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Container Housing: Ghana's Answer to the Housing Deficit?

Karen Evans Halm

Department of Architecture, School of Applied Sciences, Central University College, Miotso 00233, Ghana

The population growth in Ghana has assumed an alarming rate. The provision of urban infrastructure and housing has however not been commensurate with the demand especially in housing, thus the acute housing deficit. The idea of using shipping containers as a building component is by no means new in the Accra Metropolis as most shipping containers are re-constructed architecturally and used for temporary accommodation needs like storage, make-shift shops, emergency shelters and site offices. The concept of using these shipping containers as modular building components in architecture however, is still foreign to building practitioners and the nation at large. This research paper set out to use the containers not for luxury apartments but to harness the merits of availability, low – cost of resource, speed of construction and structural stability of the International Standard Organization (ISO) shipping containers in addressing the housing deficiency problem in the nation by meeting the basic need of shelter. Based on the hypothesis of being a cheaper alternative to the concrete and sand-crete blocks, which is the main construction technology used now, similar house types of both technologies were compared to ascertain the variation as part of the methodology for this research. The methodology also included literature reviews and case studies. The scope of this study was limited to 2-bedroom single-storey and multi-storey house types in Accra, the capital city of Ghana. In the final analysis however, this research proved that the container house is not cheaper than the traditional blockwork and concrete construction method is and is better used in temporary accommodation, in situations where time is essential.

Key words: Accra, cost analysis, housing, shipping containers.

1. Introduction

The benefit of quality affordable housing to every nation is extremely massive; it impacts on the economic, socio-cultural and political life of people. It provides shelter for sleep, serves as a shield against elements of the weather and other hazards whiles affecting the efficiency and stability of economies and financial markets. It thus has a significant impact on the productivity and growth of all nations. In a developing country like Ghana, middle-income housing is a foremost economic, political and social issue. However, for the benefit of this basic good to be attained by any country, it needs to be affordable by many households. But this is not the case in Ghana, there is insufficient housing in Ghana and even most of the available houses are poorly developed and lack the basic amenities required to make them habitable [1].

Ghana suffers from a severe housing deficit as a result of low housing delivery relative to households' growth. Mahama et al [2] suggested that the housing deficit in Ghana stood at 1,526,275 housing units. Housing deficit in Ghana is not only caused by the cost of housing but also caused by the slow construction technique of block and mortar employed in Ghana. This limits the amount of houses that can be developed.

Currently, many Ghanaians cannot afford adequate housing on their own because of poverty. At an average cost of $60,000 for instance, the average semi-detached house in Ghana will require 30 times the average annual salary of the ordinary Ghanaian. Containers are presently used in the country for temporary site offices, storage for goods and kiosks for the sale of goods and

Corresponding author: Karen Evans Halm, architect, research fields: built environment.

services. Some also sleep in them initially intending them to be temporary shelter.

The introduction of the container houses to Ghana will close the gap of housing deficit by developing a house type that is affordable to middle-income earners in Ghana and improve the construction time of houses built and therefore resulting in more completed house delivery annually. A third benefit will be the availability of another building material and technology option in the construction industry.

This research aims at developing a house types that will provide decent and affordable housing choices for low and middle income earners and households. Houses that will be constructed within a short period therefore narrowing the gap of housing deficiency in Ghana. Making use of literature review, field reconnaissance and assembly of public information, this research paper seeks to the study the possibility of using ISO shipping containers that would be modified to create living spaces that can grow from a 1-bedroom house to a 3-bedroom house at a cheaper cost. This study is restricted to low and middle income housing development in Accra the capital city of Ghana using locally acquired shipping containers.

2. Findings and Discussions

2.1 Housing Distribution in Ghana

2.2 The Price Structure of Housing Units

The study shows that a basic characteristic of the price structure of real estate properties in Ghana is the quotations in foreign currency, notably the United States Dollar. Figure 2 shows the structure of prices for different housing units. Most semi-detached houses cost between $30,000 and $90,000 while detached houses are priced between $50,000 and $110,000. Clearly, these are prices over and above the reach of the ordinary Ghanaian salaried worker [3]. Figure 3 shows the causes of the consistent price increases in housing delivery.

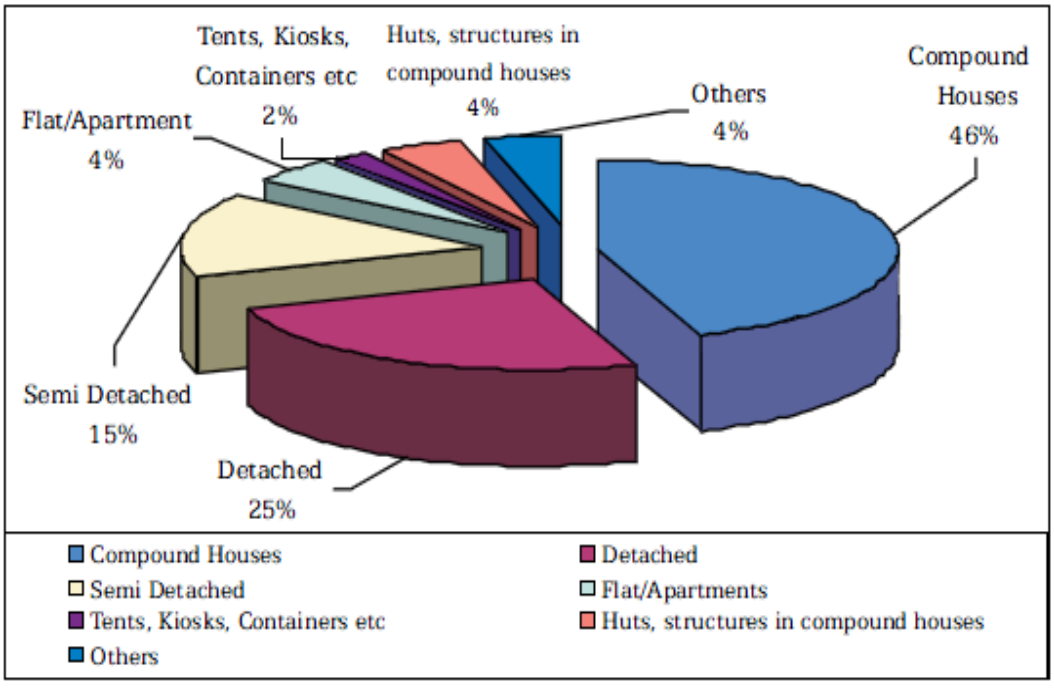

Fig. 1 Housing distribution in Ghana.

	Semi-detached			Detached			Flats	
Price Range	Frequency	Percent	Price Range	Frequency	Percent	Price Range	Frequency	Percent
below $30,000	1	4.5	$40,000-$70,000	6	27.3	Below $31,000	1	4.5
$30,000-$50,000	8	36.4	$71,000-$90,000	3	13.6	$31,000-$40,000	2	9.1
$51,000-$70,000	4	18.2	$91,000-$110,000	1	4.5	above $50,000	1	4.5
$71,000-$90,000	1	4.5	above $110,000	6	27.3	$100,000	1	4.5
Total	22	100		22	100		22	100

Fig. 2 Price Structure of Housing Units in Ghana.

	Frequency	Per cent
Cost of raw materials	19	86.4
High labour costs	6	27.3
High cost of land	11	50.0
High interest rates	4	18.2
Unavailability of land	3	13.6
Inefficient Technology	1	4.5
NOTE: Percentages do not add to 100 due to multiple responses by estate developers		

Fig. 3 Major Causes of Persistent House Price Increases.

In order for the successful implementation of the container house in Ghana, further research was done into its characteristics, and below are the findings.

2.3 The ISO Shipping Container

A standard shipping container has five closed sides and an opening at one end with a double leaf door. It comes in a variety of sizes (Table 1 below shows the dimensions of the containers chosen to be used in this research based on their availability) and is intended for transferring and storing goods of all kinds. Designed to be used by trucks, trains, and ships, its size and construction is dictated by transport conditions [4]. A standard shipping container consists of a steel construction (typically COR-ten steel). The walls are constructed using a frame and filling design which allows for modification of size and load bearing reinforcement. Both the frames and fillings are designed to take dynamic and static loads into consideration. The corner posts of a container are used to distribute loads and are designed to withstand deformations in response to changes in load distribution. See figure 4 for the structure of the container.

Table 1 dimensions of the container (Freightraders, 2010).

Dimensions –	20' Container	40' Container
(L x B x H)	(6m length)	(12m length)
External	*6.1 x 2.4 x 2.6*	*12.1 x 2.4 x 2.6*
Internal	5.6 x 2.4 x 2.4	12 x 2.4 x 2.4
Door aperture (B X H)	2.3 X 2.3	2.3 X 2.3
Volume	33.1 m^3	67.5 m^3
Empty weight	2,200 kg	3,800 kg

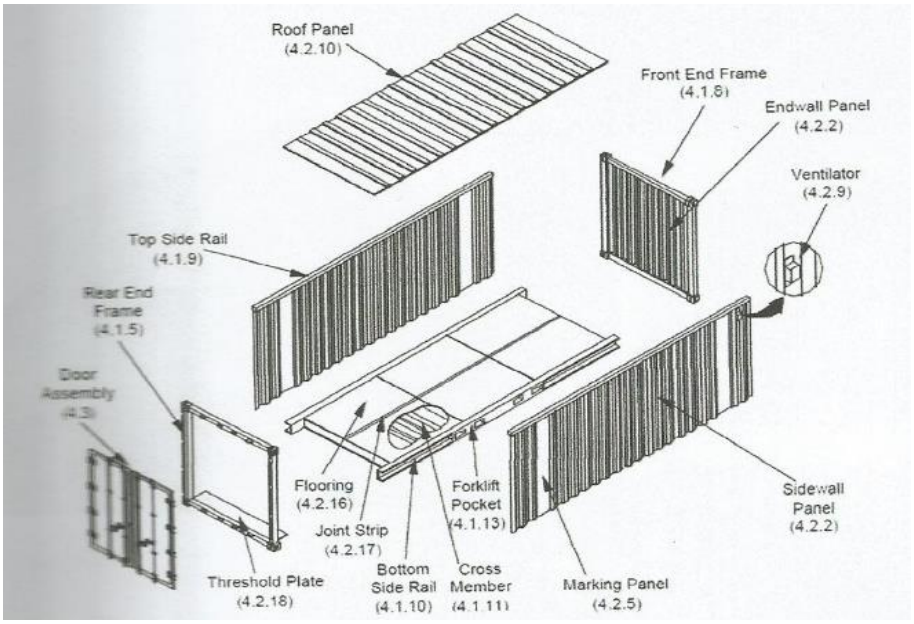

Fig. 4 structure of the shipping container [5].

Due to their strength, containers can be stacked to create multi-story structures, and the simplicity of their construction speeds the building process (Sawyers, 2011). Other advantages of shipping containers for use as housing include: durability, modularity, transportability, availability, low maintenance requirement, and reduced cost.

2.4 Factors Considered for Successful Initiation of the Container House in Ghana

2.4.1 Climate

Container housing designs to a large extent in the tropics are impossible to inhabit without the right insulation installed. For this project, the spray-on insulation type would be applied to the interior walls of the containers before being covered up with a gypsum board. The interior environment can become comfortable for any environment.

2.4.2 Modularity

Container's cell-like structure is suitable for layout systems with small rooms, but in the case where larger spaces are required the containers can be joined together to get larger spaces.

2.4.3 Availability

Used containers are widely available [6] at a cost that is lower compared to a finished structure built by other labor-intensive means such as sandcrete block and mortar.

2.5 Case Studies on Existing Container Houses

The case studies below were selected from different regions, including Ghana, where it was quite difficult as no homes have been made of shipping containers. Another limitation was the absence of Ghanaian Architects who have undertaken works to produce container accommodation.

2.5.1 Ghanaian Case Study

This container structure is located on a site owned by Micheletti & Company Limited, located on Switchback Road, Accra, Ghana. It was completed in 2012 and is used as a site office inhabited from 8am to 6pm daily. This structure is made up of one 20ft container and placed on concrete stilts (see figure 6) which serve as the foundation for the structure.

No additional insulation was used on the interior or exterior wall except the PVC cladding used on the interior wall as the internal wall finish, the same PVC cladding was used on the ceiling as finishes (see figure 7). Upon questioning, the inhabitant confirmed that the room temperature in mid-day becomes unbearable and

Fig. 5 Image of a container used as an office.

Fig. 6 Foundation type used for the structure.

Fig. 7 Internal wall cladding and cooling system.

inhabitable without a cooling system. The original shipping container wooden floor was maintained and polished. An overhead cold water tank was placed at the rear end of the structure and is used to service the toilet (see figure 8).

2.5.2 International Case Study

The Ross Stevens Container House was designed by Architect Ross Stevens, was completed in 2006, with a total Square Area of 89sqm. Being made up by three refrigerated 40-foot shipping containers, the house is divided into four levels. This was studied due to its brief which accommodates all the spaces required for comfortable habitation. The first level contains the public spaces, living, kitchen a small toilet, basement, garage and an intermediate space between the container and the rock. Vertical circulation is placed in an external corridor. The second level includes two bedrooms and an inner spiral stair which connects the second with the third levels from the interior. The final deck holds two more bedrooms.

Fig. 8 Exterior view of container accommodation.

Fig. 9 Exterior view of container accommodation similarly finished and used as a site office on the ground floor and a workers dormitory on the first floor.

Fig. 10 Shows wooden staircase used to access first floor.

Fig. 11 Images of the Ross Stevens Container House [7].

Fig. 12 Images of Chalet Du Chemin Brochu [8].

Fig. 13 Images of Container City, located at Trinity Buoy Wharf, London.

The foundation type used for this structure is a pad foundation used to support the structural members and no additional roofing material was used on the container. Nothing went to waste in this building as the materials cut out were reused on other areas of the house.

The Chalet Du Chemin Brochu, located in Quebec, Canada, was Designed by Architect Pierre Morency and completed in 2006. This was studied due to its hybrid construction system that was used. That is container and timber. The timber on the one hand, serves as thermal insulation and, on the other hand an aesthetic solution is designed in order to avoid the exposure of the corrugated walls. The house is made up using three recycled shipping containers and a basement made of concrete. The ground floor of the house is made up of two 40-foot containers which are separated by a central corridor, an inner circulation route made of timber.

In the Container City I &II designed by Architects Lacey, Nicholas & Partners in 2001 and located in Trinity Buoy Wharf, London with 34 and 22 dwellings respectively, the dwelling types were made up of studios and flats with a maximum of 5 floors. This was studied because of the possibility of container mass housing.

The containers were combined by stacking them and taking out their internal walls creating varied spacial sizes. Pad foundations were preferred at the nodes rather than deep piling, and the use of circular windows was purely for sensible engineering reasons. No stress is put on the structure, although other shapes can be used. The insulation is installed inside the external cladding behind the plasterboard, applying spray insulation over membrane waterproofing to stop condensation. The walls and ceilings are finished in plasterboard.

From the studies above insulation is a major concern in using shipping containers for housing. This is because they are made from steel which conducts heat very well. In tropical areas of extreme temperatures like Ghana, the interior of the container can become uncomfortable for the use of human occupancy.

By insulating the container from heat, providing lots of natural ventilation, the interior environment can become conducive for habitation. Polyurethane Foam is an insulating material that is currently being used in Ghana. However, there are also cheaper and more organic insulating materials that could reduce the overall cost of construction of the container homes. Clay -sawdust compact dry building panels which are usually produced as flat panels are cheaper and better eco-friendly materials that can be locally sourced. Clay insulating panels are already being produced and available for eco-conscious builders and designers to use in building project around the world.

3. Proposed Scenarios

In order to create a realistic proposal of a container house, the following were considered:

- Anthropometric studies.
- Materials
- Structure.
- Services
- Costing.
- Recycling of cut-out parts

3.1 Materials

Table 3 Materials specified for the container house.

Material Type	Location	Material Specified
Insulation	Internal, in-between steel skin and Gypsum board cladding	Polyurethane foam (spray-on)
Exterior paints	All external walls	Ceramic insulation paint
Partitioning	Internal	Gypsum boards
Partitioning for wet areas	Internal	Gypsum boards finished with ceramic tiles laid over wire mesh
Floor	Internal and	Maintain, treat and polish wooden floor in container
	External	Non-slip Ceramic floor tiles
Wall cladding	Internal	Gypsum boards finished with emulsion paint
Ceiling	Internal	Gypsum boards finished with emulsion paint
Exterior ceiling	External	T & G plastic strips
Roofing (terrace)		Container cut-outs
Roofing (main building)		Aluminum roofing
Window frames		Treated hardwood
Window glass		Tinted louvres

3.2 Structure and Loads

From an engineering point of view, loads need to go through the connection points. This allows for flexibility and makes the foundation construction easier because loads can be transferred to the foundation at the corners of the container. The skin itself is structural to the container, thus the more the openings the less its strength. Architecturally however, opening cannot be avoided due to lighting and ventilation requirements. When these openings are thus made however, additional reinforcement need to be introduced to restore the strength. Hollow rectangular steel sections are recommended for all the door and window openings created.

Pad foundation is recommended for the sub-structure with the containers erected on stilts. This reduces the cost of the sub-structure as foundation block work, R.C slab and hardcore filling costs which are typically of the strip foundation are eliminated.

3.3 Services

Utilities (water, power) and waste management plumbing should be run to the base of the foundation and then their respective location in the plan.

3.4 Costing

This cost analysis has been done based on the assumption that other factors such as land and location, cost of utilities supply to the site and roads are the same for both house types. The table below shows the cost comparisons of both construction methods for the 2 bedroom as obtained from the summary of the BOQ.

SCENARIO 1

This is a study of 2- and 3-bedroom single house units. The comparison was done between the container house and the blockwork house using the same areas. Below are figures 8 to 10, showing the architectural drawings of the container house. The 2-bedroom house was created with a total of 3, forty-footer containers i.e. 6m lengths and the 3 bedroom was created with 4, forty-footer containers. Other materials specified are shown in table 3 above.

From the BOQ produced for the 2-bedroom house, the 42m^2 house is GH₵90, 049.85 (fifty-eight thousand and sixty-one Ghana cedis) which is equivalent to $28,587.25 (twenty-eight thousand, five hundred and eighty-seven U.S dollars).

Maintaining the same area and finishes for the sand-crete block house, the 2-bedroom house which will take approximately 6 months to construct will cost GH₵ 68,452.45 (forty-nine thousand, three hundred and four Ghana cedis) which is equivalent to $21,730.94 (twenty-one thousand, seven hundred and thirty U.S. dollars).

The cost / m^2 of the container house is thus GH₵ 1382.40 ($680.65) and that of the block work house type is GH₵1173.90 ($517.40).

SCENARIO 2

In the design of the flats, the number of floors was limited to 4 floors in order to avoid the use of lifts, which will increase the cost of the project. It was created with a total of 12, forty-footer containers i.e. 6m lengths. Other materials specified are the same as those shown in table 3 above. Figures 17 to 18 show the architectural drawings for the second scenario.

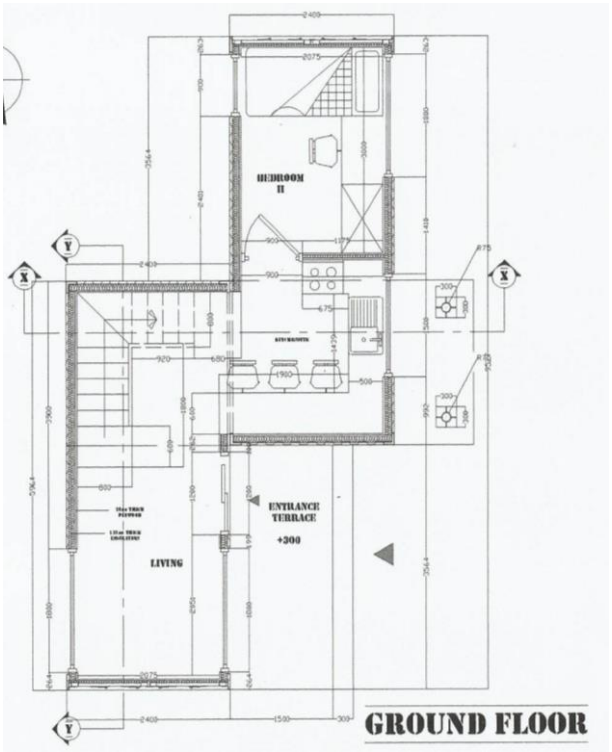

Fig. 14 Ground Floor Plan of proposed 2 bedroom house [9].

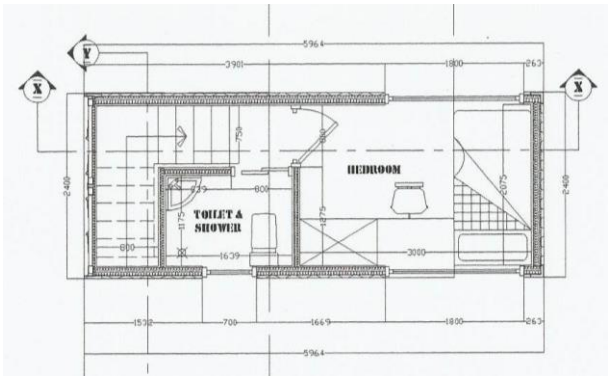

Fig. 15 First Floor Plan of proposed 2 bedroom house.

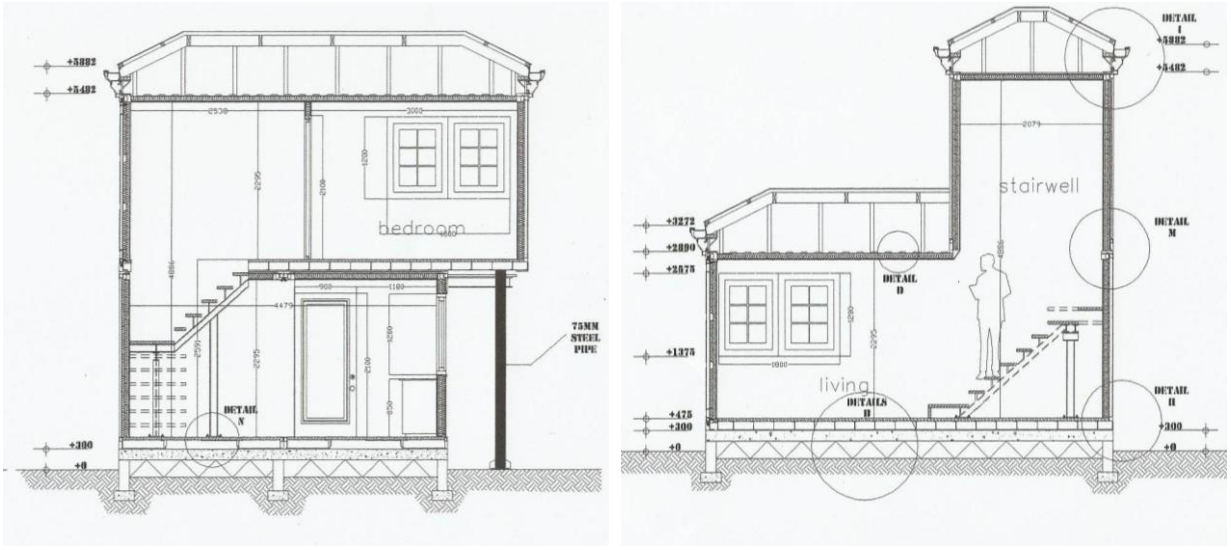

Fig. 16 Sections X-X and Y-Y of proposed 2 bedroom house.

Table 2 Brief & Accommodation Schedule – 2 bedroom.

Space	Area Provide (m^2) 2 bedroom	Area Provide (m^2) 3 bedroom
Ground Floor		
Entrance terrace	5.3	6.4
Living area	7.6	7.2
Kitchenette	6.2	6.5
Staircase /lobby	4.5	3.4
Bedroom I	6.5	8.8
Bedroom II	-	6.5
First Floor		
Bedroom II	6.5	-
Bedroom III	-	6.5
Toilet / shower	2.1	2.1
Staircase	3.2	
Total	$42m^2$	$54m^2$

Table 3 Cost comparison of scenario 1.

Description	Container (GH₵)	Cost Comparison	Blockwork (GH₵)	Remarks
Substructure	8,125.00	↓	9,293.00	The substructure cost of the blockwork house is higher a strip foundation, hard-core filling and slab have to done for the entire footprint of the building; whereas the container house only requires stilts and a pad foundation
Structural Building Fabric	23,572.00	↑	11,401.00	The cost of purchasing the shipping containers is higher than constructing the walls, floors, columns and beams of the blockwork house
Structural / Carcasing / Metal / Timber	7,599.00	↑	4,629.00	Cost is higher because it includes the cost of prefabrication and installation of galvanized steel staircase and balustrade to the exterior of the building
Cladding / Covering	3,380.00	-	3,380.00	-
Linings / Sheathering / Dry Wall Partitioning	6,817.50	↑	1,896.00	Cost is higher due to insulation and plasterboard cladding proposed for the interior of the container house and its consequent high labour cost
Surface Finishes	5,033.00	↓	6,539.00	Cost is lower because the container house does not require plastering for its walls

Table 3 to be continued

Windows / Doors / Stairs	5,574.00	-	5,574.00	-
Building Fabric Sundries	635.00	-	635.00	-
Piped Supply Systems	2,000.00	-	2,000.00	-
Plumbing Installations	1,960.00	-	1,960.00	-
Painting & Decoration	6,499.00	↑	4,667.50	Cost is higher because the container house requires special anti-rust paint and higher quantities of thinner and a consequent higher labour cost
Ventilation /Air Conditioning Systems	450.00	-	450.00	-
Electrical Supply / Power / Lighting Systems	5,165.00	-	5,165.00	-
External Work	5,000.00		5,000.00	
Preliminaries	4,093.18		3,111.48	
Contingencies	4,093.18		3,111.48	
Total	90,049.85		68,452.45	The percentage difference is 24%

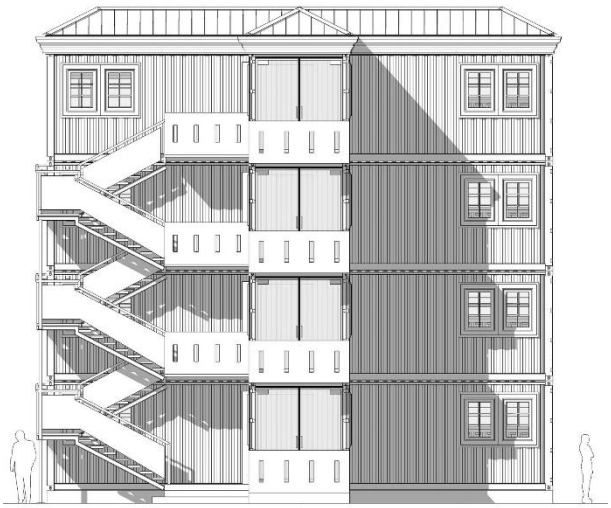

Fig. 17 Front Elevation of 4-storey container flat.

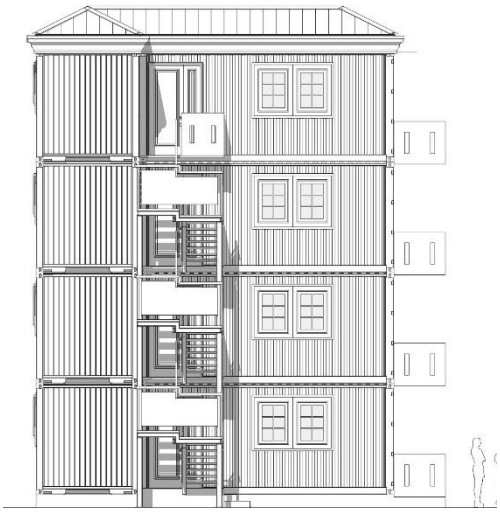

Fig. 18 Side Elevation of 4-storey container flat.

Table 4 Cost comparison of scenario 2.

Description	Container (GH₵)	Cost Comparison	Blockwork (GH₵)	Remarks
Substructure	13,300.00	-	13,300.00	-
Container Structures / Units	70,416.00	↓	102,076.00	Cost of purchasing shipping containers is cheaper than cost of construction of walls, floors, beams and columns of the blockwork house
Structural / Carcasing / Metal / Timber	25,485.00	↑	1,485.00	Cost is higher because it includes the cost of prefabrication and installation of galvanized steel staircase and balustrade to the exterior of the building
Cladding / Covering	3,510.00	-	3,510.00	-
Linings / Sheathering / Dry Wall Partitioning	40,485.00	-	N/A	-
Surface Finishes	19,615.00	↓	41,257.00	Cost is lower because the container house does not require plastering, and the blockwork house requires extra skimming

Table 4 to be continued

Windows / Doors / Stairs	18,164.00	↓	46,370.00	Cost for blockwork house includes the cost of installing galvanized steel railing to suspended walkway
Building Fabric Sundries	2,540.00	-	2,540.00	-
Piped Supply Systems	8,000.00	-	8,000.00	-
Plumbing Installations	7,840.00	-	7,840.00	-
Painting & Decoration	18,256.00	↑	15,220.00	Cost is higher because the container house requires special anti-rust paint and higher quantities of thinner and a consequent higher labour cost
Ventilation /Air Conditioning Systems	1,800.00	-	1,800.00	-
Electrical Supply / Power / Lighting Systems	17,160.00	↓	18,085.00	-??
External Work	5,000.00	-	5,000.00	
Preliminaries	25,156.60	-	25,752.70	
Contingencies	12,578.30	-	12,876.35	
Total	289,300.90	-	296,156.05	The percentage difference is 2.37%

Conclusion

The housing deficit in Ghana is over 2.5million. Inadequate housing in Ghana is as a result of the slow construction process employed in most Ghanaian construction sites and outrageous construction material prices. These have resulted in outrageous house prices for the Ghanaian low and middle income earner and therefore made the owning of a house almost impossible. Ghana needs to explore various building construction process employed in other parts of the world, processes that have been tried and tested and proven to be successful in order to meet the housing demands.

It is recommended that the government of Ghana will reduce the import duty and taxes on the building materials as all, with the exception of sand, stones (aggregate) and water, are imported thus making material prices the highest factor for the high cost of building and housing in the country.

The research has proved however that the container house, that is the bungalow house type, is more expensive and not cheaper (mainly due to the high cost of the essential materials required) than the traditional block work and concrete construction method. When used as a multi-storey flat it proved to be only 2.37% cheaper. Looking at the face value of the money however, the speed of the erection which is approximately 2 weeks will help cut out issues of inflation and material price fluctuations.

It gives an alternative to the conventional block work construction technology however the work required making it decent and habitable increases its overall production cost. Considering the 24% price difference accompanied by the spatial limitation, it is suggested that the ISO container should be used for temporary / make shift accommodation where time is a major factor, and not permanent real estate meant to be transferred to another generation.

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