ANALYSIS OF GEOMETRIC FORMS OF MODERN ARCHITECTURE: A CASE OF NAIROBI CBD

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DEDICATION

To GOD, man and time.

DECLARATION

This thesis is my original work and has not been presented in any other University or Institution for the purpose of awarding a degree to the best of my knowledge. This thesis is submitted in partial fulfilment of the examination requirements for the award of the Bachelor of Architecture degree, in the Department of Architecture at the University of Nairobi.

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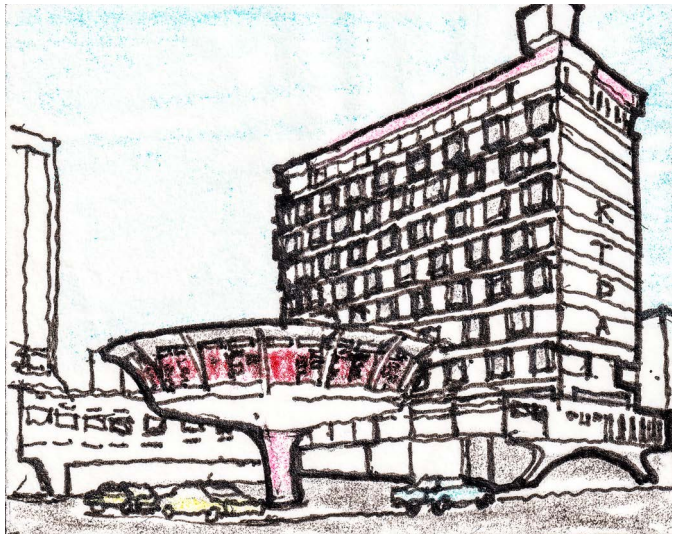

Fig 1.0; A sketch of Chai House and Florida Night Club as an example of modern architecture in Nairobi CBD. Source: Author. Placed: 04/04/2023

ABSTRACT

Geometry and form as science is indispensable to architecture. This relationship between architecture and geometry inspired research on numerous geometric theories in the modern architecture period. Inspired by this theories, this study searches for the influence of geometry in the modern architecture of Nairobi from 1963 to 1990, to explore the various geometric form-making techniques used therein. The study explores the use of geometry as a tool for designing architecture through analysis of the various precedents that were documented in this study.

The research involves a comprehensive review of existing literature on geometry and modern architecture, as well as a qualitative analysis of selected precedents of modern architecture buildings in Nairobi's CBD between 1963 and 1990. The buildings are selected based on their architectural significance and geometric relevance to the study. The analysis reveals the geometric form making techniques that were in application in the modern architecture period of Nairobi's CBD. The analysis also applies the use of geometry as a tool for architectural design by introducing a template that can be followed in the architectural design phase. The lessons learnt in this study propose recommended best practices of geometric form-making techniques of modern architecture in Nairobi's CBD and thus furthers the efforts of previous scholarly works on the city's architecture.

INTRODUCTION

CHAPTER ONE

1.0 BACKGROUND OF STUDY

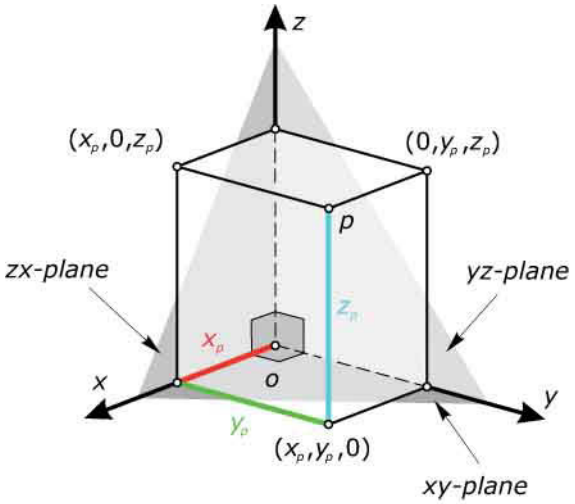

Fig. 1.1: Cartesian Coordinate system illustrating a point *p* in a three dimensional space. Source: Helmut (2007), Architectural Geometry page 15. Retrieved: 12/12/2022

Fig. 1.2: The pyramids of Giza, Egypt. Source; https://www.designingbuildings.co.uk/wiki/Great_Pyramid_of_Giza. Retrieved: 05/08/2022

"Architecture is geometry made visible", where of all the arts, architecture is the one most closely related to geometry (Bragdon, 1910). Although the main effort of most design processes is toward resultant forms of one kind or another, no methodology exists for generating, perceiving, and manipulating pure form: it is intuitive. "In short, design has no basis for a complete Form Language" (Williams, 1972). According to Helmut (2007), architecture exists in space defined by three mutually perpendicular oriented axes, the x, y and z-axis, which form the Cartesian coordinate system (Fig. 1.1). This is further reinforced by Klee (1961) adding, "All pictorial form begins with the point that sets itself in motion. The point moves and the line comes into the first dimension. If the line shifts to form a plane, we obtain a two-dimensional element. In the movement from plane to space, the clash of planes gives rise to the body (three-dimensional). A summary of the kinetic energies which move the point into a line, the line into a plane, and the plane into a spatial dimension."

"Architecture is one of the most urgent needs of man, for the house has always been the indispensable and first tool that he has forged for himself" (Le Corbusier, 1931). Building on this statement, it is important to outline the historic relationship between geometry and architecture which can be traced to early human civilization. Early Egyptian civilization is one curious case. According to Yuval (2011), by 3100 BC the entire lower Nile Valley was united into the first Egyptian kingdom, and Gest (1972), further points out that at the peak of the civilization, the pyramids of Giza were built around 2500 BC (Fig. 1.2). Bragdon (1972) adds that the sides of the pyramids in their original condition are believed to have been equilateral triangles. Further according to Unwin (1997), the pyramids at Giza are based on a square base and a crowning summit which is geometrically placed at the centre of a square plan. The overarching principle of the architecture of the pyramids at Giza is a demonstration of strict adherence to and an understanding of geometric laws. Other early civilizations such as the Babylonians and Ancient Indians have also shown a deep understanding of strong geometric relationships in their architectural order. Architectural order is derived from geometric compositions, created when the organization of the parts makes visible their relationships to each other and the structure as a whole (Ching, 1943).

From these arguments, the issue of architectural form and order of geometrical shapes is of concern. A look at Nairobi, the capital city of Kenya, yields an accessory of curious architectural forms. Nairobi

Fig. 1.3: Nairobi CBD, Parliament clock tower in the foreground while KICC left and Times Tower right form the background. Source: https://unsplash.com/s/photos/nairobi-city. Retrieved on: 13/12/2022

Fig. 1.4: Nairobi CBD, showing some of the variety in Architectural form in scale, shape and heights. Source: https://www.nationalgeographic.co.uk/travel/2021/11/. Retrieved on: 13/12/2022

reflects the history of architecture better than any other Kenyan city or municipality. The order in which the buildings were constructed and their inherent functions compare favourably to the history of Kenya. Over the years, Nairobi has collected an array of built forms including some from the colonial era, where most of the present built forms have developed after independence. The analysis of this architectural history, to bring out the underlying forces of design that create the unique architectural identity of Nairobi, one that is not entirely similar to its neighbouring cities is what this thesis intends to achieve. This thesis will further, explore the geometric language in the modern architecture of Nairobi, to understand how some architectural forms came to be conceptualized (Fig. 1.3). Through the analysis, factors such as proximity of geometric shapes and the composition of geometric shapes are going to be analysed and brought out.

The search in this study is for a theory which transcends the moment and reveals an architectural idea. The technique for this research is the careful examination and analysis of buildings. The desired result is the development of theories to generate ideas with which to design architecture (Clark & Pause, 2005). Indeed, this research is themed on the History and Theory of architecture with a particular interest in modern architecture within Nairobi CBD and its larger neighbourhood.

1.1 PROBLEM STATEMENT

Spatial order, geometry and built form is an interesting study, and within certain limits, a useful one, as a conscious effort of the creative faculty (Bragdon, 1910). Drawing inspiration from this statement the author chose to investigate the built form of Nairobi with a particular interest in the geometric compositions of modern architecture buildings in the period from when Kenya gained independence (1963) to 1990. From the outlook, the architecture of Nairobi is a product of many architects who have managed to create spatial order, geometry and built forms enough to ground a research (Fig. 1.4). It is from this basis, that the research would like to explore such a concept by exploring the geometric composition of buildings in Nairobi within the outlined timeline.

To understand the concept of geometry a broader view will need to be taken. The question of urban character as a result of the built form will be indulged. Norberg-Schulz, (1980) describes urban character as, a determinant of how things are in an urban set-up which gives a stage upon which everyday life

Fig. 1.5: Mombasa Old town, showing architectural continuity through geometry, size and colour. Source: https://www.archidatum.com/ImageGen. Retrieved on: 14/12/2022

unfolds. This can be explained by looking at a few urban cases. For example the case of Swahili towns. Swahili towns display a distinct expression in their architecture, where displays of a conscious architectural language are made (Fig. 1.5). Every building contributes both to the past and the future through the continuity of an architectural language. Similarly, by extension Nairobi and its environs have their characteristic architectural language which is told through its characteristic built forms. Through analysis, the author seeks is to find out what Nairobi's architecture wants to be (Fig 1.6), in an attempt to generate architectural knowledge from the perspective of architectural geometry of the past expressed in modern architecture buildings. It is expected that from the research a reference point for future architecture can be proposed in favour of architectural continuity. Multiple designers can realise a spatially beautiful environment (Bragdon, 1910), yet, according to Williams (1972), the total effect of design efforts from a variety of individual designers, is that our built environment might have a completely

Fig. 1.6: Shows Nairobi's CBD skyline where its latent architecture is expressed. Source: https://www.behance.net/gallery/117339333/Urban-Landscapes-Collection-II-2021-Muted-Nairobi?tracking_source=project_owner_other_projects Retrieved on: 25/03/2023

chaotic and meaningless outcome on the one hand or a rigid and uninteresting orderliness on the other hand. However, to leave architecture to chance might yield undesirable spatial outcomes, therefore, this thesis will explore the architectural expression through geometry and consequently the perceived built form, of modern architecture in Nairobi CBD between the years 1963 to 1990. Similar to Clark & Pause (2005), this thesis intends to assist in understanding architectural history, examine the basic similarity in architectural designs, identify basic solutions that transcend time and develop analysis as a tool for design. From the findings of the research, it will be possible to propose a geometric reference point from which our current architectural practices can look for inspiration or contextual linkage of the newly built forms with those of the past. “It is possible to begin to develop a consciousness of form and, more importantly, a consciousness of the relationships among forms through Form Language” (William, 1972). We can have variety without chaos and order without rigidity.

Fig. 1.7: Kenyatta International Conference Centre (KICC) as the most cited example of African Modernism as a Kenyan contribution. This image illustrates the Tower and Amphitheatre. Source: Author. Photographed on: 18/12/2022

1.2 RESEARCH OBJECTIVES

1) To document modern architecture precedents in Nairobi CBD between 1963 to 1990.
2) To analyse geometric composition techniques of modern architecture precedents in Nairobi CBD between 1963 to 1990, and;
3) To develop a geometric reference tool for architectural design in Nairobi CBD.

1.3 RESEARCH QUESTIONS

1) What are examples of modern architecture precedents in Nairobi CBD between 1963 to 1990?
2) How are geometric composition techniques of modern architecture precedents in Nairobi CBD expressed between 1963 to 1990?
3) What are the recommended guidelines for developing a geometric reference tool for architectural design in Nairobi CBD?

1.4 JUSTIFICATION OF STUDY

This study will serve as a basis for creating a design reference point for future architecture in Nairobi, to address the issue of identity. The research furthers previous studies on modern architecture in Nairobi

Fig. 1.8: An aerial view of Lamu Town, which is in the UNESCO World Heritage List. Source: https://www.youtube.com/watch?v=0LSZCcHwrtU. Retrieved on: 05/12/2019

Fig. 1.9: Map of Africa, highlighting Kenya. Source: https://d-maps.com/m/africa/afrique/afrique29.svg. Retrieved: 15/08/2022. Edited by the author

which looked at theories such as critical regionalism, as an analysis of modern architecture in Kenya. Kenya International Conference Centre (Fig 1.7) in the preceding studies had been the main case study with the mention of other precedents. This study will expand this knowledge base by analysing other precedents within the timeline scope of this research. This research, therefore, seeks to fill a knowledge gap by documenting and analysing the modern architecture movement in Nairobi between 1963 to 1990, in an attempt to decode the architectural forms and organising principles from a geometric base.

1.5 SIGNIFICANCE OF STUDY

The research will highlight a specific period in the architectural history of Nairobi. The knowledge generated through documentation of modern architecture will inform the Nairobi County Government, on decisions to come up with policies for future architectural designs in response to the already existing building forms in Nairobi. This information will be useful to future researchers such as undergraduate architectural students as a documented reference for similar research projects. It will also be of use as an initial point of entry for conservation efforts of any buildings or regions in Nairobi, such as future UNESCO efforts to lobby for the addition of Nairobi's architecture into the World Heritage List joining Lamu town (Fig. 1.8). It will also be an important document in the conservation of national heritage sites proposed by the Kenyan State through authorities such as the National Museums of Kenya.

1.6 SCOPE AND LIMITATIONS

This scope of the research is tailored to focus on the most important variables which include; the selection of geographical scope, selection of period and selection of building typologies. Globally Kenya is located in the East of Africa within its North and South half point (fig 1.9). It was a British colony from the early 20th century gaining its independence in 1963. The research begins its study from 1963 the time of independence to 1990. The building typologies in the study will be diverse but since the study is within the CBD of Nairobi it is expected that much of the precedents will be commercial and civic buildings. The architectural style is limited to modernism thus of precedents which were constructed within the time line outlined. The specific locale will be Nairobi CBD and its immediate environs.

1.6.1 GEOGRAPHICAL SCOPE

Nairobi is located in the south of Kenya (Fig. 1.10). The central business district (CBD) and its immediate environment are outlined in the map (Fig. 1.11). The justification of the area of study is based on the fact that it has the highest concentration of modern architectural works in Kenya.

Fig. 1.10: Map of Kenya, highlighting Nairobi. Source: https://d-maps.com/m/africa/kenya/kenya39.svg.Retrived: 15/08/2022. Edited by the author

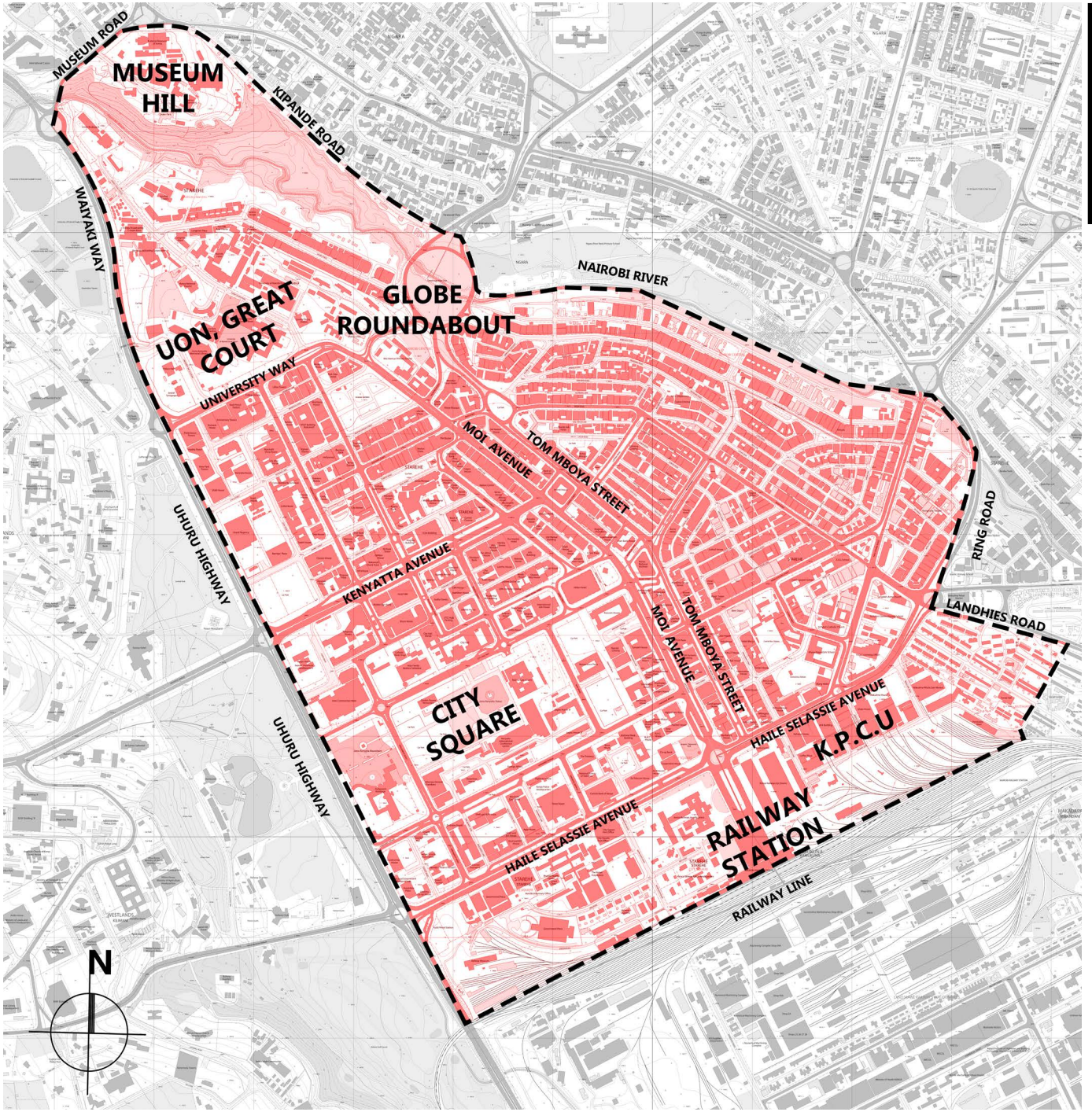

Fig. 1.11: Map of Nairobi CBD, highlighting the area of study and the surrounding scope. Source: JICA Maps (Nairobi region). Retrieved: 12/12/2022. Edited by the author.

Fig. 1.12: Kenya Parliament second chambers designed in 1962. Source: https://africasacountry.com/2020/10/the-soft-patriarchal-underbelly-of-kenyas-parliament. Retrieved on: 14/12/2022

Fig. 1.13: Lonrho House completed in 1990, showing change from modernism to the international style. Source: https://www.kenyans.co.ke/news/46287-5. Retrieved on: 14/12/2022

1.6.2 TIMELINE SCOPE

The period of the research begins after the independence of Kenya in 1963 with precedents such as the Kenyan Parliament (fig 1.12) and extends until 1990 with precedents such as Lonhro House (fig 1.13). This decision comes from an assessment of the impact of architecture before and after the introduction of glass skyscrapers in Nairobi, where it becomes the most polemical building typology at that time. During this period, modern architecture in Kenya was one of architectural and cultural curiosity in the national context. Most Iconic buildings such as the Kenyatta International Conference Centre (KICC), Kencom House and Co-operative House, famously known as the bell bottom tower, became city landmarks and some like the KICC national heritage symbols.

1.6.3 BUILDING TYPOLOGY

The research period covers a time when architectural design and construction in the country was fast-paced, and as such multiple building typologies were being developed a majority of which were located in Nairobi. In Nairobi, the main building typologies are commercial buildings, civic buildings and institutional buildings. However, for the sake of clarity and brevity, the consideration of only a few of several architectural works will be attempted, a sample of those that can contribute significantly to a geometric analysis of form research. The selection criteria for these buildings will be based on a purposive sampling technique. The sample population is going to be selected from the source list developed by the author in table 6.0 in the appendices section.

1.6.4 LIMITATION OF STUDY

As an academic research project the main limitation is the availability of data. The sources of data could not be established, the owners of the data such as building drawings and metadata were not willing to share the information and in some extreme cases, data had been lost or damaged. The author attempted to cover this challenge by looking for secondary sources such as the Build Kenya publications which had some recount of a few of the precedents. The other method was to reproduce the drawings through measured sketches.

From the proposed solution above another challenge became access to the selected precedents. The way to mitigate this challenge was to acquire current, truthful and relevant student identification documents and

Fig. 1.14: Baker, G. H. (2006). Design Strategies in Architecture. Source: https://www.barnesandnoble.com/ Retrieved: 23/03/2023

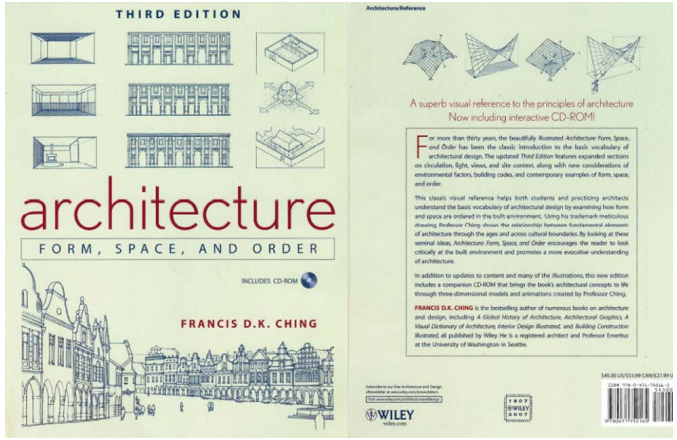

Fig. 1.15: Ching, F. (1934) Architecture: Form Space and Order. Source: http://siamnovella.com/ Retrieved on: 23/03/2023

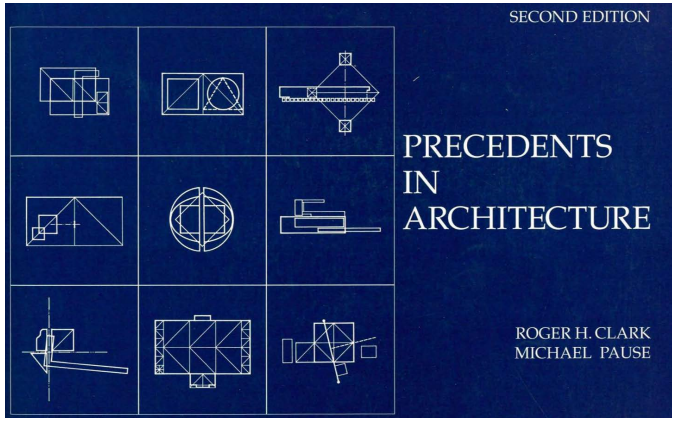

Fig. 1.16: Clark R., Pause M. (2005). Precedents in Architecture. Source: https://issuu.com/lynseylyn. Retrieved on: 23/03/2023

preparation of clear data requirements addressed to the building management to increase the chances for access to data collection. This was successful in most of the cases and thus proved to be a fruitful method.

To address the time limitation a purposive sampling technique was applied to select the most relevant buildings to investigate the geometric phenomena, pre-selection criteria of precedents and categorising them according to their decades was the method applied.

1.7 LITERATURE REVIEWED

The theoretical framework of this research is based on literature from published books, journals and articles. Majority of the literature is from published books.

1.7.1 PUBLISHED SOURCES

1. Baker, G. H. (2006). Design Strategies in Architecture: An Approach to the Analysis of Form. New York, NJ: Routledge. (fig. 1.14)
2. Baker, G. H. (2005) . Le Corbusier: An Analysis of Form. New York, NJ: Spon Press.
3. Bragdon C. (1910). The Beautiful Necessity: Seven Essays on Theosophy and Architecture. New York: The Manas Press.
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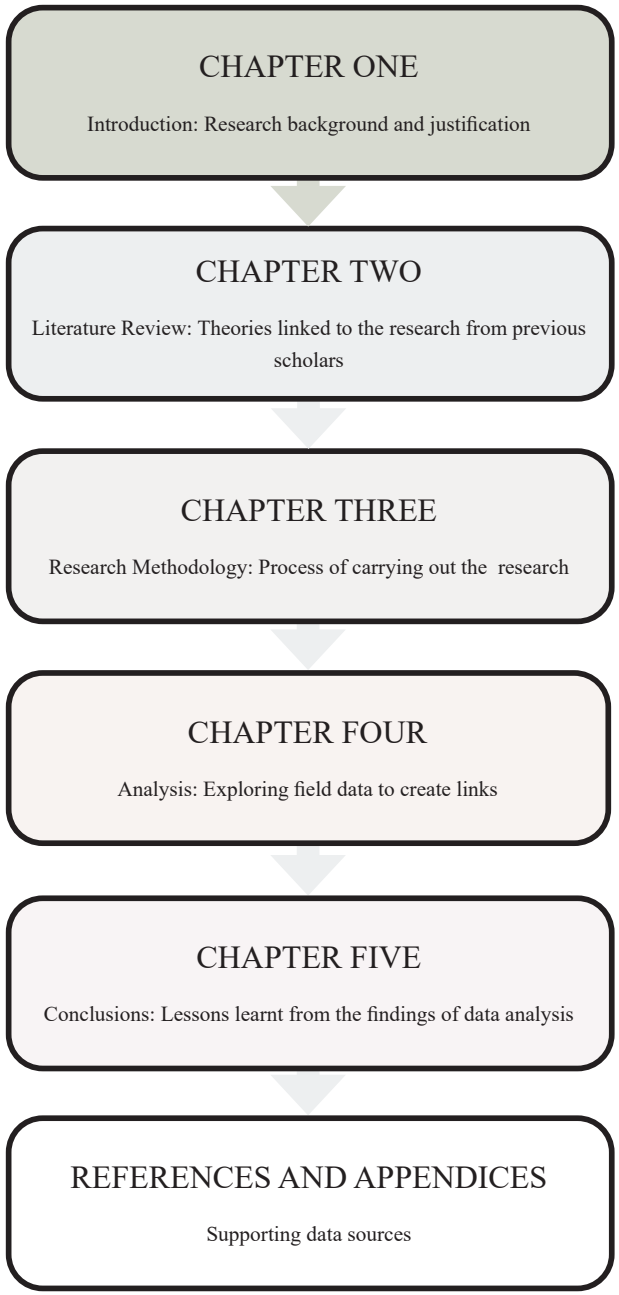

Fig. 1.17: Flow chart of the flow of the study structure. Source: Author on 27/03/2023

12. Rowland, K. (1966). Looking and seeing. London: Ginn.
13. Salingaros, N. A., & Mehaffy, M. W. (2008). A theory of Architecture. Solingen: Umbau-Verlag.
14. Unwin, S. (1997). Analysing Architecture. London: Routledge.
15. Venturi, R. (1966). Complexity and Contradiction in Architecture. Lawrenceville, NJ: Princeton University Press.

1.8 ORGANIZATION OF STUDY

1.8.1 CHAPTER ONE

Chapter one is an introduction to the research and highlights the problem, which is identified as a need to decipher the geometric language used in the modern architecture of Nairobi. It also gives an overview of the research objectives and research questions as main the guides for the study. It defines the scope of study categorised as geographic scope, timeline scope and building typologies considered. A section has also been dedicated to giving a brief definition of the terms used in the research.

1.8.2 CHAPTER TWO

Chapter Two forms a theoretic basis, through a literature review from preceding discussions on the research phenomena by other scholars. An overview of modern architecture, its characteristics and the geometric archetypes of the modern movement. A discourse on geometry and parameters influencing geometric forms will be reviewed, from which a set of research parameters will be developed for the research methodology that will guide Chapter Four based on practical research. A brief history of the city of Nairobi, and how it impacts architecture.

1.8.3 CHAPTER THREE

Chapter Three develops the research procedures from which architectural geometric form analysis can be organized. A list of data collection tools, data analysis techniques and data presentation approaches was developed for guiding the research data collection, analysis and presentation.

1.8.4 CHAPTER FOUR

Chapter Four is the application of the research methodology where data collection tools are administered in the field collecting the necessary data required for the research. From the data collected, initial data sorting and data processing were carried out to categorise similar data groups and select the most relevant data for analysis. An analysis of the data collected was carried out to investigate the phenomena selected after which it was presented in the selected formats outlined in Chapter Three.

Fig. 1.18: Sydney Opera House, Sydney, Australia. Source: https://archinect.com/news/article/149983978/. Retrieved on: 27/03/2023

1.8.5 CHAPTER FIVE

Chapter Five develops recommendations and conclusions derived form Chapter Four, which give a holistic report of the research. It gives recommendations on possible design approaches for architectural works in Nairobi CBD for a geometric design resolution.

1.8.6 REFERENCES AND APPENDICES

Chapter Six gives an exhaustive list of the supporting research material which includes a bibliography and research data collection tools used in the entire research project. The section also presents data collection tools used in the research, fieldwork sketches, tables, and illustrations as well as any other relevant material used in the entire research project.

Fig 1.19: Habitat 67, Montreal, Canada. Architect; Moshe Safdie, 1967. Source: https://www.archdaily.com/870317/canada-post-commemorates-canadas-150th-anniversary-with-habitat-67-stamp. Retrieved on: 27/03/2023

1.9 DEFINITION OF TERMS

1.9.1 LIST OF DEFINITIONS

1. **Architectural Geometry;** a collection of points and lines that outline the shape of an architectural object or form. (Helmut, 2007). A guide to realising simple and complex geometries (Fig. 1.18 & 1.19).
2. **Circle;** a plane curve every point of which is equidistant from a fixed point within the curve (Ching, 1943).
3. **Composition;** refers to the planned arrangement of parts to form a whole in the organization of elements from first principles such as form, colour, texture, scale, rhythm, hierarchy, proportion and balance.
4. **Cone;** a three-dimensional geometric body generated by the revolution of a right triangle about the

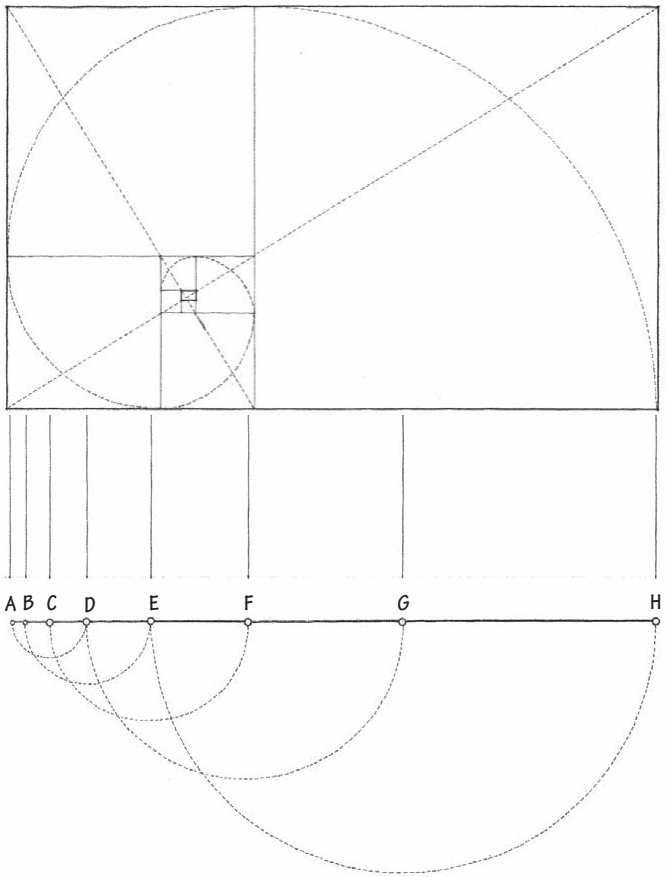

Fig. 1.20: Illustrations of the Golden Section. Source: Ching (1945) page 302 & 303. Retrieved on: 27/03/2023

central axis of a circular face (Ching, 1943).

5. **Cube;** a prismatic three-dimensional geometric body bounded by six equal square sides where the angle between any two adjacent faces is a right angle (Ching, 1943).
6. **Cylinder;** a three-dimensional geometric body generated by the revolution of a rectangle about its centralized axis passing through the centres of its two circular faces (Ching, 1943).
7. **Design;** the process of generating a physical form to enrich human existence (Williams, 1972).
8. **Form;** an external appearance which can be recognized or the manner of arranging or coordinating the elements and parts of a composition to produce a coherent image (Ching, 1943).
9. **Formative idea;** a concept that a designer can use to influence or give form to a design (Clark& Pause, 2005).
10. **Golden Ratio;** the ratio between two sections of a line, or the two dimensions of a plane figure, in which the lesser of the two is to the greater as the greater is to the sum of both (fig. 1.16)(Ching, 1943).
11. **Geometry;** is derived from Ancient Greek (*geōmetría*) 'land measurement'; from (*gê*) 'earth or land', and (*métron*) 'a measure'. It is concerned with properties of space that are related to distance, shape, size, and relative position of figures (Vincenzo, 2015).
12. **Order;** a condition in which each part of a whole is properly disposed of with reference to other parts and to its purpose to produce a harmonious arrangement (Ching, 1943).
13. **Orthogonal;** of or pertaining to right angles.
14. **Precedent;** examples of buildings which have been established over a period of time showing best practices which serve as models for development of new ideas.
15. **Pyramid;** a three-dimensional geometric polyhedron having a polygonal base and triangular faces meeting at a common point or vertex (Ching, 1943).
16. **Rectangle;** a plane figure which has two equal opposite sides and four right angles.
17. **Shape;** characteristic outline or surface configuration that delimits the figure of a form (Ching, 1943).

18. **Size;** physical dimensions of length, width and depth of a form (Ching, 1943).

19. **Sphere;** a three-dimensional geometric body generated by the revolution of a semicircle about its diameter, whose surface is at all points equidistant from the centre (Ching, 1943).

20. **Square;** a plane figure having four equal sides and four right angles (Ching, 1943).

21. **Structure;** building design element which transfers the predicted weight safely to the ground.

22. **Triangle;** a plane figure bounded by three sides and having three angles (Ching, 1943).

1.9.2 LIST OF ABBREVIATIONS

1. **CBD;** Central Business District
2. **JICA;** Japan International Cooperation Agency
3. **KICC;** Kenyatta International Conference Centre

Fig. 1.21: Map of Nairobi highlight the general Nairobi's CBD and its immediate environs. Source: JICA Maps (Nairobi region). Retrieved: 12/12/2022. Edited by the author.