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BAR 613: RESEARCH THESIS

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PREFABRICATED AND CONVENTIONAL BUILDING METHODS IN KENYA, A COMPARISON

DECLARATION

This is my original work and to the best of my knowledge has not been presented for a degree in any other institution.

Author: Kariuki Caroline Wangui

Signature…….. Date……

This thesis is submitted in partial fulfilment of the examination for the award of the Bachelor of Architecture degree, Department of Architecture and Building Science, University of Nairobi.

Tutor

Signature……...Date……

Year Master

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Signature……Date……..

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.....

My family, friends and classmates and colleagues, for all the love, support and encouragement throughout the whole academic journey.

DEDICATION

To GOD ALMIGHTY, for carrying me through it all.

To my parents, for their undying love, support, and encouragement throughout this journey.

To my friends, for not giving up on me.

Each and every person that offered time to share their knowledge and ideas.

ABSTRACT

Prefabrication has been used extensively and widely for many years around world. Pre-assembly, prefabrication, modularisation, system building and industrialised buildings are the terms frequently used to describe that the manufacture of building components are constructed either on-site or offsite in a factory covering manufactured, modular and pre-cut or pre-engineered systems. Although the terms, are often interchangeably used, their precise definitions depend heavily on the users' experience and understanding, which vary from countries to countries.

Off-site fabrication is adopted worldwide as the ideal means of producing an immense array of elements from structural members, cladding units, and bathrooms to fully-finished modular buildings. Prefabricated building construction systems have been widely adopted not only in public houses but also in private building projects. Prefabrication together with the increasing use of standardisation and mechanisation has brought a substantial change in the development of the construction industry worldwide over last few decades.

Though the development and use of prefabrication in building construction comes a bit late for Kenya, the drastic increase in the application of this technology in building projects in the recent years does regain certain momentum in this leaving-behind area. Besides the accompanying of the related advancements to the local construction industry with the adoption of more mechanisation, computer aided manufacturing, and intelligent management systems, the use of prefabrication also contributes to sustainable development by using cleaner and more resources saving production process.

As many prefabrication technologies deliver a better product because building is done in a quality controlled, sheltered environment, the move to more prefabrication in construction industry is inevitable. It is seen as one of the tenets of improving construction in the 21st century (Egan, 1998; Yeung, Chan and Chan, 2002). This is also echoed by Raysford (2000), "a much greater emphasis on off-site assembly was one of the key ingredients to changing the construction culture to retain and recruit talent and at the same time deliver improvements in performance required by increasingly demanding clients." This paper is cantered on a comparison between prefabricated building systems and conventional building practices that have been adopted by the building industry in Kenya.

TABLE OF CONTENTS

DECLARATION ..... **i**

ACKNOWLEDGEMENTS ..... **ii**

DEDICATION ..... **iii**

ABSTRACT ..... **iv**

1.0 CHAPTER ONE: INTRODUCTION **1**

1.1 BACKGROUND OF STUDY 3

1.1.1.0 History of Prefabricated and Modular CoNSTRUCTION 3

1.1 PROBLEM SATEMENT 7

1.3 RESEARCH QUESTIONS 9

1.4 OBJECTIVES 9

1.5 JUSTIFICATION OF STUDY 10

1.6 SIGNIFICANCE OF STUDY 11

1.7 SCOPE 12

1.8 LIMITATIONS 12

2.0 CHAPTER TWO: LITERATURE REVIEW **13**

2.1 DEFINITIONS 13

2.1.1 PREFABRICATION 13

2.1.1 Preassembly 14

2.1.2 Modular Construction 14

2.1.3 Manufactured Homes 16

2.1.4 Onsite Construction 16

2.1.5 Offsite Construction 16

2.1.6 Modularization 17

2.1.7 Industrialization 17
2.1.8 Modular 17
2.2 PERCEIVED BENEFITS AND CHALLENGES OF MODULAR CONSTRUCTION 18
2.3 Current Trends in Modular Construction 21
2.4 PREFABRICATION AND ITS GOALS 25
2.5 TECHNOLOGICAL APPROACHES TO PREFABRICATION AND STANDARDIZATION 28
2.5.1 United States Of America 28
2.5.2. Finland 28
2.5.3 Sweden 29
2.5.4 Japan 29
2.5.5 Netherlands/Belgium 30
2.5.6 Germany 30
2.5.7 Britain 31
2.6 PREFABRICATION IN KENYA 32
2.6.1 Cost Limitations 33
2.6.2 Flexibility 34
2.6.3 KENYA Solution Providers 34
2.6.3.1 KENYA Solution Providers COMPANY PROFILES TABLE 36
3.0 CHAPTER three: RESEARCH METHODOLOGY 38
3.1 INTRODUCTION 38
3.2 RESEARCH DESIGN 38
3.3 RESEARCH AIMS AND OBJECTIVES 40
3.4 TIME HORIZON 40
3.5 SAMPLING DESIGN 40

3.6 DATA COLLECTION METHODS 41
3.6.1 SECONDARY METHODS 42
3.6.2 PRIMARY METHODS 42
3.7 DATA ANALYSIS 43
3.7.1 DATA ANALYSIS 43
3.7.2 QUALITATIVE ANALYSIS 43
3.8 DATA PRESENTATION. 45
4.0 CHAPTER FOUR: CASE STUDY ANALYSIS 46
4.1 CASE STUDY 1 46
4.1.1.The Eastern Region Scene 47
4.1.2 Project Reviews 51
4.2 CASE STUDY 2 52
Nakagin Capsule Tower – Tokyo, Japan 52
4.3 DATA ANALYSIS AND PRESENTATION, PREFABRICATION IN KENYA 55
4.3.1 DATA ANALYSIS 55
4.3.2 MAIN ISSUES 61
4.3.3 Assessment Matrix 63
5.0 CHAPTER FIVE: RECOMMENDATIONS AND CONCLUSION 65
5.1 GUIDE FOR CLIENTS AND STAKEHOLDERS 65
When to consider off-site prefabrication 65
Issues for Clients 65
Issues for Design Teams 65
Issues for Manufacturers 66
Issues for Contractors 66

5.2 CONSTRUCTION SELECTION FLOWCHART 67
REFERENCES **68**
APPENDICES **70**
APPENDIX 1 70
PREFABRICATION PERSONAL INTERVIEW QUESTIONS 70
APPENDIX 2 72
THE PREFABRICATION QUESTIONNAIRE 72
APPENDIX 3 75
CONSTRUCTION SELECTION FLOWCHART 75
APPENDIX 4 76
Comparison of Assessment Matrix between Different Prefabrication Systems 76
..... 76

LIST OF FIGURES

Figure: 1.0.1 1
Figure: 1.0.2 1
Figure: 1.0.3 2
Figure: 1.0.4 2
Figure: 1.1.1.1.0.1 Two men building wood frame house, Omaha reservation, Nebraska 1877 3
Figure: 1.1.1.1.0.2 3
Figure: 1.1.1.1.0.3 St.mary's church 4
Figure: 1.1.1.1.0.4 St.mary's church 4
Figure: 1.1.1.1.0.5 The one-to-one dom-ino 5
Figure: 1.1.1.2.1 The one-to-one dom-ino 5
Figure: 1.1.1.3 6
Figure: 1.1.1.3.1 6
Source:www.tripcentral.ca ..... **Error! Bookmark not defined.**
Figure: 1.1.0 7
Figure: 1.1.1 Kibera, Nairobi 7
Figure: 1.1.2 Typical tenement area, Pipeline, Nairobi 8
Figure: 1.1.3 Macro flats inserted into larger housing scheme 8
Figure: 1.1.4 ..... **Error! Bookmark not defined.**
Figure: 1.1.5 ..... **Error! Bookmark not defined.**
Figure: 1.3 9
Figure: 1.4 9
Figure: 1.5 10
Figure: 1.61 The use of prefabs shortens up the time used to put up a house 11
Figure: 1.62 Computer aided manufacturing 11

Figure: 1.7 The kenyan building industry....12

Figure: 1.8....12

Figure: 2.1.0 Habitat '67 is an assembly of prefabricated concrete modules. 13

Figure: 2.1.1 Furniture house by shigeru. Use of panelized structures for the interior structural skelleton of the building....14

Figure: 2.1.2 Ibm traveling pavilion by renzo piano: this was a moving exhibition that was broken down into a series of prefabricated components that were designed with demountability and reassembly in mind 15

Figure: 2.1.3 Eames House by Charles and Ray Eames. Was famously designed to be built from 'off-the-shelf' standardized materials as much as possible. 16

Figure: 2.1.6....17

Figure: 2.1.7....17

Figure: 2.2.0....18

Figure: 2.2.2....19

Figure: 2.2.3....19

Figure: 2.2.4....20

Figure: 2.2.5 Complete building prefabrication. Building constructed offsite and carried to site. Also known as transportable building.....21

Figure: 2.3.0 Modular prefabrication-structural boxes or modules erected onsite for modularised home being assembled onsite to form a complete building. 21

Figure: 2.3.1 Component-based prefabrication. Creating components reduce the number of pieces and increase the speed of assembly e.g pre-cut framing and built-up windows....22

Figure: 2.3.2 Panelised prefabrication. Wall, floor and roof panels. Can be open or closed2-dimensional "area" elements. 22

Figure: 2.3.3 Hybrid prefabrication. Combination with another or with traditional construction e.g. Modules interspersed with panels. Involves onsite construction as well as assembly of prefabricated sections....23

Figure: 2.3.4....23

Figure: 2.3.5 Panels are extremely light-weight and easily handled by the construction team....24

Figure: 2.3.6....24

Figure: 2.4.1....25

Figure: 2.4.2 25
Figure: 2.4.3 26
Figure: 2.4.4 26
Figure: 2.35 27
Figure: 2.36 Composites are formed by combining materials together to form an overall structure that is better than the sum of the individual components 27
Figure: 2.5.1 Kannustalo's "touch" by mikko heikkinen and markku komonen 28
Figure: 2.5.2 28
Figure: 2.5.3 Japanese housing industry 29
Figure: 2.5.4 Netherlands prefab industry 29
Figure: 2.5.5 Modular Hospital Building During installation Of Open-Sided Modules 30
Figure: 2.5.6 First eight-story wooden building in Germany 30
Figure: 2.5.7 Bognor drive-thru, first modular two storey building of its kind in the Uk. 31
Figure: 2.5.8 'Timber Frame Project' 31
Figure: 2.6.1 Colourful crammed-up kayole 32
Figure: 2.6.2 Kibera slums being upgraded to new apartment by the kenyan ministry of housing and united nations habitat 32
Figure: 2.6.3 EPS Factory- front view of administration block 33
Figure: 2.6.4 EPS Factory- view inside the factory 33
Figure: 2.6.5 NSSF Nyayo Highrise, embakasi 34
Figure: 2.6.6 Nhc workers construct a sample expanded polystyrene panels house on aga khan walk on june 14, 2013. 34
Figure: 2.6.7 Hong Kong Building Centre, Mombasa rd. Nairobi, Kenya. 35
Figure: 3.1.1 Research Methodology 38
Figure: 3.1.2 Research Types 38
Figure: 3.1.3 Case Study Research Design 39
Figure: 3.1.4 pi-personal interview 39

Figure: 3.3 Sampling Design....40
Figure: 3.4 Cross-Sectional Research Study....40
Figure: 3.5.1 Preliminary considerations in selecting a sample....41
Figure: 3.5.2 Random sample....41
Figure: 3.6.1 Secondary Methods of Data Collection....42
Figure: 3.6.2 Primary Methods of Data Collection....42
Figure: 3.7.1 Quantitative research statistical analysis....43
Figure: 3.7.2 Qualitative Research Process....43
Figure: 3.7.3 Descriptive Analysis....44
Figure: 3.7.4 Qualitative Research Process....44
Figure: 3.8.1 Pie-chart....45
Figure: 4.2.1 Steel framed volumetric classbases at St andrews J & I school, Colchester, Essex....47
Figure: 4.2.1.1 Timber Panel System Hall at St.Marys Primary School, Ardleigh, Essex....47
Figure: 4.2.2 Timber Panel System Hall at Rickling Primary School, Essex.....48
Figure: 4.2.3 Timber Panel System Nursery Unit at Woodside Primary School, Norwich, Norfolk....48
Figure: 4.2.4 Timber Panel System Nursery Unit at Woodside Primary School, Norwich, Norfolk....49



Figure: 1.0.1 Prefab component

Source: http:// fileprefabricated-house-constructionjpg-wikipedia



Figure: 1.0.2 A manufactured house

Source: http:// fileprefabricated-home-constructionjpg-wikipedia

1.0 CHAPTER ONE: INTRODUCTION

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located. A modular structure however, is not a mobile structure; it is simply a structure that is built off-site as opposed to on-site. These structures are often called factory-built structures, system-built or pre-fab structures. Modular and manufactured structures however, are not the same. Manufactured buildings are not placed on permanent foundations. Manufactured homes, sometimes referred to as mobile homes can be moved from one location to another.

Prefabrication has been used extensively and widely for many years around the world. Pre-assembly, prefabrication, modularisation, system building and industrialised buildings are the terms which have been frequently used to describe that the manufacture of building components are constructed either on-site or off-site in a factory covering manufactured, modular and pre-cut or pre-engineered systems. Although the terms, are often interchangeably used, their precise definitions depend heavily on the users' experience and understanding, which vary from country to country. Prefabrication is preferred with special emphasis on the building components are made off-site in a factory. Off-site fabrication is a topic of international interest and provides an effective construction technique in term s of quality, time, cost, function, productivity and safety. It is adopted worldwide as the ideal means of producing an immense array of elements from structural members, cladding units, and bathrooms to fully-finished modular buildings.



Figure: 1.0.3

Source:http://livingstingy.blogspot.co.ke/2012_08_01_archive.html

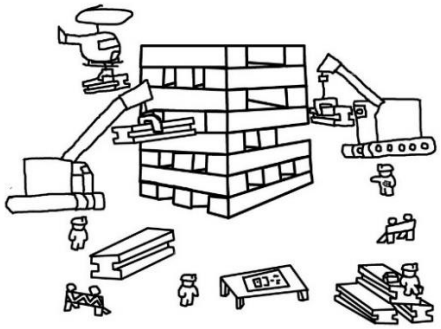


Figure: 1.0.4

Source: http:// filedeconstruction-constructionjpg-wikipedia

Architects are incorporating modern designs into the prefabricated houses of today. Prefab housing should no longer be compared to a mobile home in terms of appearance, but to that of a complex modernist design. There has also been an increase in the use of "green" materials in the construction of these prefab houses. Consumers can easily select between different environmentally friendly finishes and wall systems. Since these homes are built in parts, it is easy for a home owner to add additional rooms or even solar panels to the roofs.

Many prefab houses can be customized to the client's specific location and climate, making prefab homes much more flexible and modern than before. **Designing for flexibility** enables significant changes to be made to the building during the course of its life. This can help to delay or avoid the building's obsolescence.

This study seeks to establish the challenges being presented by the construction industry in Kenya in the application of the prefabrication concept.



Figure: 1.1.1.1.0.1 Two men building wood frame house, Omaha reservation, Nebraska 1877

Source: https:// wikipedia/ /Sears_Magnolia_Catalog_Image.jpg/



Figure: 1.1.1.1.0.2 Prefab containers

Source:https://upload.wikimedia.org/wikipedia/en/thumb/1/1d/Sears_Magnol

1.1 BACKGROUND OF STUDY

1.1.1.0 HISTORY OF PREFABRICATED AND MODULAR CONSTRUCTION

While prefabrication and modularity are commonly considered in concert with technological and material innovations, the origins of prefabricated building involve neither factory nor mass-produced materials. The process of sending complete, ready-cut building components to be assembled has been part of the construction process in **America** since the 17th century. In the 1850s, the balloon frame system of construction revolutionized the speed with which new housing could be built. In the early 20 families could order **a Sears, Roebuck & Co. home** out of a catalog and wait for an assembly kit to arrive. During World War II, prefabrication allowed soldiers to be housed in mobile shelters and then spawned the comfortable suburbs inhabited by returning GIs.

Prefabrication and modularity have made recent strides as architects and developers find new applications for the technology beyond the single family home: now urban towers can be constructed from modular and prefabricated components. While the technology has grown with the building practice itself, the widespread adoption of these design components

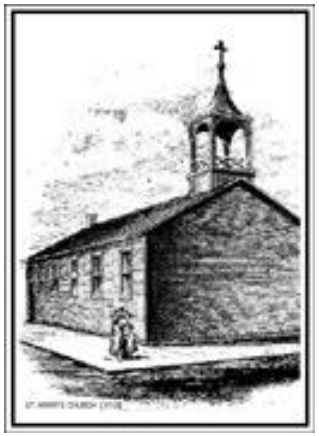


Figure: 1.1.1.1.0.3 St.mary's church

Source:(Photographer unknown, Chicago Historical Society)



Figure: 1.1.1.1.0.4 St.mary's church

Source:(Photographer unknown, Chicago Historical Society)

has faced challenges. Modularity's association with **trailer housing** has led to its public perception as unsightly and unstable, the difficulties of coordinating delivery systems and personnel has made the new construction process challenging in dense urban areas, and its lack of integration into the design process has ensured its exclusion from many projects.

In 1833, Chicago saw the first "**balloon frame"** building. St. Mary's Church, erected on Lake Street. Credited to, alternately, a man named George W. Snow and a carpenter named Augustine Deodat Taylor, the innovation of the balloon frame involved using uniform, In the early twentieth century, both domestically and abroad, architects and engineers were grappling with the question of how to efficiently and simply slender wood studs held together with newly mass-produced nails, rather than with more complex joinery. The technique, so called due to its lightness and precarious appearance, proved to be an expedient way of creating much-needed housing in burgeoning urban centres.

1.1.1.1THE INDUSTRIAL REVOLUTION AND WORLD WAR

First conceived as a prototype for mass-produced European housing, The Maison Dom-Ino was designed by Le Corbusier in 1914 as a minimalist housing prototype that would address



Figure: 1.1.1.1.0.5 The one-to-one dom-ino

Source:www.world-architects.com



Figure: 1.1.1.2.1 The one-to-one dom-ino

Source:www.world-architects.com

a Europe-wide housing shortage in the years leading up to the Great War. It was built as a transportable, flat-pack installation.

Located outside the Central Pavilion, the One-to-One Dom-Ino was put together using Le Corbusier's system B concept. The structure was first conceived in concrete and steel, but they instead decided to create the horizontal floor slabs, slim pilotis and zigzagging staircase from engineered timber. This allows the project to be flat packed and transported to different locations.

1.1.1.2 WORLD WAR II AND POST-WAR HOUSING

During world war ii, prefabricated sheet-metal construction achieved widespread use in the form of military barracks and mobile trailers which highlighted the usefulness of temporary housing. By the end of the war, sears, roebuck & co. Had ceased production on homes and the notion of prefabrication had lost its charm. By 1946, a *fortune* magazine survey indicated a sharp turn against prefabricated houses, with only 16% of respondents saying they would choose to live in one. With the subsequent post-war housing shortage, the use of prefabricated materials was necessary to shelter a severely under-housed population.



Figure: 1.1.1.3 Moshe Safdie's Habitat '67

Source:www.tripcentral.ca



Figure: 1.1.1.3.1 The large apartment building fitted together like a puzzle.

Source: www.tripcentral.ca

1.1.1.3 MODULARITY AND PREFABRICATION

After the war; the suburban boom relied on pre-cut, standardized housing designs. **Levittown**, the best-known example of the American post-war suburb, thrived on the replicability of house after house. The production was so streamlined that a house rose from the ground every fifteen minutes: "Every 100 feet, (the) trucks stopped and dumped identical bundles of lumber, pipes, bricks, shingles and copper tubing… Near the bundles, giant machines with an endless chain of buckets ate into the earth, taking just 13 minutes to dig a narrow, four-foot trench around a 25-by-32 ft. rectangle. Then came more trucks, loaded with cement, and laid a four-inch foundation for a house…"

1.1.1.3.1 1960-1990

In 1967, Moshe Safdie's **Habitat '67**, was constructed for the Montreal World's Fair. The large apartment building fitted together like a puzzle. The design was meant to be easily duplicated as the modules could be assembled anywhere, regardless of location. The 1960s also brought a growing trend of mobile home purchases as well as advocacy for modular housing to accommodate the needs of lower-income families.



Figure: 1.1.0 Kayole, Nairobi

Source: (Baraka Mwau, (2012)



Figure: 1.1.1 Kibera, Nairobi

Source: (Baraka Mwau, (2012)

1.1 PROBLEM SATEMENT

Kenya's annual demand for housing stands at over 200,000 units annually against a supply of 40,000 units. Therefore, prefabricated housing technology is starting to get popular as builders seek innovative ways to address Kenya's acute housing shortage in a cost-effective way. This technology involves manufacturing prefabs in a factory, usually in standard sections that can easily be transported and assembled on-site.

Although the use of prefabs has been widely accepted in the United States and other developed countries, the major problem faced by modular components suppliers locally is the Kenyans' lack of appreciation for and understanding of these components.

The current state of prefabrication is severely limited by numerous factors. The main obstacles can be categorized as costs and time, with these being interrelated. The main opportunity factors for prefabrication are the prohibitive aspects of building materials



Figure: 1.1.2 Typical tenement area, Pipeline, Nairobi

Source: (Baraka Mwau, (2012)



Figure: 1.1.3 Macro flats inserted into larger housing scheme

Source: http:// fileprefabricated-home-constructionjpg-wikipedia

disposal and the value of recovered materials in environmental and economic terms. Related to the economic costs/benefits recovered materials are the quality of materials, either high-quality reuse, economically recyclable or hazardous materials and materials and systems that have become obsolete or are difficult to separate. Then again, most buildings in Kenya are typically not designed to be deconstructed since they were built using conventional in-situ construction system.

There are many efforts to redefine production and achieve "eco-efficiencies" for consumer products through dematerialization, environmental management, design for environment, design for disassembly, and design for recycling. The design, construction, and maintenance characteristics of buildings are much different than consumable goods. Buildings are expected to have much longer lives, are greater capital investments, and involve a multiplicity of factors in design, construction, regulation, financing, insurance, maintenance, repair, occupancy, and ownership over time.

The perception that housing should be malleable for adaptation and disassembly carries the perception of instability, incongruent with the notion of "home as castle." Housing in fact does share many characteristics of consumable products depending upon the culture and urban location.



Figure: 1.3

Source:



Figure: 1.4

Source:

1.3 RESEARCH QUESTIONS

1) What is the current level of utilization of prefabrication techniques in the building sector of the construction industry?
2) What are the advantages and disadvantages of prefabricated techniques in the current industry?
3) What are the advantages and challenges of conventional building practices in the current industry?

1.4 OBJECTIVES

1) Investigate the current level of utilization of prefabrication technology in the building sector of the construction industry.
2) Examine the advantages and disadvantages of prefabrication technology in the building industry.
3) Examine the advantages and challenges of conventional building practices in the current industry.
4) Formulate construction techniques that will integrate prefabrication in the current conventional building practices.

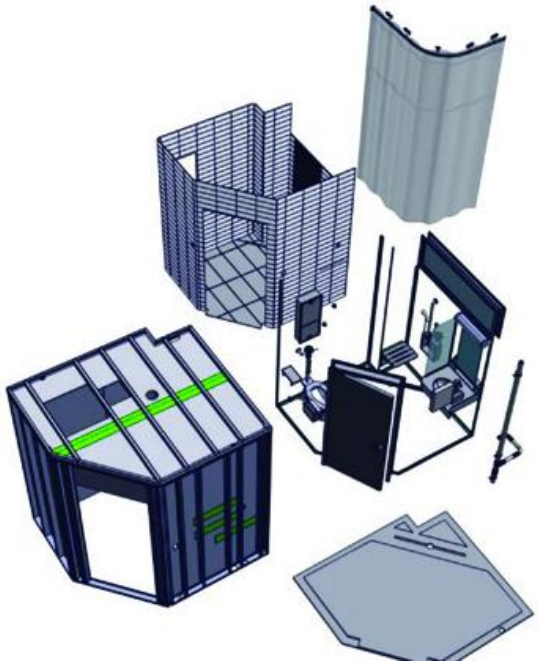


Figure: 1.5 Prefab modules

Source:

1.5 JUSTIFICATION OF STUDY

The building legacy of the 20th century has been one of waste and toxicity. The United States EPA has estimated that the materials debris from building renovation and demolition comprise25 to 30% of all waste produced in the US each year. Aesthetic conventions and economic factors that influence land use and buildings over long periods of time are not predictable by the building designer, but nonetheless, buildings can be built with the intention of adaptation and/or eventual removal.

Prefabrication can make use of the lessons learned from product design for environment, and from the obstacles encountered in the prefabrication of modern buildings. This paper will discuss principles of design for prefabrication and lessons learned from prefabrication practice to propose guidelines for design for prefabrication.

A perceived lack of innovation in prefabricated construction projects to date raises the question of why, or what is holding the industry back. The problem is that industry-wide design limitations and restrictions prohibiting building construction methods or materials are not clearly known to architects. This study is therefore designed to discover the challenges presented to architects and other construction and design professionals, involved in the design of prefabrication buildings.



Figure: 1.61 The use of prefabs shortens up the time used to put up a house

Source:http://www.constructionkenya.com/1936/prefabricated-houses-in-kenya/



Figure: 1.62 Computer aided manufacturing

Source:(discovery.dc.com)

1.6 SIGNIFICANCE OF STUDY

Prefabricated building construction systems have been widely adopted not only in public houses but also in private building projects. Prefabrication together with the increasing use of standardisation and mechanisation has brought a substantial change in the development of the construction industry worldwide over last few decades. Though the use of prefabrication in building construction comes a bit late for Kenya, the drastic increase in the application of this technology in building projects in the recent years does regain certain momentum in this leaving-behind area.

Besides the accompanying of the related advancements to the local construction industry with the adoption of more mechanisation, computer aided manufacturing, and intelligent management systems, the extensive use of prefabrication also contributes to sustainable development by using cleaner and more resources saving production process development

Environmental issues have gathered increasing attention from the construction industry all over the world the last couple of decades. Prefabrication is an innovation that further refocuses the construction industry to become more sustainable.



Figure: 1.7 The kenyan building industry.

Source: (building.co.ke)



Figure: 1.8

Source:(www.cats-solution.co.uk)

1.7 SCOPE

The study focuses on the comparison between prefabricated construction and conventional building methods in the Kenyan building industry.

This entails the analysis of various parameters that have to be met in either method of construction. The actors involved in the study include:

1) Contractors
2) Quantity Surveyors
3) Structural Engineers
4) Product Designers
5) Architects
6) Electrical Engineers
7) Civil Engineers

1.8 LIMITATIONS

1) Time- the research was restricted to the period between August and December 2015. Given the wide scope of research, the author relied mainly on secondary data for general information allowing more time for the primary data collection.

2) Appointments with some of the actors were not fruitful as the professionals were unable to meet up for the short interview sessions due to their very busy schedules, thus the scope of study was further narrowed.

3) There were financial constraints, related to scanning and making of soft copies of the hard copies architectural drawings. The author solved this by generating some of the drawings and photographing the rest for analysis and presentation purposes.