delivery point many kilometers or miles away. That means that the container will move seamlessly between ships, trucks and trains. Intermodal transportation was first used in 18th century England. In the 1950s the steel intermodal container became the standard. A typical example of intermodal freight transportation is rail, truck, ship and then truck. The truck transport used between the rail terminal and the ocean ports is a specialized form of trucking often called drayage. This is usually provided by dedicated companies who provide only this type of service.

An example of how this type of transportation scenario would progress, would be with a truck bringing an empty container to a shipper to pick up a load. The container would be loaded with freight by the shipper and then be taken by the truck to a railroad yard. It is then put on a train and moved to its destination. At the destination city it is removed from the train and delivered by truck to the consignee, where the contents of the containers are unloaded. The container is then empty for another load.

2.3 History and Current State of Shipping Container House Industry in Lagos Nigeria

The adoption of shipping container house construction method in Nigeria is relatively slow and there is no clear indicator of how far the acceptability of the idea has come. However, it is clear that in recent years, there has been a growing trend of service ancillary building being constructed from shipping containers with dry wall sheeting. There is not much literature that discuss the development of container house as low-cost house in Nigeria, but there is one prominent company driving the innovation of ISO shipping container housing in Nigeria, Tempo Housing Nigeria (THN). “Despite the slow initial acceptability of the idea, Nigerians are fast adopting the concept due to time and cost savings it affords, compared to the traditional methods of building” (**Dele Ijaiya-Oladapo**). The Netherlands based company Temporary Housing Global, moved into the Nigerian housing market in the year 2016 with the aim to leverage on decades of technology pioneered in the Netherlands to provide solution for the housing deficit crisis. THN delivered the one known container housing project in the heart of Lekki phase 1, Lagos state.

The development which sits on 900sqm of prime real estate was completed at a cost of N85,000 – N100,000 per square meter. It comprises 6 one bedroom apartments on the ground floor and 4 two bedroom apartments on the upper floor

and it took just 3.5 months to complete. According to a THN official in an interview with the Guardian newspaper, the singular challenge for the development was securing a building permit from the state government, as no codes for container architecture and construction currently exists in the Lagos state building code. This building code is important as it provides a baseline and standard for converting a shipping container into a safe habitable structure with respect to our prevailing local climatic variables, and this will provide a platform on which shipping container homes can really take off in the city of Lagos and then it can be scaled up for mass housing needs in the state.

2.4 The State of Shipping Container as a Housing System

The modern shipping container was developed Malcom McLean but he never imagined they will be used as a building material. **Philip Clark** on Monday, November 23, 1987 filed a patent called the “Method of converting one or more steel shipping containers into a habitable building”. He outlined how shipping containers can be converted into habitable, modular and economical buildings. **Nicholas Lacey** wrote his university thesis in the 1970’s on the concept of re-using shipping containers and turning them into habitable dwellings, four of Lacey’s container projects have been built to date and his concepts have been continued by a slew of other practices ever since.

Compared to steel modular house which has more flexibility in terms of size and shape, shipping container house has pre-defined standard sizes and shapes.

The weaknesses of shipping container house would be the fixed height [2393mm] and width [2438mm] limitation that do not comply with architectural requirements for indoor comfort. Furthermore, the wall and roof are not designed for residential purpose thus modification has to be made for openings [windows, doors and service pipeline], wall and roof insulation and fire resistance design. When modifying a shipping container or removing any part of the paneling, its structural integrity is weakened and compromised. Without reinforcement, the container deforms and then fails structurally. Generally, if any part of the

corrugation panel is removed steel framing will be required to frame out the opening. Extra internal steel supports and bracings are required if the shipping container house are stacked.

Allied Market Research recent report shows that the global container homes market is expected to grow at a compound annual growth rate (CAGR) of 6.5 percent from 2018 to 2025, driven by technological advancements that result in reduced construction time, cost effectiveness, ease of installation and relocation and growing awareness towards developing green building concept of resource efficiency. The container housing technology offers adequate protection from fire coming from outside to inside or from inside going to the next floor. All of these facts make container housing, when properly implemented, a far superior option for mass housing than traditional sandcrete block and concrete especially in warmer climates such as Lagos Nigeria.

2.5 The Concept of Modular Construction

Modular buildings are prefabricated buildings or houses that consist of repeated sections called modules. “Modular” is a construction term that involves constructing sections away from the building site, then delivering them to the intended site. Installation of modular sections is completed on site. Prefabricated sections are sometimes placed on site with the use of cranes. The modules can be placed side by side, end-to-end, or stacked, allowing a variety of configurations and styles. After placement, the modules are joined together using inter-module connections, also known as inter-connections. The inter-connections tie the individual modules together to form the overall building structure. Modular buildings, also called prefabricated homes or precision built homes, are built to equal or higher standards as traditionally built homes. The building method is referred to as permanent modular construction.

The motivation for using modular construction system generally arises because of client requirements for speed of construction, improved quality, and for early return of investment. Modular construction is widely used in Japan, Scandinavia and the USA. Some key advantages that may be attributed to modular construction are short build time typically 50-60% less than traditional on-site construction, superior quality product, low weight - as modular construction is about 30% of the weight of conventional masonry construction - economy of

scale, environmentally friendly construction process, flexibility, low waste, improved indoor air quality, safer construction, reduced site labor requirement and reduced professional fees.

Modular buildings can also contribute to LEED requirements in any category site-built construction can, and can even provide an advantage in the areas of sustainable site, energy and atmosphere, materials and resources, and indoor environmental quality. Modular construction can also provide an advantage in similar categories in the international green construction code.

Modular construction is the subject of continued research and development worldwide as the technology is applied to taller and taller buildings. Research and development is carried out by modular building companies and also research institutes such as modular building institute and the steel construction institute.

2.6 Potentials and Constraints of Container Architecture in The Tropical Climate of Lagos Nigeria

The shipping container: a modular, standardized, portable, stack-able, seal-able, human-scale receptacle used to transport a range of cargo all over the world, after more than 6 decades of its development, has evolved from its primary function of shipping and storage of goods and products to being converted into living structures for human habitation. Although there is no strong evidence showing who exactly was the first person to have recycled the typical intermodal freight container into a livable structure, or the first one who introduced the concept of container architecture. With many young city dwellers choosing to downsize and live in more easy-to-maintain apartments, this uncertainty as to the origin cannot restraint its popularity to be one of the favorite architectural types nowadays, especially with various examples of container buildings built worldwide based on the design by architects such as ‘the temporary shipping container city’ by O+A, Amsterdam in the Netherlands, ‘Maison container Lille’ by Patrick Partouche, and ‘Serviced apartments in Lekki, Lagos Nigeria’ by Tempohousing Nigeria. The container building architecture also has some advantages and disadvantages which determine its potentials and constraints to be used in the tropical area of Lagos, Nigeria. The strength and weaknesses of the container building architecture and its influence on the potential of its implementation in the hot humid tropics are discussed based on these specific factors:

i) Structural Strength and Durability

In terms of strength, it is reported that the standard ISO container can withstand up to 9 units high of fully loaded 24-tons stacked containers. Steel shipping/cargo containers walls are made from 14 gauge, 0.075 inch corrugated sheet steel or COR-TEN steel panels that are welded to the main structure. The top and bottom side rails and end frames are 7-gauge tubular steel. The steel used to build modern shipping/cargo container is a corrosive resistant high-strength low-alloy steel. This advantage makes it possible to be used for constructing multi-storey building with low maintenance costs. Although it is considered as a physically strong structure, in order to maintain that strength and avoid torsion due to wind loads, the vertically stacked containers should be placed along the same axis which in some ways limits the innovation and creativity in building design. The studies also showed that the shipping container will lose its inherent strength when its sidewalls need to be cut in order to be combined with other units of containers to fulfil specific needs of internal spaces, the sidewalls have to be reinforced in order to restore its structural integrity. The roof of shipping/cargo containers is constructed with die-stamp corrugated steel sheets with a certain chamber at the center. The roof's main purpose is to keep out the elements. The floor of the shipping/cargo container is 28 mm thick with 19 ply treated plywood screwed into the structural cross members. In terms of

durability, the life span is between 15 to 50 years, which is only half the life expectancy of conventional buildings. It should also be taken into consideration that when converting the ISO Container to the habitable building, with time the flat roof of the container which is supposed to be water tight will get beaten in, and the effect could be worsened in the hot humid climate of the Lagos region where rainfall is frequent in the wet seasons, therefore additional roofing is advised.

ii) Modularity and Transportability

Creating a home using shipping containers is creating art. Clean lines, colorful, shipping container homes will be a discussion piece for you and your guests. This modern look and low aesthetical value and uninteresting appearance of this 8-sided rigid box is more obvious when it stands alone. However, if some units of the container are combined, arranged and creatively composed as a whole building, it has huge potential to be a unique and outstanding architectural feature.

In fact, due to this modular characteristic, the container building is relatively easier and faster to be assembled and dismantled compared to the conventional buildings to fulfil the instance needs of particular areas. In addition, it also has

advantage in terms of expandability, where it can allow high density solution for particular community who are in dire need for dwelling.

Concerning transportability, the bottom of the shipping/cargo container has 3-4 mm thick cross members that have recesses along the bottom side rails, which allows them to be lifted with special straddle carriers. Due to this advantage, the container building has always been used as site office, emergency housing or even as a mobile clinic. In the US, its military has employed this transportability advantage of container since 1970's when it was used as soldiers' dwelling in Vietnam. In the tropics, the use of container building is quite frequent in disasters areas, where it is usually used as NGO site offices or emergency shelters in disaster displaced persons' camp, this is largely because most countries that fall within this climatic region are developing countries.

iii) Availability, Cost & Construction Technique

Many studies showed that due to the imbalance trade, there is abundance of used containers left in the major ports around the world, especially in the importing countries. This is because it is not economical to send the empty container back to the origin countries since the cost of the new container, especially in Asia is relatively cheap compared to the transportation cost of shipping it back. Therefore, the availability of the ISO container in the importing countries like US and Europe is highly available. This ISO Container has not only reduced almost 97% of the transportation cost compared to the 'break bulk' or general cargo system, but also can potentially offer relatively low construction cost due to the recycling of the used material if it is recycled to a habitable structure, as compared to conventional building. The relatively low building cost is also due to the simplicity of its construction when compared to conventional techniques, the mass production and its shorter construction period which in turn could result in reducing the building cost on the whole. In Lagos Nigeria, the availability of the used ISO Container is quite certain as a result of the country's negative trade deficit and the cost as at the time of writing is between 650,000 – 750,000 for the 40feet container and 400,000 – 450,000 for the 20 feet container size. However, it should be noted that the construction technique of the container house is not as simple as perceived, because it needs a lot of skilled workers for

welding and steel work, requires special machinery and also employs unconventional method like using a crane to place, assemble or lift the containers. This has been a constraint because such construction method and techniques are not a common skill among the contractors and builders who are comfortable with the conventional construction method. This new technique in some ways will increase the construction cost of the building container on the whole. Moreover, extensive refurbishment with the installation of the insulation layers, finishes, fittings and services are needed to ensure the comfortable indoor environment of the building containers in this hot humid climate of Lagos Nigeria, and these modifications will surely need relatively high cost of modification as compared to the container building in other climates.

iv) Sustainable Building & Indoor Comfort

A plethora of projects have shown the potential and suitability of the container to be a practical and outstanding architectural feature, especially in the temperate and cold climate regions. This architectural type is widely accepted by the end-users in those regions and often regarded as one of the sustainable or green architectural alternatives that can provide low carbon footprint building due to the recycling of used ISO Shipping Containers. This recycling approach has not only has reduced the numbers of steel container waste in their major ports, but also has been considered as a significant strategy to reduce embodied energy for construction materials. However, recent studies showed that the advantage of container architecture in terms of reducing embodied energy, especially by the recycling of used ISO Shipping Container is uncertain since major refurbishments which require energy like the replacing of floor, sandblasting of the structure and the cutting of steel for openings are needed before one used-container can be comfortably lived in. In fact, comparing it with traditional timber and concrete buildings revealed that the usage of the ISO shipping containers in buildings consumed higher energy (per square metre) and released more carbon dioxide (CO₂) into the atmosphere (per square metre) as compared to conventional building method. It therefore follows true that the less

modification (by design) needed to convert the shipping container into a habitable building, the more sustainable this Architectural type becomes.

Although the container architecture is highly accepted in the western countries, some studies showed that its effectiveness in terms of providing comfortable indoor environment in the hot-humid tropics is not very convincing due to its compatibility with the local climate conditions. In its standard form, Shipping containers are mainly made of steel, which factually has a high heat conductivity and is prone to condensation due to high moisture content if it is not sufficiently insulated. This means that in the hot and

humid conditions of the tropics which governed by the high humidity level of more than 70% in average and hot outdoor air temperature which easily can exceed 32°C during daytime, major modification works are needed to ensure thermal comfort in the indoor environment of such type of architecture. For this purpose, it should be refurbished not only by installing appropriate layers of insulation for controlling thermal, acoustic and fire protection, but also by equipping it with suitable vapor barriers, internal fittings and finishes that suits the local climate. Moreover, some steel cutting and welding works are also needed to provide sufficient openings for cross ventilation, especially if the container building is intentionally built for the low income demographic who

usually do not resort to air-conditioning for cooling, but only depend on natural ventilation with the assistance of mechanical fan to reduce the cost of living. Alternatively, Al-Obaidi et al. revealed that using reflective surface with hybrid turbine ventilator for roof without insulation constructed from aluminum sheets in hot and humid region helped to reduce the attic air temperature as well as the load of heat gain at the indoor environment. Therefore, this indication can give a good example to improve the using of natural ventilation in the container buildings in the region of hot and humid tropics. (International Conference on Environmental Research and Technology **ICERT 2015**)

CONCLUSION

Literature surveys have showed that the container building has huge potential to be one of the major architectural types that can offer durable, practical, cheaper and comfortable living space in shorter construction period, particularly in temperate and cold climate regions. However, in the hot-humid tropics, its implementation is still not widely spread due to several uncertainties regarding its specific construction technique which is quite unfamiliar with the common skills of the local builders, non-availability of building code to guide and standardize the architectural type and its physical features which is not only very compatible with the hot and humid conditions of the region.

However, these constraints that limit its potential to become one of the preferred architectural alternatives in the tropics could be outweighed by its advantages in terms of modularity, transportability and durability, provided that appropriate installation and modifications are made to the container building to ensure its comfortable indoor environment, especially for those who are in dire need for habitable space.

CHAPTER THREE: METHODOLOGY

3.1 Research Respondent

Lagos state Nigeria is a multi-ethnic state with a population of over 20,000 million citizens. It is the commercial hub of Nigeria and attracts a wide range of individuals from other states and ethnicities who are searching for greener pasture. In this research which is focused on Lagos state alone, respondents are divided into three categories in which different sampling techniques will be used. Each category will have dedicated sets of questions. Category one is for the designer of container structure; category two is designed for the developer, owner or contractor while the category three is designed for the public. Slovin formula will be used to analyze the number of respondent needed for this research. 100 citizens comprising of different ethnicities, genders and age group of 18- 40 years old from Lagos Nigeria will be picked randomly and invited to answer the questionnaire through Google Docs and distributed survey questionnaire.

Slovin Formula, $n = N / [1 + NL^2] = 100000 / [1 + 100000 * 0.05^2] = 400$

Where:

n = sample size

N = population

L = margin of error

Additionally, a face to face interview will be conducted to gain inside perspective knowledge of design and construction aspect of a container house. The targeted person to be interviewed would be, but not limited to a representative of the leading company in container housing in Nigeria, THN who have already done container building projects in Nigeria. An invitation letter would be sent to them through emails to ask for the permission to accept for an interview / knowledge session at their convenient time and place.

3.2 Research Instruments

For the most effective research study, three types of primary data collections system were adopted. All these three unique data instruments system were incorporated together to specifically answer the research question. It focuses on the feasibility of using ISO Shipping Container to build low cost houses. All the primary data collected through interviews and questionnaire is strictly private and confidential. The database collected is not to be dis-closed, distributed and will not be revealed to any third party without obtaining prior consent from the ownership. This survey takes sixty days to complete. The survey questionnaire is structured to contain a set of relevant questions with choices of answers that the respondents would choose from.

The primary data collected through questionnaire is divided into three sections, with each section tailored towards the different types of respondent and to answer different types of research questions. Section A is designed for Designer of Container House Project; Section B is designed for the developer/Owner/Contractor of the Container House Project and Section C is designed to test the acceptability of the public towards living inside a shipping Container House.

In this research, the instruments used are survey questionnaire with a variety of question types and interview. In general, of all three sections, open ended question, closed-ended Likert scale question, dichotomous questions and open format questions were used in order to obtain the necessary data from the aspiring business persons, knowledgeable designer and also the public. The survey questionnaire was designed in such a way to get all the necessary information about the feasibility of container house as alternative to conventional building materials [e.g. concrete]. The survey questions in Section A, B and C will be created in survey monkey platform, and participants invited to participate in this survey. Researcher will also distribute hardcopy of survey questionnaire to university students. The questions were listed in such a way that it will provide a free and lenient flow of information which is needed in the study. The researcher noted questions that needed improvements or modification and were appropriately executed all throughout the survey.

CHAPTER FOUR:

DISCUSSION OF STUDY AREA

4.1 Introduction

This chapter follows after the field work findings that dealt with an integration of experiences, perceptions, and discussions on the prospects of shipping container architecture. The fact-finding journey assisted in unpacking the perceptions of shipping container developments to inform the researcher and tackling the sub-questions. This chapter supplies a summary of the discussion that has been carried throughout this research report.

This penultimate chapter of this research report offers an overview of the research process; it thereafter outlines the benefits of this research for planning and following that, it indicates the limitations that came about during the course of the research.

4.2 DATA FROM SURVEY FINDINGS

QUESTION	ANSWERS	YES	NO	OTHERS
Are there inadequacies in the current housing supply models?	35	35	0	-
If yes, would shipping container house be different?	35	30	5	-
Are shipping containers safe and habitable?	67	56	11	-
Have you designed one before?	35	7	28	-
Are there any shipping container houses in Lagos you know about?	67	2	65	-
Have you constructed one before?	32	0	32	-
Are they cheaper to build?	32	32	0	-
Would you recommend shipping container for social housing in Lagos?	32	24	8	-
Can you raise a family in a shipping container house?	32	15	17	-
Does the building material determine if you would reject a house?	32	10	22	-
Do you know anyone living in a shipping container house?	32	0	32	-

4.3 Discussion of Result from Survey Questionnaires

The findings table shows the survey respondents. This questionnaire survey is conducted from December 2019 until January 2020 to 100 respondents from the age of 18 to 40 years old. Researcher assumes that Malaysian citizen from the age of 18 to 40 years old will be the future prospective container house designer, developer and buyer, with the projection of 5 to 10 years from the actual implementation of container project. The respondents are selected randomly to represent the whole Lagos state residents.

From the findings table, it can be clearly seen that the public (Lagosians) response on if they will be willing to live in a container house is split and it is understandable, given the rarity of the housing model in Nigeria. However, it should be considered a win for container housing because out of the respondents, 47% are willing to raise a family in a house built from shipping containers while 53% aren't, representing a 50% acceptability before the idea is even implemented. This speaks to the willingness of the public to accept new modes of housing supply. Alternatively, it could be interpreted as an indication that the current mode of housing supply has deteriorated to the extent that respondents are willing to accept "anything" just so they can have shelter over their heads.

Having said that, the former is more likely because respondents genuinely believe that the current mode of housing could use some improvements, as seen in their answer to question 1 on the table above.

From the interview conducted by the guardian newspaper, Dele Ijaiya Oladapo of Tempo Housing Nigeria, the company currently driving container housing in Nigeria reveals that Nigerian developers are fast adopting the container housing concept as a result of the advantage of the time and cost savings it affords. According to the THN official, it should be noted that while shipping container housing is a cost effective mode of commercial property delivery, the cost saved when compared with reinforced concrete and masonry is more accurately about 30%. This implies that the greatest advantage to this system of housing is not its cost advantage but its tremendous speed of delivery. Container homes can be delivered in less than a quarter of the time it would take to deliver a masonry home of equal scale. Furthermore, respondents were concerned about the comfortability of living inside a container house given that container structures are all made from steel and Nigeria is located just below the equator whereby it is exposed to tropical weather throughout the whole year.

In the beginning, the research intended on unpacking the perceptions held towards shipping container developments to see if they would be a viable option for social housing in Lagos state, however, during the course of the research, it

became apparent that containers might be a better route for entry level social housing, an arrangement which is lacking in the current system of social housing supply in Lagos state. The findings have shown that residents see the container development as adequate housing and their respective units as homes where they can generally express themselves, grow and develop.

4.4 Overview of Research

Reverting to the main research question, which is ‘How do shipping Container housing units relate to preconceived ideas/perceptions about housing and ideas about a home and how can it achieve high acceptability?’ In tackling this question, this report looked deep into this relatively new housing typology. The existing container housing typology was utilised as a case study, to understand the experiences and perceptions of residents within and around the development. The constructed questionnaires (chapter 2) served as discussion guidelines and were directly linked to the key themes of this report. The key ideas that came from the literature review were adequate housing and the notion of home with regards to cargotecture. The ideas that emerged from the theoretical framework were used to develop the sub-questions and played a significant role in fostering the fieldwork process as well as laying the foundation for the analysis of the findings. Prior to engaging with the participants, the questionnaires were tested on my close colleagues and other students and lead to minor changes being made before going into the field. The researcher identified participants by approaching any residents of Lagos state between the ages 18-40 that have lived in the state for at least five years.

One of the key findings was the positive response from respondents towards container development for housing of a higher density provided that they remain disguised (similarly to the case study building). The choice to conceal the

building with other building materials has proven to make residents feel more at home as opposed to an informal dwelling. People need to see value in what they live in and feel like they are residing in something better than the informal dwelling they would've built themselves. Subsequently, the residents in the vicinity saw value in the case study building, hence they are living there.

The general impression that was created from the encounters with the research participants is that shipping containers are adequate building blocks that can create home spaces for urban residents. The participants within the vicinity also verified that they indeed saw the building as adequate housing and that they felt at home within their respective units.

The lack of financial institutions support also poses as a barrier to the use of shipping containers. Even though the participants found containers housing to be adequate and meet their standard of what a home should be they were not keen on owning a container home, most of them were only willing to rent in a container built home. A significant portion of the residents found the container housing to not be a worthy investment as it would be difficult to trade or obtain. This shows that even though a unit might fulfil the needs of the residents, it does not necessarily mean that they will be keen on accepting it as their own. **Botes (2013)** connects this to the existing norms and cultural expectation that is present in each person. This also suggests that container housing would be more optimal in the rental market.

CHAPTER FIVE:

CONCLUSION, RECOMMENDATION AND CONTRIBUTION TO KNOWLEDEGE

5.1 Introduction

This chapter also provides recommendations directed to key agents in the production of space, Architects, local government officials, the related state departments as well as private developers in estate development. Taking into consideration chapter two of the literature review, chapter four of the findings and the fact that the objective of this research report was to supply a sample of the perceptions held towards ISO shipping container housing developments, this chapter also offers critical points which enhance the understanding of the implications of using shipping containers to provide social housing in Lagos Nigeria.

5.2 Benefits of the Research and Implications for Urban Planning

Very little literature has unpacked the user-end perspectives of the few shipping container housing developments in the city of Lagos and such research may assist in enhancing the knowledge base by providing an understanding of the implications of shipping container residential developments on housing. The aim of this report was to begin a discussion on alternative building materials to provide a way forward related to the current housing challenges. The housing backlog in Lagos state continues to haunt the government and this report proposes a consideration of an emerging typological solution that may prove to alleviate some of the issues. This report will be a useful addition to the existing literature on alternative building methods, particularly shipping container housing projects in the City of Lagos.

This research report has introduced various concepts that relate to container housing and has also revealed people's perceptions towards it. The findings can inform future decision-making processes and similar development initiatives in the city. This body of research has also brought together two intertwined fields –planning and architecture. Work that enhances the connection between disciplines offers knowledge to both schools of thought whilst creating a platform for multitude of cross-references within the built environment. In addition to that, the fact that this research was conducted during a time when

shipping containers are serving as housing solutions in other parts of the world while Lagos city is characterized by rapid urbanization and homelessness, brings significant relevance. The study of the perceptions of shipping container housing has provided lessons for both students and professionals in urban planning and estate development.

Even though perceptions are merely ideas that people have in their heads towards a certain person, place, object or product that determine how they form an opinion towards it, they offer some insight of how people feel (**Tighe, 2010**). Perceptions are generally informed by a range of elements like cultural norms and preferences as well as the existing knowledge one may have on a specific topic. A consideration of architects, developers and residents' opinion is a critical element of the housing development planning process.

5.3 Limitations Encountered Throughout the Study

As is with much other research, during the course of this study the researcher was confronted by a number of challenges. One of the first challenges encountered in the course of this research was the fact that there is still a limited amount of academic research on the reuse of containers for housing and even more rare is with reference to Lagos Nigeria. In addition to that, container housing is still a relatively new typology in Lagos and other African cities. This means that there are only a few shipping container residential developments in the city and this narrowed down the case study options. Another impediment encountered during the study was the lack of access to resident in the case study building as Lekki phase 1 is a very private neighbourhood, this posed as an obstacle in acquiring first-hand information about the development. There is little to no literature on the development, subsequently, I relied heavy on the published articles and interviews to gain insight about the case study building. With what has been flagged as limitations during this study, this report recommends that more rigorous qualitative research is done on alternative building methods, particularly container housing. The knowledge base of cargotecture (container housing) needs to be expanded and explored. This report also encourages academics to capture the experiences and views of other shipping container developments in the city to unpack more implications of this type of typology in different contexts.

5.4 Recommendations:

Recommendations to policy makers

This report recommends that adequate measures be taken by policy makers to lay down comprehensive building codes to guide the design, appraisal and construction quality of shipping container housing, encourage financial institutions to recognize shipping containers developments as adequate housing. This can, in turn, assist in recognizing container housing as appropriate collateral. Urban regeneration policies are influential elements that attempt to rebuild communities and improve service coordination, policy makers' needs to take into account Alternative Building Technologies (ABTs) like shipping containers. Policy makers are recommended to encourage the private sector and other key stakeholders that shape space to make use of alternative building material through policies. This would not only 'normalize' the use of unconventional materials but it would also improve awareness and possibly change negative perceptions held towards ABTs.

This report recommends the City to start thinking about the possibilities that containers hold and to think of containers as more than temporary housing. This report argues that container housing needs to be more supported by the Ministry of Housing through its policies to increase the awareness of how effective they can be in home-making for not only residents but for financial institutions as well.

Recommendations to developers and architects

The mixed feelings that people have towards containers as building blocks need to be better understood and interrogated before a building is constructed. This brings me to the need for public engagement and public participation prior a development. Another key finding was that the choice to conceal the building had a significant impact on how participants perceived the case study building. Given that, this research report encourages developers and architects interested in residential ISO shipping container developments to disguise the buildings as this has implications on how people perceive their designated living space.

Containers hold a number of benefits as they are more environmentally friendly and more cost-effective. Containers also, are more of a viable option when looking to accommodate a significant number of people in a short period of time. The use of shipping containers cuts construction costs by almost a third compared to what masonry and concrete can do. In light of this important point, this report encourages developers and architects to explore this building material.

5.5 Conclusion

This research study has shown that the general consensus among the residents in Lagos state towards a container home. This study, in a broader sense, has revealed the benefits and limitations of this type of architectural typology to find out the implications of providing shipping container social housing within the context of Lagos state. This study serves as a foundation into many realms that have not been extensively explored by the urban planners in Lagos state. Container housing is an increasingly popular trend internationally and an emerging one in the Nigerian context and active research on these building routes could yield interesting literature on approaches towards providing housing.

The right to access adequate housing is a universal right as a sense of home is a universal need and containers are viable resources that can assist in meeting this need in cities (**Brandt, 2011**). The interviews with the respondents in Lagos state have shown that containers can satisfy this need without compromising their quality of life. The findings discussion has also revealed that the growing demand for affordable and adequate accommodation is still unmet and container architecture provides a chance by which the demand can be met with urgency. The findings are hoped to inform developers and the state of the possibilities of employing shipping containers within the context of Lagos state and its benefits over masonry blocks and reinforced concrete construction. The idea of container housing is an important aspect to the discussions on increasing densities and providing well located low-cost housing.

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APPENDIX/APPENDICES

APPENDIX A: QUESTIONNAIRES

PART 1

(For The Container House Designer)

Are there inadequacies in the current housing supply models? YES ☐ NO ☐

If yes, would shipping container house be different? YES ☐ NO ☐

Are shipping containers safe and habitable? YES ☐ NO ☐

Have you designed one before? YES ☐ NO ☐

If yes, what were the advantages gained and challenges you faced in the design?

.....

.....

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.....

.....

.....

What kind of building is a shipping container suitable for? (Please tick as appropriate)

- ☐ Residential
- ☐ Office building
- ☐ Service building
- ☐ Healthcare

Others, please specify.....

.....

.....

.....

Are there any shipping container houses in Lagos you know about? YES ☐ NO ☐

If yes, where is it located?.....

.....

.....

PART 2

(For The Contractor / Developer)

Would you invest in shipping container housing? YES ☐ NO ☐

Are they cheaper to build? YES ☐ NO ☐

Are shipping containers safe and habitable? YES ☐ NO ☐

Would you live in a container house? YES ☐ NO ☐

Have you constructed one before? YES ☐ NO ☐

If yes, what were the advantages gained and challenges you faced in construction?

.....

.....

.....

.....

.....

What kind of building is a shipping container suitable for? (Please tick as appropriate)

- ☐ Residential
- ☐ Office building
- ☐ Service building
- ☐ Healthcare

Others, please specify.....

.....

.....

.....

Would you recommend shipping container for social housing in Lagos? YES ☐ NO ☐

PART 3

(For The Public / Lagosians)

What do you think of a house built from shipping containers?

Excellent ☐ Good ☐ Indifferent ☐ Bad ☐

Would you be willing to live in one? YES ☐ NO ☐

Can you raise a family in a shipping container house? YES ☐ NO ☐

Does the building material determine if you would reject a house? YES ☐ NO ☐

Do you know anyone living in a shipping container house? YES ☐ NO ☐

What preconceptions do you have of a shipping container house? (Please tick as appropriate)

☐ It will be hot inside

It is too small to live in

☐ I will feel cramped in it

☐ It's actually cool and ill like to try it

☐ I've never heard of that before

☐ It is cheap housing

Others, please specify.....

Are there any shipping container houses in Lagos you know about? YES ☐ NO ☐

If yes, where is it located?.....

APPENDIX B: CASE STUDY BUILDING PICTURES







