National Universities Commission

Core Curriculum and Minimum Academic Standards CCMAS)

CCMAS Book Series

Fundamentals of Architecture

Book 1 Volume 1

Architecture, Architectural Science Technology and Naval Architecture

General Editor: **Abubakar Adamu Rasheed**
MNI, MFR, FNAL, HLR

Editors:
William B. Qurix OFR, FNIA, FCIMC, MNIM
Oludolapo O. Amole MNIA

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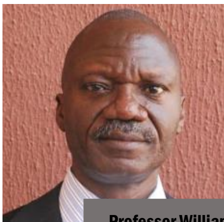

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Core Curriculum and Minimum Academic Standards (CCMAS)

Architecture

Fundamentals of Architecture Book 1 Volume 1

ARCHITECTURE, ARCHITECTURAL SCIENCE TECHNOLOGY AND NAVAL ARCHITECTURE

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Foreword

The National Universities Commission is empowered by the Education (National Minimum Standards and Establishment of Institutions) Act, CAP E3, Laws of the Federation of Nigeria, 2004, to lay down minimum academic standards in Nigerian Universities and to accredit the degrees therefrom. According to this and in its sustained commitment to the revitalisation of the Nigerian University System, the Commission launched the "Core Curriculum and Minimum Academic Standards (CCMAS)", in December, 2022. The document has been adjudged by both internationally and locally revered scholars, as a standard and fit-for- purpose, designed to meet the demands of the 21st Century.

To ensure the efficient delivery of the CCMAS, it has become fitting and necessary to develop a reference document that would contain innovative and simple topics for all disciplines/programmes to serve as a guide for students and lecturers. This novel idea informs the development of the CCMAS Book Series, which presents to Nigerian universities the fundamentals of each discipline, aimed at deepening the understanding of the CCMAS, for the overall improvement in teaching and learning, and ultimately, for the production of nationally relevant and globally competitive graduates from the System.

The excitement and wide acceptance of the Book Series stems from the fact that several scholars in their respective disciplines sent in their contributions, which are rated topnotch in all ramifications. There is no gainsaying that the Book Series is a welcome masterpiece as it expounds what the CCMAS offers and the many lessons and motivations to draw from its optimal implementation, for the overall good of society.

The effort of the National Universities Commission in the development of the CCMAS and following up with associated innovative initiatives like the CCMAS book series is commendable. Consequently, I congratulate the Executive Secretary, National Universities Commission, Professor

Abubakar Adamu Rasheed *mni, MFR, FNAL* for adding another feather to his feather-filled cap within his reltively short period in NUC. Kudos must be given to the Distinguished Emeritus Professor Okebukola led NUC Strategy and Advisory Committee (STRADVCOM) and staff of the National Universities Commission for driving this process to fruition. There is no way this initiative can become a reality without the contributions of the scholars who developed the texual materials. Consequently, I laud the erudite scholars of Nigerian universities, who have demonstrated their love for academic excellence in sharing their knowledge with humanity through the instrumentality of this project.

I commend the CCMAS Book Series to staff and students of Nigerian universities and indeed to scholars all over the globe as the contribution of the Nigerian University System to academic development and excellence.

Happy reading.

Malam Adamu Adamu
Honourable Minister of Education

Preface

In keeping with its mandate of making university education in Nigeria more responsive to the needs of the society, the National Universities Commission commenced the journey to restructure the BMAS in 2018, introducing in its place, the Core Curriculum and Minimum Academic Standards (CCMAS), to reflect the 21st Century realities, in the existing and new disciplines and programmes in the Nigerian University System. The arduous process, which was birthed through continued stakeholder interactions over the course of four years, produced seventeen documents to cater for each of the disciplines in the Nigerian University System. A key feature of the CCMAS document is the unique structure that provides for 70% of core courses for each programme, while allowing universities to utilise the remaining 30% for other innovative courses in their peculiar areas of focus.

Following the conclusion of the development and review process as well as a series of editing, the CCMAS documents were lau nched in a grand ceremony on the 5th of December 2022. With the launch, the job of the Commission was far from over as this was only the beginning of a three-phase process in the development/review and implementation of the CCMAS document. Having completed phase one, which is the launching of the CCMAS, NUC proceeded to phase two, which involves the development of the 30% CCMAS by the universities. At the same time, the plan for capacity building for effective implementation of the CCMAS as well as the development of textual materials to support the implementation of the CCMAS were taken on board.

The need to have customised (bespoke) texts to support the implementation of the CCMAS was pointed out by an erudite Professor (President of the Nigerian academy of Education) during one of the General Assemblies and was processed through the NUC Strategy and Advisory Committee (STRADVCOM). Emeritus Professor Nimi Briggs was unanimously nominated as the Project Coordinator. The series of textual materials are called the *CCMAS Book Series* and titled *Fundamentals Series* in the first project.

The contributors across the 17 disciplines have been drawn from the six geopolitical zones and proprietorship of universities such that there is collective ownership. The major denominator for selection was scholarship in the discipline, which was reflected in the narrative of each book. The various chapters showcase and give examples from local published research so that visibility can be given to ideas from Nigeria and Africa on the topics. While definitions and models from "western" scholars are mentioned, these are de-emphasised as much as possible. The time is ripe to show the world, through this book, that Nigerian scholars, over the last 70 years at least, have been in the frontline of research in the published topics and now able to provide generic and contextual definitions, models and examples in the respective disciplines for scholarly work the world over.

The contents target the compulsory courses in the CCMAS and will be published in a series. As much as possible, the books attempt to sync with the levels of delivery of the curriculum that is 100 level; 200 level and so on. The books are written in very simple English, well-illustrated and rendered in the typical course-material format of objectives, content to be learned, summary, evaluation, exercises and references.

The Commission is optimistic that these series will serve as a guide to support the implementation of the CCMAS documents in the Nigerian University System and beyond and adequately equip the trainers and students in making university education more responsive to the needs of society.

Professor Abubakar Adamu Rasheed, *mni, MFR, FNAL, HLR*
Executive Secretary

Message from the Project Coordinator

Emeritus Professor Nimi Briggs (RIP)

With the launching of the 17 documents of the new Core Curriculum and Minimum Academic Standards (CCMAS) on Monday 5th December 2022 by Vice- President Professor Yemi Osinbajo, *GCON,* Nigeria's National Universities Commission (NUC) accomplished a major feat in its quest to rapidly revitalise the nation's university system.[1] In this regard, the Commission working though its *Strategy Advisory Committee (STRADVCOM),* had, in 2019, identified 10 priority areas that needed urgent attention, one of which is, the introduction of a reengineered curriculum that addresses 21st century challenges. Such a curriculum, it was envisaged, should lay emphasis on skills acquisition and learning outcomes and should be able to stand side by side with those from the World's best universities in the quality of its content as well as being relevant on issues affecting the local communities in which individual universities are located. Thus, CCMAS documents were developed to provide 70% of the contextual materials and compulsory credit units required for graduation at the bachelor's level across the entire chain of degree courses offered by all universities in the country.

That done, attention shifted towards enabling individual universities to develop the additional 30% of the curriculum from issues that are peculiar and relevant to their core mission and local circumstances, as approved by Senates of their individual universities, capacity building and training of staff on the delivery of the CCMAS and the production of books that would cover the contextual materials of the CCMAS.

It is expected that utilisation of the CCMAS series in the Nigerian Universities System will commence in the 2023/2024 academic session. Stringent efforts were therefore made to conclude the production of the series of books, the first in the series, well in advance of that period.

Nimi D. Briggs

February 2023

Note: Sadly, Emeritus Professor Nimi Briggs passed on April 10, 2023. He is resting in the realisation that this project is “safely delivered”, he being a globally renowned scholar in obstetrics and gynecology.

Editors' Note

The Book Fundamentals of Architecture (book 1) is presented in two volumes. Volume 1 contains materials from three of the programmes in the Faculty of Architecture which are: Architecture Architectural Science Technology, Naval Architecture. The book has 12 chapters which are sequentially arranged according to programme.

Book 1 covers the contents of the compulsory courses for 100-level students with some stretch to 200 level courses. It is a book that has benefitted from multiple authorship by seasoned Professors who have taught the topics in their chapters for at least five years. Contributors are also drawn from public and private universities in all the six geopolitical zones in Nigeria. This is to give a rich flavour of examples and case studies from across the country on the various topics. Each chapter has a main author, who is responsible for coordinating materials from co-authors and acts as a sub - editor for the chapter.

Editorial work has been done in using the American Psychological association style.

The development of the book went through a 12-step process. These are:

Sequence	Activity
Step 1	• Set up Editorial Committee • Layout of Chapters
Step 2	• Call for Expression of Interest (EoI) with the chapter layout advertised from which potential authors will select.
Step 3	• Selection of contributors based on geographical spread and expertise in having taught the top for at least five years. As much as possible, each chapter should be co authored by scholars from different universities.

	• Submission of signed Acceptance Form
Step 4	• Development of first draft (Version 1.0)
Step 5	• Collation of first draft by Editorial Team
Step 6	• Plagiarism check
Step 7	Three-way review by • Scholars external to the writing team • Internal to the writing team: exchange of chapters for review among the contributors • Final-year students selected across universities in the Nigerian university system
Step 8	• Revision of Version 1.0 based on feedback from the three clusters of reviewers. Product is Version 2.0
Step 9	• Check by Editorial Technical Team for compliance with suggestions for improvement made by the three clusters of reviewers. This can be done at plenary with all contributors present.
Step 10	• Second revision by authors based on the feedback at plenary/by the editorial technical team review of Version 2.0. Product is version 3.0
Step 11	• Professional editing/copy editing of Version 3.0. Product is Version 4.0.
Step 12	• Printing/publication of Version 4.0.

Professor William B. Qurix OFR, FNIA, FCIMC, MNIM
Professor Oludolapo O. Amole MNIA
Editors

Message from the Association of African Universities
(Endorsement of the CCMAS Book- *Fundamentals of Architecture Book 1 Volume 1*)

It gives me great pleasure on behalf of the Association of African Universities; an umbrella organization representing higher education in Africa, to endorse the innovative development of the Core Curriculum and Minimum Academic Standards (CCMAS) and its accompanying CCMAS Book series, by the National Universities Commission of Nigeria.

The Association of African Universities commends the National Universities Commission for embarking on this innovative revolution of reviewing the curricula of universities in Nigeria. This project is coming at a time when there is an urgent need to ensure that graduates of African universities possess the necessary skills that will promote the development of Africa. The development of the CCMAS has provided national guidance on the quality of learning for graduates in our universities and has also given room to each university to reflect their unique vision and mission in their own contributions through the courses that are developed by their faculty members. Faculty members are being empowered to undertake their normal teaching activities to achieve the laid down learning outcomes for each course and program.

The Book series will not only ensure that quality learning takes place but will also give room for the learners to learn in their own time and space. The Book series are aimed at ensuring that learners in Nigeria can develop the skills and competencies necessary for personal and national development, including critical thinking, decision-making, mental agility, creativity, innovation, problem-solving, and logical thinking, among others. This will help the graduates of our institutions to be competitive in a world where the ability to generate, use and disseminate knowledge, coupled with the ability to develop new ideas about how to do things better and faster, is now the deciding factor in the growth of people and nations.

The Association of African Universities fully commends the National Universities Commission of Nigeria for this revolution in curriculum engineering. The process of developing the book series has followed world best practices with appropriate peer review activities that involve the learners. This initiative is therefore commended to all African Universities as we embark on the continental program of decolonizing the curricula of African universities to build the Africa that we want and need. We hope that other countries in Africa will be able to learn from this revolution in teaching and learning being promoted through this book series.

Prof. Olusola Oyewole
Secretary-General
Association of African Universities, Accra, Ghana

Dedication

Dedicated to

Professor Abubakar Adamu Rasheed *MNI, MFR, FNAL, HLR*

who offered exceptional service as the Executive Secretary of the National Universities Commission (NUC) from 2016 to 2023.

Topics Covered in Fundamentals of Architecture Book 1 Volume 1

ARC 101	Introduction to Architecture
ARST 111	Regulatory Bodies in the Study of Architecture in Nigeria
ARC 203	The Building Industry
ARC 205	The Significance of History, Theory and Criticism in Architecture
FAA 103	Graphics in Architecture, Graphics Conventions and Graphics Representation of Building Elements
FAA 104	Materials and Tools for Design
FAA 121	Computing Environment (Operating Systems)
FAA 221	Basics of Word Processing, Data Analysis and Presentation Software
ARC 207	Principles of Sketching Human Figures and Furniture (Freehand Drawing) - 3D Modelling
FAA 126	Sustainability and the Built Environment
ARC 206	Service Life and Life Cycle Assessment of Buildings
ARC 201	Introduction to Architectural Design
ARC 202	Anthropometrics, Ergonomics and Basic Characteristics of Space and Place
ARST 202	Climate Considerations in Design
ARST 201	Analysis, Synthesis and Evaluation in the Design Process
ARST 203	Identifying Quality Control Mechanism in Buildings
ARST 207	Technical and Environmental Aspects Associated with the Built Environment

ARST 206	The Relationships between Structures and Architectural Design
ARC 204	Basic Building Components
ARC 208	Construction Site Management
NARC 103	Fluid Mechanics, Hydrostatics and Stability

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CHAPTER ONE: INTRODUCTION TO ARCHITECTURE

Introduction to Architecture

Prof. Mbina, Anthony Adomi, *University of Uyo*

Overview

Architecture is defined as the art and science of designing buildings and structures. A wider definition would include within this scope the design of any built environment, structure or object, from town planning, urban design, and landscape architecture to furniture and objects. It could also be defined as the manipulation of shapes, forms, space and light to change our environment. Studying architecture requires strong technical knowledge in the fields of engineering, logistics, geometry, building techniques, functional design and ergonomics. It also requires a certain sensibility to arts and aesthetics. Furthermore, it also requires a preoccupation with human questions and society's problems. Architecture is a very broad and humanistic field that is at the same time technical, artistic and social.

This text focuses on the definition and components of architecture. It explores both human and environmental as well as technical elements that contribute to architectural design. It offers a description of the design process and how various functional needs could be addressed by the architect.

Objectives

The objectives of this text are to:

1. define architecture;
2. identify the origin of the word "architecture";
3. define the word design;
4. differentiate the difference between architectural design and other types of designs;

5. describe the different processes of architectural design;
6. produce architectural design concepts;
7. explain the different architectural design concepts; and
8. explore the different elements of architectural design.

What is Architecture?

The word "Architecture" derives from the Greek word "architekton" (in Latin "architecton") which means "construction master" or master builder. Furthermore, the Neologisms Dictionary defines Architecture as "the science and art of constructing buildings, according to some proportions and rules determined by the character and destination of the buildings". However, there are many other definitions given by dictionaries, specialists or even by outstanding scholars with technical expressions and sometimes even "poetic" rendition.

As a science, architecture has suffered over time substantial transformations and completions, because of the progress of society, of the appearance of some modern technologies and of some construction materials with superior performances, as well as because of the appearance of some functional necessities far different in relation to those of the constructions of the past centuries.

From here results the reluctance of certain people to consider contemporary architecture an artistic creation, although any construction, regardless of its destination and functionality can produce emotional reactions by composition, by expression, by accomplishing a perfect symbiosis between aspect and functionality.

With all the transformations that intervened over time regarding the content of architecture as science, the fundamental characteristics, the "laws" and basic principles of architecture are kept and remain true. Therefore, the fundamental attributes of a construction that architecture must ensure are utility, solidity and aesthetics.

The changes in architecture, considered by some as "the most conservative of human arts and sciences" were, and will still be mainly quantitative and less qualitative and their premises have a main motivation - demographic growth and the general tendency of people to live in urban settlements and in conditions that are as comfortable as possible.

What is Design?

A design is a plan or specification for the construction of an object or system or for the implementation of an activity or process or the result of that plan or specification in the form of a prototype, product, or process.

Design is the process of envisioning and planning the creation of objects, interactive systems, buildings, vehicles, and many other objects.

Design is user-centred, i.e., users are at the heart of the design thinking approach. It is about creating solutions for people, physical items or more abstract systems to address a need or a problem.

Design is a very broad concept, and its meaning can greatly vary from one field to another.

Design permeates many aspects of our lives and branches out into many different subgenres, from product design, sound, virtual reality, interaction, to designing cars, video games, software interfaces, the home and offices interior etc.

1. Design is an activity of linking theory with problems.

2. Design is an intuitive and reasoning activity.

3. Design is an activity of exploring solutions.

4. Design is an activity that designers are engaged in intellectually and socially, shifting between analytic, and evaluative modes of thinking.

5. Design is an activity that links the problem in hand with past experiences.

6. Design is an activity that includes political and economic trends.

7. Design is a creative problem solving activity.

8. Design is not an activity of innovation.

9. Design is an activity of verbal, numerical, and form exploration.

10. Design is an activity of gathering information about social and functional needs of a group of people.

Misconception about design

Design may sometimes be categorised as a fancy sounding word, because when we hear words such as fashion design, etc, it is fashion and beauty that comes into our minds. There seems to be a certain number of misconceptions surrounding it. Is design simply a process of making pretty looking things? Not really. Design does not focus purely on aesthetics, nor is it about adding ornaments to an item. Rather it is about making the user's interaction with the environment more natural and complete. Design is not about making things pretty just for the sake of it.

Architectural Design

Architectural design is a discipline that focuses on covering and meeting the needs and demands of users, to create living spaces, using certain tools and especially, creativity. Therefore, the aim is to combine the technological and the aesthetic, despite the general belief that architecture is only a technological task. Although the term design has a broad meaning, it usually refers to the combination of the creative and technical part, setting the basis for a project or an idea.

Therefore, architectural design is considered the basis and the first phase before bringing the idea to reality. In this section therefore, we shall be discussing more about what architectural design is, its different types and sight a few helpful examples.

Additionally, architectural design mixes design, understood as the creative process, and architecture, which is based on the creation and presentation of solutions at a technical level. By mixing both disciplines, architectural design seeks the values and formal qualities of the works, through spatial experiences. In general, we associate it with drawings, sketches or outlines of a project, and it is one of its fundamental bases. In this aspect of architectural design, there are also other factors involved that are related to geometry, space or aesthetics, among others. After all, architecture, and therefore architectural design, is made up of many elements and processes or phases.

When designing, an architect must consider that he or she should carry out an analysis, to design and build according to the needs and resources, always keeping in mind the aesthetics and technical characteristics, as well as the basic rules of construction. That is why the process, capable of identifying all these variables must consider that it is necessary to reflect the needs, both artistically and technically on the paper (or software). In this case, the lines are the main elements of the architectural design, which define several aspects such as the shape, dimension and positioning of the different spaces integrating the project.

Types of Architectural Design

Architecture is made up of a large number of specific disciplines. We can not only keep the constructive part, but we must consider other branches that help to create a complete project. The basis of the architectural design therefore is to know what the use of the space is, but the aesthetic aspects also intervene. This means that it is not easy to typify architectural design, in just some categories as this could be infinite. Thus, we can classify architectural design according to its use, according to its intention, its aesthetics, and of course its technical aspects.

The examples of architectural design could also be infinite for the same reason, adding the fact that trends change a lot, reacting to many other factors. In this case, we can talk about some trends in modern architecture and design that have influenced many architects or designers when creating their projects. By seeing design as a conceptual representation, we can see that reflected in some elements.

For example, we can talk about a construction trend that brings together architecture and nature, inserting natural elements into the construction of buildings. The aim here is to disconnect from urban areas through natural aspects, incorporated into the buildings themselves. Therefore, the example of biophilic design presents three essential points:

1. connection with nature through sensorial stimuli,
2. evocation of the presence of nature through the imitation of forms, or
3. construction of spaces that imply a sensation of calm and rest.

In some places, this type of architectural design has already been implemented. They are clear examples of the design of biophilic architecture that not only presents a goal of rest or disconnection from the urban environment, but also helps in certain cases to improve the patient's health (in the Hospital), or to lower the temperature.

In addition to these examples, we could refer to other types of design, such as minimalist, modernist, Victorian, classic, avant-garde or vernacular, among many others. Consequently, architectural design is essential to provide a basis for a final architectural construction, since it considers different factors of usability of spaces that would not be understood in a technical way, but also introduces the creative aspect in the process.

The Design Process

Problems are best solved when approached in a comprehensive and systematic way. The goal of the design process therefore is to guide and organise work to turn ideas into concrete solutions. Designers do research and collect information about the problem they are considering: who is the person facing this problem? Why? How are other people trying to solve it? From this research, they make a general hypothesis and identify the main features that should be part of the answer. Then with these key aspects in mind, the designer embarks on what is known as the four phase design process.

The process of designing a building, space or structure typically consists of design phases. It is important to understand and remind oneself of these phases, to bear in mind exactly what is to be accomplished bearing in mind that these processes take time and are invaluable.

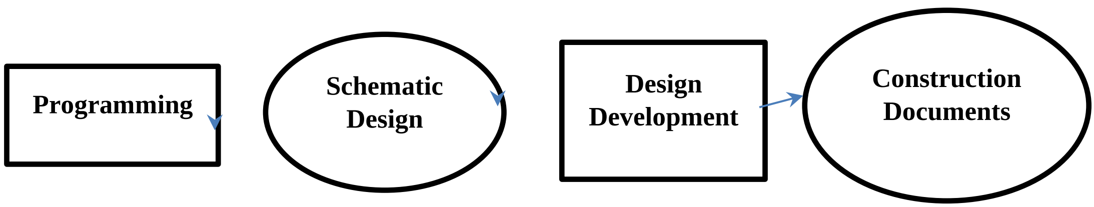


Figure. 1: *The Design Process as conceived by Author*

Programming Phase

1. Programming is the activity of determining the "program" or set of needs that a building needs to achieve.

Schematic Design Phase

2. After establishing the program for a project, the focus in the architectural design process shifts from what the problems are to how to solve those problems.

3. During the schematic design process, the focus is on the "scheme", or overall high-level design.

4. Here, minor details should be ignored to instead focus on creating a coherent solution that encompasses the project as a whole.

Design Development Phase

1. During the design development phase of the architectural design process, the scheme is defined into the final design.

2. In previous phases, the focus has been on the project as a whole.

3. During Design Development, it becomes important to give individual attention to each aspect, each space and each detail of the project

Construction Document Phase

1. At this stage of the architectural design process, the focus shifts from design to communicating the design and providing all information necessary for construction.

Design Concepts - Art or science?

While not being exactly an art or a science, it takes elements from both. Art is about creating something that expresses the author's vision, ideas and feelings. While designers can express feelings and leave impressions through their work, doing so is not their prime objective. So, it takes the creating aspect of art, as it is about crafting an item, a tool, and an experience. On the other hand, it takes the problem-solving aspect of science. It exists primarily to address a particular need. To quote Steve Jobs (co-founder, chairman and CEO of Apple): "Design is not just what it looks like and feels like. Design is how it works."

Architectural Design Concept

One of the questions often asked by students is 'how do you develop architectural concepts? The design process can be very daunting to new students, who often find it difficult to find a direction in their design. They are often asked, 'what is your concept?' by their lecturers and respond by staring blankly back at them. In this section, we will take a close look at architectural design concepts and how it fits in with the design process.

What is a concept?

Concept can generally be defined as an:

1. abstract idea;
2. intention or plan;
3. idea or invention to help sell or publicise a commodity; and
4. idea, notion, theory, conviction or opinion.

A concept is an idea, a theory or notion, but in architecture we could also describe a concept as 'an approach' to the design. When we think of architectural concepts, we think of an abstract idea, one that is unchanging throughout the design process. This is not necessarily the case; a concept can be linked to many factors, and can evolve as the design grows.

Architectural concepts are the designers' way of responding to the design situation presented to them. They are a means of translating the non-physical design problem into the physical building product. Every project will have critical issues, central themes or problem essences, and the general issues of designing a building can be approached in a number of ways.

What is an Architectural Design Concept?

A concept is an idea, notion, or thought that is the fundamental building block of any project. In architecture, a concept is usually the approach taken to complete the project. It is what drives the project forward and provides a basic framework within which to function.

An architectural design concept is an abstract idea that guides the project and is the project's core identity. It is not to say that it remains constant over the entire duration of the project. As the structure's design changes, the concept can also undergo evolution. An architectural design concept is the first part of the project and precedes all other activities in the design process. It is only when the design concept has been developed and finalised can the project begin in earnest.

Designers use architectural concepts to respond to the design situations they face. The concept helps them translate conceptual designs into functional physical structures. It is one of the elements that remain as important initially as after the project. Architectural design concepts can originate from several different sources and can result in multiple variations and outcomes. Central themes, critical issues, and other factors can also affect the development of a concept.

How to Develop Architectural Design Concepts

'What is your design concept?' This is the question we hear often when architecture students as well as architects present their works. The concept is an essential part of most designs—it represents the idea behind a design; what it stands for, who it is made for. Design concepts in architecture can convey a message or a particular feeling. Designs with strong concepts always tend to stand out from the crowd. But how do we come up with a concept? In this section we will be discussing how to Develop Design Concepts in Architecture. Below are ten suggestions by the Architectural Community, 2022 on how to develop an architectural design concept:

Read books

They say there is no friend as loyal as a book. Books act as gateways to the vast world around us. Even in the field of architecture, there is no dearth of books on every topic imaginable. If you are on the lookout for a concept, books are an excellent starting point. Looking into the variety of ways that ideas can be formed and executed is always a good start.

Books can give you context through examples and studies. Who knows? Maybe a particular image you find in a book might just reignite your brain and lead you to your next great concept. Books act as gateways to the vast world around us ©pixabay.com.

Sketch out your ideas

An architect is inseparable from his or her sketches. It is an integral part of an architect's identity with many famous architects being recognized by their sketches alone.

Sketching can really help with designing concepts. When you sketch, your brain thinks, and that thought is almost instantly drawn on paper by your hands. This allows you to express ideas that you might have had in your mind but couldn't quite understand. Sketching those ideas out on paper can lend clarity to them and simplify your design process. Even when you are not on the lookout for a concept, it is a good habit to keep a sketchbook with you and sketch whenever possible. This way, you can look back on your sketches and find possible ideas from them.

Look into case studies

Studying from the works of those before us is one of the best ways to understand what works, when, and where. You can look up case studies of the type of concept you are searching for. Case studies can help us understand how different architects have designed according to the various constraints that they have been presented with.

If you are unsure of how to approach a particular site or context, looking up case studies with similar constraints can give you an idea of what to expect and an understanding of how to tackle it. You can even visit the sites directly if possible. Incorporating aspects from your case studies into your design will enhance your concepts and make them even more interesting. Case studies can help us understand architecture better.

Approach your idea from different angles

A design concept doesn't need to be just about form or aesthetics. Sometimes, the concept for a structure might be based on other factors like context, climate, culture, function, etc. For example, the functions of a school might require a design that has a lot of open gathering spaces for various student activities. A house for a large joint family might need a lot of rooms. A particular material might need to be used extensively because of its cost and availability in a region. Aspects like these need not just be considered as factors but can also be actively involved in forming the concept of your design.

Take a break, do something else

Sitting for hours and hours at your desk, brainstorming for a design concept in architecture need not always lead to success. Sometimes your brain just needs a break. At this point, you should stop working and do something else such as reading a novel, taking a walk, calling and talking to a friend. If such short breaks are not cutting it for you and you still feel tired and uninspired, perhaps it is time for a longer one.

Yes, even in the field of architecture (one of the most hectic careers in the world), sometimes you just have to stop working and let your mind and body rest. You could do a workout, watch a movie, help in the kitchen, or cook something yourself. When you set your work aside and do something else, it rejuvenates your brain and before you know it—that elusive concept is now right within your eyesight.

Break it down – make a list

Most times, that increasing pile of work and deadlines never seems to stop growing. If you start feeling overwhelmed by the sheer amount of work that you must get done, that can stop the creative juices of your brain from flowing. Any creative thoughts you might have had come to a standstill as you feel anxious and tense. When this happens, it is time to break out the list and break it down.

Make a list of all the major tasks that you have to complete in a day. (You can even do weekly and monthly lists) After that, you can break down each large task into several smaller actions. This way the work seems much more manageable. You can even mark the amount of time you will allot for each task to make sure you don't fall behind on any work.

Design in 3D

Once you have a design concept in mind, a good next step would be to think in 3D. You can do this in many ways—manually sketching out a 3D view or perspective, making a physical model by hand, or using one of the several software available for the task like SketchUp or Revit.

Seeing your design concept in three dimensions can help you understand how your idea can work vertically as well as in a plan. Often, we make the mistake of limiting our ideas to plans and one-sided views that may not make the full scope of your concept clear. Visualising your concept in 3D can make you realise how feasible your concept is and how it can be implemented in the real world.

Explore Various Permutations

Never get stuck with just one concept or design. Explore various permutations of the same idea; look at various ways in which the same concept can be implemented. How can we make a design better? What aspects should be changed and what should be retained? These choices can provide you with several variations for your design.

Should the walls be made of bricks or bamboo? Should the house have a courtyard or should it have plenty of balconies? Do I need a window here or would an open verandah be better? Don't just opt for one type of design. Think about all the possibilities. When it comes to ideas, the sky is the limit. Explore various permutations of the same idea.

Go Analytical

A concept need not just be about the physical form and spaces of your design. It can also be highly analytical. A large amount of data about various aspects of the design can sometimes be the groundwork from which a strong concept emerges. If you feel like it fits the situation, then go fully analytical.

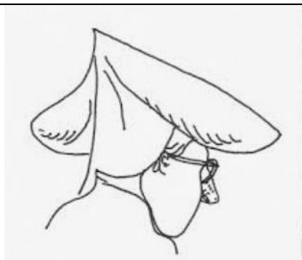
Data-driven design, if done correctly, can have excellent results. The data can be about the character of spaces (like inclusivity in public design), effects of spaces on people (like productivity in office spaces, customer satisfaction in shops), or how a particular material affects the atmosphere of a space.

Just like through shapes, concepts can also be developed through data. If the data, you have necessitates the need for a particular kind of structure or design that can be the focal point around which you base your concept. There are several software like QGIS, Green Building Studio by Autodesk, etc., that can calculate these data estimations for you as data driven designs can have great results.

Start over if necessary

Even the best ideas can sometimes end up not being feasible. In such cases, it is better to just start over. Maybe your initial design concept in architecture was great but somewhere along the line the essence of the original idea was lost. A compromise between realising the concept and realistically finishing your design can sometimes be made, but that might not always be worth it.

Sometimes, it is better to just start over. You can even keep your initial idea and start over from the initial stages of design. But in other cases, the very concept needs to be rethought.

S/No	Concept	Design
01	 Seals at Sea	 Sydney Opera House
02	 Monks’ cap	 Chapel at Ronchamp
03	 Ship at Sea	 Ministry of Defense (Ship House, Abuja)

04	 Army Officers' Cap Source: Richer Export Inc,	 National Theatre, Lagos
05	 Hands in Prayer	 Church Building

Figure. 2: *Source*: Mavelikara, 2023

Summary

The main thrust of this write up was to address the issue of Architectural Design for beginning students of architecture. There was therefore the need to briefly explain what architecture is and a few expectations for venturing into this course. Some background information on what architecture feels inevitable. In the course of going through this discussion, it is hoped that basic knowledge would have been gained from knowing what architectural design is, the different processes of architectural design, and how concepts are developed in architecture. A few examples were sighted to drive these points home.

Exercises

1. What is:
    a) Architecture?

b) Design?

c) Concept in Design?

d) Design Process?

2. a) List the four phases of the architectural design process.

   b) Write short notes on two of these phases.

3. From any natural or man-made object around you, generate an architectural design concept.

4. Using any of the items listed below to form an architectural design concept: human palm, leaf, a cube, an umbrella, or face mask.

5. Discuss in detail the elements of architectural design concepts.

References

Anderson, Jane (2011) Architectural Design, Basics Architecture 03, Lausanne, AVA academia, p. 40. ISBN 978-2-940411-26-9.

Brooks, F. P (2010). The Design of Design: Essays from a Computer Scientist. Pearson Education. ISBN 9780321702067.

Carey, Susan (2009). The Origin of Concepts. Oxford University Press. ISBN 978-0-19-536763-8.

Condrea, Ionut; Botezatu, C.; Slătineanu, L.; Oroian, B. (2021). "Elaboration of the initial requirements in the design activities". IOP Conference Series Materials Science and Engineering. 1037 (1): 12002. Bibcode:2021MS&E.1037a2002S. doi:10.1088/1757-899X/1037/1/012002. S2CID234019940.

Cross, N., (2006). Design and Designing: Block 2, p. 99. Milton Keynes: The Open University.

Cross, Nigel (2011). Design Thinking: Understanding How Designers Think and Work. Berg. pp. 3 & 140. ISBN978-1-84788-846-4.

Dictionary meanings in the Cambridge Dictionary of American English, at Dictionary.com (esp. meanings 1–5 and 7–8) and at AskOxford (especially verbs).

Goguen, Joseph (2005). "What is a Concept?” Conceptual Structures: Common Semantics for Sharing Knowledge. Lecture Notes in Computer Science. Vol. 3596. pp. 52–77. doi:10.1007/11524564_4. ISBN 978-3-540-27783-5.

Huppatz, D. J. (2015). "Globalizing Design History and Global Design History". Journal of Design History. 28 (2): 182–202. doi:10.1093/jdh/epv002. ISSN 0952-4649. JSTOR 43831904.

Kanaani, Mitra (2023). The Routledge companion to ecological design thinking: healthful ecotopian visions for architecture and urbanism. New York, NY. ISBN 978-1-003-18318-1. OCLC 1332789897. Archived from the original on 2022-08-27. Retrieved 2022-08-19.

Margolin, Victor (2009). "Design in History". Design Issues. 25 (2): 94–105. doi:10.1162/desi.2009.25.2.94. eISSN 1531-4790. ISSN 0747-9360. S2CID 57562456.

Mbina, Anthony Adomi (2021) Lecture Notes on Introduction to Architecture. University of Uyo www.rethinkingthefuture.com.

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Prof. Mbina's research interests include architectural history, architectural communication and the effect of architecture on the environment. He has published widely in both national and international academic and professional journals. Prof. Mbina is a very humble and patient fellow. He is married with children.

Regulatory Bodies in the Study of Architecture in Nigeria

Dr. Samuel O. Fakolade, *Anchor University, Lagos.*

Overview

Academic programs in Nigeria Universities are normally and should be approved by the National Universities Commission (NUC), a body set up for this purpose. This is to ensure quality assurance of all academic programmes. Working in synergy with the NUC and in the same spirit are the professional bodies which also regulate their programs to ensure compliance with established standards. The time and modus operandi may be different, but their overall aim is the same.

This text provides an overview of the relationship between the NUC and ARCON (Architects Registration Council of Nigeria), the professional regulatory body concerned with the study of Architecture in Nigeria. It also identifies and discusses issues relating to resource verification and accreditation of this program.

Objectives

The objectives of this text are to:

1. describe the structure of the course as regards academic and professional recognition;
2. identify the acceptable standards of instructions;
3. describe the relationship between the NUC and the regulatory body; and
4. itemise and list the requirements for resource verification and accreditation.

The Registration Bodies

The regulatory bodies involved in Architectural programs are the National Universities Commission (NUC) and the professional bodies viz; the Architects Registration Council of Nigeria (ARCON) and the Nigerian Institute of Architects (NIA). With the efforts of these bodies, each approved and accredited University is expected to produce adequate and appropriate graduates.

The National Universities Commission (NUC)

The NUC was established in 1962 as an advisory agency in the cabinet office. In 1974, the NUC became a statutory body which today has been transformed into a veritable arm of government in the annals of University Education in Nigeria. Any programme not endorsed by the body is not legally recognized and would be declared null and void. Without the NUC licence as declared by Akinwunmi and Adepoju, (2009), no program is expected to commence ab initio. As a matter of fact, no University is legally allowed to operate without a NUC approval licence. The NUC gives approval to commence after a resource verification of the program. It is only then that a program be legally recognized and included in the admission brochure of the Joint Admissions and Matriculation Board (JAMB).

After the approved commencement, the NUC comes again to conduct accreditation after three years in operation. This is to ascertain quality assurance of staffing, facilities and students. As long as the program exists, these accreditations are repeated periodically, when the program extends to post graduate level, another resource verification takes place to confirm that the resources are adequate. The NUC accreditation is therefore not a once and for all exercise. It is constantly repeated at designated intervals to ensure that the University courses do not slack or retrogress in standards according to Ibijola, (2014).

In a nutshell, the NUC performs the following tasks to the University system;

1. Grants approval for the establishment of higher educational institutions offering degree programs in Nigerian Universities whether public or private to start with.

2. Grants approval for academic programs run in Nigerian Universities. Any program not known to the NUC or not approved by it, is null and void.
3. Ensures quality assurance and control of all academic programs offered in Nigerian Universities in terms of facilities, staff and students.
4. Facilitates an avenue for all external aids, grants and supports to the Nigerian Universities.

The Professional Regulatory Bodies in Architectural Programs.

One of the features characterising professional courses is the availability of a regulating body for its studies and practise, carried out by an association of already accomplished members of the profession. In the study and practice of Architecture in Nigeria, the regulatory body is the Architects' Registration Council of Nigeria (ARCON), established under Architecture (Registration etc.) Act, Chapter A19, and the laws of the Federation of Nigerian, 2004. This Federal Government agency is given the responsibility of ensuring the quantity standard of Architectural education, tutelage and practice in Nigeria.

According to the Act setting it up, ARCON is charged with establishing and maintaining a register of persons entitled to practise as Architect in Nigeria and determining the standards of knowledge and skills to be obtained by persons seeking to become members of the Architecture profession and to perform other functions conferred on the council by the Act. It must be noted that ARCON performs the role in conjunction with the Nigerian Institute of Architects (NIA) which it delegates to carry on some functions. The Nigeria Institute of Architects (NIA) is capable of doing this because of its composition and membership.

In figure 1**,** the roles of the regulatory bodies are summarized from inception of the program till not only when the student graduates but also gets registered and becomes principal consultant. This is still not the end of regulation; the ARCON keeps the registers of the Architects. This means that the Architects must conform to the ethics of the profession and renew his license yearly as stipulated.by the provisions of the laws.

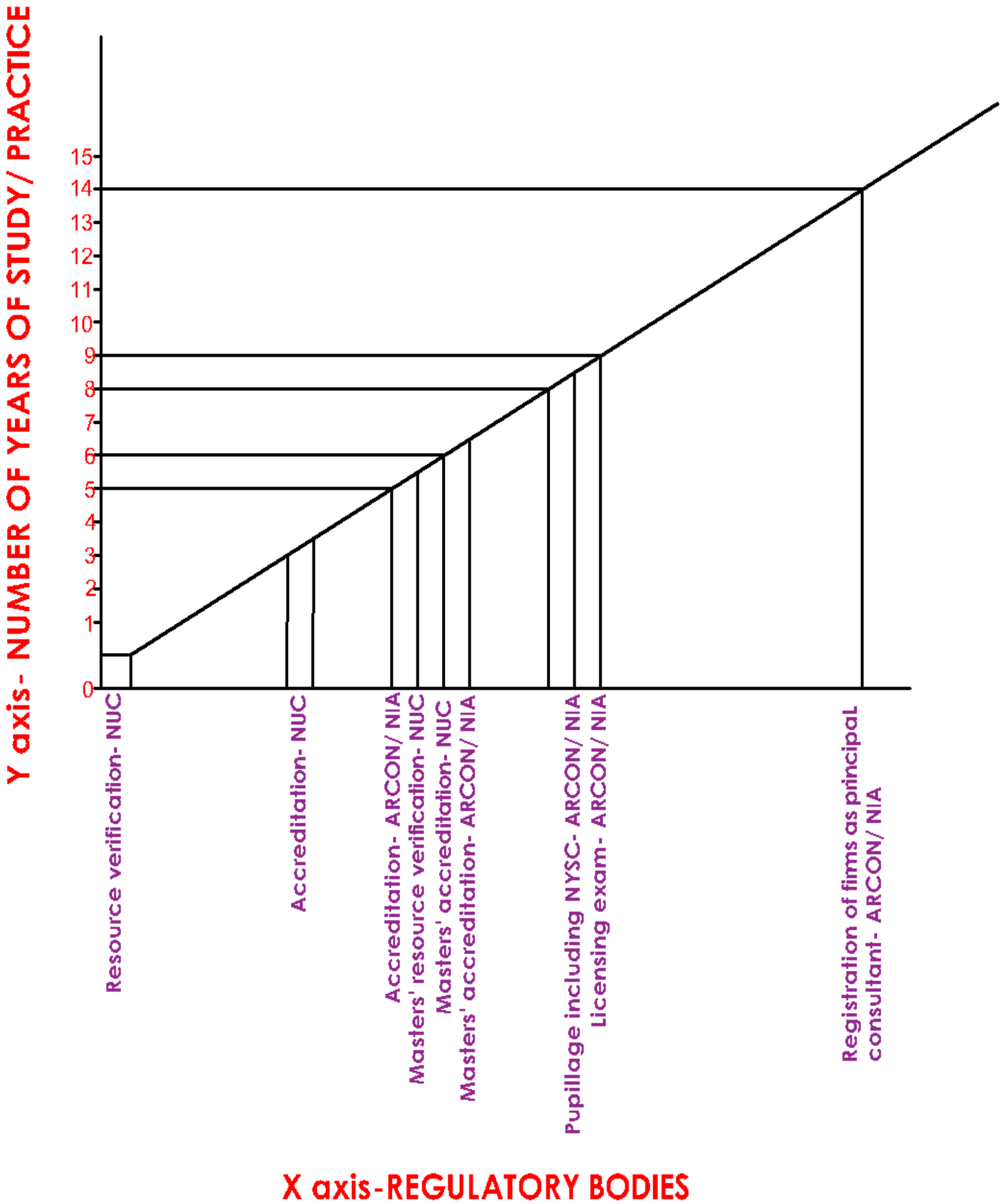

Figure 1. *Summary of Regulations by NUC and Professional Bodies*

The birth & functions of the professional bodies on Architectural Programs

Historically, Architecture as a discipline evolved from apprenticeship whereby a pupil Architect was trained under a master for a number of years before being called to practice as Architect. Langar (2017), confirmed that this system produced the likes of Frank Llyod Wright, Louis Sullivan, Mies Van der Role and many others. Formal training in Architecture came into Nigeria around the 19th century as against France which started in the 17th century according to Olotuah, Taiwo & Ijatuyi (2016) Specifically, a group of Nigerians studying in UK under the inspiration of Royal Institute of British Architects (RIBA), conceived the idea of a professional body for the Nigerian Architects. After all the spade works, the Nigerian Society of Architects was launched at the Federal House of Representatives in Lagos on 1st April 1960. The name was later changed to the Nigerian Institute of Architects (NIA). The NIA pursues the permanent political interest of members of the profession. In this spirit, the NIA canvassed for the establishment of a regulatory body that would be a link with the government, to strengthen and legalise the Architectural profession.

Thus, with concerted efforts and lobbying, the Federal Government promulgated decree 10 on May 12th, 1969, setting a decree 'Architects Registration Council of Nigerian (ARCON)' during the military tenure of Gen. Yakubu Gowon as the Head of State and Commander-in-Chief of the Armed Forces of the Federal Republic of Nigeria. This is now an Act in the present dispensation as ". (ARCON) CAP A19 – Architect (Registration etc.) Act; Laws of the Federation of Nigeria 2004" (ARCON Handbook).

The ARCON is a government body that regulates the standard of education, ethical rules and professional conduct for the study and practice of Architecture in Nigeria. In the discharge of its role, the ARCON delegated right from the onset that the 'Institute' – The Nigeria Institute of Architects will conduct the examination on its behalf under its supervision. Thus, there is a symbiotic relationship with the Institute – its mother'. In the amendment carried out in 1990, to ensure that the old ambiguity regarding who is responsible for conducting the professional competence examination and establishing it as a prerequisite for registration, a new sub-section, to section 7 (4) of the principal act was inserted as follows 'c' –That he has passed the professional practice competence examination (PPCE) conducted by the Institute'. (ARCON, 2014)

The NIA, which has adequate manpower and other resources as a professional body, has carried out this function flawlessly since the inception of these bodies. To demonstrate the manpower resources, the NIA constitutes each accreditation team to include a member of Association of Architectural Educators of Nigeria, (AARCHES), one of the standing committees of the Institute.

The law establishing ARCON provided for a 49 – member board. The members are appointed from various interest groups to reflect the political and social set up of the society. The group are the supervising Federal Ministry (FMWH), the states of the Federation, the education sector and the professional body of Architects. All members are fully registered Architects, and their appointment is for a period of five years. At the expiration or dissolution of the board, the President, Registrar and the Treasurer remain to perform skeletal duties and register Architects who pass the professional practice exams by the Institute, until fresh appointment is made. Since the board of ARCON is only a policy making body, it relies mainly on the NIA which has the necessary facilities, personal and perpetual life span for the execution of its policies and programs. The Nigerian Institute of Architects (NIA) is charged with professional membership exams, accreditation of school of Architecture among others under the auspices of ARCON.

Regulation of Membership

Every profession has its own responsibility and challenge to present an appropriate public image. One way of doing this is by careful selection of membership. Since the inauguration of ARCON in 1969, there have been regulations and well defined rules since ARCON is empowered by the law to regulate the study and practice of Architecture. Registration is not voluntary but obligatory since "a person shall not practice or carry on business under any name, style or title containing the word 'Architect' unless he is a person registered under the Act i.e. (ARCON) CAP A19 – Architect (Registration etc.) Act; Laws of the Federation of Nigeria 2004" (ARCON Handbook).

After graduation from an accredited University and having satisfied the pupillage requirement, the gateway into being registered is the passing of the professional practice exams conducted by the NIA. The pivotal role of conducting the examination has been delegated to NIA since the beginning. The exams aim to:

1. test knowledge of professional practice and ability to apply it;
2. review practical experience already gained during pupillage; and
3. reveal understanding of the ethics and responsibilities of the professional.

The candidates are examined as complete persons to ensure that they have a reasonable standard of professional competence and a sense of responsibility. The successful candidates are sent to ARCON for registration and their names be included in the registers of Architects. Only those whose names are in this register are legally authorized to practice Architecture and address themselves as 'Architects'. in Nigeria having been confirmed as educationally and professionally qualified to practice. Such Architects must maintain professional integrity and decorum and fulfil all obligations to remain in the register.

Summary

The text described succinctly the emergence and roles of the regulatory bodies concerned with the study of Architecture in Nigeria universities. The relationship between NUC and ARCON, the professional regulatory body in maintaining set standards for the study of Architecture was detailed out. The issues relating to resource verification and accreditation of the program to validate the study of Architecture was also covered. At the end, a number of exercises to test the assimilation of knowledge were included.

Exercises

1. Can a university run any program without the approval of the NUC?
   a. What is the relevance of adequate resources deployed into a program of studies?
   b. Differentiate between resource verifications and accreditation.
2. List the bodies responsible for accreditation of Architectural programs in Nigerian Universities.
3. What are the roles and relationships common to the following bodies in the study of Architecture in Nigeria; NUC, ARCON, NIA and AARCHES.?

REFERENCES

Akinwunmi, F. S, and Adepoju, T.I (2009) Roles of Educational Agencies in Nigeria System.*In J. B Babalola and A. O. Ayeni (Eds); Educational Management: Theories* and Tasks. Pages 165-180

ARCON (2014) Register of Architects. Entitled to Practice in Nigeria. 2014 Edition

Ibijola Yinka, (2014) Accreditation Role of the NUC and the Quality ofthe Educational Input into Nigeria University System. Universal Journal of Educational Research 2 (0) 648– 654.

Langar, S. Z (2019) (Incredibly Famous Architects who didn't Poses an Architecture Degree). https\\www.archdaily.com

Olotua, Taiwo & Ijatuyi (2016) Pedagogy in Architectural Design Studio and sustainable Architecture in Nigeria, *Journal of Educational and Social research 157-164*. www.nuc.edu.ng (2022) National Universities commission Nigeria Education Verification System.

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He studied Architecture at the University of Nigeria, Nsukka (1977-1983), where he was the best graduating student carting all the six prizes in the Department. He also did an MSc in Construction Management at the University of Lagos, a Diploma in Architecture/Construction Engineering at the Construction Technology Institute of South Korea and PhD in Housing Materials from the Department of Geography and Planning of Lagos State University, Ojo.

He was among the young crop Architects employed by the Fed. Govt. to replace the expatriates in the 80s and he remained with the Federal Government of Nigeria for 31 years in various capacities and locations including being the Federal Controller of Housing & Urban Development for six years in three states, (four of which was in Lagos State), Resident Supervising Architect for Federal Secretariat in Asaba, Project Architect for Centre for Management Development in Lagos, Head of capital procurement in Ministry of Police Affairs, and Head of Public Private Partnership, in the Federal Ministry of Transport retiring in 2015 to academics.

He was employed as a Senior Lecturer at the Bells University of Technology, Ota from Nov. 2015 till 2021 where he was a Deputy Dean of College of Environmental Sciences in 2020-2021. From there, he joined the University of Lagos as an adjunct lecturer in 2019 till date.
He was invited with some colleagues to set up Architecture in ANCHOR University, Ayobo-Lagos where he was appointed the pioneer Head of Department from August 2022 till date.

He was the only member of the NIA Board of Architectural Education for continuous 21 years (1986-2017) He has taken part in accreditation to virtually all schools of architecture in Nigeria including being in the Commonwealth Association of Architects'

Validation team to Ahmadu Bello University and University of Lagos in 2009.

Apart from being an examiner to professional practice exams, he was an external examiner/Juror of NIA/ARCON to many schools of Architecture in the country such as ABU, FUTM- Minna, Covenant University, KUST, Wudil- Kano among others.

He was the executive of the Lagos State chapter of NIA for 8 years including being the Hon Secretary in 1995-1997. He was elected an Ex Officio of the National Council in 2015-2017. He is a Fellow, NIA (2005) Fellow, Inst of Const. Industry Arbitrators (2006) Member, Project Mgt. Inst.,Member, Purchasing & Supply Mgt. of Nig. and Member, Architectural Educators of Nigeria (2016)

Building Industry

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Overview

The building industry is the architects' domain of primary interest. Hence, an adequate understanding of the industry is vital in the study of architecture. The essence of this chapter is to introduce to students the building industry as a sub-set of the construction industry. The building industry is complex and is driven by human, environmental, technical as well commercial interest.

This text identifies and describes the key features and components of the building industry as well as the various stakeholders in the building industry and their various roles with an emphasis on the architect-who is traditionally known as the leader of the building team. The chapter ends by highlighting the role of the building industry in national development.

Objectives

Readers of this chapter are expected to be able to:

1. discuss the historical evolution of the building industry;
2. identify the different types of buildings;
3. describe the basic features of the building industry;
4. identify the professionals and non-professional stakeholders in the building industry;
5. explain the roles of the different professionals in the building industry, particularly those of the architect; and
6. describe the vital roles the building industry plays in national development.

Understanding the Building Industry

The building industry is part of the construction industry. The construction industry is divided into three major areas, namely building construction, heavy or engineering construction (infrastructure), and industrial construction (Spence & Kultermann, 2011). Building construction deals with the design and erection of different types of buildings, while heavy construction involves the design and construction of large infrastructure projects such as highways, bridges, dams, subways, tunnels, waterworks, and communication networks. Industrial construction refers to the construction of large-scale manufacturing, processing, and chemical plants such as refineries, fertiliser plants, power generating plants, and others.

The building industry includes all the people, technology, and process involved in the planning, designing, erecting, operating, and managing of the delivery and operations of buildings (Nwankwo & Obasi, 2021). A building can be seen as both a process and a product. As a product, a building is a space for different human activities achieved by putting together different manufactured and non-manufactured materials using human efforts and machines. Building as a process refers to the series of activities leading to the realisation of a building as a product.

Historical Evolution of the Building Industry

Four distinct eras can be identified in the evolution of the building industry. These eras are described in this section of this Chapter.

1. Paleolithic and Neolithic eras: Historical facts indicate that the early man had no permanent place of abode, as he was moving from one place to another looking for and gathering food. At this time there was no knowledge of how to construct shelter and thus lived in the open using trees as shades (Fletcher, 1996). Later on, the early man began to live in caves (Figure 1) which were temporary residences that provided him shelter from the elements of weather and security from wild animals (Kpamma, 2011).

It was between 10,000 B.C and 5,000 B.C. when man learnt to cultivate, that he began to settle down near the fields, cultivated, and started erecting buildings in the form of temporary huts using mud and grasses (Figure 1). According to Intsiful (2012), the first type of building erected by man was in the form of a tent constructed with simple materials such as sticks, grasses, and hides of animals. The tents were easy to assemble and dismantle and moved to another location as the need arose.

Figure 1: *Early man's cave*
Source: English Heritage (N.D)

Figure 2: *Palaeolithic hut*
Source: Humanities LibreTexts (2023**)**

2. Ancient Egyptian and Mesopotamia: The account by Fletcher (1996) revealed that the emergence of permanent settlements in the form of agricultural villages gave rise to the use of mud bricks in the construction of residential buildings between 7500 B.C. and 6000 B.C. At this time, ancient Egyptians and Mesopotamia introduced new building materials and techniques to the building industry, which were used to construct the world's earliest buildings finished with stones, while their counterparts in Mesopotamia invented columns, capital, and cornice. In the third millennium BC, the foremost buildings such as the ziggurats (Figure 3) (or temples) of Mesopotamia and the mastabas (or early tombs) of Egypt (Figure 4) were constructed with sun-dried mud bricks, while around the second millennium B.C, stones were used as substitutes for mud in the construction of the great pyramids in Egypt (Medjo, 1997).

Figure 3: *Ziggurat (Ancient Mesopotamia)*
Source: Corbet (2014)

Figure 4: *Mastaba (Ancient Egypt)*
Source: Encyclopedia Britannica (N.D).

***Ancient Greek and Roman Civilisations*:** Between the 7th and 5th centuries BC, the ancient Greeks contributed to the evolution of the modern building industry through the discovery of cement in the form of lime, which served as a binding material. This marked the earliest contribution of Europe to the evolution of the building industry. In the 1st century BC, the Romans leveraged the discovery of cement to develop concrete. This made it possible for the development of some architectural and engineering forms such as arches, vaults, and domes. This development not only enhanced the aesthetics of buildings but added to their structural stability and also introduced more building materials into the building industry.

Figure 5: *Parthenon- Ancient Greek*
Source: Khan Academy (2014)

Figure 6: *Parthenon- Ancient Roman*
Source: The Collector (2023)

4. Era of the Industrial Revolution: The first industrial revolution of the 18th century came with a wide range of new building materials such as cast iron, steel, and glass among others. These materials contributed to the evolution of building forms and sizes that were hitherto considered not possible (see Figure 6). The second industrial revolution of the late 19th century took advantage of the synergy between iron and steel and the discovery of electricity to produce building components in factories leading to the standardisation, mass production, and prefabrication of building components, and modularisation of building design.


(a)


(b)

Figures 6 (a&b): *Buildings in the First Industrial Revolution*
Source: Garber (2017)

Further, the development of computers, the Internet, electronic, and digital technologies in the third industrial revolution of the 1970s, led to the automation of building design and construction process (Keogh & Smallwood, 2021). The fourth industrial revolution (4IR) witnessed the application of information and communication technologies (ICTs) in the building industry. This era introduced the Internet of Things (IoT), artificial intelligence (AI), and autonomous production leading to the application of autonomous or self-organised logistics such as robots and drones in the building industry (Sawhney, Riley & Irizarry, 2020). Consequently, several activities hitherto done by human labour in the building industry have been taken over by machines and electronic systems and applications.

Added to this is the emergence of the concept of sustainable development towards the end of the 20th century. In recognition of the three pillars of sustainable development: economic development, social development, and environmental protection, the building industry is moving towards ensuring that its processes and products are socially and economically responsive to the needs of the people and have little or no negative impact on the environment (see Figure 7 a&b). This informs the current emphasis on sustainable buildings and how building processes can help to achieve sustainable human settlements.

(a)

(b)

Figures 7(a & b): *Buildings in the 20th Century*
Source: Mafi (2019)

Types of Buildings

The building industry is responsible for producing and managing the following types of buildings**.**

1. *Residential buildings*: This is perhaps the first type of building ever developed by man to provide housing accommodation and support services for individuals, households, or families for living, raising children, and even for some sorts of commercial activities. They occur

as either one family (single family) or more (multiple families) residences.

2. *Institutional buildings*: These are mainly for administrative and other purposes. Examples include office buildings, schools, hospitals, railway stations, bus terminals, arenas, community/civic and conference, convention centres, museums, public libraries, parliamentary buildings, and others.

3. Industrial buildings: These are buildings where the industrial production of goods and services takes place. Examples include refineries, power plants, chemical plants, and manufacturing plants. Their design depends mainly on the type of machinery and labour to be used and the process that they support. Most of these projects are privately funded.

4. Commercial buildings: Commercial buildings are meant solely for commercial activities. Examples include shopping centres/malls, markets, bank buildings, cinemas, hotels, and resorts.

5. Recreational/Sports buildings: These are buildings designed and constructed for recreational and/or sporting activities. Examples are stadiums, indoor sports halls, and other sporting facilities.

6. Religious buildings: These are buildings that serve as worship centres. Examples are church buildings, mosques, temples, and shrines.

7. Mixed-use buildings: These are buildings that serve more than one purpose. A typical mixed-use building serves residential, commercial, and recreational/leisure purposes.

Features of the Building Industry

The following are some of the key features of the building industry that are noteworthy.

Complexity: The building delivery process involves the use of different types of materials, tools, equipment, plants, and machinery, different sizes of contracting entities, vendors and suppliers, specialists, consultants, supervisors, and managers. Apart from the building process involving several activities taking place simultaneously, sequentially, or at random, the participants are usually independent of one another but work together to realise building projects of various types and sizes. These, among others, make the building industry a very complex industry when compared to any other products or services industry.

***Multiplicity of agencies' participation*:** There are several agencies regulating and controlling the design, planning, erection, operation, and management of buildings. Every one of these regulatory agencies is independent of the others. For example, in Nigeria, apart from the regulatory agencies of the different professional associations such as the Architects Registration Council of Nigeria (ARCON) for the architects, and the Council for the Regulation of Engineering in Nigeria (COREN) for the Engineers in the building industry, several other government agencies like the Ministry of Works and Housing, Town Planning Authorities, Physical Development Commission and Boards and the Fire Service, Standard Organisation of Nigeria (SON) and others control the various activities in the building industry. The implication of this is that there is a multiplicity of codes, regulations, and standards for professionals and operators in the building industry must comply with.

Complex and temporary inter-relationships and interactions: As explained earlier, activities and processes in the building industry involve several government and non-governmental agencies and organisations. The interrelationship and interaction between these stakeholders are usually very complex, contractual in nature, and project-based which end as soon as the building project is over. This is because each building project differs from the others due to variations in the work environment, different technology levels, and multiplicity of input resources. Hence, each participating agency or organisation usually sees a typical project from its own narrow and specific perspective resulting in the stakeholders working in a conflict-prone environment in delivery building projects

High level of safety hazards: Building construction is a highly accident-prone activity and process. This is because building construction works are done using heavy equipment and machines and temporary structures such as scaffolds and falsework. Moreover, the working environments, nature of work, and a large number of participants make building construction work much more hazardous and straining due to difficult terrain, uncertainties of the natural environment, and exposure to heat, light, and sound. As a result, none of the safety precautions usually adopted in permanent work environments where workers work in controlled environments can be applied to the building industry. This situation informs the rating of the building industry as one of the high-risk industries in the world.

***Low productivity*:** Compared with other industries, the building industry is considered a low-productivity sector. This is due to several factors including the very complex, fragmented, and unique nature of projects, the involvement of a wide range of participants (Dixit et al., 2019), less-than-optimal working conditions, and the diversity of products and inputs and scarcity of trained and skilled manpower required to achieve projects (VanTam et al., 2021). There is also the issue of multiple agencies' participation and regulatory framework, and the adverse effect of weather conditions on construction works. These, among other factors, contribute to low productivity as seen in time and cost overruns in building project delivery.

Environmental Polluter

Buildings and building processes have been associated with adverse environmental impacts as they contribute to environmental crises through resource depletion, energy consumption, and waste generation (Zhang et al., 2019). Research has also shown that the construction industry, which the building industry is part of has been described as the 40 percent industry as it is responsible for the consumption of about 40 percent of natural resources and the production of about 40 percent of all waste globally (Dahiru, Dania, & Adejoh, 2014).

Figure 8 shows that across the building lifecycle, natural resources are drawn from the environment in the forms of raw materials and energy, and waste is generated in the production, transportation, and assemblage of building materials and the operation and demolition of buildings. Thus, making the building industry one of the most resources and energy intensive and a major polluter of the environment.

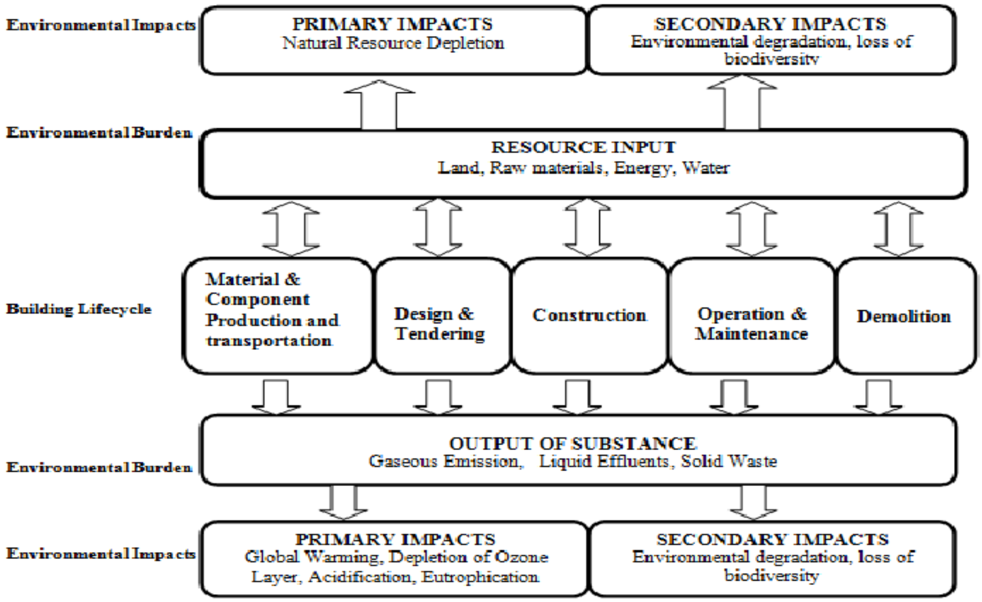

Figure 8: *Environmental Polluter Features of the Building Industry*
Source: Authors' Conception

Components of the Building Industry

The building industry is made up of different components. These components are discussed in this section of this book.

Materials: As noted earlier, the building industry involves the conversion of different kinds of materials into buildings and waste products. Each building material is distinct due to its intrinsic and attributive properties (Spence & Kultermann, 2005). The intrinsic properties are the physical and chemical properties and are divided into structural and non-structural properties. The structural properties are important in ensuring the structural safety and stability of buildings, and thus the materials must have adequate strength, stiffness, and resistance to fatigue for a given loading condition. The non-structural properties are surface and environmental interaction properties, thermal properties, electrical conductivity, and sound insulation characteristics.

Attributive properties of materials are mainly those attributed to materials. They include cost, sustainability, processing, connectability, and constructive properties. It is noteworthy that the properties of materials determine how they will be fabricated, the skill levels and the number of workers, and the size and type of equipment required for the building work on the site (Spence & Kultermann, 2005).

Technology: Technology refers to the tools and processes for changing raw materials into works, products, and services. It is mainly the technical tools, equipment, and knowledge applied in the conception, design, erection, and operation of buildings. The key aspects of technology are objects, tools or equipment, and techniques used in converting raw materials into building products and components and assembling them into buildings (Intsiful, 2012). Technology in the building industry can be indigenous (i.e. originated with the people based on local knowledge) or foreign (i.e. imported from other countries or localities). It is noteworthy that the contemporary building industry is technology-driven, though many developing countries are lagging in this aspect.

Information

As is true with the construction industry, the building industry across the world involves the generation and exchange of a huge quantum of information (Ibem *et al.*, 2016). Thus, the industry has been described as an information-intensive industry. Research has shown that the planning, design, and construction of buildings involve complex and fragmented activities and the generation and exchange of both structured and unstructured information (Babalola, Ibem & Ezema, 2019). The information tool is an important component of the building industry because it helps to ensure that informed decisions are made on any aspect of the building process.

In the building industry, the key information describes the technologies, processes, standards, regulations, and policies that guide the conduct of the industry activities. The basic information exchanged in the delivery of building projects includes that in the architectural, structural, services (mechanical and electrical), drawings bills of quantities, and others. There is also written information in building codes, regulations, bye-laws, and design standards. In Nigeria for example, there is huge information in the National Building Code of 2006, building regulations and bye-laws, and structure design codes.

People

This refers to the human beings who take part in the building process. They come from different backgrounds and include skills such as professionals (architects, engineers, builders, planners, quantity surveyors, land surveyors, estate surveyors/valuers, construction managers, landscape architects, interior architects, designers, etc.). Others are unskilled workers such as operators/tradesmen (e.g. bickers, carpenters, plumbers, electricians, painters, tillers, interior decorators, labourers, etc.). We also have contractors, building materials manufacturers and suppliers, clients (building owners), building users, and researchers. The professionals use their mental capability, while the operators apply their strength in the building delivery process. The clients (individuals, corporate organisations, government) provide the financial resources for the successful take-off and completion of building projects, while the building users are those who occupy or use the building when completed.

Stakeholders and their roles in the Building Industry

The different groups of stakeholders in the building industry can be classified into six distinct groups. These include the following:

Owner or user group: This group determines the need to be met in building projects and supplies the finances required to fulfil this need.

Design group**:** This consists of experts like architects, structural designers, services engineers, quantity surveyors, land surveyors, planners, and geotechnical engineers. Their key role is to supply the specifications, information, designs, and schedules of the project and perform supervision and perform quality control functions.

Construction group: This group is made up of different categories of contractors, material suppliers, builders, construction project managers, and other professionals (e.g. architects, engineers, landscape architects, interior architects, and designers) and operators (e.g. tradesmen, labourers) involved in the construction process.

Regulatory group*:* This group is responsible for regulating the activities of the client, design, and construction groups. Their presence is to ensure that buildings meet the basic health and safety requirements. Membership of this group includes town planners, environmental and public health officers and fire officers, and professional bodies in the building industry. Others include those responsible for ensuring that both locally manufactured and imported building materials meet the specified minimum standard for use in the industry. In Nigeria, these include the Standard Organisation of Nigeria (SON) and the Ministries of Works and Housing.

Manufacturing group**:** This includes the manufacturers of building materials and components, machinery and equipment, tools, hardware, and software packages used in the procurement of building projects.

Research group: The research includes those involved in different kinds of research and development. Examples include research institutes such as the Nigerian Building and Road Research Institute (NIBBRI), several research groups in Universities and Polytechnics as well as research and development units of building materials and equipment manufacturers.

Professionals and their roles in the building industry

The different professionals and their roles in the building industry are discussed in this section of this Chapter. Note that this discussion is not in any particular order.

Land Surveyor

The first professional to work on a piece of land is the Land Surveyor. The Land surveyor has special knowledge and skills in establishing the relative positions of places on or beneath the surface of the earth by measuring distances, directions, and elevations. In a building project, the land surveyor is responsible for determining the location (latitude and longitude), property boundary (shape), the area of the landed property (size) and defining boundaries of the landed property. The land surveyor also works in the construction phase, especially during the setting of the building to ensure that there is the correct placement of foundation footings and columns (Nwankwo & Obasi, 2021). He/she is also involved in establishing levels and benchmarks that would be used as reference points in the construction work. The Nigerian Institution of Surveyors (NIS) is the association for Land Surveyors, while the Surveyors Registration Council of Nigeria is the regulatory body for the practice of land surveying in Nigeria.

Architect

According to the Federal Republic of Nigeria (2004), architecture is the art and science in theory and practice of design, erection, commission, maintenance, management, and coordination of all allied professional inputs, thereto of building or parts thereof and the layout and master plan forming a comprehensive institution, neighbourhood, establishment as well as any other organised space opened or enclosed, required for human and other activities. Given these, the architect is traditionally considered the head of the building team and thus plays a leading role in the building industry. In any building project, the architect usually represents the client and is saddled with the responsibilities of conceiving, designing, and supervising the erection of the building. In addition, the architect also coordinates the activities of other professionals in the building team to ensure that their inputs are consistent with the overall goal of the project.

The architect's duties at the pre-contract stage include receiving the brief from the client, developing the brief (architectural programming), and producing a schematic design for the approval of the client (Nwankwo & Obasi, 2021). Thereafter, the architect goes on to produce detailed, annotated working drawings and specifications, which form part of the contract documents. The architect is also involved in the supervision of the construction building to ensure it is done in line with the working drawings and specifications. The associations for practitioners of architecture in Nigeria are the Nigerian Institute of Architects (NIA) and the Association of Consultant Architects of Nigeria (ACAN). The practice of architecture in Nigeria is regulated by the Architects Registration Council of Nigeria (ARCON).

Town Planner

Town planning is "a process involving a recurring cycle of operations, for preparing and implementing plans for changing systems of land use and settlements of varying scale' (Basorun, 2015:128). Town Planners are also called Urban Planners and are responsible for designing the layout of towns, cities, and villages. They also ensure that their layouts are followed as planned to ensure a balanced and orderly development of an area. In addition, they are responsible for dividing communities into different land uses such as residential, commercial, and industrial areas, and assessing the environmental, economic, and social impact of proposed physical development projects.

In Nigeria, many Town Planners work with town planning/physical development authorities and they play a critical role in building plan approval (Okeke, Sam-Amobi& Okeke, 2020). They particularly ensure that the established setbacks in the buildings and bye-laws are met before the building permit is given to any developer. The practice of town planning in Nigeria is regulated by the Town Planners Registration Council of Nigeria (TOPREC), while the Nigeria Institute of Town Planners is the association for Town Planners in this country.

Landscape Architect

Landscape Architecture is the intentional altering of the naturally occurring landscape in a preconceived manner to achieve a desired result. Hence. Landscape Architects are designers of the outside of buildings to make them functional and attractive. Their designs include different textures and sizes of public parks, gardens, and playgrounds, within private and public spaces and institutions. Landscape Architects offer advice on on-site planning, roads, walkways, flowers, shrubs, and trees within spaces between and around buildings. Their main area of focus is the provision and management of green (grasses, shrubs, trees) and blue (water bodies) infrastructure within private and public spaces in villages, towns, and cities). Hence, their role is to enhance the green content of the built environment thereby complementing the efforts toward mitigating the effects of urban heat islands and other climate change-induced environmental crises. The Society of Landscape Architects in Nigeria (SLAN) is the umbrella organisation for Landscape Architects.

Interior Architect and Designer

Interior Architects and Designers are responsible for the design of the interior spaces of buildings. These include non-structural alterations, furnishings, fixtures and fittings, lighting, and colour schemes. They work closely with architects and engineers to provide functional improvement, aesthetic enrichment, and psychological enhancement of the quality of life in interior spaces (Ching & Binggeli, 2018). Interior architects and designers help to create designs for the layout and configuration of the internal space of a building or structure. They often take responsibility for fixing installations such as kitchens, bathrooms, and surfaces and making interior spaces functional, safe, and beautiful by determining space requirements and selecting decorative items, such as colours, lighting, and materials. The Interior Designers Association of Nigeria (IDAN) is the professional body for interior designers and suppliers in Nigeria.

Quantity Surveyor

The Quantity Surveyor(QS) is the cost consultant in the building industry. QS primarily prepares the bill of quantities and tender documents and gets involved in tender evaluation at the pre-contract stage. During the construction phase, the QS manages and monitors the project cost, be it new construction, maintenance, or renovation work to ensure that the total cost of the project does not exceed the estimated cost. In addition, the QS is usually involved in monitoring and recording progress on site, preparing variation order calculations/negotiations, payment certifications, financial statements, and final accounts. The Quantity Surveyors Registration Board of Nigeria (QSRBN) is the regulatory body for the quantity surveying profession, while the Nigeria Institution of Quantity Surveyors (NIQS) is the association for Quantity Surveyors in Nigeria.

Services Engineers

These include Electrical and Mechanical Engineers engaged in the design of electrical and mechanical services in buildings. The Electrical Engineer estimates the electrical loads and designs the layout of the electrical supply and distribution systems in buildings. The design of electrical systems in buildings shows the locations and types of lighting systems, lighting points, electrical sockets, fans, and air conditioners. Electrical Engineers also supervise the installations of the electrical fittings and installations in the building during the construction phase of the project.

Mechanical Engineers are directly involved in the design of the mechanical and sanitary services in buildings. Their drawings show how freshwater enters the building and wastewater leaves the building; the different sanitary installations and fittings in buildings. Mechanical Engineers determine the sizes and locations of service pipes within and around the immediate surroundings of the building. In Nigeria, the Electrical and Mechanical Engineering professions are regulated by the Council for the Regulation of Engineering in Nigeria (COREN). Both the

Electrical and Mechanical Engineers belong to the Nigerian Society of Engineers (NSE), which is the umbrella organisation for all Engineers.

Structural Engineer

Structural Engineering is a specialised area of Civil Engineering concerned with the safety and structural integrity of buildings. The Structural Engineer usually calculates the strength of structural members required to enable them to carry the loads expected in the entire lifespan of buildings after carrying out appropriate structural analysis. They ensure appropriate designs of structural members such as columns, beams, and slabs. The services of a Structural Engineer are most needed in buildings of more than one floor. He/she usually relies on the report produced by the Geotechnical Engineer on the soil-bearing capacity to design an appropriate foundation for buildings. Similarly, the architect's drawings guide the Structural Engineer in the design of the sizes of structural elements of the building. The Council for the Regulation of Engineering in Nigeria (COREN) is the body that regulates the practice of Structural Engineering in Nigeria. Structural Engineers are also members of the NSE.

Geotechnical Engineer

Geotechnical Engineering is also an aspect of Civil Engineering that deals mainly with the performance of the soil. A Geotechnical Engineer conducts site investigations to determine which type of foundation is suitable for a proposed building and also considers the types of risks landslides and earthquakes pose to a proposed building on a particular site. The geotechnical report of the geophysical survey is used by the Structural Engineer to design the foundation of buildings on a particular site. The Council for the Regulation of Engineering in Nigeria (COREN) is the government agency that regulates the practice of Geotechnical Engineering practice in Nigeria. Geotechnical Engineers are also members of the NSE.

Builder

A Builder is a professional trained to manage the construction and maintenance of buildings. A Builder is trained to understand the architectural and engineering drawings and specifications and he/she uses them to ensure that the construction is in line with the drawings and specifications. In building projects, the builder is responsible for producing a work schedule and deciding the best methods of construction to adopt. For small structures, the builder can make structural calculations. The Council of Registered Builders of Nigeria (CORBON) is the body that regulates the activities of Builders, while the Nigerian Institution of Builders (NIOB) is the umbrella organisation for Builders in Nigeria.

Construction Project Manager

The Construction Project Manager oversees the project delivery process from conception to planning, design, and final occupation. The CPM works as the eye of the employer as he/she is given the authority to appoint all consultants and contractors on behalf of the client. He/she is also responsible for seeing the project through the tendering process and coordinates all activities of parties involved to ensure that the work is done according to specifications, on schedule, and within cost limits. The other responsibilities of a CPM include the monitoring of quality, time, scope, and cost parameters and risk management. The ability to undertake effective communication, coordination, and negotiations is a prerequisite for a good Construction Project Manager. The Chartered Institute of Project Managers of Nigeria is the umbrella association for Project Managers in Nigeria.

Estate Surveyor and Valuer

According to Atoyebi (2020), the Estate Surveyor and Valuers are professionally trained in the art and science of real estate management to direct and supervise an interest in landed properties with the sole aim of obtaining optimum returns for the owners of such properties. Estate Surveyors deal with the management of land and landed properties, management, and maintenance of buildings, and in some cases play the role of facilities managers. The Estate Surveyors and Valuers Registration Board of Nigeria (ESVARBON) is the body that regulates the practice of estate surveying in Nigeria. The Nigerian

Institution of Estate Surveyors and Valuers (NIESV) is the professional association for Estate Surveyors and Valuers in Nigeria.

Role of the Building Industry in National Development

Like all the other sectors such as agriculture, manufacturing, and services industry, the building industry plays a key role in the socio-economic development of any nation in the following ways.

1. It provides the basis upon which other sectors of the economy operate.
2. Employment generation as it employs a large number of skilled professionals such as architects, engineers, quantity surveyors, and land surveyors, and unskilled workers such as tradesmen, labourers, and others (Saka & Adegbembo, 2022).
3. It helps to generate business activities and employment in other sectors of the economy such as manufacturing, transport, commerce, and financial services owing to its interlinkages to other sectors in sourcing its primary inputs
4. The industry contributes to infrastructural development through the provision of different types of buildings that enable other sectors such as water and power supply, telecommunication, and others to function effectively.
5. Activities in the building industry contribute to the growth of financial institutions, which in turn helps the local and national economies to grow.
6. The building industry also brings about new technologies, through innovation and technology transfer, thus promoting the advancement of technology (Hogan, 2020).

Summary

In this chapter, the building industry and its historical evolution from the Palaeolithic period to modern times were presented. The major characteristics and the different types of buildings produced by the building industry were also identified and discussed. In addition, the different key components of the building industry were identified and described. The chapter also identified the different groups of stakeholders and their key roles in the building industry as well as the key professionals and their specific roles in the building industry. This Chapter concluded with the identification of the six roles of the building industry in national development.

Exercises

1. Discuss concisely the historical evolution of the building industry from the Palaeolithic era to the modern era
2. Discuss five major characteristics of the building industry and the different types of buildings produced by this industry
3. Visit a construction industry in your community and find out the following: a) how many employees they have, b) list the categories c) the type of work done by each category.
4. Describe how the building industry contributes to the environmental crisis witnessed now in your locality.
5. Using the example in 3 above, what role do you think the industry plays in employment generation?
6. Name any five professionals in the construction industry and discuss their roles in the delivery of building projects.

References

Atoyebi, F. (2020). Roles of estate surveyors and valuers in the society. Access at https://www.linkedin.com/pulse/roles-estate-surveyors-valuers-society-femi-atoyebi/ on 9/3/2023.

Babalola, O., Ibem, E.O., & Ezema, I.C. (2019). Implementation of lean practices in the construction industry: A systematic review. *Building and Environment*, 148:34-43.

Basorun, J.O. (2015). *Basics of urban and regional planning*. Akure: Sharon Publishers.

Encyclopedia Britannica (N.D). Mastaba. The Editors of Encyclopaedia. Available online at https://www.britannica.com/technology/mastaba. Retrieved on 15th July 2023.

Corbet, B. (2014). The Great Ziggurat of Ur. Available online at https://www.ancient-origins.net/ancient-places-asia/great-ziggurat-ur-001767. Retrieved on 1st June 2023

Ching, F.D.K. & Binggeli, C. (2018). *Interior design illustrated* (4th Edition). New Jersy: John Wiley & Sons.

Dahiru, D., Dania, A. A., & Adejoh, A. (2014). An investigation into the prospects of green building practice in Nigeria. *Journal of Sustainable Development, 7*(6),158–167.

Dixit, S., Mandal, S.N., Thanikal, J.V. & Saurabh, K. (2019). Study of Significant Factors Affecting Construction Productivity Using Relative Important Index in Indian Construction Industry. E3S Web Conference, 140(09010) https://doi.org/10.1051/e3sconf/201914009010

English Heritage (N. D). Pre-History: Architecture. Available Online at https://www.english-heritage.org.uk/learn/story-of-england/prehistory/architecture/. Retrieved on 1st June 2023.

Federal Republic of Nigeria (2004). Architects' Registration Council Act, CAP A19 Architects' (Registration, etc.). *Laws of the Federation of Nigeria*. Lagos: Federal Government Press.

Fletcher, B. (1996). *History of Architecture*. Architectural Press: Jordan Hill, Oxford.

Garber, J.(2017). History of Architecture – Industrial revolution (18th century) & Revival (1880 –1940). Available Online at https://johngaber.wordpress.com/2017/11/10/history-of-architecture-industrial-revolution-18th-century-revival-t1880-1940/. Retrieved 1st June 2023.

Hogan, P. (2022). Five ways construction will supplement economic recovery and growth.https://onekeyresources.milwaukeetool.com/en/construction-leads-economy-in-pandemic. Accessed on 9/3/2023.

Ibem, E.O., E.B. Aduwo, P. Tunji-Olayeni, E.A. Ayo-Vaughan & U.O. Uwakonye (2016). Factors influencing e-Procurement adoption in the Nigerian building industry. Construction. Economics and Building, 16: 54-67.

Intsiful, G. (2012). Historical Overview of Construction in West Africa. In Laryea, S., Agyepong S., Leiringer, R. & Hughes W. (eds). *Construction in West Africa.* West Africa Built Environment Research (WABER) Conference & EPP Book Services Ltd: Accra, Ghana. Pg.35-50.

Keogh, M., & Smallwood, J.J. (2021). The Role of the 4th Industrial Revolution (4IR) in Enhancing Performance within the Construction Industry. OP Conf. Ser.: Earth Environ. Sci. 654: 012021. doi:10.1088/1755-1315/654/1/012021.

Khan Academy (2014). Introduction to Greek architecture. Available online at https://www.khanacademy.org/humanities/ancient-art-civilizations/greek-art/beginners-guide-greece/a/introduction-to-greek-architecture. Retrieved on 1st June 2023.

Kpamma, E.Z. (2011). The Building Industry: Yesterday, Today and The Future by Means of Appropriate Technology. A Paper delivered at the 1st Centre for National Culture (CNC) Symposium on Cultural Economy at the Sunyani Polytechnic, Sunyani, Ghana, 25th March 2011.

LibreTexts (2023). Paleolithic Architecture. Available online at https://human.libretexts.org/Bookshelves/Art/Art_History_%28Boundless%29/02%3A_Prehistoric_Art/2.02%3A_The_Paleolithic_Period. Retrieved 1st June, 2023.

Mafi, N.(2019). 9 Buildings That Prove Sustainable Architecture and High Design Are a Perfect Pair. Architectural Digest. Available online at https://www.architecturaldigest.com/gallery/buildings-prove-sustainable-architecture-high-design-perfect-pair. Retrieved on 1st June 2023.

Medjo, D. (1997). Time to Rewrite History. West Africa, No. 4143, 31st March- 6th April 1997, Pp 531.

Nwankwo, S.I. and Obasi, S.C.E. (2021). *Introduction to Architecture*. Enugu, Jamoe, Publishers.

Okeke, F.O., Sam-amobi, C.G.& Okeke, F.I.(2020).Role of local town planning authorities in building collapse in Nigeria: evidence from Enugu metropolis. *Heliyon*, 9(7), e04361

Saka, N. & Adegbembo, T. F. (2022). An assessment of the impact of the construction sector on the Gross Domestic Product (GDP) of Nigeria. *Journal of Surveying, Construction, and Property*, 13 (1),42-65.

Sawhney, A.; Riley, M. & Irizarry, J. (2020). *Construction 4.0-An Innovation Platform for the Built Environment*; Routledge: New York, NY, USA.

Spence, W.P. & Kultermann, E. (2011). *Construction Materials, Methods, and Techniques- Building for a Sustainable Future*. Cengage Learning: Delmar, USA.

The Collector (2023). What is the Difference between the Parthenon and the Pantheon? Available online at https://www.thecollector.com/differences-between-parthenon-vs-pantheon/. Retrieved on 1st June 2023.

Van Tam, N., Toan, N.Q., Hai, T.D., & Quy, N. L. (2021). Critical factors affecting construction labour productivity: A comparison between perceptions of project managers and contractors. *Cogent Business & Management*, 8: 1-17.

Zhang, Y., Wang, H., Gao, W., Wang, F., Zho, N., Kammen, D.M. & Ying, X. (2019). A Survey of the Status and Challenges of Green Building Development in Various Countries. *Sustainability* 11:1-29.

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The Significance of History, Theory and Criticism in Architecture

Prof. W.B. Qurix, *Bingham University, Karu*

Overview

Architecture is the art and science of designing and constructing buildings. It deals with space and its function. It serves both functional and aesthetic purposes; group as well as individual demands. The aspirations, norms and ethos of society are reflected in its architecture, and in that regard, architecture is dynamic and evolutionary. The dynamic nature of Architecture warrants the use of different methodologies in learning its essence. History, Theory and Criticism are very important in understanding the nature and influence of architecture. They provide a basis for its interpretation and contextualization.

The aim of this text is to explore the importance of theory and criticism as methodologies for understanding the history of architecture. The historical linkage between classical and contemporary architecture is brought to the fore with the aim of providing a panoramic view of the evolutionary process of Architecture. This text explores existing historical methods, theories and criticism and their significance in Architectural interpretation. The period in view is from antiquity to contemporary. It provides an insight into how theory and criticism help in the perception of architecture and understanding between Architecture and society.

Objectives

The objectives of the text are to:

1. identify different methodologies used by architectural historians in the teaching of architecture;

2 identify the role of theory and criticism in perception and meaning in architecture;
3 describe the essence of architecture;
4 identify the characteristics of different architectural epochs;
5 describe briefly, the characteristics of Architecture in some selected places; and
6 explore the evolutionary process of Architecture from classical to contemporary periods.

Conceptual Clarifications

History of Architecture

Historically, Architecture may have begun with the design of the pyramid of Djoser in 2630 by Imhotep (Jarus, 2022). Its journey through the prehistoric, antiquity, Modern to Contemporary period is rich in content and context. Architectural history is robust, rich in content and context. It is a description of facts, events, buildings, environment, society and their inter relatedness. It traces the sequence of occurrences and the process through which a fact emerges as well as factors responsible. Historians use various methods. However, three key methods have been identified as follows.

Historicism

Historicism is an approach to studying history that emphasises the importance of understanding historical events and developments in their specific cultural, social and political contexts. This approach assumes that historical events are shaped by the unique circumstances of the time and place in which they occur, and that they cannot be fully understood outside of that context. Historicism also emphasises the role of interpretation in understanding history, recognizing that different people and groups may interpret the same historical events in different ways. It is a study of process through objective research. It answers what and how of an event, fact or building. It relies on socio-cultural values which are not based on generalised laws.

Historicity

Historicity indicates the fact that something has a historical basis or is rooted in history. It is the quality of being historically accurate or authentic. For example, a historical novel that accurately depicts the events and people of a particular time period is said to have historicity. In contrast, something that is historical or anachronistic does not have historicity, as it does not accurately reflect the historical context in which it is set. This establishes the level of authenticity, specific nature of facts and the social and material content inherent in a write up. It is usually done with cross-referencing, comparison of opinions and facts. For example, the account of Greek and Roman scholars on neoclassical architecture presents divergent views but certain archaeological findings have supported the viewpoints canvassed on Roman Architecture.

Historiography

Historiography refers to the study of the methods and principles used in writing history. This includes the examination of how historical knowledge is created, constructed, and communicated over time. Historiography also includes the analysis of the different approaches and interpretations that historians have used to understand and interpret the past. This includes the examination of primary and secondary sources, the use of different analytical frameworks, and the consideration of different perspectives and biases. The goal of historiography is to understand how and why historical narratives are constructed and to assess their reliability, accuracy, and objectivity. This concerns itself with how historical research and interpretation shift from time to time and from place to place. It examines the sources and methodologies of history, whether traditional narratives, archaeological excavations or pictorial documentation.

Theory

Architectural theory is the spirit behind creativity or innovation. It is the philosophical underpinning that directs the practice of architecture. It helps designers to create their manifestos or emblems of their work.

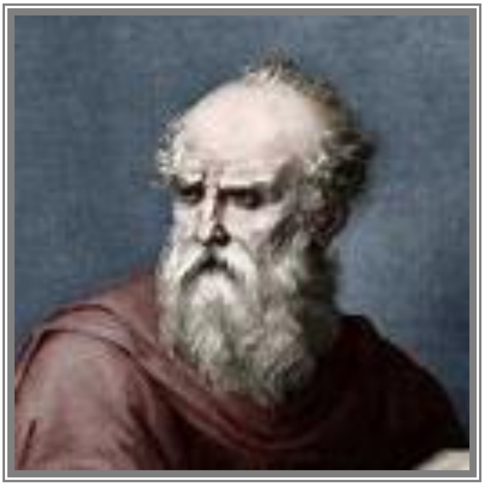

Figure 1. Portrait of Vitruvius
Source:www.fineartamerica.com

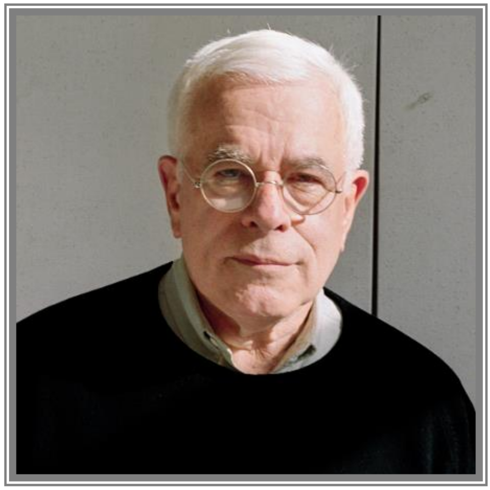

Figure 2. Peter Eisenman
Source :www.pintrest.com

Theory drives the interpretation of architecture. From the theory of Vitruvius which stipulates that good architecture satisfies three qualities i.e. (utilitas or utility, firmistas or firmness and venustas or beauty) many theories followed from the period of antiquity to the contemporary era. Examples include Louis Abbe de Cordemoy's principles of ordinance, bien séance and distribution which connotes; correct proportion, beauty and balance, Le Corbusier's five principles of modern architecture, Peter Eisenman's De Constructivist theory of Contemporary architecture.

Criticism

Architectural criticism is an evaluative commentary based on certain philosophy or theory or based on functional expectations which establishes authenticity and focus. The critic is expected to understand the context of the evaluation and to remove self from it. Although it often relies on the critic's "interpretative licence" to dis-entangle certain facts. There are many authors of architectural theory and criticism, adopting different methods in writing. However, there seems to exist some key authors that have captured the essence of history or theory and in some cases criticism. These include; Cruickshank, D. (1996) Ed; which covers Antiquity, classical period and the modern era; Benevelo, L. (1996) which covers History and Theory of Neoclassical period to the modern movement; Jencks, C. and Kropt, K. (2006) devoted to compilation of diverse theories that have driven the practice of architecture from the modern era to contemporary period. Qurix, W.B. and Sagada, M.L. (2022) which attempts to present the theory and philosophy behind Nigerian Architecture. Others are Nnimno, B and Okechukwu, N. (2018), Nnimno, B. and Okechukwu, N. (2018), Veronika, K. (2021).

The Essence of Architecture

The essence of architecture is creating functional and aesthetically pleasing spaces that meet the needs of the people who use them. Architecture involves designing buildings, structures, and spaces that are safe, efficient, and sustainable, while also being visually appealing and inspiring. It is about finding the balance between form and function, and creating structures that enhance the lives of the people who use them. Architecture involves considering the cultural and historical context of a place, and designing buildings that reflect the local culture and traditions. Ultimately, the essence of architecture is about improving the built environment in a way that benefits both individuals and society as a whole. The rational aspect deals with stability, functionality and buildability while the emotional aspect deals with aesthetics and formal expressions. To achieve this, the architect goes through a five year grilling in both theory and practice. Architects usually express themselves in styles which are a reflection of the society, and in that regard different styles have evolved from the period of antiquity such as; Greek Architecture, characterised by beam and post, Doric columns, entablature (lintels) and their precision as seen in the design of the Acropolis. Modern Architecture characterised by simple forms, plane walls and wide openings was said to be reflective of the spirit of the times Qurix, (2007).

Other Architectural epochs are identified as follows:

Roman Architecture is identified with hemispherical arches used for aqueducts, domes, the Pantheon, as well as unique columns;

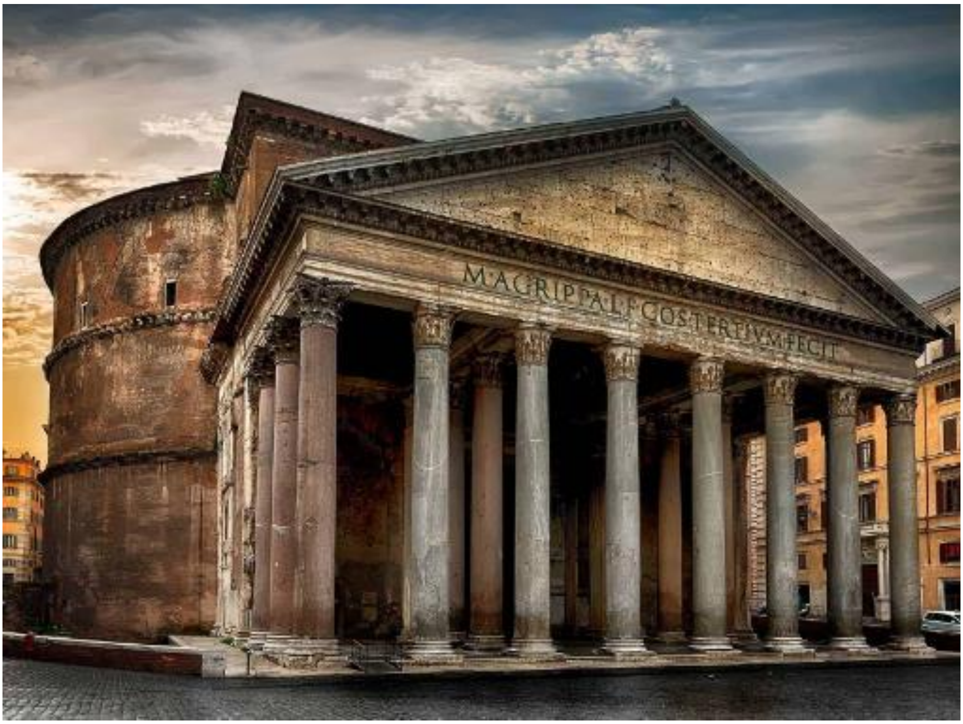

Figure 3. the Pantheon
Source:www.booking.com

Romanesque Architecture was characterised by rectangular and circular Basilicas and masonry works;

Byzantine Architecture had the Hagia Sophia is a distinguished feature;

Figure 4. Hagia Sophia
Source:www.booking.com

Baroque was characterised by moving columns and unstable appearance;

Islamic Architecture was characterised by pendentive domes and calligraphy;

Renaissance Architecture was characterised by rational design, re-created Italian windows, unique domes e.g (St Paul's Cathedral London);


Figure 5. St. Pauls Cathedral, London
Source:www.getyourguide.com

Gothic Architecture; characterised by buttresses, ribs and fins, stained glass;

Neoclassical Architecture (British parliament), Victorian style;

Modern Architecture and **Contemporary Architecture** characterised by diverse forms and expressions.

Some of the key buildings that constitute historical landmarks include the Greek's Acropolis and Agora, the Roman's Pantheon and Forum, the Byzantine's Hagia Sophia in Istanbul, Renaissance's St Paul Cathedral London, the British parliament of the Neoclassical period. The era of Modern Architecture i.e., early to late twentieth century was characterised by rich experiments and transformation occasioned by the Industrial Revolution and establishment of humanist disciplines such as political economy and sociology. Many architectural styles are associated with the modern movement such as Modernism, Postmodernism, Regionalism, High-Tech and Late Modernism. Modernism has been traced to the Neo-Classical period in the works of Auguste Perret and Julien Gaudet as well as Le Corbusier's early works. Notable architects of this era include Le Corbusier, Frank Lloyd Wright, Mies Van-der Rohe, Walter Gropius and Phillip Johnson, Femi Majekodunmi, Habitat Associates, Multisystem, Triad Associates, Adeniyi Coker, and Modulor Associates. (Qurix, 2002). In the contemporary era, the prevalence of multiple styles is noticed such as; Late Modernism, Post Modernism i.e., incorporating historical as well as emotive elements into design. Others are New Modernism, which has the appearance of unstable forms, Green and Sustainable Architecture, which aims to cut down carbon footing, Foams and Sponges; which depict meshy architecture and voids and Complex Simplicity i.e., Cubic expressions with voids, terraces and capping and the Classical Revivalist style especially in Nigeria; which attempts to combine classical architecture with traditional and modern forms (Qurix 2022).

The focus of architectural historians

Architectural historians focus on the study of architecture as a form of art and cultural expression throughout history. They analyse the design, construction, and evolution of buildings, structures, and urban spaces. They examine the social, political, economic and cultural factors that influenced architectural styles and movements throughout different periods of history. They also analyse the materials, techniques, and technologies used in construction and how they impacted the development of architecture over time. Additionally, architectural historians study the role of architects and builders in shaping the built environment and how their work reflects the values and aspirations of the societies in which they lived.

The Relationship between Classical Architecture and Modern Architecture

Classical Architecture and Modern Architecture are two distinct styles with different design principles and aesthetics. Classical Architecture is characterised by its use of traditional forms, such as columns, arches, and pediments, and its emphasis on symmetry and proportion. Modern Architecture, on the other hand, is characterised by its use of new materials, such as steel, concrete, and glass, and its focus on function and simplicity (Glancey, 2018), (Hopkins, 2022).

Significance of History Theory and Criticism in Architecture

History and criticism play a significant role in architecture because they provide architects with a deeper understanding of the context and cultural relevance of their work. By studying the history of architecture, architects can gain insight into the evolution of building techniques, materials, and design principles, as well as the social, political and economic factors that have influenced architectural styles throughout history (Nkogu, 2001) Ed. Theory plays a significant role in understanding architecture because it provides a framework for analysing and interpreting the meaning and significance of buildings and other structures. Architectural theory helps to explain the social, cultural, and historical context in which buildings were constructed, as well as the aesthetic and functional principles that influenced their design. It also provides a way to evaluate the success or failure of a building in achieving its intended purpose or conveying its intended message. Criticism allows architects to receive feedback on their work and helps them to refine their design ideas. Through critical analysis, architects can identify strengths and weaknesses in their designs and make necessary adjustments to improve the functionality, aesthetics, and sustainability of their buildings. Criticism plays an important role in understanding contemporary architecture by providing a critical analysis of the design, aesthetics, functionality, and cultural significance of buildings and structures. It helps to identify the strengths and weaknesses of a building, and to evaluate its success in meeting the needs of its users and the broader community. Criticism also helps to contextualise contemporary architecture within the larger historical and cultural context, and to explore its relationship with other disciplines such as arts, engineering, and urban planning (Rendell, et'al 2007). By engaging with critical discourse, architects, designers, and the public can gain a deeper understanding of the complex issues and challenges facing contemporary architecture, and work towards creating more innovative and sustainable buildings and structures.

Architectural Development in some Continents

The essence of architectural development in some continents has been described briefly as follows;

Europe

The history of architecture in Europe is vast and diverse, reflecting the continent's long and rich cultural heritage. European architecture is characterised by its ornate details, use of classical orders, and emphasis on symmetry and proportion. One of the most significant contributions of European architecture is the development of Gothic architecture, which originated in France in the 12th century. Gothic architecture is characterised by its pointed arches, ribbed vaults, and elaborate decoration, and is often associated with the grand cathedrals of Europe. Another important aspect of European architecture is the influence of the Renaissance, which originated in Italy in the 14th century. Renaissance architecture is characterised by its use of classical orders, such as columns and pilasters, and its emphasis on symmetry, proportion, and perspective. In more recent times, European architecture has been influenced by modernist and postmodernist architectural movements. Architects such as Le Corbusier and Frank Lloyd Wright have made significant contributions to contemporary

European architecture, creating innovative structures that reflect both traditional and modern design principles.

History of architecture in Europe lies in its ability to adapt to changing cultural and environmental conditions, while maintaining a connection to classical and traditional building techniques and cultural heritage. The use of technology in architecture gained prominence and reached sublime in the Pompidou Centre in Paris, Lloyds Bank in London and the Swiss Building and others. Europe has indeed played a pioneering role in the evolutionary process of Modern as well as Contemporary Architecture.

America

America developed its architecture through the pioneering works of the Engineering School comprising Daniel Burnham, Louis Sullivan, and later the works of the emigrant Europeans such as Walter Gropius, Mies Van-der Rohe, Richard Neutra, who promoted Modern Architecture. On the other hand, the works of Frank Lloyd Wright brought a unique style to American Architecture (prairie style). Landmark buildings emerged as early as 1932 such as the Empire State Building and the Chrysler Building. Others were John Hancock in Chicago and later the Seer's Tower, now Willis Tower. In 1974 when glass panels fell from the John Hancock Building Modern Architecture was pronounced "dead." Highly symbolic Buildings are noticeable in parts of America such as the John F. Kennedy airport, AT&T Building and the Louis House by Phillip Johnson.

Figure 6. Willis Tower
Source:www.lewiscarlystyle.com

Japan

The history of architecture in Japan is characterised by a unique blend of traditional and modern influences. Japanese architecture is known for its simplicity, harmony with nature, and attention to detail. Traditional Japanese architecture is heavily influenced by Buddhist and Shinto religious beliefs and practices, and incorporates elements such as sliding doors, tatami mats, and paper screens. One of the most distinctive features of Japanese architecture is the use of wood as a primary building material. Traditional Japanese buildings are often constructed without nails, using intricate joinery techniques that allow for flexibility and durability. In addition to traditional architecture, Japan has also been influenced by modernist and postmodernist architectural movements. Architects such as Tadao Ando and Kenzo Tange have made significant contributions to contemporary Japanese architecture, creating innovative structures that reflect both traditional and modern design principles. The essence of the history of architecture in Japan lies in its unique ability to blend traditional and modern influences, creating a distinctive architectural style that is both functional and aesthetically pleasing. Japan had a traditional form of architecture derived from its culture and tradition. It was characterised by use of flat screens, overhanging sailing roofs and narrow spaces.

The contact between Kenzo Tange and Le-Corbusier, Isozaki Arata and the Metabolist group helped in shaping Japanese architecture in the late 20th century (Qurix 2007). The design of the Tokyo Olympic stadium in 1960 and the Prefecture in Kagawa exemplified a blend of traditional Japanese architecture with Modern Architecture. Expressive use of concrete elements with "Cartesian coordinates' ' reflective of a typical Corbusien order are visible in modern Japanese architecture. The Nagakin Capsule Tower reflected a new approach known as "Metabolism ", a home grown Japanese Architecture which mimicked Biological principles.

India

India benefited from Le-Corbusier's work in the mid-20th century, when the new capital Chandigarh was being designed. The Law courts, houses of Parliament and secretariat reflected a blend of traditional Indian architecture, in its cosmic elements and the modernist approach of Le-Corbusier: The secretariat building inspired a number of Bureaucratic office designs across the world including Nigeria's Federal Secretariat, Lagos, Kaduna and Abuja particularly, as it concerns the Cartesian Coordinates as an expression associated to Le Corbusier.

Africa

The history of architecture in Africa is rich and diverse, reflecting the continent's cultural and environmental diversity. African architecture is characterised by a deep connection to the natural environment, the use of local materials, and the incorporation of symbolic elements and cultural traditions. The architecture of ancient African civilizations, such as Egypt, Ethiopia, and Zimbabwe, is particularly notable for its monumental structures and elaborate decorative features. In more recent times, African architecture has been influenced by European colonialism, as well as by modernist and postmodernist architectural movements. Today, African architects are exploring new approaches to sustainable design, incorporating traditional building techniques and materials, and creating innovative structures that respond to the unique challenges and opportunities of the African context.

Nigeria

The history of architecture in Nigeria is diverse and reflects the country's rich cultural heritage. Nigerian architecture is characterised by the use of local materials, such as mud, wood, and thatch, and the incorporation of symbolic elements and cultural traditions. Nkogu, (2001) Ed, (Qurix 2002). One of the most significant contributions of Nigerian architecture is the use of earth architecture, particularly in the form of mud-brick buildings. Mud-brick architecture is prevalent in many parts of Nigeria, and is characterised by its thermal mass, which helps to regulate temperature and humidity. Another important aspect of Nigerian architecture is the use of traditional building techniques, such as the use of palm fronds for roofing and the incorporation of decorative elements such as intricate carvings and murals.

In recent times, Nigerian architecture has been influenced by European colonialism, as well as by modernist and postmodernist architectural movements. Colonial influence on Nigerian architecture was as far back as the nineteenth century through Missionaries as well as the colonial administrators. Some of the early Church buildings such as the Christ Church Cathedral, Marina Lagos, built between 1925 and 1947; The Mapo hall in Ibadan in 1925 and the Shita-Bay Mosque in 1992. The Colonial public works department built several residential buildings using heap roofs, deep pouches and classical columns while paying attention to tropicalisation of the buildings (Osasona, and Hyland 2006). Recently, Architects such as Demas Nwoko have made significant contributions to contemporary Nigerian architecture, creating innovative structures that reflect both traditional and modern design principles.

Figure 7. Christ Church Cathedral, Marina Lagos
Source:(Teniola, 2017)

Modern Architecture took firm roots in Nigeria since the early 1960's with the transnational training of Nigerians in London who returned to set up practices in the early 60s especially in Lagos. The immediate impact was to transform our traditional architecture which was largely characterised by huts, thatched roofs, scattered planning and minimal spaces, into vernacular Architecture. By the early seventies modern architecture had spread to various parts with multiple styles being experimented with simultaneously without a focus. The call to evolve a Nigerian architecture in the 80's has forced designers to look for local alternatives and this has produced the Revivalist style of the 1980’s (Qurix, 2007). Recent issues such as sustainability and green architecture have influenced the practice of architecture in Nigeria while the curriculum of architecture in schools have been re-designed to allow for flexibility, interdisciplinary connection and emphasis on Entrepreneurship. Landmark buildings include, UBA House, Lagos, Union Bank building, Lagos, Ministry of Foreign Affairs building in Nigeria, Abuja, PTDF building, ECOWAS building, Abuja and the Ship House building in Kaduna as well as NNDC Plaza in Kaduna.

Figure 8. ECOWAS Headquarters Building, Abuja
Source:www.thezimbabwemall.com

Outstanding traditional buildings include, Gidan Hausa in Kano, Jos Museum (MOTNA).

Figure 9. MOTNA, Jos
Source: www.hellotravel.com

The Akwa Nibo Nise Palace in Awka, Oba of Benin Palace, and several Bales and Chiefs houses in Ife and Lagos.

The Future of Architecture

The future of architecture is likely to be shaped by a number of factors, including advances in technology, changing social and environmental needs, and evolving design trends. One of the most significant trends in architecture is the use of sustainable and environmentally friendly materials and building techniques. As concerns about climate change and resource depletion continue to grow, architects are increasingly exploring ways to reduce the environmental impact of buildings, through the use of renewable energy sources, green roofs, and other sustainable design features. Another important trend is the increasing use of digital technology in the design and construction process. Architects are using 3D printing, virtual reality, and other digital tools to create more complex and innovative designs, and to streamline the construction process. In addition to these trends, the future of architecture is likely to be shaped by changing social and cultural needs, such as the need for more affordable housing, more flexible workspaces, and more accessible public spaces.

Figure 10. 3D Printed House, Germany
Source: www.theconstructionindex.co.uk

Architects will need to be responsive to these needs, while also balancing the demands of aesthetics, functionality, and sustainability. The future of architecture is likely to be characterised by innovation, creativity, and a commitment to sustainability and social responsibility. Architects will need to be adaptable and flexible, able to respond to changing needs and to harness new technologies and design trends to create buildings and spaces that are both beautiful and functional. The computer has literally taken over the way we design in the Contemporary period. Digitalization of Architecture has aided quick delivery, peer review and information modelling, leading to more functional Architecture. The current challenges of environment, climate change, demographic changes, Refugees and internally Displaced persons are bound to affect architecture. Available digital tools allow for predictive architecture. It is believed that predictive architecture based on parametric assessment would dominate architecture. This means that Building Information Modelling, as well as environmental control tools, will play a major role. The perception of architecture and its meaning would vary from place to place based on its problem solving potency. Form would continue to play an important role but more as a medium of expression.

Summary

The importance of Theory and Criticism and their relationship to the history of architecture has been reviewed. This was done mainly through conceptual clarifications of some key methodologies used by Architectural historians with specific examples of how they are applied. The characteristics of architecture were identified in different epochs and continents such as Europe, America, and India. It is clear that perception of architecture is determined by place and factors such as climate and technology as well as current theory and critical evaluation. It is expected that architecture would become predictive, rely on parametric indices and form would still be relevant, but would take the place of an expressive entity. Technology would enable new innovations in architecture and architectural theory and criticism would probably gain more emphasis than history.

Exercises

(a) Identify 3 prominent Buildings globally ,in each of the following countries:

UK

America

France

China and

South Africa

Comment on their characteristics and style.

(b) Identify 3 key Buildings in Nigeria that were built before 1960, between 1980 – 2000 and after 2000:

In each case, comment on their characteristics, style and Architects

References

Carlyle, L. (2018).Willis Tower Chicago Cityscape [photograph].https://lewiscarlyle.com/product/willis-tower-chicago-cityscape

Construction News (2023). Germany's first 3D printed house. https://the constructionindex.co.uk

Cruickshank, D. (1996) Ed Sir Banister Fletchers' A History of Architecture CBS Publisher Mumbai

Fineartammerica (n.d) Portrait of Vitruvius. https:/fineartamerica.com

Glancey, J. (2018) Architecture A Visual History, Phaidon London

Hagia Sophia (2016) 5-five-5. Hagia Sophia, Instanbul-Turkey. https://5-five-5blogspot.com/2015/03/hagia-sophia-instanbul-turkey.html

Hopkins, O. (2022) Architectural Styles; A Visual Guide, Laurence King, London

Jencks, C. and Kropt K (2006) Theories and Manifestoes of Contemporary Architecture A. Wiley Academy

Moffet M. et'al (2003) A World History of Architecture Mc Graw Hill, London

National Museum Jos(n.d.) National Museum Jos. https://www.hellotravel.com/nigeria/national-museum-jos

Nkogu, U.O. (2001) E.d Architects and Architecture in Nigeria, Attribute to Professor E.A. Adeyemi

Nnimno, B. and Okechukwu, N. (2018) Beyond Simple Lines: The Architecture of Gabriel Yakubu and Archcon Kraft Books

Nnimno, B. and Okechukwu, N. (2018) Dotted Lines: The Politics and Architecture of G. Y. Aduku Kraft Books

Osasona, C.O. and Hyland D.C. (2006) Colonial Architecture in Ile Ife Book Builders, Ibadan

Owen, J. (2022) Step Pyramid of Djoser; Egypt's First Pyramid www.lifescience.com 29(12) retrieved on 10/3/23

Pintrest (n.d.) Peter Eisenman Interview.https://www.pintrst.com/pin/356795457734765313/

Teniola, E. (2017). The Cathedral Church of Christ, Marina, Lagos at 150. https://www.premiumtimes.com/2017/10/07

Qurix, W.B., and Sagada M.L, (2022) The Essence of Contemporary Architecture ABU Press

Qurix, W.B., Suleiman N.E. (2015) Transformation and Continuity of Architecture in Kaduna city, Nigeria from 1900 – 2000 Canadian Open Environment and Earth Science Journal 1(1) 1-16

Qurix, W.B. (2007) Reflections of Modern Architecture and Post Modernism in Nigeria, ABU Press

Qurix, W.B. (2002) The Evolution of Modern Architecture in Nigeria, Journal of Association of Architectural Educators 6(2) 67 – 78

Qurix, W.B. (2001) From Classicism to Modernism; The Legacy of Professor E.A. Adeyemi, Journal of Association of Architectural Educators Feb (1-5).

Rendell, J. et'al (2007) Critical Architecture Routledge, London

St. Pauls Cathedral (n.d.) St. Pauls Cathedral. https://www.getyourguide.com/Activities

The Zimbabwe Mail (2003) China to Build New ECOWAS Headquarters in Abuja. https://www.thezimbabwemail.com/world-news

Veronika, K (2021) Biomimetics for Designers, Thames and Hudson London.

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Prof William Barnabas Qurix has taught History and Theory of Architecture in Ahmadu Bello University since 1988 and has over time mentored many students in this unique area of Architecture. In the Late 90s, he taught Recent Developments In Architecture to Ph.D. students. His publications both Internationally and locally have focused on History, Theory and Criticism including his two books; Reflections of Modern Architecture and Post Modernism (1998) and The Essence of Contemporary Architecture in (2022). He has the privilege of having established two schools of Architecture, i.e., in Kaduna State University and Bingham University respectively.

Professor Qurix has considerable experience in professional practice and project management spanning over 30 years and has considerable experience in Public Service, having been the Chairman of an Urban Planning Board, Commissioner of Works and twice as Vice Chancellor.

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He is married with three children, one of which is an architect.

CHAPTER TWO: GRAPHIC COMMUNICATION

Graphics in Architecture, Graphics Conventions and Graphics Representation of Building Elements

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Overview

Graphics in Architecture is a powerful communication tool. It helps to give meaning to architectural designs for architects and others to understand and appreciate the designs made. Graphics is used in representation of symbols, letterings and materials in the various works of art and designs. Graphics has gone beyond symbols and letters into complete modelling of building spaces and its functions in real-time. It creates a strong sense of place, fulfils human needs, helps users find their way and communicates a building better, (SimPaul, 2021).

The aim of this text is to explore various conventions and representation of building elements in design. It discusses graphic communication and its relationship with architectural aims.

Objectives

The objective of this text is to:

1. define architectural graphics;
2. identify graphic conventions and their uses in architecture;
3. describe the different graphical communications available;
4. discuss building elements and materials and their graphical representation; and
5. describe the future of graphics in Architecture.

Meaning of Graphics

Graphics is a communication tool in architecture and other design disciplines. It helps to convey the meaning and aesthetics in the drawings or designs to others (outsiders and non-architects alike). Architectural Graphics is used for communicating ideas to people other than the designer. It helps people to appreciate and understand the design better. This is done in several ways, which is used to visually communicate and identify the sense and identity in architectural projects.

Graphics comprises symbols, letterings and materials to convey architectural ideas properly. In the time past architectural graphics dealt with symbols and lettering used in delivery of the design in two dimensions. As such there were symbols for every item, element and material to showcase the design implicitly.

Architectural Graphics

Architectural Graphics focuses on the techniques, methodologies and graphic tools used in conveying architectural ideas, (Ching, 1996). It is used to communicate a building function, purpose and message, in fact everything about the building. This fosters a strong conversation between a person and the building (place). It is an essential tool of architectural design in communicating information of topography, colour and form influencing interaction with and the identity of place and space, (Sim, 2021).

There are new forms of architectural illustrations that are fast becoming essential creative weapons in the design armoury. In the past, Architecture was presented only in 2-dimension (plans, elevations and sections); subsequently perspectives tried to depict a 3-dimensional form of what was drawn. Recently, there are more techniques, especially with the use of computer drafting that try to show architectural works in three (3) dimensions.

Graphics Conventions

Graphics is a crucial component of architectural design. A good design should be clean, legible and attractive, enabling responses from the audience, (Sim, 2021). Graphics in architecture consist of symbols and lettering. Architectural symbols are science of its own, that conveys the meaning in the architectural work. They define elements like floor levels, lighting types, service location and so on. They play a very important role in any architectural drawing, where they can be broken into services symbols, lightning symbols, electrical symbols, plan, elevation and section symbols.

Architectural works are done to scale, to be able to fit key information into a few pages of drawing. In doing this, symbols are used, also reduced to the same scale of the drawing. Every line drawn has a meaning and so there are symbols for everything in the drawing. Both the drawing itself and materials of construction to be used are represented, (Vasques, 2023).

Floor plan shows topographic features, right of way, property lines, easements and north arrows. For instance, for a door symbol, one can go down as far as showing the door type, hinge position, swing (direction and mechanism of opening and closing) and so on; this happens for every item of design in that floor plan.

The material of construction is a subcategory of architectural symbols where it displays materials to be used, there should always be a legend showing what is used for one not to be confused. This is very necessary as some material symbols differ in plan and elevations, so a legend clarifies what is done or used.

Architectural graphic symbols are grouped into six categories under floor plan symbols. A floor plan is an imaginary slicing of a house across the walls at about 1.5 metres above ground level and looking down. The plan, elevation and section have six different groupings in use.

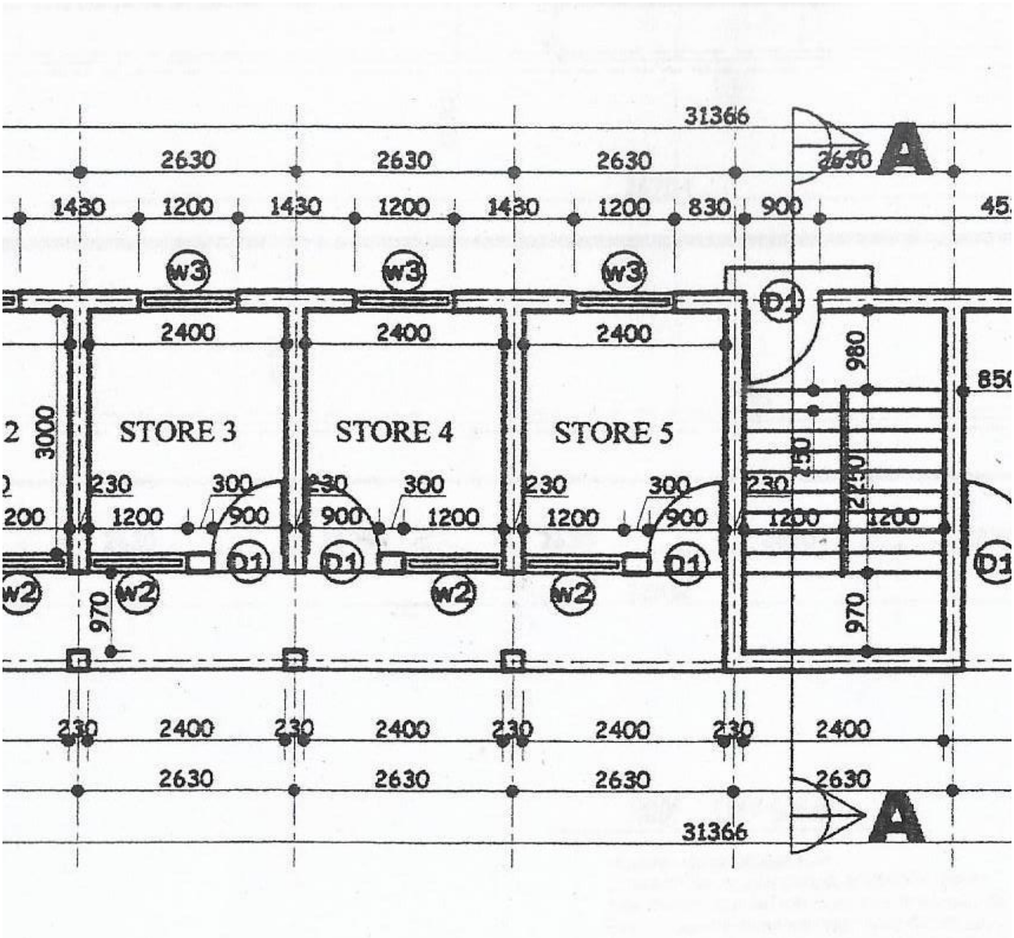

Figure 1. *Floor plan showing various symbols as used.*

Source: Author's fieldwork, (2015)

These six groups are

1. Compass; the symbols here are used in indicating directions on plan and orientation of the property, see fig 4 showing the north arrow.
2. Door symbols depict a door drawn as two parallel lines showing width of door, a curved portion (a range of motion) showing direction of swing and a rough idea of the clearance area, most times the doors are numbered, see fig 1. The numbering helps in keeping track of the various sizes of doors to be used.
3. Window symbols depict a window as three parallel lines, it is also numbered. The numbers show the different sizes of window used, see fig 1, the different types of windows are numbered to track different sizes and types.
4. Stairs symbols seems to be the simplest depicted with two parallel lines with treads shown across these two lines.
5. Walls symbols are differentiated between the exterior and the interior, load bearing and partition. Double lines for both, but the interior is light and the exterior is dark and thick.
6. Appliances; these are shown in furniture plans, whereby all the fixtures and other fittings are shown. They are drawn with a thin fine line that resembles the furniture or fitting in question in the position of use, see fig. 2.

Figure 2. *Typical furniture floor plan showing typical furniture symbols*

In addition to architectural plans, there are symbols for other mechanical, electrical and plumbing (MEP), they are more complicated than architectural plan symbols, their main function is to convey exact location and routes for connectivity.

In all design disciplines including urban design, urban planning, landscape architecture, etc symbols are used to communicate the design intent and construction details of the various elements of the project better. There are symbols for every material used in the construction of buildings and the furniture items used in their furnishing.

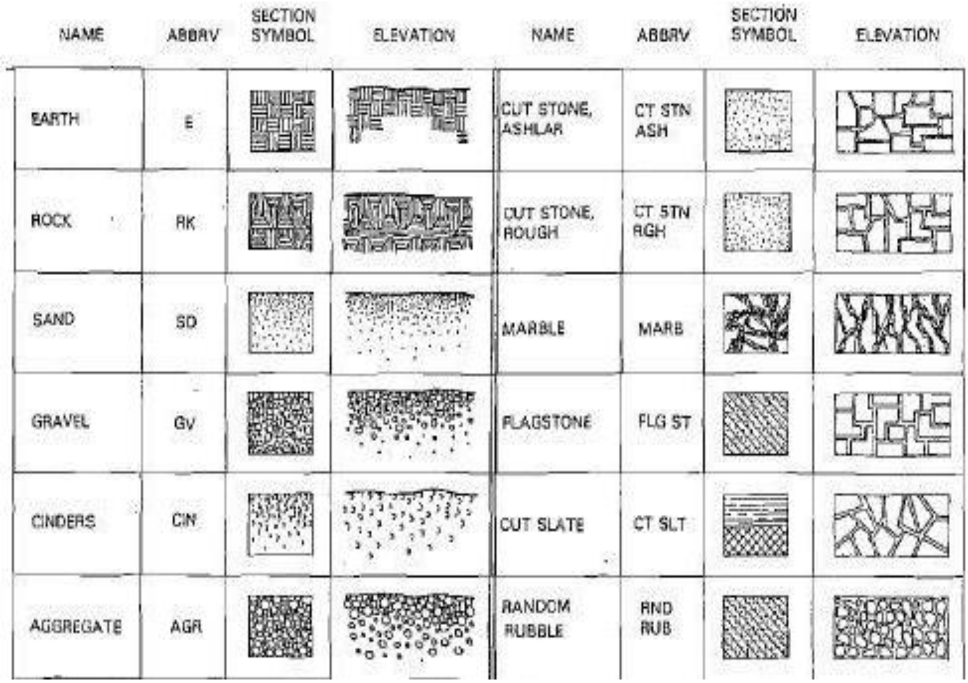

Figure 3. *Some building material symbols*

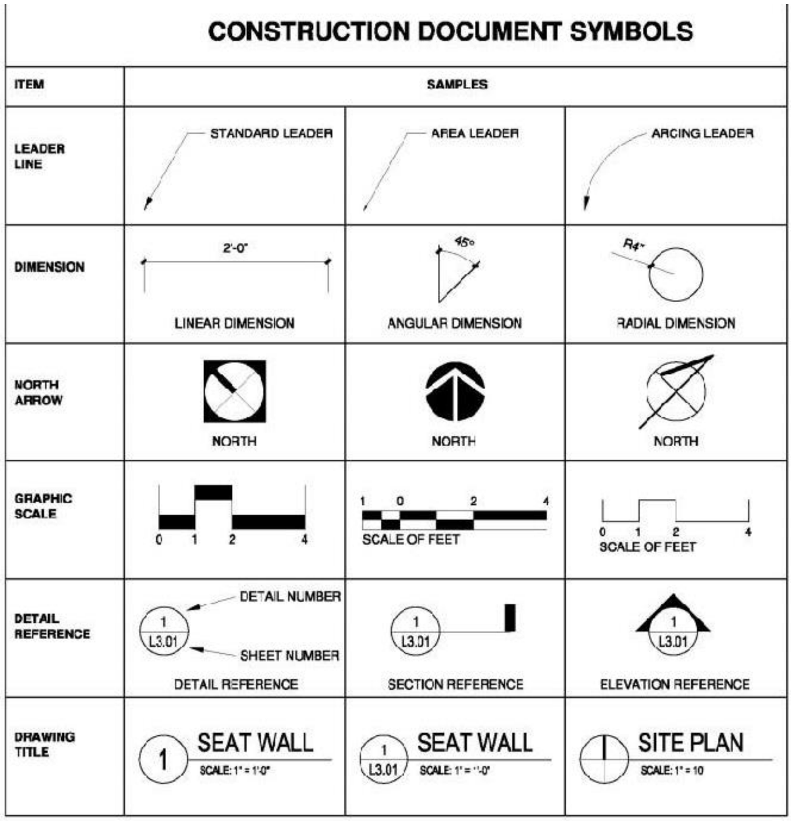

Figure 4. *Landscape Architecture design symbols*
Source: Hopper, L. J. (2007)

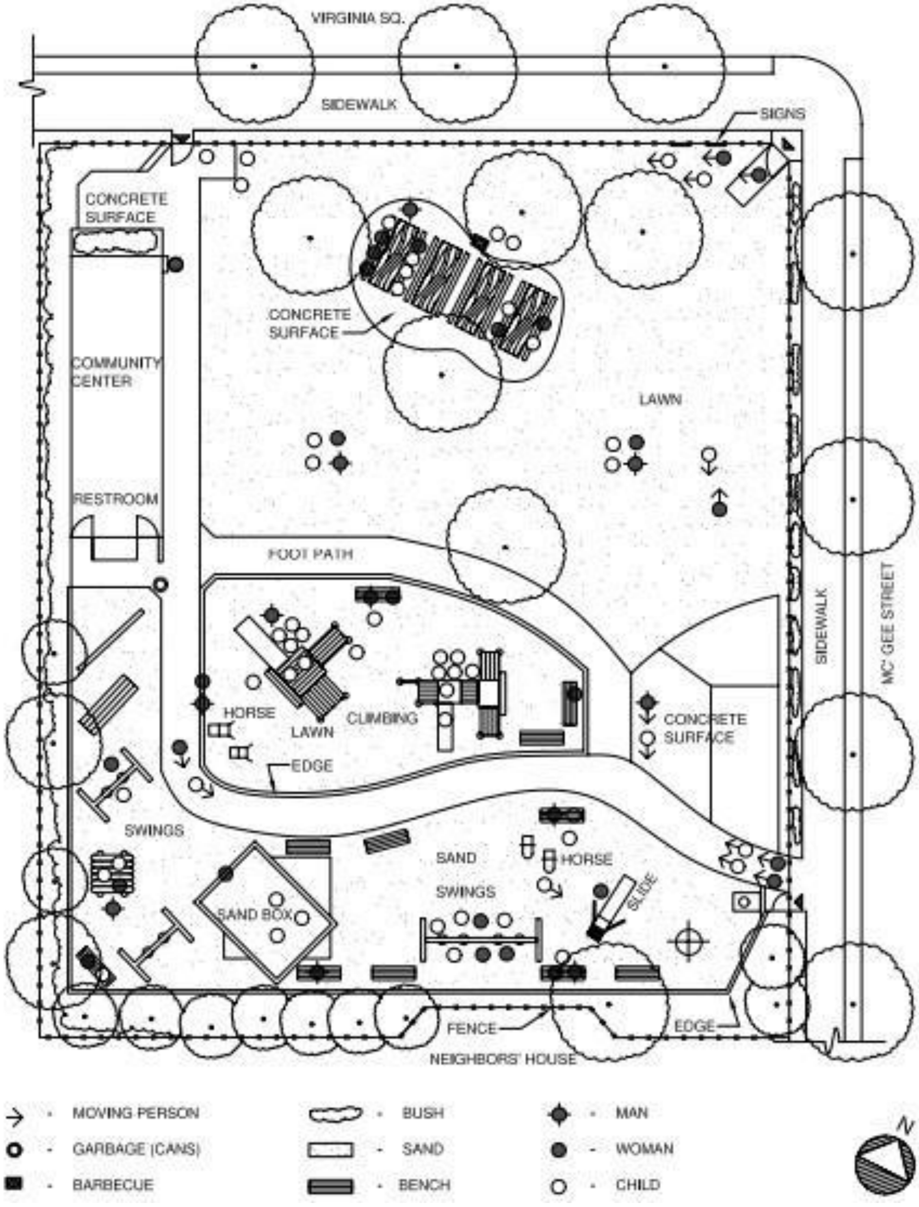

Figure 5. *Landscape Architecture material symbols*
Source: Hopper, L. J. (2007)

In addition to all the graphic symbols as discussed, is graphic lettering whereby one has to learn to write like an architect, this has been virtually taken over by computer lettering styles. Lettering is still an essential and important aspect of architectural graphics fulfilling important requirements of graphical shapes and symbols.

Lettering comes in the form of labels, titles, notes, dimensions and identifications, (Grant, 1987). Lettering in architecture should be legible, consistent and conform to industry standards. Lettering enhances the drawing by making it easy to interpret and pleasant to look at, the same drawing can also be ruined by unreadable and unsightly lettering. Legibility is the hall mark of a good lettering and an important part of graphic composition.

Figure 6. *Different lettering styles*
Source: Giesecke, F.E et la. (1986)

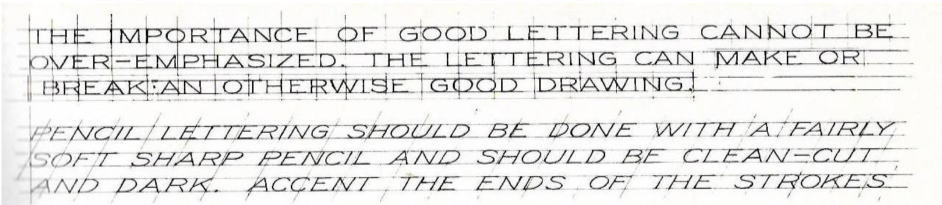

Figure 7. *Freehand pencil lettering*
Source: Giesecke, F.E et la. (1986)

Innovations in Graphics

Graphic design and architectural design are compulsory complements of each other from the beginning of time. Graphic design is used to visually communicate and identify the sense of identity in architectural projects (new design, renovation or planning project). Graphic design is intentional in that it considers the ranges of materials and finishes to be used. It covers logo design, visitors' orientation and information graphics, (Stavros, 2021).

Graphic design adds value to architectural projects by visualizing architectural concepts (strategies, diagrams, renderings, illustrations and presentations), representing a project during construction (identity, copywriting, photography, plans and elevations, maps, infographics, video/motion, social media and additional marketing) and designing for completed architectural project (printed collateral, web design, wayfinding/signage, etc).

In the various innovations in graphics design, computer simulations have added a new dimension which has increased the benefits of graphic design. This benefit extends to the advertising world and other visual communications by educating, informing and being very persuasive.

Among all types, graphic design has diversified, the major area of much interest to architecture is in the motion design (animation and 3D works) and the environmental graphic design combining the visuals, architecture and landscaping to produce and create signs, maps, murals, etc. Keskeys of architizer presents five areas where graphic design can powerfully represent architectural works, as follows;

Concept process diagrams that show the thought behind a design through. a) Sun path (informing on the size and location of glazing and decks). b) Prevailing wind direction (informing on the location of openings for passive ventilation). c) Greenery (informing on the locations of public open spaces and amenities). d) Views (informing on building orientation and outlooks).

An 'X-Ray' 3D floor is shown as a transparent architecture model showing the interior layout and exterior character of the project simultaneously. It helps the client to understand and follow the work as it progresses.

Exploded Axonometric is the architectural equivalent of a scientific "dissection" whereby a building is pulled apart to reveal each component in isolation. It can be pulled vertically or horizontally and show the effect in dotted lines and can also be re-assembled the same way. It allows every element to be viewed in minute details. It can be done on any 3D modeling software. This follows the format of the manual axonometric projections done in 2D, the additional viewing of the inside of the project not just the outside is the innovative aspect.

Infographics is a compelling format used to persuade multiple stakeholders about a proposal. It deals with statistics on key demographics, traffic, etc to justify a proposal of large scale design. It also combines simple views (3D models, site maps, diagrams with iconography) with key statistics.

Audio surveillance and lighting models is the use of colour coding to show the scope and range of audio, visuals and illumination devices within a project, (Keskeys,).

Summary

Graphics in architecture is a powerful communication tool which is the backbone of architectural design. In fact, all design disciplines have one form of graphics representation in use. It behooves the students to internalize these symbols and lettering for proper usage and application in their future design proposals. It is hoped that this introductory material has opened avenues of critical thinking and research interest in architectural graphics representation.

Exercises

1. Give at least two scales used in architectural works for the following (site plan, plan, detailing).
2. Draw three types and sizes of door openings (900mm, 1200mm and 1800mm).
3. Draw symbols for any three construction materials in section and elevation.
4. On an A4 paper, fill up halfway with freehand lettering, then the other half with stencil lettering.

References

Callender, J. H. (1982) Time-saver standards for architectural design data. New York: McGraw-Hill Book Company.

Ching, F. D. K. (1996) Architectural graphics. ISBN 0442022379

Giesecke, F.E., Mitchell, A., Spencer, H.C., Hill, I. L. & Dygdon, J. T. (1986) Technical drawing. New York: Macmillan publishing company.

Grant, W. R. (1987) Landscape graphics: plan, section, and perspective drawing. New York: Billboard publication.

Hopper, L. J. (2007) Landscape architectural graphic standards. Students' edition. Canada: John Wiley and sons.

Keskeys, P. (na) 5 Architectural graphics and diagrams to powerfully represent your project. www.architizer.com.cdn.amproject.org.

Offor, J. N. (2011) Fundamentals of architectural graphics. Enugu: Immaculate publishers.

Sim, P. (2021) Why is graphics important in architecture? www.simpauldesign.com.

Stavros, T. (2021) Why graphics design is important? Linkedin.com

Vasquez, A. (2023) Architectural symbols to remember for architects.

(n.a.) Architectural drawing symbols. archaeosoup-architecture guides+resources.html.

(n.a.) Architectural graphic design. www.rsmdesign.com.

(n.a.) How graphic design helps shape better architecture. www.theupstudio.com.

(n.a.) What is architectural graphic design? www.velocityconsultancy.com.

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Materials and Tools for Design

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Overview

In order to conceptualise and explain original design concepts, landscape architects need access to a wide array of drawing materials and equipment. The ability to visualise, communicate, be precise, be creative, be flexible, and document one's work are all reasons why drawing materials and tools are crucial for landscape architects. The materials consist of pens, pencils, and other writing instruments, as well as erasers, scale rulers, T-squares, compasses, drawing boards, and computer-aided design (CAD) software.

This text deals with the selection of drawing materials and equipment by designers. It deals with the application of different tool types to achieve different drawing outcomes that are desired.

Objectives

The objective of studying drawing materials and tools for landscape architects are to:

1. identify the various types of drawing materials and tools commonly used by landscape architects;
2. develop skills to create high-quality landscape designs that express design thoughts and ideas;
3. list the drawing materials essential for creating distinct landscape effects;
4. illustrate how to use different drawing techniques, to create depth, texture, and shading in landscape drawings; and
5. explore the use of digital drawing tools and software, such as CAD programs, in landscape architecture.

The Different Types of Drawing Materials and Tools

Pencils

Pencils are an essential tool in a landscape architect's toolkit. They have a wide application because of their adaptability, low cost, and easy operation. A mix of letters and numbers, such as 9H, HB, and 9B, identifies the various kinds of leads found in pencils. The hardness of lead can range from the most difficult to the gentlest, with H standing for "hard" and B standing for "blackness." Pencils with a higher hardness grade, such as those with an H rating, have a lighter line weight and are the finest choice for drawing lines and details that are precise and clear. They are very helpful when it comes to drafting and making technical drawings. Due to the fact that they can be readily erased or refined, H pencils are also useful for quickly drawing out first ideas and concepts. Landscape architects frequently use H pencils when outlining plans, elevations, and sections.

Pencils with a softer lead, such as those with a rating of B, provide a darker line weight and are typically utilised for shading and tone work. B pencils are your best bet when it comes to giving drawings depth, contrast, and substance. The higher the B rating, the darker the line generated, and the softer the lead that was formed. When designing landscapes, architects often use B pencils to create shading and add depth to their designs. When it comes to creating shadows and gradients, which may lend a sense of realism and depth to a drawing, soft pencils are very beneficial tools.

Not only do pencils have a range of lead hardness options, but they also come in a variety of forms and sizes. For instance, landscape architects might use a mechanical pencil, which enables them to draw exact lines and requires significantly less sharpening than a standard pencil. They could also use a clutch pencil, which has a bigger lead capacity and is better suited for shading and drawing broad lines. In addition to their versatility, pencils are long-lasting sketching tools that can endure the deterioration caused by repeated usage. In contrast to other drawing tools such as markers or watercolours, Pencils do not smear or bleed, making them an excellent choice for creating precise drawings with a high level of detail.

In essence, pencils are the most fundamental sketching instrument that landscape architects utilise, and they are available in a wide variety of lead hardness levels. When drawing exact lines and details, use a harder lead, but you should use a softer lead for shading and toning. Several kinds of pencils, such as mechanical and clutch pencils, are used by landscape architects because each drawing calls for a unique set of specifications to be fulfilled.

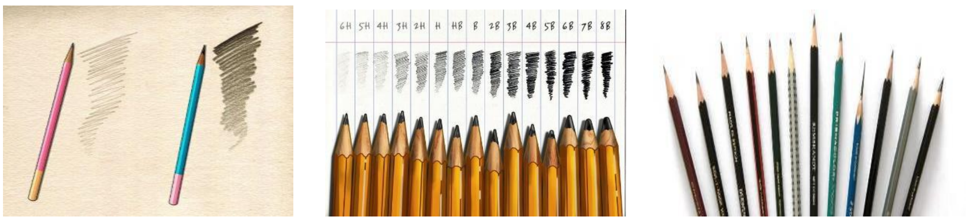

Figure 1. *What the letters "H" and "B" on pencils mean*
Source. 5-Minutes Crafts, 2022.

Erasers

Erasers are a vital tool for landscape architects and other artists because they enable them to easily remove undesirable lines, smudges, and marks from the drawing paper without destroying the surface. In addition, erasers are inexpensive and can be found at almost any office supply store. There are many different kinds of erasers available, such as gum erasers, plastic erasers, and kneaded erasers, to name a few.

Kneaded erasers, also known as silicone erasers, are a popular choice among landscape architects because they are malleable and can be shaped and moulded to fit into tiny areas. They are formed from a material that is both flexible and malleable, often consisting of a combination of gum and rubber, and are, therefore, very easy to mould into a point or a wedge-shaped tip. This enables landscape architects to precisely and controllably erase undesirable marks and lines from their drawings.

One of the many benefits of using kneaded erasers is that, unlike standard erasers, they do not leave any residue or crumbs behind when used. Because of this, they are perfect for use on fragile paper surfaces, such as tracing paper or vellum, where even the smallest smudge or scratch can completely ruin the drawing. Kneaded erasers are reusable and can be cleaned and reshaped as needed, making them a decision that is economical and kind to the environment. However, it is essential to note that while kneaded erasers are fantastic for removing graphite and charcoal, they may need to be more successful for erasing ink or other media. This is something that should be kept in mind. Because of this, landscape architects may require various erasers to employ, depending on the kind of drawing they are producing and the materials they are working with.

Figure 2. *Pencils*
Source. *Fine Art Tutorials* ,2023.

Pens

Regarding the drawing process, landscape architects rely heavily on pens as one of the most important tools. They are available in various styles and dimensions, each well-suited for a distinct set of sketching methods and effects.

Fine-tip pens are normally available in diameters ranging from 0.05 mm up to 0.3 mm, and they are utilised for drawing fine lines and lettering. They are ideal for including minute particulars, such as outlining the margins of trees and plants, drawing hatching lines to create texture, and labelling design elements, and they come in a wide variety of shapes and sizes. Technical drawings, such as site plans and elevations, can also be accomplished using pens with fine tips.

On the other hand, pens with more comprehensive tips are preferred when shading and filling huge areas. These pens, which generally come in sizes ranging from 0.5 mm to 1.0 mm, produce bolder lines that are ideal for creating shadows, filling in huge spaces, and creating depth, and their standard diameters range from 0.5 mm to 1.0 mm. Landscape architects utilise pens with thicker tips to give contrast and dimension to their designs, such as producing shadowing on a hill or filling in a pond. Some examples of this may be found below.

One must understand that pens can include a variety of inks, some water-based, others oil-based, and others pigment-based. Oil-based pens are more smudge-resistant and produce bolder lines than their water-based counterparts. Water-based pens are superior for generating rapid sketches because of their ease of blending. Pigment-based pens are well-known for the exceptional quality of the ink they produce, which is resistant to fading and can create crisp lines. Some pens are designed to achieve particular effects, such as a calligraphy pen, which may make lines and curves that appear graceful and flowing. The use of these pens can lend a drawing a more decorative air, and they are frequently put to work producing titles or other ornamental motifs.

When creating drawings in landscape architecture using pens, it is essential to select a pen suited to the specific kind of drawing that will be made. Pens with broader tips are more suited for adding shade and texture, while fine-tip pens are perfect for producing intricate blueprints and designs because of their ability to fit into tight spaces. Because this can affect the drawing's clarity and durability, selecting a pen with high-quality ink that will not smear or fade over time is another consideration that should be considered.

Figure 3. *Drawing Pens Source.* Cole, 2021.

Markers

Markers are a common and widely used drawing tool that landscape architects employ in order to give colour and texture to their drawings. They are available in many different varieties, such as water-based, alcohol-based, and solvent-based markers. Landscape architects can employ the distinctive qualities of each different kind of marker to generate various effects.

Because they are simple to blend and produce a transparent effect, landscape architects frequently go with watercolour markers as their medium of choice. They perform admirably on paper intended to be used with watercolour techniques, such as mixed media or watercolour paper. Because they are available in such a wide variety of hues and shades, they may be utilised in a wide variety of ways to produce genuine colour gradients and shading.

Another popular option for landscape architects is the use of markers that are based on alcohol. They dry quickly and provide colours that are intense and vivid. Because they come in such a wide variety of hues and tones, they can be utilised in the production of designs that are both elaborate and detailed. Marker paper and Bristol board are two examples of smooth paper surfaces that perform well for their application.

Landscape architects use markers based on solvents less frequently, despite these markers having unique qualities that can be advantageous for specific design reasons. Due to the fact that they are both permanent and weatherproof, they are ideal for use in outdoor design projects. They are also perfect for drawing on non-porous surfaces, such as glass or plastic, as their ink does not absorb into the surface.

While using markers, it is essential to think about their characteristics and how they will behave when combined with the drawing paper. For instance, watercolour markers are most effective when used on paper specifically for watercolour techniques, but alcohol-based markers are most effective when used on smooth paper surfaces. In addition, landscape architects need to think about the level of transparency or opacity they want to create with their markers, as well as the particular colour palette they want to employ to get the intended effect.

Figure 4. *Markers.* *Source*. Craft Thinking, 2021.

Paper

When creating drawing, landscape architects must have access to paper as an essential medium. There are many different kinds of paper that can be used, and the one that is chosen will depend on the stage of the design process as well as the effect that is intended. The following is a list of some of the most frequent varieties of paper utilised by landscape architects:

Tracing paper is a type of translucent paper that enables landscape architects to generate various overlays and modifications of their designs. Landscape architects commonly use this type of paper. At the early stages of the design process, when numerous design options are being explored and changes are made to the drawing, it is usual to practise using this tool. Tracing paper can also come in handy when it comes to making rapid sketches and rough draughts.

Vellum paper: Vellum paper is a high-quality paper that has a smooth surface and is frequently used for more intricate drawings because of these characteristics. It is resilient and can tolerate erasures and changes in the original text. While generating a polished and detailed drawing in the later phases of the design process, vellum paper is frequently employed as a common medium to work on.

Sketch paper is a thin, lightweight type of paper typically utilised to create preliminary sketches and ideas. It is simple to dispose of or recycle, which makes it popular for use in rapid drawings, and it may also be used again. In comparison to tracing paper and vellum paper, the durability of sketch paper is lower; nonetheless, it is more cost-effective and simpler to work with.

Watercolour paper: Paper for watercolour paintings and renderings often consists of watercolour paper, a special kind of paper that is both thick and absorbent. It is frequently utilised by landscape architects to generate representations of their plans that are accurate and precise, and it is one of the reasons why. A wide variety of watercolour paper is available, each offering a distinct feel and surface quality that can be tailored to achieve a particular effect.

Graph paper is a specific variety of paper that has been printed with a grid on its surface. Graph paper is also known as dot paper. It is widely used for the creation of precise and accurate drawings, including site plans and technical drawings, amongst other types of drawings. There is a wide range of grid sizes to choose from when purchasing graph paper; this allows users to accommodate their needs for varying degrees of precision.

The stage of the design process as well as the effect that is desired to be achieved, are both factors that dictate the type of paper that is used. Landscape architects must carefully consider the kind of paper that should be used for each design they develop. This is because the kind of paper used may significantly impact how the drawing turns out in the end.

Figure 5. *Paper Source*. Utrecht, 2023.

Scale Rulers

In landscape architecture, scale rulers are essential because they enable designers to precisely represent the size and proportions of various elements in their designs. Scales Rulers are commonly fabricated from plastic or metal, and their surfaces are engraved with markings and measurements specific to the scale being utilised. The scales 1:50, 1:100, and 1:200 are used most frequently in the field of landscape architecture. These scales illustrate the proportional relationship between the object's size in the drawing and the object's size in real life. For instance, if the scale is 1:50, the drawing is one millimetre to every fifty millimetres in the real world. To use a scale ruler, choose the appropriate scale for the drawing you are working on, and then measure distances on the drawing using the markings on the scale ruler. If a designer is working on a drawing at a scale of 1:100 and wants to represent a distance of 10 metres, they would measure 10 centimetres on the drawing using the ruler designed for the 1:100 size.

Scale rulers can be used to precisely represent the size of objects and elements in a drawing and their utility in measuring distances. Scale rulers are often made of metal. For instance, if a designer is working on a plan view of a garden and wants to represent the size of a tree, they can use the scale ruler to ensure that the tree is represented at the correct size relative to the other elements in the drawing. This can be accomplished by ensuring the tree is represented at the correct size relative to the other elements in the drawing.

In landscape architecture, scale rulers are essential because they ensure that plans are appropriately represented and help minimise problems that might result from erroneous scaling. They are a crucial tool for communicating designs to clients, contractors, and other stakeholders, and they are a fundamental component of the toolkit of a landscape architect.

Figure 6. *Scale Rules* *Source.* Artnews, 2020.

T-Squares

T-squares are a form of drawing tool utilised to produce straight lines, mainly when drawing plans, elevations, and other technical drawings.

They comprised a long blade or edge positioned horizontally and referred to as the "head" and a blade or edge positioned vertically and referred to as the "shaft." The T-head square is often crafted from either wood or plastic, while the shaft can be built from either metal or plastic.

The head of the T-square should be positioned to align with either the top or bottom edge of the paper when it is put against the edge of the drawing board. The vertical shaft is then utilised as a guide to producing straight lines perpendicular to the margin of the paper. Landscape architects can eliminate the necessity for freehand line drawing by using a T-square, which enables them to verify that lines are straight, even, and exact.

Several variants of the T-square can be purchased, such as those that are adjustable and fixed. Adjustable T-squares feature a sliding head that can be rotated to various angles, making them the ideal tool for drawing diagonal lines or slanted lines due to the head's versatility. Fixed T-squares have a head that is secured in place and can be used to draw straight lines in either the horizontal or vertical plane.

In the field of landscape architecture, T-squares are an indispensable tool since they enable the creation of accurate and precise drawings that are straightforward to read and comprehend. When it comes to the drafting process, landscape architects can save time and effort by making use of a T-square, which allows them to easily and quickly make straight lines on their drawings.

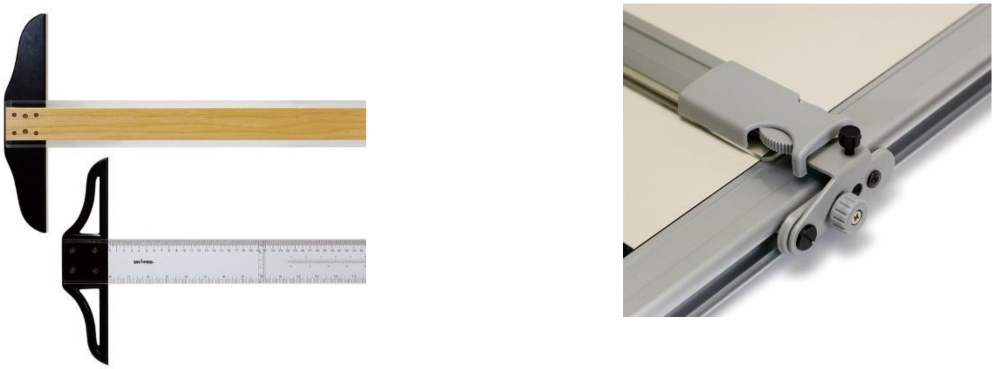

Figure 7. *T-Squares Source.* Mau Art and Design, 2023.

Compasses

Compasses are an essential drafting tool that landscape architects use to make circles and arcs of specific sizes with high precision and accuracy. They are made up of two arms that are attached to one another by a hinge, and at the end of each arm is a pointy tip that can be manipulated to form circles and arcs of varying diameters. A tip is at the end of one of the arms, while the other has a pencil or pen attached to it. The user can make circles of varying sizes by manipulating the distance between the sharp tip and the pencil, which in turn controls the circle's diameter. The ability to precisely design circular forms, such as tree canopies, roundabouts, and water features, makes compasses essential for landscape architects. In addition, you may form accurate arcs with them for garden walks, retaining walls, and other curved structures. Using a compass helps guarantee that the circles and arcs are symmetrical and have even proportions, which is an important step in developing an aesthetically acceptable design.

When using a compass, the user must first adjust the arms so that they have the desired diameter. After that, they position the pointed end of the compass at the point in the middle of the circle or arc they want to create, and then they draw the form using the pencil or pen linked to the other arm of the compass. The compass can be turned about its central point to produce either a complete circle or an arc, depending on the kind of form that needs to be made.

Compasses are available in various shapes, sizes, materials, and designs; some compasses have extra functions, including angle adjustments and rulers. Some compasses also feature a magnetic component, which enables them to be utilised on magnetic surfaces like whiteboards. When selecting a compass, landscape architects should consider the project's size and the desired precision level. They should also examine the compass's material and how long it will last.

Figure 8. *Compasses* *Source*. Cantu, 2021.

Drawing Boards

Drawing boards are an indispensable piece of equipment for artists, designers, and architects of all stripes, including landscape designers. When used for sketching, painting, or drafting, they are intended to supply a flat and stable surface, which helps to ensure that the resulting lines and forms are correct and constant. A wide range of drawing boards are available on the market, each made of a different material, ranging from wood to plastic to metal.

Drawing boards made of wood are quite popular among professionals because of their longevity, sturdiness, and the fact that they provide a flat, stable surface. In order to cater to a wide range of preferences, they are offered a selection of different finishes, such as smooth, textured, or unfinished. Unfortunately, wooden boards are notorious for being cumbersome and pricey, making them less than ideal for individuals on a tight budget and students. Plastic drawing boards are both lightweight and portable, making them a good option for those who need to work while on the move, such as students, hobbyists, or people who need to work in several locations. They come in various colours, sizes, and forms, and some may even be purchased with stands that let the user alter the angle at which they are functioning. Drawing boards made of metal are less widespread, but they are known for their exceptional durability and sturdiness. They are built to resist heavy use and have a long lifespan due to their sturdy construction. They can also include extra features that help with precise measurements and lines, such as parallel rulers or angle guides. These features can be purchased separately or packaged together.

Drawing boards are also available in various configurations, including tabletop and portable models. Tabletop drawing boards are often larger than standard drawing boards and are designed to be placed on a desk or worktable. They offer a firm basis for the completion of larger projects. Portable drawing boards were initially developed for artists and designers who needed to work while on the move. As a result, they are an excellent choice for landscape architects who need to sketch while in the field. Drawing boards cater to a wide range of requirements and inclinations, they are a flexible and helpful instrument that any designer or artist can utilise.

Figure 9. *Drawing Boards*. *Source.* Spectrum, 2021.

Computer-Aided Design (CAD) Software

Computer-Aided Design (CAD) software is a type of programme that landscape architects utilise to produce accurate and detailed drawings. These drawings can be 2D plans, 3D models, or renderings. Landscape architects can develop complicated designs quickly and efficiently using CAD software, granting them the flexibility to modify their work rapidly.

The computer-aided design (CAD) programme provides various tools and functions developed expressly for landscape architecture. They include specialist plant libraries, terrain modelling tools, and environmental analysis tools. Landscape architects can use these tools to produce precise and detailed designs, taking into consideration elements such as the sun's angle, the direction of the wind, and the drainage of water.

Landscape architects can work with other professionals involved in a project, such as contractors, engineers, and architects, thanks to the capabilities of CAD software. Designs may be easily shared and modified, eliminating the need for protracted back-and-forth communication and significantly reducing the number of errors and misunderstandings that might occur. The capacity to build three-dimensional models and renderings of the design is another advantage offered by CAD software. Customers can form a more accurate mental image of the completed project, which can help eliminate misconceptions and ensure that the end result lives up to their expectations.

Computer-aided design (CAD) software is becoming an increasingly crucial instrument for landscape architects since it enables the creation of exact and comprehensive drawings quickly and efficiently and provides the capability to adapt and modify existing designs readily. It also makes it possible for landscape architects to cooperate with other professions effectively and develop client visualisations that accurately represent the finished project.

Sketch Pad

Sketch Pads are an important tool for landscape architects as they enable quick, spontaneous brainstorming and the investigation of design ideas. They are a multipurpose tool that can be used in a range of situations, such as on-site visits, in the midst of meetings, or even while travelling. They are also a helpful technique to build one's own unique style and maintain a record of one's evolving design ideas.

Figure 10. *Sketch Pad* *Source*. Komtrak, 2022.

Measuring tools:
Tape measures, rulers, and protractors are essential tools for landscape architecture, allowing designers to accurately measure and record distances, angles, and measurements of a site or design. They can be fabricated from metal, plastic, or cloth and are available in various lengths. They also help to decrease errors and inaccuracies, resulting in a more efficient and productive design process.

Figure 11. *Measuring tools.* *Source*. Freepik, 2023.

Geographic Information System (GIS)

Landscape architects use geographic Information System (GIS) software to analyse and interpret geographic data, such as topography, slope, and aspect. It can also be used to evaluate and simulate vegetation data, such as tree canopies' coverage, species distribution, and growth rates. This information can be used to build planting plans customised to the site's characteristics and support local ecosystems. GIS software enables landscape architects to make more precise and well-informed decisions based on facts from the natural environment.

Summary

The importance of drawing materials and tools cannot be overstated in the field of landscape architecture. In order to develop and express their design concepts, landscape architects make use of a wide range of materials and instruments, ranging from the more conventional pencils and pens to the most cutting-edge CAD software. These tools make it possible for landscape architects to produce drawings that are precise and thorough, allowing them to successfully express their ideas to customers and other stakeholders. Landscape architects are able to craft aesthetically pleasing and practically useful outdoor areas with the assistance of these tools. These spaces can contribute to the enhancement of the natural environment and offer years of enjoyment. Hence, in order to produce projects that are successful, it is essential for landscape architects to have a comprehensive awareness of these technologies and the ways in which they can be utilised effectively. By mastering these tools and materials, landscape architects can create clear and professional designs that communicate their vision to clients, stakeholders, and contractors.

Exercise

1. Why should you make sure that the paper you use for your landscape drawings is of a high quality?
2. In a drawing of a landscape, why is it essential to make use of a range of different line weights?
3. How do coloured pencils and markers bring depth and character to a landscape drawing?

4. Why is it necessary to make sure that the paper you use for your landscape drawings is of a high quality?
5. How can the use of computer software such as AutoCAD make the process of drawing landscapes more effective?

References

Archimash (2020). How To Use An Architectural Scale Ruler (Metric). Available from https://archimash.com/articles/use-an-architectural-scale-ruler/ Accessed on 23/02/2023.

Art news (2020). The Best Architectural Scales for Extreme Precision. Available from

https://www.artnews.com/art-news/product-recommendations/best-architect-ruler-1202692836/ Accessed on 28/02/2023

Cardaci. D, Powell, W. F., Stacey, N., (2018). Drawing: Basic Textures in Pencil A Beginner's Guide to Realistic Textures in Graphite. Walter Foster Publishing.

Cole, M. (2021). 16 of the Best Drawing Pens for Professionals and Beginners. Available from https://mymodernmet.com/best-drawing-pens/. Accessed on 23/03.23

Craft Thinking (2021). Ultimate Guide to Different Types of Art Markers. Available from https://craftythinking.com/different-types-of-art-markers/ Accessed on 28/02/2023

Dream Civil (2022). Drawing Pencil: Hardness of Pencil (HB Pencil, 2H Pencil, 2B Pencil, 4H Pencil, 4B Pencil, 6B Pencil & 6H Pencil). Available from https://dreamcivil.com/drawing-pencil/. Accessed on 01/03/2023

Fine Art Tutorials (2023). Available from https://finearttutorials.com/guide/types-of-erasers/ Accessed on 22/03/2023

Freepik (2023). Measuring tools. Available from

https://www.freepik.com/premium-vector/school-ruler-elements-semicircular-composition-arrangement-various-kinds-rulers-measurement-tape-triangle-protractor-metal-centimeter-plastic-scale-illustration-white_7907560.htm. Accessed on 22/03/2023

Fussell, M. (2022). Different Types of Erasers. Available from https://thevirtualinstructor.com/blog/different-types-of-erasers. Accessed on 28/02/2023

Lohan, F.J. (2012). Pen & Ink Techniques. Dover Publications

Bleicher, S. (2023). Contemporary Colour: Theory and Use. Taylor & Francis. Taylor & Francis.

Farrelly , L. (2008). Basics Architecture 01: Representational Techniques. Bloomsbury Academic.

Hepler, D.J., Wallach,P.R, Hepler,D. (2012). Drafting and Design for Architecture & Construction. Cengage Learning

History of Pencils (2023). Drawing Compass - History and Types of Compasses. Available from http://www.historyofpencils.com/drawing-tools/drawing-compass/ . Accessed on 28/02/2023

Komtrak (2022). Refillable Notebooks. Available from https://www.pinterest.com/pin/komtrak-notebooks-refillable-and-you-can-put-different-types-of-paper-for-different-art-mediums-in-one-place--255579347591876307/ Accessed on 28/02/2023

Mau Art and Design (2023). T-Squares. Available from

https://art-design-glossary.musabi.ac.jp/t-squares/ Accessed on 28/02/2023

Spectrum (2021). Drawing Boards . Available from https://www.vistaplan-drawingmanagement.co.uk/product/spectrum/ Accessed on 28/02/2023

Utrecht(2023) Tracing Sketch Rolls. Available from https://www.utrechtart.com/products/canson-tracing-sketch-rolls/ Accessed on 28/02/2023

5-Minutes Crafts (2022). What Types of Pencils There Are. Available from https://5minutecrafts.site/improve-life/what-types-of-pencils-there-are-1392/ Accessed on 26/02/2023.

BIODATA OF ASSOCIATE PROFESSOR DORCAS AYENI

Dr. Dorcas Ayeni, an Associate Professor in the Department of Architecture at the Federal University of Technology Akure (FUTA). is an accomplished architect and academic specialising in Landscape Architecture and Sustainable Tourism. She holds a Bachelor of Science in Architecture and a Master of Science in Architecture from Ahmadu Bello University, Zaria. She obtained her PhD in Architecture and Sustainable Tourism from De Montfort University, Leicester, in the United Kingdom.

With a passion for research and education, Dr Ayeni has received grants and awards throughout her career. She has published over 80 papers in esteemed local and international journals and has served as a reviewer for reputable academic journals. Additionally, she has supervised several Master and doctoral students.

Dr Ayeni is a registered architect and a member of several professional organisations, including the Nigeria Institute of Architects, Architects Registration Council of Nigeria, Society of Landscape Architects of Nigeria, Nigerian Institute of Chartered Arbitrators, Architectural Educators in Nigeria, International Council on Monuments and Sites Nigeria (ICOMOS). She has held leadership positions within the Nigerian Institute of Architects Ondo State Chapter.

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Beyond her academic and professional achievements, Dr Ayeni is actively involved in philanthropic work. She founded the Widows and Widowers Window of Hope, a non-profit organisation that supports widows, orphans, and "seniors.". She also enjoys travelling, has visited over 22 countries globally, and is keenly interested in collecting flags.

She has significantly established collaborative partnerships between FUTA and international universities, including London South Bank University and De Montfort University

CHAPTER THREE: INTRODUCTION TO BASIC COMPUTER APPLICATIONS

Computing Environment (Operating Systems)

Boguslawa Prucnal-Ogunsote, *University of Jos*

Overview

In architectural education worldwide there is a shift of purpose towards training computer literate graduates to be conversant with the computing environment and equipped with sound knowledge of operating systems amongst others, capable of handling the recent challenges associated with rapid technological advancement. This knowledge is essential for technology-enhanced education and training in architecture. It is also a necessary consequence of increased competitiveness in the profession of architecture and the pervasiveness of the IT industry. Computer literacy requires students not only to pass this course but to integrate the knowledge of the computing environment into studio works, practical and theory courses and in the future to use the knowledge and skills in their professional careers. (Prucnal-Ogunsote, 2023; Prucnal-Ogunsote & Ude, 2008).The expectations and pressures from professional architectural practice also necessitates the training of computer literate graduates, knowledgeable in the computing environment. Computing environment for both the personal computers and laptops that use the similar OSs as well as mobile devices that use mobile OS is presented through simple explanations of complex systems.

This text discusses digital computers and covers their electronic principles. Computer hardware and software components and specifically Windows Operating System that manages the hardware and software resources of the computer system are discussed. It is followed by a discussion on techniques for downloading programs, file management tasks, storing documents online through cloud computing, programming languages as well as coding. Trending technologies are reviewed to indicate the changes in the IT industry that may affect and transform future architectural professions, making this course even more important.

Objectives

The objectives of this text are to :

1. identify electronic principles behind the operation of computers;
2. define digital computing;
3. distinguish desktop computers from laptop computers;
4. identify basic hardware computer components;
5. discuss operating system and system software;
6. identify and discuss application software and software categories;
7. give step by step instructions for performing application software (program) installation based on different sources;
8. create a system of folders and subfolders to store meaningfully named files;
9. identify programming languages presently used for coding; and
10. identify and discuss the new technologies that are already transforming the architectural profession.

Introduction to Computing Environment

The computer today has become an integral part of the architects' daily life. It is widely used for various applications, for administration and for design. The works involving 3D rendering and animations are usually done on desktop computers, but it is the portable and handy laptop that can be carried anywhere. The laptop is commonly used in Nigeria for architectural works and for other office works. Noteworthy to notice is the fact that laptops, even though they are "mobile", use an OS that is not mobile, originally designed for desktops. Mobile devices that actually use mobile OS are used for mobile calls, for Internet connectivity, for providing Wi-Fi to the computers, for Internet searches and for professional networking. While the previous chapter reviews the history and the types of computers required for CADD (Computer Aided Design and Drafting), this chapter is broadening the view of the computer environment and specifically focuses on components, on OS, software downloading and on file management while references to modern technologies are often made.

The computing environment is determined by the main software, the OS which defines all the experiences when using a computer and manages the hardware and software resources of the computer system (Figure 1). The OS provides a way for applications to deal with the hardware without having to know all the details of the hardware, and it is the software that makes all the programs work. It organizes and controls the hardware on computers. It is the first software that is seen after turning on the computer, and the last software that is seen when turning off the computer.

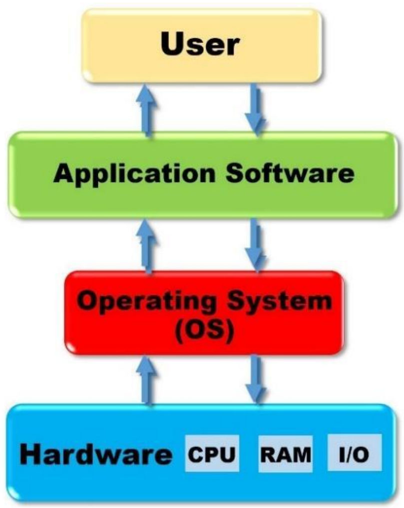

Figure 1: *Components of computer system. As conceived by author*

Digital computer

A **digital computer** known as **personal computer (PC)** and often referred to as **desktop** is defined in this discourse as a device that is used by both architectural students and by practicing architects for various aspects of their works including documentations, reports, letters, and with great importance assigned to creating their architectural portfolios consisting of their design works. Among the PCs are desktop computers, workstations and very commonly used laptops. The notebook, tablet, mobile devices including smart phones and other handheld devices are also PCs. The recent technologies promote mobility, and the devices are becoming much lighter. Among them are light-weight laptops, tablet computers and the hybrid version of 2-in-1 desktop PCs. Important to note is that the smartphones significantly outnumbered the number of PCs in use. All of the above are designed for a single user only, thus called "personal". The PCs are all digital devices, and all are made of two components: hardware and software. The hardware encompasses all physical aspects and therefore they can be seen and touched. On the other hand, the software is invisible. Software encompasses the operating system, the system software and the application software commonly known as programs.

Digital computer is defined as a machine, or a device designed in a way that the user can issue instructions and commands. The computer stores the instructions for the tasks at hand in its memory, performs different tasks while running a program, and does the assigned tasks. From there, the main operations of digital computers are referred to as input – processing - output**.** This is actually the essence of a digital computer. All the operations the computer does are guided by digital codes made of only two characters, the digits 0 and 1. The two digits making up a code are referred to as binary code. PCs are very dependable in executing tasks. They are usually connected to the Internet or intranet through modem. PCs are often connected to other devices such as printers and scanners. The specifics and demands of the architectural profession still require the use of desktops.

Desktop computers

Among the distinct types of desktop computers are full-sized desktops, desktop computers, gaming desktops and all-in-one desktops (referred to as 2-in-1). The first two are very similar with the major difference of the sizes of the system units. Full-Sized Desktop has a rather big desktop unit which requires much space on or under the desk but is least expensive and easiest in upgrades and repairs. On the other hand, the Desktop Computer's unit is at least half of a full-sized desktop. The third one, Gaming Desktop looks very much like the previous two but with a larger case to host fastest processors, large hard drives, big RAM and very importantly, the most sophisticated graphic cards. There is enough room for upgrades. They are used for architectural renderings and architectural animations. Finally, the All-in-one desktop is slim, compact, modern and fashionable. It combines the operational components of the desktop unit with the monitor, is thus tightly packed and saves space. As a consequence, the model is difficult to upgrade and repair.

Laptop computers

The laptop computers can generally be classified by the screen size and by their weight. The other way of classification is by the OS. To the categories by size belong notebook laptops, ultraportable or subnotebook laptops and desktop replacement laptops. The name notebook laptop is interchangeably used with notebook computer, however technically notebook laptop is defined as one with the screen size smaller than 15.6". A notebook laptop's weight is about 2.3 kilograms, so it is light and relatively small. Approximately, it is 36 cm long, 25 cm wide and 2 cm thick. The ultraportable or subnotebook laptops are actually smaller than notebook laptops, with the screen size of between 13.3' to 14" and they weigh only about 1.8 kilograms. With the attractive small size come also disadvantages of a limited number of ports. Desktop replacement laptops are bigger in size with the screen size of about 17.3”, they are heavier with the weight between 2.7 kilograms and 4.7 kilograms but with much better specifications, so they are more powerful.

The categories of laptops considered by OS mainly belong: Windows Laptops; MacOS Laptops; Linux Laptops and Chromebooks (Chrome OS Laptops). Windows Laptop runs Microsoft Windows OS which is the most popular OS and is considered in several sections of this discourse in respect of different aspects. Mac OS just like Microsoft Windows is a graphical OS. It is very good, more expensive but it can only be installed on Apple laptops. The Linux OS belongs to the group of open-source systems. Linux is least popular out of the three presented OS but it is also multi-vendor, just like Windows Laptops. Chromebooks use Linux-based Chrome OS and are developed by Google. Their advantage over others is that they are very fast and very light (Ashiedu, 2023).

Electronic principles behind operation of computers

Digital Computers are machines that use a binary number system in signal transmission which has two digits only: 0 and 1. Presently, most electronic signals are *digital signals,* and they consist of rapid pulses of voltage that repeatedly switch the current off and on. They encode data as digital signals, in a string of 0’s which means that current is off and 1’s which means that current is on. A code combination of eight digits is called a *byte*. Larger units are called respectively kilobytes, megabytes and gigabytes and the capacity is constantly increasing. Computer’s circuits are very small, and they are closely packed together making the computer fast and affording a small size of the computer. This is a remarkable progress made in comparison to early computers. The majority of modern electronic devices, including computers and many mobile phones, encode data as digital signals. Compared to analog signals, digital signals are easier to transmit and are more accurate.

Analog Computers have a limited capacity in accepting computing problems. The outcomes and results may not always be accurate. Analog signals consist of *continuously changing voltage* in an electric circuit. Signals are subject to distortion and noise, so the analog computers are used sparingly, mainly used in microphones and some phones to encode sounds as electronic signals.

Quantum Computer is an experimental computer which is utilizing quantum mechanical phenomenon. The basic unit of information called *qubit* can be compared to *bits* in digital electronics. There is much hope in this technology because this evolving technology may be capable of quick solutions to the problems that are beyond the capacity of a digital computer. That phenomenon is referred to as "quantum supremacy".

Basic Hardware Components

In this section different components of a digital computer are examined. The external components are called computer *hardware* while the internal invisible programs that run the computer are called *software***.** The hardware are all the physical parts and parts of the computer that can be seen and touched such as the computer system unit, which is a big rectangular box and the peripheral devices including the monitor, keyboard and mouse. Among other peripheral devices are: printer, scanner, external hard drive, speaker, and webcam (Figure 2).

System unit of a desktop computer

The *system unit* is sometimes called a mother ship and sometimes it is referred to as a console. The most important part of the system unit is a central processing unit (CPU), which is essential to the functioning of a computer. It is connected to the motherboard which ties all the parts of the computer together. Among the other components of a system unit are RAM and ROM, hard drive, video card, optical disc drive, and hard drive (Figures 2 & 3). The system unit is connected to the outside with the power supply plugged into the power supply unit which powers other units. The external cables plug into specific ports of the system unit situated usually at the back (CK-12 Foundation, 2019). Almost every external computer component connects to the system unit via ports using cables. The hardware components of a system unit explained below are CPU, RAM & ROM, hard drive, motherboard, GPU and I/O devices.

CPU (microprocessor)

The central processing unit (CPU) is also called a microprocessor and it is the heart of a computer. It is a chip with an integrated circuit. The more powerful the microprocessor chip is, the faster and more efficiently the system runs. It is connected to the motherboard and communicates and manages the internal and external devices. The three components of a microprocessor are arithmetic, logic and control unit. The CPU acts as the brain of a computer and carries out program instructions and controls the entire computer system. It reads and interprets the program instructions, transforming them into control signals that activate other parts of the computer. A key component common to all CPUs is the program counter, a special memory cell that keeps track of which location in memory the next instruction is to be read from. It is measured in Megahertz and Gigahertz, where Herts means Cycles per Second. (NM State, 2021; Ogunsote & Prucnal-Ogunsote, 1994).

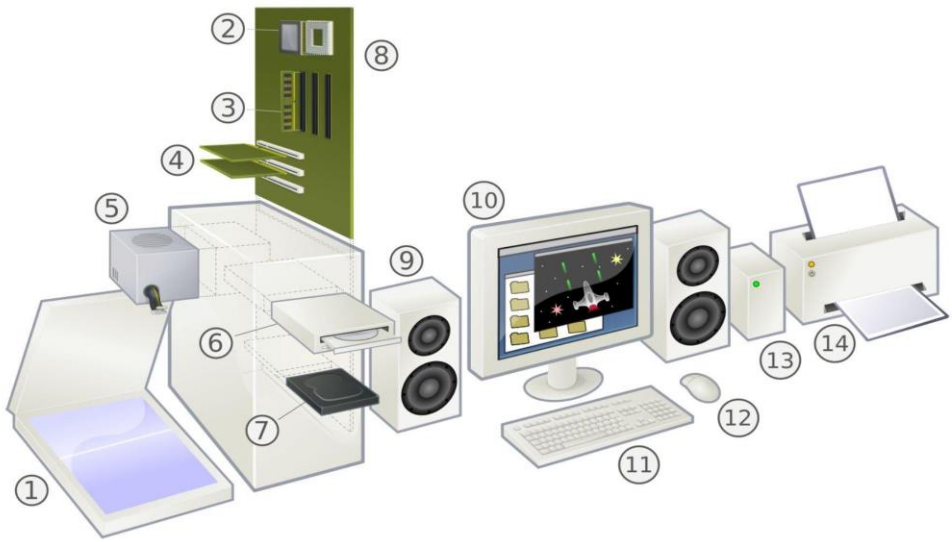

Figure 2*: Computer Components and Peripheral Devices. Source: Team Leverage Edu, 2022.*

1. Scanner 2. CPU 3. RAM 4 .Expansion cards 5. Power supply 6. Optical (disk) drive 7. Hard drive 8. Motherboard 9. Speaker 10. Monitor 11. Keyboard 12 Mouse 13. External hard drive 14. Printer.

Memory: RAM & ROM

Memory is measured in bytes. One byte is almost equivalent to one character in a word processing document. A kilobyte is equivalent to 1,024 bytes while a megabyte is equivalent to 1,025 kilobytes. All the known digital memory units are listed below:

Memory Unit	Equivalent
1 byte	8 bits (a bit is a smallest unit of data and a s binary digit, either 0 or 1)
1 kilobyte (KB)	1,024 bytes
1 megabyte (MB)	1,024 kilobytes (KB)
1 gigabyte (GB)	1,024 megabyte (MB)

1 terabyte (TB)	1,000 gigabytes (GB)
1 petabyte (PB)	1,000 terabytes (TB)

Random Access Memory (RAM) is the computer's main memory. In the process of executing a program first of all it has to be loaded into RAM. When the computer is switched on, the information is stored in the RAM but the information is erased when the computer is turned off. Memory cells can be accessed for information transfer to or from any desired random location and hence the name random access memory. RAM is a microchip that temporarily stores programs and data that are currently being used and temporarily stores information that the CPU uses while the computer is on. Anything stored in RAM is lost when the computer is turned off.

Read only Memory (ROM) is a type of computer storage that contains permanent data that can only be read, just as the name implies. ROM is a microchip that stores important information such as start-up instructions. This remains even after the computer is turned off. Programs are stored in the ROM during manufacturing.

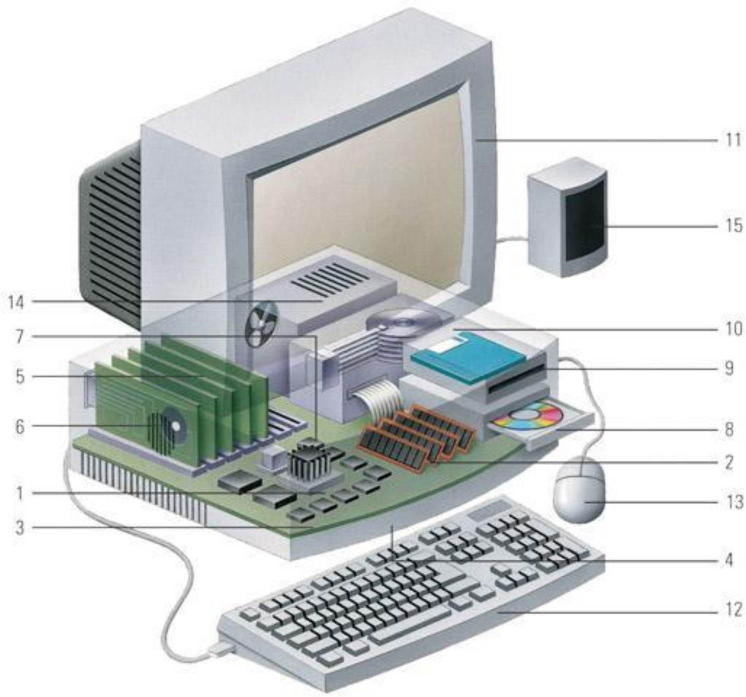

Figure 3. *Main components of a computer. Source: (marshall University Libraries), 2020.*
1. CPU 2. RAM 3. BIOS and ROM chips 4. Motherboard. 5. Expansion cards 6. Video card 7. Expansion slots 8. Optical (disk) drive 9. Floppy disk drive 10. Hard drive. 11. Monitor 12. Keyboard 13. Mouse 14. Power supply 15. Loudspeaker.

Hard drive

Hard drive is the main storage medium of a computer. It is providing storage for programs and data. Hard disk uses one or more rigid rapidly rotating disks (platters) coated with magnetic material. These platters store data magnetically using a similar method as a recording head when recording data onto magnetic recording tape. One can read and write data to the platter surface through the magnetic heads, usually arranged on a moving actuator arm. These parts are not seen because they are inside CPU or enclosed with a case in the external hard drive used for storing the extra data.

Motherboard

The motherboard is a big board inside the computer connected to the CPU, hard drive, ROM, and RAM, video cards, and others. It allows all these parts of the computer to receive power and communicate with one another. The input and output devices are plugged into it to be able to perform their tasks. The motherboard–contains several extra slots, into which additional cards can be plugged, for example a new memory module.

Graphic Processing Unit (GPU)

Graphic Processing Unit (GPU) or video card is a specialized processor that is created to accelerate graphics processing. The GPU helps to generate high-end visuals or 3D models. They are created to support graphic intensive applications and can help to access high-graphic-intensive 3D CAD programs. Used by many industries like gaming industry, sciences, for financial services, and even healthcare. The newly built GPUs are optimized and created specifically for the field of AI with ML and deep learning. In the process of trying to create an algorithm that can think like a human brain their capacity is used along with CPU (Team Leverage Edu, 2022).

Input/Output (I/O)

Handling **Input/Output (I/O)** devices is one of the main functions of an OS. A significant portion of the code of an OS is dedicated to managing **I/O**. The unprocessed data is sent to the computer with the help of input devices, the data is processed and sent to output devices. The act of processing is mainly regulated by the CPU. Among the **input** devices are mouse, keyboard, joystick, image scanner, webcam, microphone, touchscreen, and light pen. They help to send requests in the form of commands and data to the computer, where it is processed by CPU and the outcome is generated. Some of the **output** devices are computer monitor, printer, sound card, video card and loudspeaker. They are used by the computer to convey a visual response using a monitor or convey sound using speakers. The output devices are used to convert the machine's response for the computer user to be able to understand. Among the combined ***input/output*** devices are hard disk drive and optical disc drive. The I/O devices including CD-ROM/DVD drives and USB Ports are connected to the system unit and subsequently to CPU through connectors (Figures 4 and 5).

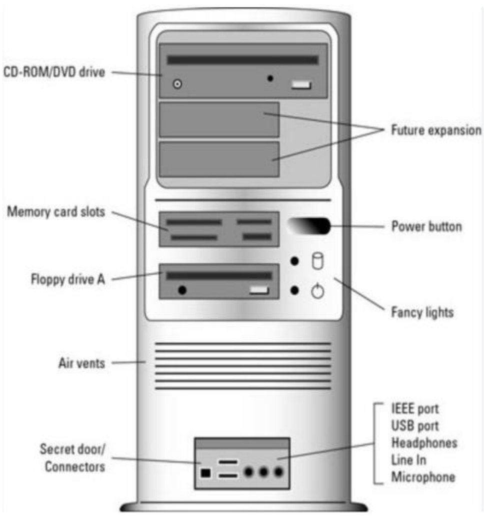

Figure 4. *A front of a system unit with connectors, drives and ports. Source: For Dummies (2016).*

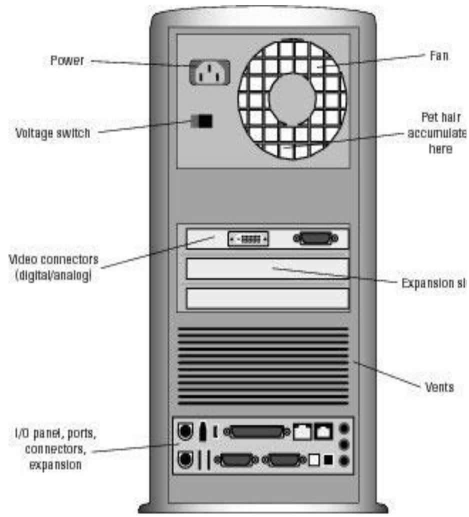

Figure 5. *A back of a typical system unit with the connectors. Source: For Dummies (2017).*

Computer Software

The computer system is navigated by the OS and the applications are run by the user who is also a part of the computing system. The software parts comprise the OS, computer software and application software, such as word processors, spreadsheets, database system or computer aided design and drafting (CADD) software. In this section discussed are the following: system software, OS, Windows OS, mobile OS, software types and software license, application software, mobile apps - software for mobiles and tablets, software licence: on-premise and hosted application software.

System Software

The **system software** is designed to provide a platform for all the other software. It comprises OS (example Microsoft Windows OS, Linux or Apple macOS), device drivers, middleware, utility software, bootstrap program, shells and windowing systems. The programs are designed to start and run computer systems and networks. They run in the background and are not visible to the users. The system software does not require any intervention even though they make the user's work possible, and it is the main software while using the computer.

Operating System (OS)

The OS is a very specific software that bridges the gap between the hardware and the user. It operates the computer system by communicating and controlling the hardware elements including the hard disk, RAM & ROM, CPU and I/O devices. The OS defines all the experiences when using a computer. It manages the hardware and software resources of the computer system. It provides a good interface to the users allowing them to operate the application software and to control the computer. It runs in the background every time the computer is put on. Some of the popular PC operating systems are Microsoft Windows, Apple Mac OS and Linux, with their various versions/updates. Windows is capable of running on several kinds of PC hardware while Mac OS X is capable of running only on Apple hardware.

The moment the computer is switched on the computer system starts its operations and it boots up. At this point a bootstrap program, stored in ROM, activates and initializes all aspects of the system. Active become all core components vital to the operation of the computers, the CPU registers, device controllers, RAM and hard disk. This is followed by loading into the memory the OS, for example *Windows* which enables user's input, and the user can actually start executing his tasks. OS enables the hardware, software and the data to be used properly and in an efficient way. It makes sure that each application gets the necessary resources in the process of using many applications simultaneously and that they run effectively. It provides a platform of communication between seemingly incompatible elements: between hardware devices; between programs; between devices and programs; and most importantly between the user and the hardware. It optimizes the limited capacity of the computer so that the user has optimum benefits and that the applications continue to run even when hardware and software is being upgraded.

Windows OS

Windows is a modern OS, a product of Microsoft Corporation, and it is most commonly used. Over the years Windows released Windows XP in 2001, Vista in 2007, Windows 7 in 2009, Windows 8 in 2012, Windows 10 in 2015, and Windows 11 in 2021 which at the year 2023 it is still the latest version for most of PC's and tablets (Beebom, 2022). Awaited version, Windows 12 is expected to be released in 2024. The software makes it possible for mobile device applications, such as Android apps, to run on the Windows desktop which is very convenient for the app users.

Windows 11 has a very friendly and enticing environment which has been evolving over the years. The previous upgrade was Windows 10 which had several versions from 2015 to 2022, with the last, Windows 10 Version 22H2 still being used. Windows OS is very popular, and it has about 76% of market shares of the global OS market. This is the system that is mostly used by the students of architecture and by professional architects and others. Noteworthy to mention is that there is an abundance of databases of Windows OS guides which can be used to gain an in-depth knowledge of Windows.

Mobile Operating Systems (mobile OS)

A mobile operating system (or mobile OS) is an operating system specifically designed for mobile devices but excluding laptops, which use the same OS as the desktops. The distinct characteristics are blurring up gradually with the trend of mobile computing and with computers becoming smaller and lighter. Mobile OS is user friendly, and it is similar to the PC's operating system but with many more new features including touch screen, voice recorder, Bluetooth, speech recognition, video, camera and WiFi, and Global Positioning System (GPS). There are several mobile OSs including: Microsoft Windows OS, Google Android , Apple iOS by Apple, Bada by Samsung Electronics, RIM'S BlackBerry, Linux, OSP 2 and Symbian OS by Symbian Ltd. Mobile OS provides an environment for other programmes (apps) to run on mobile devices.

Software types and software license

Software is basically a set of instructions or programs to carry out a task and can be classified into two types: *system software* and *application software* (often referred to as program). In this section discussed are the following: application software; mobile apps - software for mobiles and tablets; and software licence on premise and hosted application software.

Application software

The **applications software** is designed to accomplish tasks for a specific purpose. It needs to be downloaded and installed. Application software cannot function independently. It runs only with the support of the OS. Application software runs in a foreground and performs a task based on user request. The commonly used desktop computer applications are word processors, web browsers, media player, Photoshop, and et cetera. The most popular types of software used by architects are AutoCAD, Revit Architecture, ArchiCAD, and SketchUp. Note some of the popular categories of applications listed below:

S/No.	Software Category	Names of Application Software
1.	Commercial CADD	AutoCAD, Revit Architecture, ArchiCAD
2.	Word Processing	Word by Microsoft, Pages by Apple
4.	Spreadsheet	Excel, Google Sheets
3.	Graphic and Design	Adobe Photoshop, CorelDraw, Paintshop
6.	Web Browsers	Microsoft Edge, Chrome, Opera, Firefox
7.	Multimedia	Media Player, VLC Media Player, Spotify, MX Player
8.	Educational	Teams, Google Classroom
10.	Online communication tools	ChatGPT, 4-GPT, Brat, Skype, Hangouts, Google Meet, Zoom, and WhatsApp

Mobile Apps - software for mobiles and tablets

Mobile application (an app) is a software that is built for a single purpose and performs a sole function for users. It is specifically designed to run on mobiles and tablets. Apps can run on desktops, provided the OS supports those apps. Perhaps the most popular in Nigeria is the mobile banking app, used frequently for online cash transfers, followed by WhatsApp, the chat app that gained popularity in the society. Mobile apps are used for communication, especially that they can send images, scans, photographs and videos and thus making them very effective means of communication. The popular in Nigeria *Facebook* Messenger has a particular advantage over *WhatsApp* in the aspect of accessibility to uploaded/downloaded documents which is always active unlike in WhatsApp where the access to some attachments ceases after a month. The most popular WhatsApp is commonly used for social networking and especially for very convenient group chats. It provides an effective means of communication in social and professional environments to the extent that one may simultaneously belong to several WhatsApp groups.

Software licence – on premise and hosted application software

On premise application software was the traditional method where the software was purchased with licence, installed on the PC, and maintained afterwards. In that case one owns the server (computer) internally and completes all the back-ups and upgrades of the software. On-premise software provides increased security since one has a total control of the software.

Hosted application software is similar to on premise where the software is purchased with licence, and maintained but it is installed on the third party server. Though remotely hosted, one still owns the software that one purchased (Fingent, 2022). It is purchased through authorized platforms, and it is likely to be subject to a yearly or monthly subscription renewal. The user is notified on subsequent upgrades, of the software and on the new versions.

Performing Basic Installation

Installation typically involves code (program) being copied/generated from the installation files to new files on the computer for easier access by the OS, creating necessary directories, registering environment variables, providing separate programs for uninstallation, and et cetera. The section below discusses the process of installation and also presents a sample process of installation of the programme by Microsoft Windows users from CD, DVD, or USB flash and through downloads. The installation process for software or apps depends on the OS. It is different for Windows and macOS. It also varies depending on the device, it installs differently on a computer, smartphone, or tablet. It also varies depending on the program one is installing.

One should confirm the system requirements for the program, game, or utility before attempting to install. The manual of the README *file* usually contains instructions on how to install a program. The file could be located at the software website or in a text file in the same directory as the installation files. In case of a slow installation, one needs to close or disable any other running programs. After installing a new program, the reboot request may necessitate restarting the computer. Many computer games are downloaded and managed through digital distribution platforms like Steam.

Installing application from CD, DVD, or USB flash drive

After inserting the disk into the drive, the startup screen may start automatically if there is an AutoPlay feature. Almost all software programs have their own built-in installation programs. If the installation program is on a CD-ROM or DVD, just by inserting the disk the installation program should start automatically. After that, one has to follow the onscreen instructions, otherwise one needs to launch the installation manually. To launch it manually one needs to open *My Computer* or *Windows Explorer,* and then to select the drive containing the installation CD. After opening the drive, the content of the installation disk will be displayed. The file *setup.exe* or *install* file should be located. Double clicking it starts the installation process. In the instance when the programme can't be downloaded because there is no disk drive on the computer, the content of the CD or DVD can be copied to USB flash using another computer that actually has a disk drive, and then the programme should be installed using the same steps as above.

Downloading application from the Internet

Many programs are available for downloading from the Internet and among them are computer drivers, software for hardware devices, games. The source should always be checked for trustworthiness. Below are the steps for downloading the program from the Internet:

1. Open the web browser, open the website providing the link to the program, open the link to the program, select download the program.
2. The program will be saved in downloads folder after clicking *Save* but after selecting *Save as* the folder needs to be selected by the user
3. Double-click the icon to start the setup process if the downloaded file is executable. The file content should be extracted first if the downloaded file is compressed (.zip).
4. Once the files are extracted, double-click the *setup* or *install file* to install the program. (Computer Hope, 2022).
5. In case the installation process is interrupted, one should respond to the displayed message to continue.
6. There will be a notification on the screen after the download is done in a form of a dialog box prompting to *Run* the newly downloaded program.

File Management Tasks

File management deals with the control and organization of various files (documents) in the system. The files can be stored on the hard disk or on the flash drive. The environment is created for the user to store and access the **file,** which is characterized by its name, size, type, location, date and time. The best way to manage the files is through My Documents or Windows Explorer application, where all of them are accessible. The Explorer is used to manage the files, it can copy, delete and launch (open the file).

Document creation and conversion

The file is usually created in an application by using commands *File* and *New* and after inputting information a command *Save* or *Save As* is used to store the information in a file format and into a designated folder. The saved document can be easily converted into another format. Usually in the process of saving using *Save as* option there is a given option *Save as type:* where many types of new formats are listed. For example in Microsoft Word document after selecting option Save As and selecting option Save as type: one can select the DPF (*.pdf) format and a new converted to Portable Drawing Format document will be created.

Folders

A concept of a *folder* is provided by the OS and is defined as a way of grouping files together. The folders are organized in a hierarchical manner, which allows users to have subfolders under the folders. This allows one to organize the files just as one will organize a physical environment. The files can be kept in the designated folders and subfolders in a logical manner.

File management

One needs to be purposeful in file management. For example, architects may deal with office work with drawings, reports, photographs, letters, accounting, and et cetera as well as with personal information. A folder may be created for each important aspect. This will help to keep the professional and personal files separate. The initial setting if thought through can last a lifetime. The logical hierarchy should be followed for folders, subfolders and files. For example, if one already created a folder named *Drawings* the subfolders may re-present different years in which the works were done and they may be named: *Drawings 2021,* Drawings 2022*,* and *Drawings 2023* or just *2021, 2022,* and *2023.* The best way is to follow a consistent naming convention and a sequential way of naming the subfolders or making use of metadata - data about data - while creating the names of *folders, subfolders,* and *file* names, making use of information that's used to describe the data that's contained in them. The names should be meaningful. The files should always be saved into a designated folder. They should be organized at the time they are created, copied or moved. The reward is that the needed file will be easily found and it is a great way of working.

Cloud computing

Cloud computing is an online service that offers online data storage, and it requires Internet connectivity. The stored data and cloud applications can be accessed from remote servers and databases. The type of data stored via cloud computing include documents, spreadsheets, notes, images, audios, contacts, videos and more. A defined space that can be accessed is allotted free, but the payment has to be made if extra space is needed and the payment is usually renewable yearly. The service is very useful if one needs to recover lost data, deal with volume of data that exits the PC's capacity, or access data through many devices but for the last the storage resources need to be shared. *Infrastructure as a service (IaaS)* offers other services in addition to the ones mentioned above. IaaS also offers paid network resources through the Internet, and through the provided service a device can be configured to run an application and IT systems. Examples are Amazon Web Services (AWS) and Rack space. Among the major cloud computing providers are iCloud, Dropbox and Google Drive, as discussed below.

iCloud. The requirement for the user to access this service is the latest version of an Internet browser such as Firefox or Chrome. Edge, Opera or Safari are also supported. It is simple to access iCloud from Apple products just by signing in. To store and access documents on iCloud one needs to sign into *iCloud* usually on Apple products. To use it on any non-Apple devices, one must access the service via a web browser.

Required is access to the latest version of Firefox, Chrome and Edge. Safari and Opera are also supported. When using Android and Samsung phones one needs to navigate iCloud.com or use an existing Apple ID credential or create a new account. This allows you to see shortcuts to iCloud Drive.

Dropbox allows you to back up files in the cloud, share photos and videos, and more. One can save and access files from any device and share them with anyone. Basic Dropbox comes with 1 TB of free storage for individuals and the storage can be increased with one's needs. Using this service allows us to store a large amount of data, including photos, videos and important files. One may access files or work remotely. The work can continue and run simultaneously on many devices including mobile devices. With offline sync and access, the documents that are saved to the system are always available. The work can continue offline when away from Wi-Fi (Dropbox, 2023). From the author's experience it is very convenient in a professional environment, while working as a team on architectural designs, as the work will be updated automatically, and the updates made available to team members in a real-time environment.

Google Drive is a file sharing platform that provides a personal, secure cloud storage option to share content with other users. As a result, a file can be updated in real time in different locations almost simultaneously. The service was launched in the year 2012 and allows users to store files in the cloud (on Google's servers), access and synchronize files across devices, and share files, all in one secure place. The files such as documents or spreadsheets can be created and shared online and accessed from anywhere. Any files added and shared can be edited by the team members and everyone stays up to date in a real-time environment. When the file is stored in Google Drive, it allows access to the user while it does not affect the disk space of the used computer. Drive uses Google AI to predict and surface what's important for one in real-time. It recognizes important content, collaborators and events, using features like Quick Access and ML-based search enhancements to connect each user with files that may require attention (Google Workspace, 2023). The author specifically recommends its use as an easy means of working on resources shared with other users in a comfortable computing environment.

Programming - Coding Experience as a Valuable Employment Asset

Program, as name suggests, are simply set of instructions that are developed to work in a single platform and usually written by computer programmer in programming languages such as COBOL, FORTRAN, BASIC, C, C++, HTML, CSS, Java, Python, and et cetera. Even though the term program is interchangeably used with the term application software they do not mean the same.

Coding is the process of using *programming languages* to give instructions to a computer. These instructions power the websites, software, and applications people use every day. The coding skills enable one to develop a website, computer game, or an app. Coding is considered to be a valuable skill that one can build. It is a highly in-demand tech skill. With time, dedication, and Internet access, anyone can learn to code. It is considered an asset to professional and personal development. For the beginners, there are languages that do not use data structures or algorithms, such as *HTML* or *CSS*. According to Juvier (2022) languages like *Java* and *Python* are also great for the beginners. Several of the most-in demand employability skills fall under computing. On top of the list of modern skills, according to Brit (2023), most in-demand is Cloud computing and Artificial Intelligence (AI). They all require coding for software development. For example, to start coding one can learn fundamentals of Machine Learning which are being developed and advanced with Python.

Python is a popular programming language for beginners with friendly syntax and versatility and with a wide range of applications. Much of

Python code reads like English. This helps beginners to learn basic concepts like functions. It is often used to build websites and software, automate tasks, and conduct data analysis. Python is a high-level, general purpose language, meaning it can be used to create a variety of different programs and isn't specialized for any specific problems. (Williams, 2020).

Java is a general-purpose object-oriented programming language that is used to build and run applications. It is used for building and scaling cloud applications, developing chatbots and powering enterprise applications. Java is mostly used by websites that have the capacity to run animations and promote interactivity. Like Python it has a wide range of applications and like, Python Java's syntax is easy to read and understood by human programmers – often, complex tasks can be handled by one command.

Trending Technologies in Computing

Technologies in the computing environment are changing continuously while the capacity of computers doubles every two years. Over the last six decades the computing environment changed drastically with a computer becoming very powerful while its size reduced from an entire room to a briefcase size of a laptop, and then to a mobile handheld device. The interface transformed from the environment where one had to type the commands in DOS OS and in first versions of AutoCAD to an environment that all is at a reach of a mouse click in the OS environment or in a new CAD application. As a result of the continuous changes in technology some trending technologies of 2023 are mentioned here, and among them are Cloud Computing, Mobile Apps, Artificial Intelligence (AI), Virtual Reality (VR) and augmented reality (AR) and Internet of Things (IoT) METAVERSE, Devops, Full Stack Web Development, Robotic Process Automation (RPA), Big Data, Edge Computing, Hyper Automation, 5G Cell Processing (Linchpin, 2023;

Saurabh, 2023). Some of the trending technologies, relevant to architectural profession, are listed and then discussed below:

1. Cloud Computing basically means storing data through the Internet and using designated platforms to do that.
2. Mobile Apps used by many companies.
3. Artificial Intelligence (AI) and Machine Learning (ML) technologies are transforming the way computers are used.
4. Virtual Reality (VR) and augmented reality (AR) is like experiencing virtual life in extremes.

This industry is constantly evolving, and architects will also have an advantage over the use of Cloud computing for storing and for running applications. Architectural companies are trying to optimize the benefits of mobile computing and are integrating them to do their business by for example using WhatsApp, Zoom and Facebook Messenger. Much interest is generated globally around mobile app - ChatGPT, an artificial intelligence chatbot developed by OpenAI, launched in November 2022, which interacts in a conversational way (OpenAI, 2023). The latest news is on Brat by Google and newly released GPT-4, which in early tests stunned many users with its ability to perform sophisticated tasks like for example by building a working website from a hand drawn sketch (Kelly, 2023). ML transforms computing and New Scientist Instant Expert (2022) asserts that: "Sometime in the future the intelligence of machines will exceed that of human brain power". These developments will bring many changes to the architectural profession in the very near future.

The biggest players in computing, Google, IBM, and Facebook, are making the use of AI and ML their priority. Interesting to note is that AI route phone calls, are used for ATM card transactions and are used in a medical field for interpreting results. The VR has been used by architects for over a decade. AR is more efficient, cost-effective, and easier to use and gradually is taking over from VR and it also needs to be embraced by architects.

Summary

This chapter presented a computing environment with emphasis on Windows OS. It defined the digital computer and explained electronic principles behind the operation of digital, analogue, and quantum computers. It identified and extensively discussed the basic computer hardware and software of computer components. The hardware covered all the parts of a computer system that are tangible physical objects such as the system unit with central processing unit, memory, motherboard, and et cetera. The explanation was given on principles of OS, and specifically the Windows OS, and on Mobile OS.

There is a detailed discussion on system software and application software and its categories as well as software for mobiles and tablets. The step by step instructions provide a guide on program installation and downloading. The necessity of file management tasks is heightened along with the explanations for creating, saving and converting files, and very importantly managing folders and subfolders. Storing documents online through cloud computing was also included. Programming languages as well as coding experiences were presented as a valuable employment asset. Trending technologies are reviewed to reflect the recent development in the computing environment in architecture.

Exercises

1. Explain the components of a computer system.
2. Define the electronic principles of Digital, Analogue and Quantum Computers.
3. Explain different types of desktops and laptops based on size and on OS.
4. Discuss the role played by CPU and RAM while running an application on a digital computer.
5. Explain the role played by the Operating System in the computing environment.

6. Distinguish between System Software and Application Software.
7. List any five popular application software categories and list the programs associated with them.
8. List the steps in downloading a software application (program).
9. Design file/subfolder/folder structure for saving your continuous assignments for 100 and 200 Level courses. Name your folder, subfolders and filenames using conventions recommended in this chapter.
10. Explain the techniques for storing documents online.
11. Discuss the coding (programming) experience as a valuable employment asset.
12. Explain how the trending technologies in the computing environment may affect the architecture profession in the future.

References

Ashiedu, V. (2023, March 6). Types of Laptops: What is the Best Way to Choose a Laptop? iTG. https: //www.itechguides.com/types-of-laptops.

Beebom (2022, August). Windows 12 is Coming! YouTube video. https://www.youtube.com/watch?v=lKaK82n4weg.

Brit, J. (2023, January 17). 20 In-demand Skills for Today's Work Environment. Indeed. https://www.indeed.com/career-advice/finding-a-job/in-demand-skill.

CK-12 Foundation (2019, May 29). Electronic Device. https://flexbooks.ck12.org/cbook/ck-12-middle-school-physical-science-flexbook-2.0/section/20.17/primary/lesson/electronic-device-ms-ps/.

Computer Hope (2022, December 31). How to Install Software. http://www.computerhope.com/issues/ch000561.htm.

Dropbox (2023). Join over 700 million registered users who trust Dropbox. Dropbox official website. https://www.dropbox.com.

Fingent (2022). Types of Application Software: Guide for 2022. Blog: Fingent: Shaping the Future. https://www.fingent.com/blog/a-detailed-guide-to-types-of-software-applications/.

For Dummies (2016, March 27). Basic Skills. Front of your computer console. A Wiley Brand. https://www.dummies.com/article/technology/computers/basic-skills/the-front-of-your-computer-console-202101/.

For Dummies (2017, February 2). Basic skills. The back of your computer. A Wiley Brand. https://www.dummies.com/article/technology/computers/basic-skills/the-back-of-your-computer-console-202239/.

Google Workspace (2023). How teams of all sizes connect, create, and collaborate. workspace.google.com.

Juvier, J. (2022, June 29). How to Start Coding: The Ultimate Guide for Beginner Programmers. Blog: Hubspot. https://blog.hubspot.com/website/how-to-start-coding?hubs_content=blog.hubspot.com%2Fwebsite%2Fhow-to-start-coding&hubs_content-cta=Coding%20vs.%20Programming.

Linchpin, T. (2023). Trends Transforming the Technology Industry in 2023. https://linchpinseo.com/trends-in-the-information-technology-industry/.

Marshall University Libraries (2020, July 16). Technology Reference: Computers & Electronics. Computer from Philip's Encyclopedia. https://libguides.marshall.edu/c.php?g=1049889&p=7620403.

New Scientist Instant Expert (2022, July 12). New Scientist Instant Expert: Machines that Think. Nicholas Bradley. ISBN-13. 978-1529381955. 224 pp. https://www.amazon.com/Machines-that-Think-New-Scientist/dp/1529381959.

NM State (2021). Technology in Credo: Computers & Electronics. New Mexico State University Grants. https://grants-nmsu.libguides.com/c.php?g=893862&p=6427954.

Kelly, S. M. (2023, March 21). Google begins rolling out its ChatGPT rival. CNN. https://edition.cnn.com/2023/03/21/tech/google-bard/index.html.

Ogunsote, O. O. & Prucnal-Ogunsote, B. (1994). ABC of Personal Computers. Introduction to Computer Aided Design. Asekome Press, Zaria. ISBN 978-2528-25-0. 131 pp.

OpenAI (2023). Introducing ChatGPT. Blog. https://openai.com/blog/chatgpt.

Prucnal-Ogunsote, B. (2023). IWD 2023 DigitALL 2 with Prof Bogda Prucnal-Ogunsote: Technology and Innovation for Gender Equality. The Architects' Resourcery, Architectural Documentaries Presentations. Youtube video. https://youtu.be/cXhbyczhg.

Prucnal-Ogunsote, B. & Ude, O. A. (2008). The Status Quo of Technology-enhanced Architectural Education in Nigerian Universities Vis-à-vis Professional Practice. Proceedings of the e-Learning Africa 2008 3rd International Conference on ICT for Development, Education and Training. Accra International Conference Centre (AICC), Accra, Ghana, May 28 – May 30, 2008.

Saurabh (2023). Top 10 Trending Technologies to Master in 2023. Blog: Edureka! https://www.edureka.co/blog/top-10-trending-technologies/.

Soft112 (2023). Archimedes: An Architecture Open CAD. https://archimedes-an-architecture-open-cad.soft112.com/.

Team Leverage Edu (2022, November 21). Components of Computer. Blog. https://leverageedu.com/blog/components-of-computer/.

Williams, S. (2020). Python Machine Learning for Beginners 2021: A Comprehensive Guide to Master the Basics of Python Programming and Understanding How it Works, How is Correlated to Artificial Intelligence and Deep Learning. Independently Published. 242 pp.

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2. Prucnal-Ogunsote, B. (2001). Classification of Nigerian Architecture. *Journal of the Association of Architectural Educators in Nigeria (AARCHESJ)*, 1:6, 48-56. AARCHES, Akure.
3. Prucnal Ogunsote, B. & Ogunsote, O.O. (1988). COLDHOT A Design Aid for Multi Index Thermal Stress Analysis. *Architectural Science Review*, 31:3, 99-106. Sydney, Australia.

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Basics of Word Processing, Data Analysis and Presentation Software

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OVERVIEW

Prior to the advent of computers and its associated technologies, the processing of words for document creation was a herculean and time-consuming task. Then, typewriters and cyclostyling machines were the main instruments used in preparing and producing type-written documents. It was very tedious using typewriters (Fig. 1). The fonts and/or command characters are hard-punched directly on the papers, and mistakes could only be corrected using correction fluids. The multiplication of copies of documents was only possible through the use of cyclostyling machines (Fig. 2).

Figure 1: *Typewriter*

Figure. **2**: *Cyclostyling machine*

However, the narratives have changed with the adoption of computer as document creation mechanism. A computer is an electronic device that has two main parts: hardware and software (Nandan, Sharma, Raut, Sharma, & Kamal, 2022). The hardware describes the physical parts whereas the software comprises a set of commands or instructions given for the performance of tasks. The monitor, keyboard and central processing unit (CPU) make up the hardware. Nandan, Sharma, Raut, Sharma, & Kamal, (2022) stated that there are different kinds of software: system, utility, language and application. The application software relates directly with word processing and is also known as application packages. They are programs designed by skilled application programmers to meet the needs of the users in the performance of specific tasks or problem (Jingfa, 2023). The system software is the operating system (OS) of the computer system. The utility software helps in the smooth running of the computer system and the language software is used to produce understandable machine language.

This text deals with exposing the students to the rudiments of word processing and the necessary actions to be taken for creation of document using the computer system. The interaction and application of the basic devices of the computer system will be described to enable the student to appreciate word processing and its intricacies.

OBJECTIVES

The objectives of this text are to:

1. identify the basic devices used for word processing and word processors;
2. operate the Microsoft (MS) Word 2019 Application Software;
3. identify the basic components of MS Word 2019;
4. describe tab functions of Microsoft Word 2019;
5. open and close, create, edit, save, and print MS Word documents;
6. describe other features of MS Word such as Tables, Graphics, Table of Contents, and References; and
7. describe how to apply shortcut keys in preparing documents.

WORD PROCESSING

Word processing is a sub element of application software. It is an application program that makes it possible for documents such as letters, reports, newsletters, tables, brochures, and web pages to be created. It permits the addition of pictures, tables, figs, plates, and charts to documents where required (National Institute of Open Schooling, 2019).

WORD PROCESSORS

To execute the functions associated with word processing, processors are required. Therefore, word processors are electronic devices or computers application software that enable the composition, editing, formatting, and sometimes printing of different kinds of written materials or documents (Stodocu, 2023).

DEVICES USED IN WORD PROCESSING

The keyboard, mouse, monitor, printer, and CPU are needed for word processing as shown in Fig. 4.





Keyboard Mouse Monitor
Printer CPU

Figure. **4**: *Devices used for word processing.*

EXAMPLES OF APPLICATION SOFTWARE PACKAGES

i. word processing packages (microsoft ms word, wordperfect, wordstar, openoffice.org, writer, libreoffice writer, abiword, kword, lyx, google docs, softword, and corelwordperfect, etc.);
ii. spreadsheet packages - lotus 1-2-3, microsoft ms excel, quatro pro, d-base paradox, and ms access, etc.;
iii. accounting packages – dac excel, pacioli 2000, etc.;
iv. graphic packages – lotus freelance, corel draw, venture, etc.;
v. architectural packages – autocad, archicad, revit, sketchup, etc., and
vi. customised packages – payoff packages, stock control packages, etc.

However, it should be noted that Microsoft (MS) Word application software package appears to be the most common and its 2019 version would be used to describe the basics of word processing, data analysis and presentation in this course material (International Centre for Information & Communications Technology Studies, 2019). This software is used to create, format and edit any document (Tutorials Point, 2023).

MICROSOFT WORD (MS) 2019 APPLICATION SOFTWARE PACKAGE

OPENING OF MS WORD

1. Ensure that the electric power is switched on and proper connections made of the components of the entire computer system (Keyboard, Mouse, Monitor, Printer, and CPU, etc.).
2. At the bottom part of the computer screen, click on "Start" button (Fig. 5) and type Microsoft Word in the search button (Fig. 6) and the MS window screen layout (Fig.7) will prop up.

Figure. 5: *The start button*

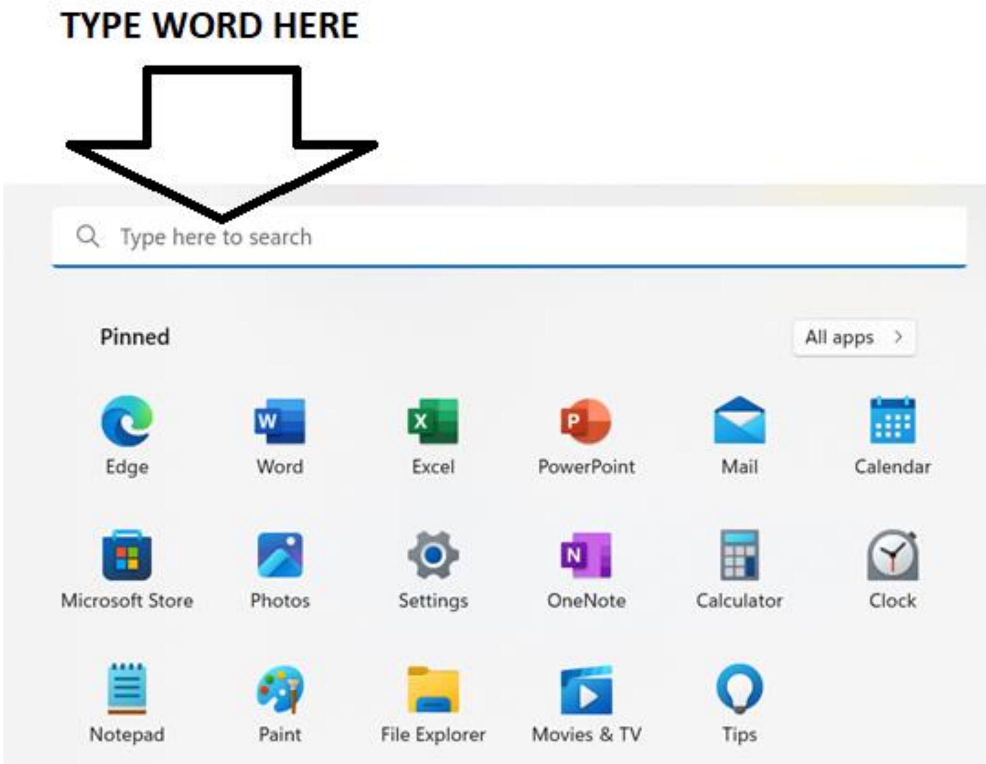

Figure. **6**: *The Search button*

THE COMPONENTS OF 2019 MS WORD WINDOW

As shown in Fig 7, there are a series of horizontal and vertical bands known as bars (Khalid, 2020). We are going to examine the contents and functions of these bars in this following section.

A. Title Toolbar

This is found at the topmost level in the window. It contains three sections placed at the left, centre and right sides (Fig 8). The left side of the Title toolbar contains the Quick Access Toolbar which can be conFig.d according to one's choice with the tools that are most regularly used. The centre of the Title toolbar shows the address of Word document as saved, whereas the right side of the Title toolbar displays the 'Minimize', 'Enlarge' and 'Close' buttons. It also has the 'Sign in' and 'Ribbon Display Options' tabs.

Figure. 8: *The Title Toolbar*

B. Menu/Ribbon Toolbar

Under the title toolbar, is a Ribbon referred to as the Menu toolbar which contains several icons: File, Home, Insert, Draw, Design, Layout, References, Mailings, Review, View, Help and Tell me what you want to do (See Fig. 9).

Figure 9: *The Menu Toolbar*

THE MS WORD 2019 SCREEN LAYOUT

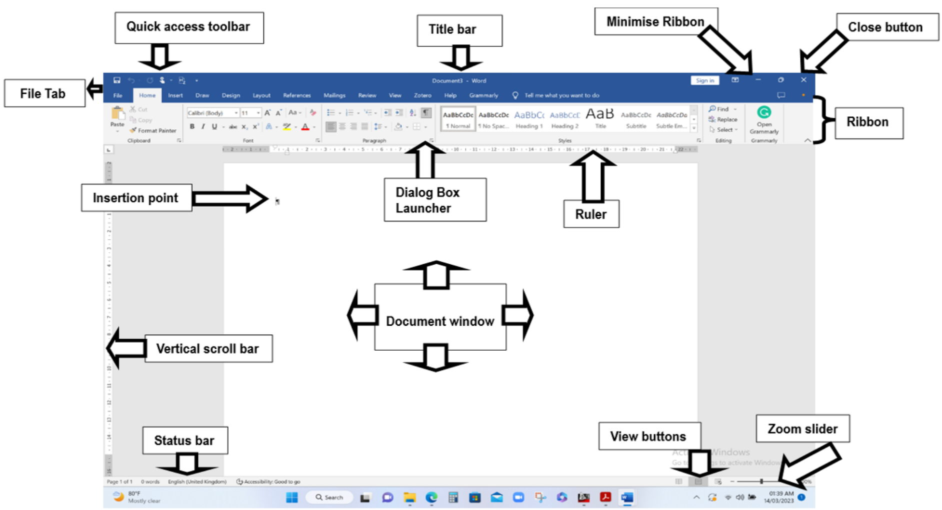

Figure. 7: *The Microsoft Word 2019 screen layout*

Details of the Tabs Used in the 2019 MS Word Window Menu Toolbar

Under the MS Word 2019 the Menu toolbar has many tabs in the Ribbon as shown in Fig. 9.

1 File Tab

The sub contents and functions of the File tab are as shown in Fig. 10. In this 'File' menu are contained, options for the creation of documents (New), opening of an existing document (Open), storage of documents (Save, Save As), printing of documents (Print), and others like History, Info, Share, Export, Close, Account, Feedback and Options (GeeksforGeeks, 2021).

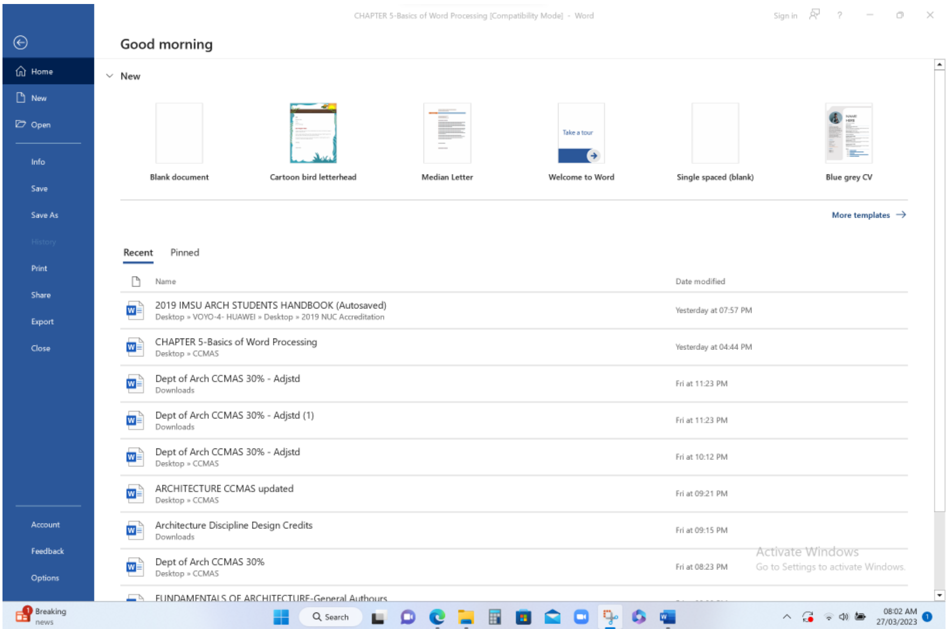

Figure. 10: *The File tab displaying the contents.*

2 Home Tab

The 'Home' tab has five (groups) thus: Clipboard, Font, Paragraph, Styles, and Editing and other installed apps e.g., 'Grammarly app' as shown in Fig. 11. The clipboard has the 'Paste and Format Painter functions. The 'Cut' and 'Copy' are activated whenever a text is highlighted.

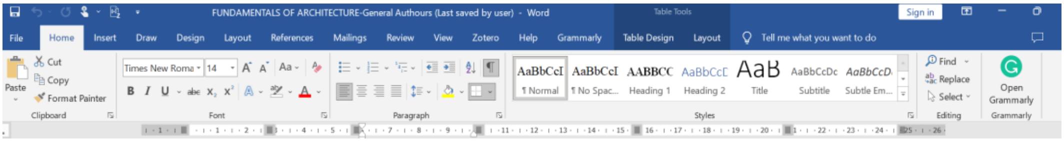

Figure. 11: *The 'Home' tab displaying the Ribbon and contents.*

3 Insert Tab

The 'Insert' tab has Pages, Tables, Illustrations. Add-ins, Media, Links, Comments, Header & Footer, Text, and Symbols groups shown in Fig. 12. This tab plays a vital role in the analyses and presentation of information in word processing particularly the Tables. Illustrations, and Text groups.

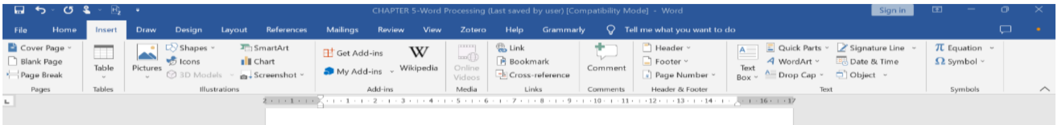

Figure. 12: *The Insert tab and contents*

4 Draw Tab

The 'Draw' tab shown in Fig. 13 has the Tools, Pens, Convert and Insert functions. They are useful in graphical presentation especially for freehand drawing using different types of pens.

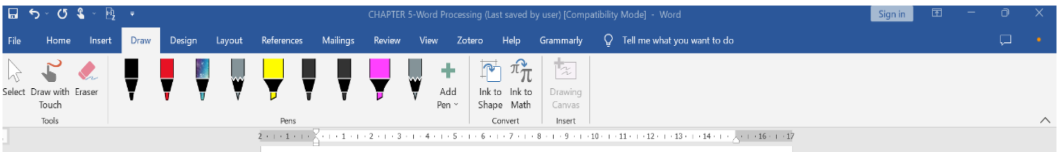

Figure. 13: *The Draw tab and contents*

5 Design Tab

The 'Design' tab shown in Fig. 14 has several options for formatting documents which are inside the Document Formatting' and 'Page Background' groups.

Figure. 14: *The Design tab and contents*

6 Layout Tab

The Layout tab has three (3) groups as indicated in Fig. 15. In the Page Setup group, we have Margins, Orientation, Size, Columns, Breaks, Line Numbers, Hyphenation icon, and the dialog launcher box. The Paragraph group has the Indent, Spacing tabs, and the dialog launcher box. The Arrange group has the Selection Pane and Align as the only active icons amongst others. There is also the dialog launcher box in all the groups and they provide avenues for further information used for formatting of the documents.

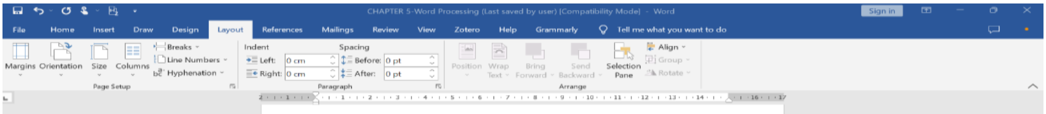

Figure. 15: *The Layout and contents*

7 References Tab

The Table of Contents, Footnotes, Research, Citation & Bibliography, Captions, Index, and Table of Authorities are the groups contained in the References tab as shown in Fig. 16. The sub icons of the various groups contained in this tab help in the organisation and provision of relevant information on the sources of materials used in the preparation of documents particularly reports, projects, theses and dissertations,

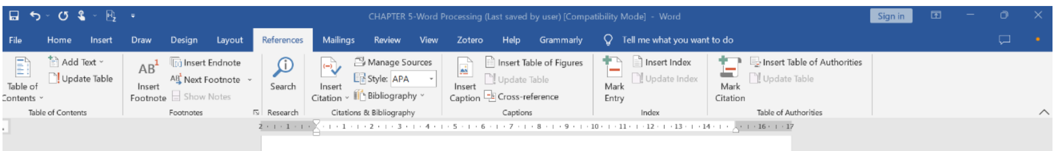

Figure. 16: *The References and contents*

8 Mailings Tab

In the Mailings tab, opportunities abound in the creation of letters especially when similar pieces of information are to be distributed to a large number of recipients. The Create, Start Mail Merge, Write & Insert Fields, Preview Results and Finish groups are contained in this tab and are illustrated in Fig. 17.

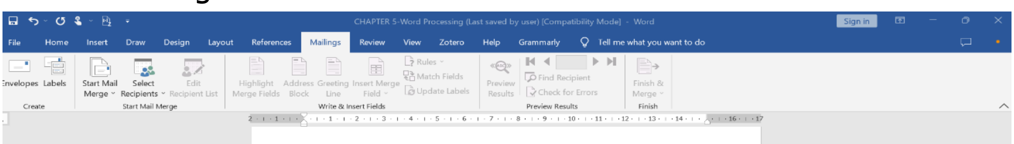

Figure. 17: *The Mailing tab and contents*

9 Review Tab

This tab has 10 groups: Proofing, Speech, Accessibility, Language, Comments, Tracking, Changes, Compare, Protect, and Ink (see Fig. 18). The Review tab like others assist in the formatting of a document.

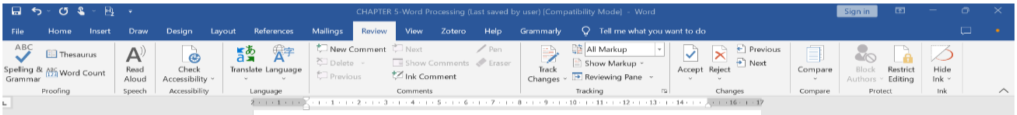

Figure. 18: *The Review tab and contents*

10 View Tab

The View tab provides information on Views, Immersive, Page Movement, Show, Zoom, Window Macros, and SharePoint groups as shown in Fig. 19.

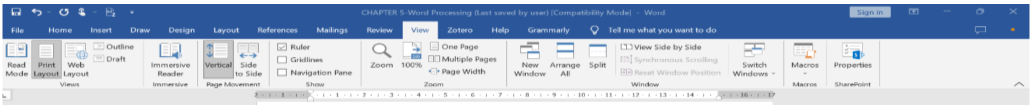

Figure. 19: *The View tab and contents*

11 Help Tab

The Help group shown in Fig. 20 has the links to the get assistances from (i) the MS Office and (ii) an Office support agent's contact, (iii) provides a link to give back information that would improve the MS Office and (iv) opportunity for online training and learning content,

Figure. 20: *The Help and contents*

12a Other Installed Programs Tab – 'Zotero'

This is a special program (Zotero) installed to aid in the provision of references and citations used in the preparation of documents. The sub-contents are as shown in Fig. 21

Figure. 21: *The Zotero App and contents*

12b Other Installed Programs Tab – 'Grammarly'

This is a special program (Grammarly) installed to aid in the proof-reading and correction of spellings and grammar formulations used in the preparation of documents. The sub-contents are as shown in Fig. 22.

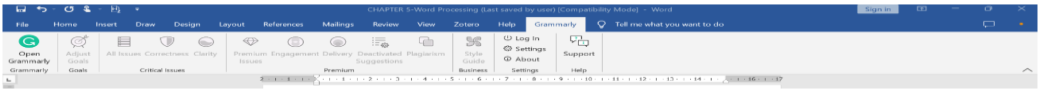

Figure. 22: *The Grammarly App and contents*

13 Tell me what you want to do Tab

As the name implies, this tab 'Tell me what you want to do' provides guides in whatever you ask the computer system with regards to the preparation of documents.

OPENING OF A DOCUMENT

Creating a new document

1. Go to the 'File' tab in the Menu toolbar (Fig. 9).
2. Click on 'New', or
3. Using the shortcut key method, press together 'Ctrl + N' on the keyboard.

Opening an existing document

1. Go to the 'File' tab in the Menu toolbar (Fig. 9).
2. Click on 'Open', or
3. Using the shortcut key method, press together 'Ctrl + O' on the keyboard.

PROCEDURES ON HOW TO EDIT A DOCUMENT

Text Insertion

1. Place the cursor at the beginning of the document page

2 Type the letters (alphabets/numerals/notations) as displayed in the keyboard.
3 Use the mouse to move the cursor to the desired positions, or use ‘Up’, ‘Down’, ‘Left’ and ‘Right’ arrow buttons.

Text Selection

1 To select the desired font character i.e. (make Bold/ Italicise/ Underline/ Strikethrough/ Subscript/ Superscript/ Increase Font Size/ Decrease Font Size/ Change Case/ Clear All Formatting/ Text Effects and Topography/ Text Highlight Colour/ Font Colour), the text should be highlighted first by dragging the mouse over it, while keeping the left mouse button depressed.
2 Alternatively, press down the ‘Shift’ key on the keyboard while using the arrow buttons to highlight the texts.
3 Using the shortcut key methods on the keyboard and/or with the mouse:
   a. to select the whole word, double-click (clicking/pressing the right button of the mouse two times consecutively) within the word;
   b. to select paragraph, triple-click (clicking/pressing the right button of the mouse three times consecutively);
   c. to select several words or lines, drag the mouse over the words, or press down ‘Shift’ while using any of the arrow keys;
   d. to select the entire document, go to the ‘Editing’ group under the ‘Home’ tab of the Ribbon, choose Editing > Select > Select All; or
   e. press the ‘Ctrl + A’ on the keyboard simultaneously.

Text De-selection

1 Click anywhere outside of the selection on the page, or
2 Press an arrow key on the keyboard.

Additional Text Insertion

1 Typing > put the cursor at the desired point and start typing.
2 Copy and Paste > highlight the text, right click on the mouse, select Copy, paste at the desired point provided the cursor is at the place where the pasting is to be done in the document.

3 Cut and Paste > highlight the text, right click on the mouse, select Cut, paste at the desired point provided the cursor is at the place where the pasting is to be done in the document.

4 Drag > highlight the text, click and drag to the desired point in the document.

Text Deletion

1 Use the 'Backspace' button on the keyboard to delete to the left of the cursor.

2 Use the 'Delete' button on the keyboard to delete to the right of the cursor.

3 Also, use the 'Delete' button to delete highlighted text.

PROCEDURES ON HOW TO SAVE A DOCUMENT

1 In the Menu toolbar, go to 'File' tab (Fig. 9) and click 'Save'

2 In the Menu toolbar, go to 'File' tab and click 'Save As' especially when the document is in another format or version e.g., to PDF, XPS, or another version of Word that is not 2019.

3 Press 'Ctrl + S' on the keyboard.

4 Click on the 'Save' icon on the Quick Access Toolbar see Fig. 9.

PROCEDURES ON HOW TO PRINT A DOCUMENT

1 In the Menu toolbar, go to the 'File' and click 'Print'.

2 In the displayed print dialog box, select the appropriate name of the printer as saved.

3 Select the number of copies.

4 Set all the printing parameters as desired in the page setup: margins, paper and layout.

5 Click the 'Print' button and thereafter, close the print dialog box.

PROCEDURES FOR OTHER FORMATTING FEATURES

In the Menu toolbar, click on the 'Layout' tab and three (3) groups: Page Setup, Paragraph, and Arrange will prop up in the Ribbon. In the Page Setup group, there are Margins, Orientation, Size, Columns, Breaks, Line Numbers, Hyphenation icon, and the dialog launcher box in the Ribbon. The Paragraph group has the Indent, Spacing tabs, and the dialog launcher box. The Arrange group has the Selection Pane and Align as the only active icons amongst others. There are also the dialog launcher boxes in all the groups. They provide avenues for further information used for formatting documents.

The 'Margins' allows for the setting of the borderline gaps at the top, bottom, left, right of the document. It also has the provision to set the gutter and gutter position in the document. The 'Orientation' has provision for the document to be presented in either the portrait or landscape format. The 'Size' shows the paper sizes. The 'Columns' indicates the number of columns to be set in the document just like the ones found in newspapers, magazines, newsletters and brochures publications. The 'Breaks' is meant for the creation of a new page when there is more text on a page than the margins can accommodate.

TABLES

Generally, Tables are used to present data in a table format. The tables can be reproduced as follows:

1. Position the cursor where the new table is desired to be placed.
2. Go to the Menu toolbar and click the 'Insert' tab on the Ribbon and click the 'Tables' button on the Tables group, and the table can be reproduced using any of these five ways:
   a. Highlight the number of row and columns
   b. Click 'Insert Tables' and select the number of rows and columns.
   c. Click the 'Draw Table', design your choice table by inserting the numbers for rows and columns.

d. Click ‘Excel Spreadsheet’ if the table is to be imported from Excel program.
e. Click ‘Quick Tables’ and choose a template from the drop-down tool.
f. Position the cursor in the cell where you want to enter the information and begin to type.
g. If need for modification arises, click the table and notice that two new tabs would prop up on the Ribbon: Design and Layout. These are useful to conFig. information for table design and layout.

GRAPHICS

The quality of presentations in a document can be enhanced by the interplay of different aspects of graphics. The insertion of symbols and special characters: Shapes, Pictures, Charts, SmartArt, WordArt, and Watermarks go a long way in the document enhancement. These can be achieved by the following procedures:

1 Position the cursor where the graphic element is desired to be placed.
2 Go to the Menu toolbar and click the ‘Insert’ tab on the Ribbon and click the ‘Pictures/ Shapes/ Icons/ SmartArt/ Chart/ Screenshot’ button as appropriate on the Illustrations group.
3 For Shapes – the mouse pointer would convert to a cross +, then drag using the mouse the + across the screen to make the desired shape.
4 For Pictures – double click the sample folder, select the picture and click ‘Insert’.
5 For SmartArt/ WordArt – click the arrow on the left side of the graphic to insert text or type the text in the graphic.
6 For Resizing of Graphics – click the graphic, and a new tab ‘Shape Format’ would appear on the Ribbon, input the desired parameters on the Size group to produce the desired size and shape.

TABLE OF CONTENTS

The table of contents can easily be created by the click of a button, if any of the Heading Styles (Normal, Heading 1, Heading 2, Heading 3, etc.) contained in the Styles group in the Home tab is used to format the document. Or if the text for the table of contents is selected and on the Table of Contents group in the Reference tab, click 'Add Text', and click the 'Level' that you want to label your selection. To create the table of contents, do as follows:

1. Position the cursor where the table of contents is desired to be placed.
2. Go to the Menu toolbar and click the 'Reference' tab on the Ribbon and click the 'Table of Contents' button as appropriate on the Table of Contents group.

REFERENCES AND CITATIONS

It is pertinent to avoid the stress associated with the manual development of reference list especially when large sets of information are involved, and they are supposed to be arranged chronologically with all the punctuation marks correctly inserted. This is avoidable if the reference tool in the MS Word 2019 or any other tools e.g., Zotero, RefX, etc. is used. In this section, a review of the method of preparing references and citations would be presented using the following ways:

1. Put the cursor where the citation is required, click the 'References' tab on the Ribbon, click either 'Insert Citation', 'Manage Sources', 'Style', or Bibliography' as appropriate.
2. **Click** 'Insert Citation' **and select** 'Add New Sources' or 'Placeholder' as appropriate.
3. In the 'Add New Sources', a new field **'Create Source'** that would prop up, select type of source i.e., Journal article, Book, Book section, Conference Proceedings, etc. Go to the **'Author'** and select **'Edit'.** Type the **Last/First/Middle** name(s) of the author(s) one after the other if they are multiple, then select **'Add'**

and **'Ok'.** Next fill other fields appropriately. You can select **'Show All Bibliography'** for more details and select **'Ok'.**

4 The author's last name and year will automatically appear in the body of the document. However, it may be necessary to further edit what was shown to sync with the beginning of sentence or end of sentence style in APA citation system. Recall that if it is the end of sentence, the parentheses will cover both the author's name and year of publication. This is what the system would provide, but for the beginning of the sentence using APA's citation format, additional editing works will be required.

5 Highlight the citation in the body of the document, which is now in field version, click the arrow; a drop-down list containing the following would prop up**: 'Edit Citation', 'Edit Source', 'Convert Citation to Static Text', and 'Update Citations and Bibliography.** Select **'Edit Citation',** under **'Suppress'** click **'Author'** and **'Title'** and select **'Ok'.** Then, manually type the name of the author preceding the year which is already in parentheses.

6 Click **'Style'** and select 'APA' or any other from the dialog box as appropriate.

7 For **Reference Listing - a**t the end of the write-up, put the cursor on a new page and go back to **'References' in the Ribbon** and select **'Bibliography', y**ou would notice **'Bibliography', 'References',** and **'Works Cited';** click **'References'** and your APA reference list will greet you. Further, it may be necessary to edit the font type, size and spacing by highlighting the field and doing the needful accordingly.

8 At any point a new citation is added, simply highlight the reference list, right-click and select 'Update the Field' tab.

SHORTCUT KEYS

Ctrl + A Select All

Ctrl + B – Bold
Ctrl + C – Copy
Ctrl + D - Duplicate objects (Also opens the Font Dialog box when no object is selected)
Ctrl + E - Align Centre
Ctrl + F – Find
Ctrl + G – Go To
Ctrl + H - Replace text in a document.
Ctrl + I – Italics
Ctrl + J - Justify text alignment
Ctrl + K - Insert Hyperlink
Ctrl + L - Align Left
Ctrl + M - Increase Indent (left indent)
Ctrl + N - New (open new document)
Ctrl + O – Open
Ctrl + P – Print
Ctrl + Q - Remove Paragraph Spacing in a document.
Ctrl + R - Align Right
Ctrl + S – Save
Ctrl + T - Hanging Indent
Ctrl + U – Underline
Ctrl + V – Paste
Ctrl + W – Close
Ctrl + X – Cut
Ctrl + Y - Redo (reverses an undo action)
Ctrl + Z - Undo (reverse the last performed action on a document).

CLOSING OF DOCUMENT

1 To close a document, click the File Tab and click 'Close'.

2 Always save document before closing.

SUMMARY

In this text, the roles of devices such as keyboards, mouse, monitors, printers, and CPUs in word processing and as word processors have been exemplified based on the requirements of MS Word 2019. The layout of MS Word 2019 has been explained according to the functions of its tabs to enable students understand how to open new and existing, edit, save, format, draw tables, insert symbols and special characters for graphics, create table of contents and prepare citations and reference lists in documents. The text also has information on shortcuts and commands that can be applied to quicken time spent on document creation. It is expected that this text will open up avenues for students to appreciate the basics of word processing, data analysis and presentation.

EXERCISES

1 Mention any four (4) devices used in word processing?

2 Give five (5) examples of application software packages that you know?

3 Differentiate between word processing and word processor?

4 Mention the steps to be taken to open and close MS Word 2019?

5 What are the basic components of MS Word 2019?

6 List any ten (10) tab functions in MS Word 2019?

7 Describe how a new document can be created in MS Word 2019?

8 What are the shortcuts for the following commands?
(To make Bold; To Copy; To Paste; To Save, and To Justify Text Alignment).

9 What are the commands for the following shortcuts?
(Ctrl + D; Ctrl + F; Ctrl + U; Ctrl + Y, and Ctrl + Z).

REFERENCES

GeeksforGeeks. (2021). *Introduction to Microsoft Word.* Retrieved March 27, 2023, from geeksforgeeks: https://geeksforgeeks.org/introduction-to-microsoft-word/

International Centre for Information & Communications Technology Studies. (2019). *ADAPTI IOPT Manual.* Abuja: Digital Bridge Institute & Nigerian Communications Commission (NCC). Retrieved from https://www.dbi.edu.ng

Jingfa, S. (2023). *Introduction to computer application .* Retrieved March 27, 2023, from Academia.edu: https://www.academia.edu/28549511/INTRODUCTION_TO_COMPUTER_APPLICATION

Khalid, S. (2020). *Word Processing.* Retrieved March 26, 2023, from Sldeshare: https://www.slideshare.net/SaniaKhalid6/word-processing-233054464

Nandan, M., Sharma, A., Raut, R. D., Sharma, V., & Kamal, M. S. (2022). *Introduction to computer applications.* India: BlueRose.

National Institute of Open Schooling. (2019). *Basics of Word Processing.* Retrieved March 27, 2023, from nios: https://nios.ac.in/media/documents/sec229new/Lesson3.pdf

Stodocu. (2023). *Module 1 - Word Processing.* Retrieved March 28, 2023, from stodocu: https://www.studocu.com/in/document/university-of-kerala/office-automation/dca-oap-word-word-processing/42867030

Tutorials Point. (2023). *Elements of word processing.* Retrieved March 27, 2023, from Tutorialspoint: https://www.tutorialspoint.com/computer_concepts/computer_concepts_elements_of_word_processing.htm

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CHAPTER FOUR: FREEHAND DRAWING

Principles Of Sketching Human Figures and Furniture (Freehand Drawing) - Beginners Course Outline

Adeoye Olugbenga Adewolu PhD, *Bells University*

Overview

Principles of Sketching Human Figures and Furniture (Freehand Drawing) is essential in furniture design as they help ensure that the furniture is comfortable and ergonomically suitable for its intended users. This program – Principles of Sketching Human Figures and Furniture (Freehand Drawing) has been designed for the 100 to 200 Level students in the undergraduate program of the Faculty of Architecture in a Nigerian University. Sketching human figures and furniture is an important aspect of freehand drawing. Sketching human figures involves capturing the gesture, posture, and anatomy of the human body. Understanding the basic shapes and proportions of the human body is crucial for creating accurate and expressive figure drawings.

This text is focused on the principles and techniques for sketching human figures and furniture and the essential skills and techniques necessary to create accurate and expressive drawings and sketches for a variety of purposes.

Objectives

The objective of this text is to:

1. list the materials and tools needed for freehand sketching;
2. apply the basic principles of freehand sketching to design drawing;
3. identify the techniques for adding detail to figures and furniture; and

4. illustrate presentation drawings proportionally.

Materials and Tools Needed for Freehand Sketching

The materials and tools needed for freehand sketching can vary depending on the artist's preference, the subject matter, and the intended outcome of the sketch (CivilSeek, 2018). However, some basic materials and tools that most artists use for freehand sketching are:

Sketchbook or Drawing Pad - A sketchbook or drawing pad is an essential tool for freehand sketching. It provides a surface for the artist to draw on and is portable enough to carry around.

Pencils - Pencils are the most common tool used for freehand sketching. They come in a range of hardness and are used for drawing lines of varying thickness and value.

Compass - A compass is used to create circles or arcs in the drawing.

Coloured Pencils - Coloured pencils can be used to add colour and detail to the drawing.

Watercolours can be used to add a wash of colour to the drawing and create interesting effects.

Basic Principles of Freehand Drawing

Freehand drawing is an art form that relies on the artist's ability to observe and translate what they see into a two-dimensional image. There are several basic principles of freehand drawing that are essential for creating accurate and expressive drawings. Here are some of the most important principles:

Line: The line is the most basic element of drawing. It is used to define shapes, forms, and textures. The artist can use different types of lines such as thin, thick, curved, or straight to convey different qualities of the subject.

Shape: Shapes are created by the lines and outlines of the subject. They can be simple or complex, geometric or organic, and are used to define the subject's form.

Form: Form refers to the three-dimensional quality of the subject. It is created by the use of shading and highlights to create the illusion of depth and volume.

Proportion: Proportion refers to the relationship between the different parts of the subject. It is important to understand the basic proportions of the subject to create accurate and realistic drawings.

Understanding Proportions

The importance of proportions in sketching

Proportions are one of the most important aspects of freehand sketching, as they help to create an accurate and realistic representation of the subject. Proportions refer to the relative size and position of different parts of the subject, also understanding them is essential for creating a convincing drawing (Peachpit, 2018).

In summary, proportions are essential for creating accurate and convincing drawings. They help to convey important information about the subject and create a sense of balance and harmony in the drawing. By paying close attention to proportions and ensuring they are accurate, artists can create more effective and visually appealing sketches.

Breaking Down Figures and Furniture into Basic Shapes

Breaking down figures and furniture into basic shapes is a useful technique for freehand sketching. By using simple shapes as a foundation, artists can more easily capture the overall form and proportions of the subject and then build upon it with more detail and complexity. Here are some examples of how to break down figures and furniture into basic shapes:

Human Figures: When sketching human figures, it can be helpful to start with simple shapes such as circles, ovals, and rectangles. The head can be represented by a circle, the torso by a rectangle, and the limbs by cylinders or rectangles. These basic shapes can then be refined and adjusted to create more accurate proportions and details.

Chairs: When sketching chairs or other furniture, it can be helpful to start with basic shapes such as rectangles, triangles, and circles. The back of a chair, for example, can be represented by a rectangle, while the legs can be represented by cylinders or triangles. These basic shapes can then be refined and adjusted to create more detailed and accurate drawings.

Tables: Tables can be broken down into basic shapes such as rectangles, circles, and triangles.

Using Proportion to Create Realistic Sketches

Proportions are an essential tool for creating realistic sketches. Understanding how to use proportions in your sketches can help you to accurately capture the size and shape of your subject and create a drawing that is visually pleasing to the viewer. Here are some tips for using proportion to create realistic sketches:

Pay Attention to Scale: Another important aspect of using proportion is paying attention to the scale of your drawing. Make sure that the size of your subject is appropriate for the size of your paper or canvas and adjust your proportions accordingly.

Use Basic Shapes: Breaking down your subject into basic shapes can be helpful in establishing the correct proportions. Use circles, ovals, and rectangles to create a basic framework for your sketch, and then refine it as needed.

Practice: Using proportion effectively in your sketches takes practice. Take time to experiment with different techniques and approaches, and don't be afraid to make mistakes. With practice, you'll develop a better understanding of how to use proportion to create realistic and compelling sketches.

Starting with Basic Shapes

The importance of starting with basic shapes

Joshua Nava showed that starting with basic shapes is an important aspect of freehand sketching. It can help you to establish the overall form and proportions of your subject and create a foundation for adding more detail and complexity to your drawing (Joshua Nava Arts, 2023). Here are some of the main reasons why starting with basic shapes is important:

Establishing Proportions: Basic shapes can be used as reference points for establishing the proportions of your subject. For example, you might use a circle to represent the head, and then use that as a reference point to establish the height and width of the figure. By establishing the correct proportions early on in the sketch, you can create a more accurate and realistic drawing.

Creating a Framework: Starting with basic shapes can create a framework or structure for your drawing. This can help you to establish the overall composition of the drawing and make decisions about how to position and arrange the different elements of the subject.

Different Shapes Used in Sketching Figures and Furniture

Sketching figures and furniture requires a range of shapes to capture different elements of the design. Here are some common shapes used in sketching figures and furniture:

Circles: Circles are used to create round objects such as the head, joints, or the base of a lamp.

Ovals: Ovals are elongated circles and can be used to sketch objects that are slightly elongated or tapered.

Rectangles: Rectangles are used to create boxes or rectangular shapes such as tables, chairs, and bookshelves.

Squares: Squares are used to sketch objects that are square or have a square base such as boxes, cubes, and some chairs.

Triangles: Triangles are used to create pointed shapes such as the top of a Christmas tree or the roof of a house.

Trapezoids: Trapezoids are used to create objects that are tapered or slanted such as the legs of a table or a chair.

Arcs: Arcs are used to create curved lines such as the backrest of a chair or the sides of a sofa.

Lines: Lines are used to create straight edges or connect different shapes in the design. Using Basic Shapes to Establish Composition And Proportion

Using basic shapes is a fundamental technique in establishing composition and proportion when sketching figures and furniture. Here are some tips on how to use basic shapes to create a balanced composition and accurate proportions:

Start with the Gesture: Before adding any details, sketch out the gesture of the figure or furniture piece. Use a loose line to indicate the overall shape and movement of the subject.

Refine the Shapes: Once you are satisfied with the overall proportions, refine the shapes by adding more detail. Use smaller shapes to create the details such as the head, arms, and legs.

Gestures

The Purpose of Gestures in Freehand Drawing

Gestures are an essential part of freehand drawing as they help artists to capture the overall movement and energy of the subject. The purpose of gestures in the freehand drawing is to create a loose, fluid sketch that captures the essence of the subject in a few quick strokes (DonCorgi, 2023).Here are some reasons why gestures are important in freehand drawing:

Capture the movement: Gestures help to capture the movement of the subject, whether it's a figure, animal, or object. By sketching the gesture, the artist can quickly establish the direction and flow of the subject.

Establish the proportions: Gestures help to establish the overall proportions of the subject. By sketching the basic shape and position of the subject, the artist can quickly check for any major proportion issues.

Techniques for Creating Gestures

Creating gestures is an essential skill for freehand drawing. Here are some techniques for creating gestures:

Use your whole arm: When creating gestures, it's important to use your whole arm, not just your wrist or fingers. Use broad, sweeping strokes to capture the overall movement of the subject.

Draw quickly: Gestures should be created quickly and without hesitation. The purpose of gestures is to capture the energy and movement of the subject, so quick, loose strokes are essential.

Using Gestures to Warm Up and Establish Movement

Using gestures is a great way to warm up and establish movement in your freehand drawing. Here are some tips for using gestures to warm up and establish movement:

Start with quick sketches: Begin with a series of quick, gestural sketches. Use your whole arm and draw loosely to capture the energy and movement of the subject.

Focus on the overall shape: When creating gestures, focus on the overall shape and movement of the subject. Don't worry about capturing every detail, instead, aim to capture the essence of the subject.

Experiment with Different Lines: Experiment with different types of lines, such as thick and thin lines, curved and straight lines, and long and short lines. This will help to create a sense of movement and energy in your sketches.

Anatomy

Understanding basic anatomy in Freehand Drawing

Understanding basic anatomy is crucial in freehand drawing as it helps artists accurately depict the human form and create realistic and dynamic figures (University of Port Harcourt, 2023). Here are some key areas of anatomy that are important to understand in the freehand drawing:

Skeletal structure: Understanding the skeletal structure of the human body is essential in freehand drawing as it provides the foundation for the figure. Knowing the basic shape and placement of bones will help artists accurately depict the proportions and movement of the figure.

Proportions: Understanding the proportions of the human body is essential in freehand drawing as it helps artists accurately depict the size and shape of the figure. Knowing the basic proportions of the head, torso, arms, and legs will help artists to create more realistic and balanced figures.

Perspective: Understanding perspective is important in freehand drawing as it helps artists accurately depict the three-dimensional form of the figure. Understanding how the figure appears from different angles and how it interacts with the environment will help artists to create more realistic and convincing figures.

Applying Anatomy to Create Realistic Figures

Applying anatomy is essential in creating realistic figures in freehand drawing. Here are some tips for applying anatomy to create realistic figures:

Start with the skeletal structure: Begin by sketching the skeletal structure of the figure. This will help you to establish the overall proportions and movement of the figure.

Practice regularly: Practice drawing figures regularly, paying close attention to the anatomy of the human body. By practicing regularly, you can improve your ability to apply anatomy to create realistic figures.

Experiment with different poses: Experiment with different poses and positions to create dynamic and expressive figures. Pay attention to how the muscles and bones change shape as the figure moves and interacts with its environment.

Understanding the Skeletal and Muscular Structure

Understanding the skeletal and muscular structure of the human body is essential in freehand drawing as it provides the foundation for the figure. Here are some key areas of the skeletal and muscular structure that are important to understand:

Skeletal structure: The skeletal structure of the human body includes the skull, spine, ribs, pelvis, and limbs. Understanding the placement and shape of bones is essential in creating realistic and proportionate figures. The skull, for example, provides the basic structure for the head, while the spine and ribs give shape to the torso.

Muscles: The muscular structure of the human body includes both voluntary and involuntary muscles. Understanding the major muscle groups and how they interact with one another is essential in creating realistic and dynamic figures.

Joints: Joints are where bones come together and allow for movement. Understanding the structure and function of joints is essential in creating figures that move realistically. The shoulder joint, for example, is a ball-and-socket joint that allows for a wide range of movement in the arm.

Light and Shadow

The Role of Light and Shadow in Creating Depth and Dimension

Light and shadow play a crucial role in creating depth and dimension in freehand drawing. By using shading techniques, artists can create the illusion of three-dimensional space on a two-dimensional surface (The Virtual Instructor, 2022). Here are some ways in which light and shadow can be used to create depth and dimension:

Highlight and shadow: By identifying the areas of a drawing that are receiving direct light and those that are in shadow, artists can create the illusion of form and depth. Highlighted areas are the brightest and most intense parts of a drawing, while shadowed areas are the darkest and least intense.

Value: The value of a drawing refers to its range of lights and darks. By using a range of values, artists can create the illusion of depth and dimension. A high contrast drawing with a wide range of values will appear more three-dimensional than a drawing with a limited range of values.

Texture: Light and shadow can be used to create the illusion of texture in a drawing.

Techniques for Creating Shading and Highlights

There are several techniques for creating shading and highlights in freehand drawing. These techniques help to create the illusion of form, depth, and texture in a drawing. Here are some of the most commonly used techniques:

Hatching and cross-hatching: Hatching involves creating a series of parallel lines to create shading or texture. Cross-hatching is similar but involves creating a series of intersecting lines. By varying the distance and angle of the lines, artists can create a range of shading effects.

Contouring: Contouring involves using lines to follow the contour of an object or figure to create the illusion of depth and form. By varying the thickness and intensity of the lines, artists can create a range of shading effects.

White charcoal: White charcoal is a tool that can be used to create highlights or to lighten areas of shading. This technique is often used in combination with other shading techniques to create a range of values.

Observing Light and Shadow in Real-Life Subjects

Observing light and shadow in real-life subjects is an important step in creating realistic drawings. Here are some tips for observing light and shadow in real-life subjects:

Observe the direction of light: Take note of where the light is coming from and how it falls on the subject. This will help you to identify the areas of the subject that are in light and those that are in shadow.

Experiment with different lighting conditions: Experiment with different lighting conditions, such as natural light or artificial light, to see how they affect the appearance of the subject. This will help you to develop a better understanding of how light and shadow work in different conditions.

Adding Detail

The Importance of Adding Detail to Sketches

Adding detail to sketches is important because it can bring a drawing to life, making it more interesting and engaging to viewers. Detail can help to create the illusion of depth and texture and can add realism to a drawing (GCF Global, 2023). Here are some of the reasons why adding detail is important:

Creates realism: Adding detail can create the illusion of realism in a drawing. This can help viewers to better understand the subject and appreciate the skill of the artist.

Enhances texture: Adding detail can help to enhance the texture of a subject. For example, adding fine lines or cross hatching to a drawing of a tree can create the illusion of bark texture.

Provides context: Adding detail can provide context to a drawing. For example, adding details to the background of a portrait can provide a sense of location and atmosphere.

Engages viewers: Adding detail can engage viewers by providing them with interesting elements to discover. This can help to hold their attention and make the drawing more memorable.

Techniques for Adding Detail to Figures and Furniture

There are several techniques that can be used to add detail to figures and furniture in a drawing. Here are some of them:

Use fine lines: Fine lines can be used to add texture and detail to a drawing. For example, adding fine lines to clothing can create the illusion of fabric texture.

Add shading: Shading can be used to create depth and texture in a drawing. By adding shading to a drawing of a piece of furniture, you can create the illusion of depth and make it appear more three-dimensional.

Use crosshatching: Cross Hatching is a technique where lines are drawn at different angles to create shading and texture. This can be used to add detail and texture to clothing or furniture.

Add highlights: Highlights can be used to create the illusion of reflective surfaces or shiny objects. By adding highlights to a drawing of a piece of furniture, you can create the illusion of a shiny surface.

Paying Attention to Small Details

Paying attention to small details is important in freehand drawing because it can make the difference between a good drawing and a great one. Small details can add realism, depth, and interest to a drawing, making it more engaging and memorable to viewers. Here are some tips for paying attention to small details:

Use a reference image: A reference image can be helpful in identifying small details in a subject. By studying a reference image, you can gain a better understanding of the small details that make up the subject.

Take your time: Paying attention to small details requires patience and focus. Take your time and work slowly to ensure that you are accurately capturing all of the small details in your drawing.

Use a magnifying glass: A magnifying glass can be helpful in identifying and drawing small details. It can help you to see details that are difficult to see with the naked eye.

Break the subject down: Breaking the subject down into smaller parts can help you to identify and draw small details. By focusing on one part of the subject at a time, you can ensure that you are capturing all of the small details.

Different Angles

The Importance of Sketching Subjects from Different Angles

Sketching subjects from different angles are important in a freehand drawing for several reasons (Joshua Nava Arts, 2023). Here are some of them:

Improves observation skills: When you draw a subject from different angles, you are forced to observe it more closely. This helps you to see the subject in a new way and to notice details that you may have missed before.

Improves understanding of form: When you draw a subject from different angles, you get a better understanding of its form. This is because you are able to see the subject from different perspectives and see how the form changes as you move around it.

Adds variety to your drawings: Drawing a subject from different angles adds variety to your drawings. It allows you to create a more dynamic composition and show different aspects of the subject.

Improves technical skills: Drawing a subject from different angles can be challenging, but it can also improve your technical skills. It requires you to think more carefully about proportions, perspective, and foreshortening, which can help you to improve your skills in these areas.

Techniques for Sketching Subjects from Different Angles

Sketching subjects from different angles can be challenging, but there are some techniques that can help you to do it effectively. Here are some techniques for sketching subjects from different angles:

Start with simple shapes: When you are sketching a subject from a new angle, it can be helpful to start with simple shapes. You can sketch the basic shapes of the subject and then build up the details. This can help you to establish the overall proportions and structure of the subject.

Use perspective guidelines: Perspective guidelines can be helpful in sketching subjects from different angles. You can use vanishing points and horizon lines to establish the perspective of your subject and to ensure that your proportions are accurate.

Pay attention to foreshortening: Foreshortening is the distortion that occurs when a subject is viewed from a different angle. It can be challenging to capture, but paying attention to the foreshortening can help you to create a more realistic drawing.

Understanding the Importance of Perspective

Perspective is an important concept in art that refers to the way objects appear to the eye in three-dimensional space. It is the technique used to create the illusion of depth and distance on a two-dimensional surface like a piece of paper or canvas. Understanding perspective is essential in a freehand drawing for several reasons:

Creates a sense of depth and dimension: Perspective creates the illusion of depth and distance in a drawing, which makes it more realistic and engaging.

Adds realism and accuracy: By using perspective, you can create a drawing that accurately represents how the subject appears in real life. This can make your drawing more believable and relatable to the viewer.

Helps to establish composition and balance: Perspective can be used to create a sense of balance and harmony in a drawing. By using perspective lines and vanishing points, you can create a composition that is visually appealing and balanced.

Summary – Practice

The Importance of Regular Practice

An amazing response from Quora showed that regular freehand practice is essential for anyone who wants to improve their drawing skills (Quora, 2018). Here are some reasons why:

Improves muscle memory: Drawing is a skill that requires hand-eye coordination and muscle memory. Regular practice can help to develop these skills, making it easier to draw accurately and quickly. Builds Confidence: Drawing can be a challenging activity, especially if you're just starting. Regular practice can help to build your confidence and improve your overall technique.

Encourages experimentation: Regular practice can also encourage experimentation with different styles, materials, and techniques. Trying new things can help you to develop your own unique style and push your artistic boundaries.

Helps to Identify Weaknesses: Regular practice can help you to identify areas where you need improvement. Once you know your weaknesses, you can focus on improving them.

Techniques for Practicing Regularly

There are several techniques that can help you to practice freehand drawing regularly: Schedule Drawing Time: Set aside specific times each day or week for drawing. Treat it like an appointment that you can't miss.

Start with short sessions: If you're new to drawing or finding it difficult to make time, start with short drawing sessions. Even just 10-15 minutes a day can make a difference.

Challenging Yourself to Sketch New Subjects

Challenging yourself to sketch new subjects can be a great way to improve your drawing skills and creativity. Here are some tips for taking on new drawing challenges:

Choose a subject you are not familiar with: Drawing something you're not used to can be a great challenge. It can help you to push your skills and try new techniques.

Break down complex subjects: If the subject is complex, try breaking it down into smaller, more manageable parts. This can make it easier to approach and tackle.

Experiment with different materials: Trying out different materials can be a fun way to challenge yourself. For example, if you typically draw with a pencil, try using ink or watercolours.

Exercises – Final Project

Applying all Principles Learned to Create a Final Project

Creating a final project in freehand sketches is an excellent way to bring together all the principles and techniques you've learned. Here are some steps to help you create a final project:

Choose a subject: Decide on a subject that you're interested in and that you'd like to sketch. It could be a person, an object, or a scene from nature.

Gather your materials: Choose the materials you want to use for your sketch. This could be pencils, charcoal, markers, or any other medium you feel comfortable with.

Plan your composition: Think about the composition of your sketch. Where will the subject be positioned? What will the background look like? Sketch some rough thumbnails to plan out your composition.

Final touches: Once you're happy with your sketch, add any final touches or details to bring it to completion. This could include adding shadows or highlights, refining lines, and edges, or adding a background.

Creating a final project in freehand sketches can be a rewarding and fulfilling experience. By applying all the principles and techniques you've learned, you can create a unique and personal work of art.

Critique and Feedback from Instructor and Peers

Getting critique and feedback from an instructor and peers is an essential part of improving your freehand sketching skills. Here are some tips for receiving critique and feedback:

Be open-minded: Keep an open mind and be willing to accept criticism. Remember that feedback is meant to help you [students] improve, not to tear you down.

Listen actively: Listen carefully to what the instructor and peers have to say. Pay attention to their suggestions and take notes if necessary.

Ask questions: If you don't understand something, ask for clarification. Ask questions that help you to better understand what you can improve on and what you did well.

Take action: Use the feedback you receive to make improvements to your work. Take action on the suggestions you receive and apply them to your future sketches.

Offer feedback to others: Giving feedback to others can also help to improve students' own skills. They should always try to give constructive criticism that is helpful.

References

CivilSeek. (2018). Free Hand Sketching; Its Methods, Instruments, Principles. http://civilseek.com.

DonCorgi. (2023). Gesture Drawing Definition And 7 Benefits You Need To Know! DonCorgi.

GCF Global. (2023). Beginning Graphic Design: Fundamentals of Design. GCF Global.

Joshua Nava Arts. (2023). Freehand Drawing Or Sketching - Technical Drawing. Joshua Nava Arts.

Peachpit. (2018). 3.4 Maintaining Proportions | Visualization and Sketching. Peachpit.

Quora. (2018, February 23). What are the advantages of having skills in freehand drawing? Retrieved from Quora.com: https://www.quora.com/What-are-the-advantages-of-having-skills-in-freehand-drawing - Accessed on 09 March 2023

The Virtual Instructor. (2022). Drawing Lessons. TheVirtualInstructor.com.

University of Port Harcourt. (2023). Life Drawing For Artists Understanding Figure Drawings. University of Port Harcourt.

BIODATA OF ADEOYE_OLUGBENGA_ADEWOLU, Ph.D., MNIA

Dr. ADEOYE OLUGBENGA ADEWOLU is an esteemed senior lecturer in Architecture with an illustrious career spanning over 30 years in the university system. As a highly respected and experienced educator, Dr. ADEWOLU has made significant contributions to the field of architecture through teaching, research, and related works. Having obtained a Ph.D. degree in Architecture, Dr. ADEOYE ADEWOLU possesses a deep understanding of the subject matter and has developed strong expertise in various aspects of architectural theory and practice. Their extensive knowledge and passion for the discipline have been instrumental in shaping the minds of countless students who have had the privilege of being taught by them. Dr. ADEWOLU's teaching philosophy centres around fostering critical thinking, encouraging creativity, and nurturing a deep appreciation for the art and science of architecture. He is known for his engaging teaching style, employing innovative pedagogical techniques to ensure students receive a comprehensive education that combines theoretical concepts with practical applications. In addition to his teaching responsibilities, Dr. ADE ADEWOLU has actively pursued research endeavours throughout his career. Their scholarly work focuses on exploring emerging trends in architecture, sustainable design practices, and the integration of technology in the field. By staying at the forefront of advancements in the architectural domain, Dr. ADE ADEWOLU continually seeks to inspire students and fellow professionals alike, encouraging them to push boundaries and envision new possibilities.

Dr. ADEWOLU's contributions extend beyond the confines of the classroom and research lab. He has actively participated in academic committees, served as a mentor to aspiring architects, and collaborated with industry professionals to bridge the gap between academia and practice. His efforts to promote interdisciplinary collaboration and knowledge exchange have played a pivotal role in enhancing the architectural community within Nigeria and beyond.

Recognised for his expertise, Dr. ADE ADEWOLU has been invited to present at national and international conferences, delivering thought-provoking talks on topics such as sustainable design, urban planning, and the role of architecture in shaping societies. Their research findings have been published in reputable journals, further contributing to the body of knowledge in the architectural field.

With a career spanning three decades, Dr. ADEOYE OLUGBENGA ADEWOLU continues to be an influential figure in the realm of architecture education. Their commitment to excellence, dedication to their students, and unwavering passion for the subject have solidified their position as a respected authority in the field. As an author, their insights and expertise will undoubtedly enlighten readers and inspire future generations of architects and designers.

CHAPTER FIVE: COMPUTER AIDED DESIGN

3D Modelling

Nenchi Deborah. W. *Bingham University,* ***Karu*** **& Alao Amos. Atumye.**

Overview

This course seeks to provide students with an in-depth understanding of 3– dimensional software (3D) software in modelling and its application in landscape architecture design and planning. Students will learn how to create 3D models from 2D drawings using Computer Aided Design (CAD) and visualizations of landscape designs with buildings and topography using 3D applications.

This text aims to equip students with the techniques of designing landscapes in a studio setting. It focuses on collaboration, communication, and critical thinking with different 3D software.

Objectives

The objectives are to:

1. develop a proficiency in the use of 3D software for designing landscapes with buildings and topography;
2. create detailed 2D and 3D models and visualisations of landscape designs using 3D, models from site analysis and survey plans;
3. design different landscapes with buildings and topography in a design studio setting, with a focus on collaboration, communication, and critical thinking; and
4. use the application of 3-D to real-world landscape architecture projects, using case studies.

Introduction to 3D in Landscape Architecture

Computer-Aided Design (CAD) is the use of computer-based software to aid in design processes. CAD software can be used to create two-dimensional (2-D) drawings on X and Y axis or three-dimensional (3-D) models on X, Y, and Z axis. Computer modelling is used by different design professions to communicate their designs in a more effective way in addition to 2-dimensional drawings. The 3D applications enable modelling in landscape design (such as park design, residential landscaping etc) and in landscape planning (such as land restoration projects, ecological projects etc).

There are 3 phases of landscape design in which the use of models becomes necessary (1). creating an appropriate knowledge base from the evaluation of the existing conditions to provide data which will guide the decision-making process.

(2). carrying out the actual design and evaluating it.

(3). presenting for public discourse the finished design at a defined time and space.

In doing this, the designer provides an explanation to those that may lack the understanding and interpretation of the design details and what environmental issues that may be associated with it. (Nijhuis & Stellingwerff, 2011) citing Appleyard 1977.

The design phases, therefore, have the added advantage when 3-D modelling is used. Right from the process of analysis of site conditions to the critical thinking to provide the design solution and the presentation for critique in landscape design and planning projects. The clientele is usually not all professional, they may be decision-makers or stakeholders who may not understand the details presented. There is the need to move from 2-D presentations to providing 3-D models that provide visibility and ease for evaluating the designed forms created much better, a process which can be likened to “mimicking” the actual scientifically on a smaller scale, and on a virtual interface.

CAD has evolved from 2D CAD (flat drawings) of products, 2.5D CAD (Prismatic models), and 3D CAD (solid, wireframe, and surface). 3D modelling is the process of creating three-dimensional representations of an object or a surface in an X, Y, and Z axis. 3D models help to determine an object's size, shape, and texture. It also aids the designer to explore the physical aspects of a design without conceding to physical on-site limitations.

3D modelling is considered an effective communication tool to reach out to other designers, clients and other stakeholders. Developing this skill is essential for the landscape architect whose profession is to provide functional outdoor spaces with an aesthetic appeal. (Nijhuis & Stellingwerff, 2011) describes the processes of doing this to involve the internally conceived sketchy thoughts of the designer creatively being translated in a rigorous design process into a visible and physically appreciable form.

There is an array of 3D software available to the landscape architect and making a choice may be difficult for a beginner. Software’s come in different degrees of complexity, and some are better for certain projects than others, this is what should be the deciding factor when a choice is to be made.

The importance and benefits of 3D CAD (models) in the Landscape Architecture Industry

1. Computer-Aided Design in 3-D modelling is a versatile tool in the landscape design and planning industry as it has come to change the way and manner in which computer drafting is being done. It has the capacity as a design tool in providing virtual designs that are realistic.

2. CAD 3-D design models are useful in landscape design for emphasising the topography around landscape forms and for grading to show low ground or depressions and high or raised ground. After this, the building(s) and other landscape features can be added. This gives a proper appreciation of the terrain around the features on a site, which many may find difficult to interpret or fully comprehend when using 2-D drawings alone.
3. The virtual drawings produced can be saved and retrieved at any time keeping them safe, unlike the traditional means of drafting. Files backed up by libraries are available to enrich the quality of design work.
4. The software provides applications that can be used to customize certain functions offering more possibilities such as in computer animation.
5. Communication possibilities are also available using the internet "Add On's" in a virtual environment. Landscape designers can meet other people who may assist in broadening the landscape design scope, or even contribute to the design. It is possible on this interface to correct compare and make inputs to ongoing design work.
6. On 3- D CAD, corrections can be made on hidden portions. When lines and dashes are missing, they can be redrawn.
7. On 3D CAD files can be imported and exported into it from another application. For instance, 2-D drawings which is the starting point for any 3-D drawing can be imported from a previous work for instance.
8. With the high competitiveness within the industry, 3D CAD application aids fast and efficient documentation with its flexible options for specifying materials, providing specifications, producing bills, etc.

9. The 21st century has seen a rise in 3D modelling in design, and in Nigeria, the opportunities for graphical expression are infinite. With the evolution of technology, landscape designers, landscape planners, and clients can visualize the final project before it is built or implemented. In this way, problems with the project can be visualised ahead and necessary corrections and or improvements can be made that were not obvious in the 2D design.
10. Artificial intelligence is the future of all CAD applications including 3- D modelling. This is an application that will revolutionize the industry with numerous possibilities such as sitting and watching robots do design work with little assistance.

Getting Started on 3D CAD

For this course, it is assumed that your project has been designed in a 2D software such as auto CAD. And the user is familiar with the title bar, menu bar and tool bar of the default Windows operating system operations.

Opening the Google Sketchup software for the first time, you must choose the appropriate International System of Units (S.I unit) and a predefined template. To do so, go to the "Units" section of the "Model Info" dialogue box. For small projects the Millimetre metric unit of measurement is advised.

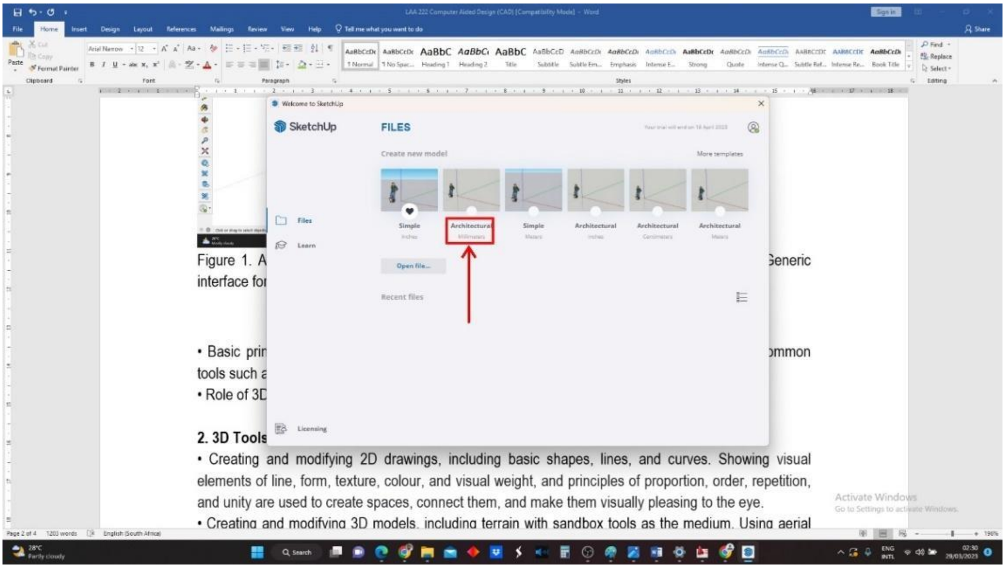


Figure 1. *Showing how to select Imperial Unit for modelling "millimetres".*

Overview of 3D and its features

This includes interface and workspace customisation and understanding of basic 3D modelling tools. Lines, eraser, arc, push/pull, offset, move, rotate, scale, tape measure, paint bucket, orbit, pan, zoom and zoom extents

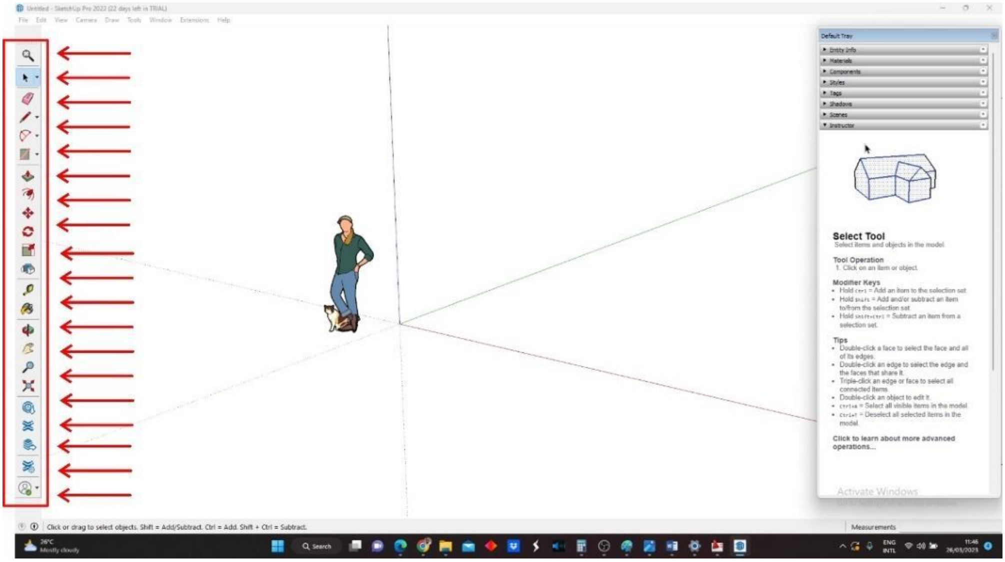


Figure 2. *Showing the predefined tools for 3D drawing.*

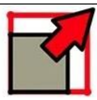
Source; Author 2023

All 3D CAD software comes with universal toolkits and screen features for making 3D models and drawings. In Sketchup, there is a wide variety of pre-defined 3D objects that users can modify using 3D commands.

The Status bar and the Ribbon bar of the user interface are where you'll find the majority of Sketchup's icons. The default icons on the home screen are described below. It is also important to limit the visible toolbars to enable the user to have a enough 3D workspace on the screen or arrange the toolbars and ribbons in a properly stacked manner.

Below are the generic tool names, visual representations and description:

Table 1:

S/No.	Visual	Tool Name	Description
EDIT			
1.		Pick	Use to select areas on the model to work on.
2.		Eraser	Used to delete lines on the model.
3.		Paint Bucket	Use to assign colours or materials on model.
4.		Scale	Used to resize model
5.		Move	Used to move/stretch model.
6.		Off-set	
7.		Push/Pull	Used to push or pull a model.
CAMERA			
8.		Zoom extents	Used to make your entire model visible in the drawing area.

9.		Zoom Window	Use to drag a model to a model to a precise view.
10.		Pan	Used to move the model horizontally or vertically on the workspace.
11.		Orbit	Use to rotate model in 360-degree views or spin the model around.
VIEWS			
12.		Perspectiv e	This icon shows the model in 3D perspective view.
13.		View/Top	This icon shows the model in 2D plan view.
14.		View/Right Side	This icon shows the right side of the model in 2D perspective view.
15.		View/Left Side	This icon shows the left side of the model in 3D perspective view.
16.		View/Front	This icon shows the frontside of the model in 3D perspective view.
TEXT			

17.		3D Text.	Used to inscribe 3D text on models

You can use keyboard shortcuts to quickly access any input command. Utilize shortcuts to hasten your work and greatly reduce the strain on your eyes and mouse hand. You slow down each time you take your eyes off your design. Spend some time honing your keyboarding skills and creating your own unique keyboard shortcuts.

Basic principles and concepts of 3D in landscape architecture

This includes terminology and common tools such as line, push, pull, zoom, rotate, etc. The 3D workspace has 3 different axes, which are the X-axis (horizontal), Y-axis (depth), and Z-axis (height). These parameters are used to define the location of your 3D models in the 3D universe.

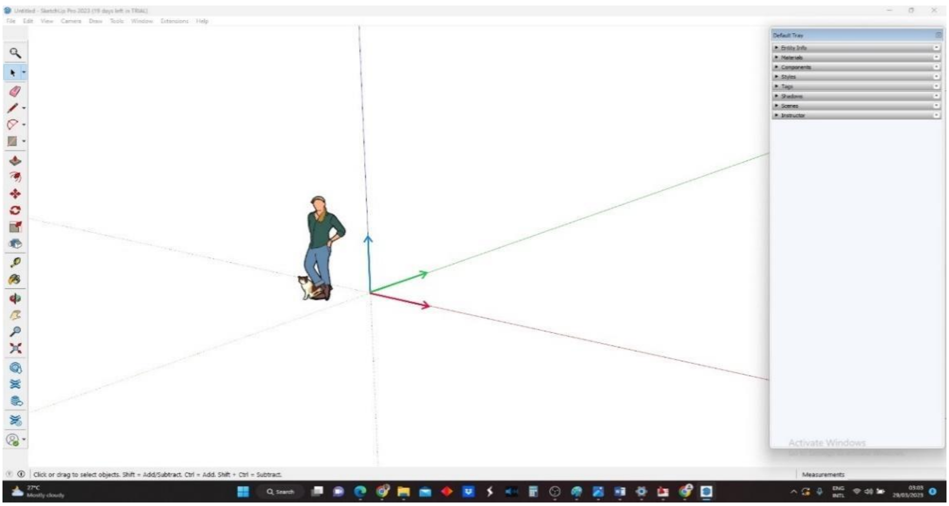
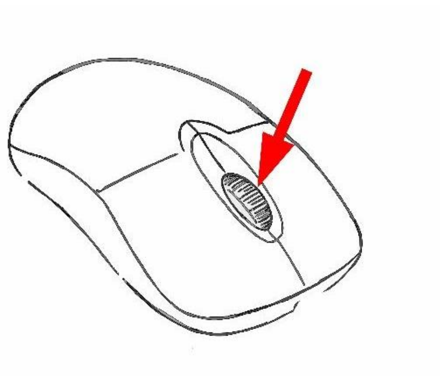


Figure 3. *A Graphic User Interface (GUI) workspace of the Google SketchUp interface is also called the '’3D viewport. (A Generic interface for most 3D Design software).*

Navigating the 3D workspace., 3D Tools and Techniques

The orbit, pan, zoom, zoom extents, and camera are very important tools for manipulating a 3D model, this is basically where the 3D medication of your model is hinged. The process is activated by using the scroll wheel of your mouse. The scroll wheel is one of the most important components of a 3D input operation.



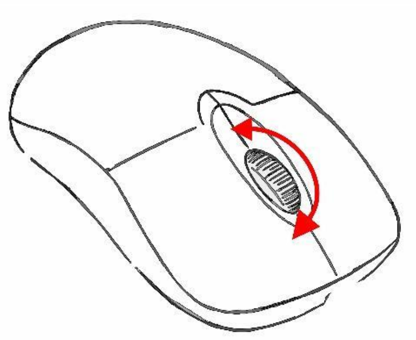


Figure 4: *Showing the scroll wheel can be pressed in.* *Figure 5: Showing the scroll wheel can be rolled for zoom operations*.

Holding down the scroll wheel button enables the user to orbit the model while scrolling the wheel in plate b enables the user to zoom in or out of the model space.

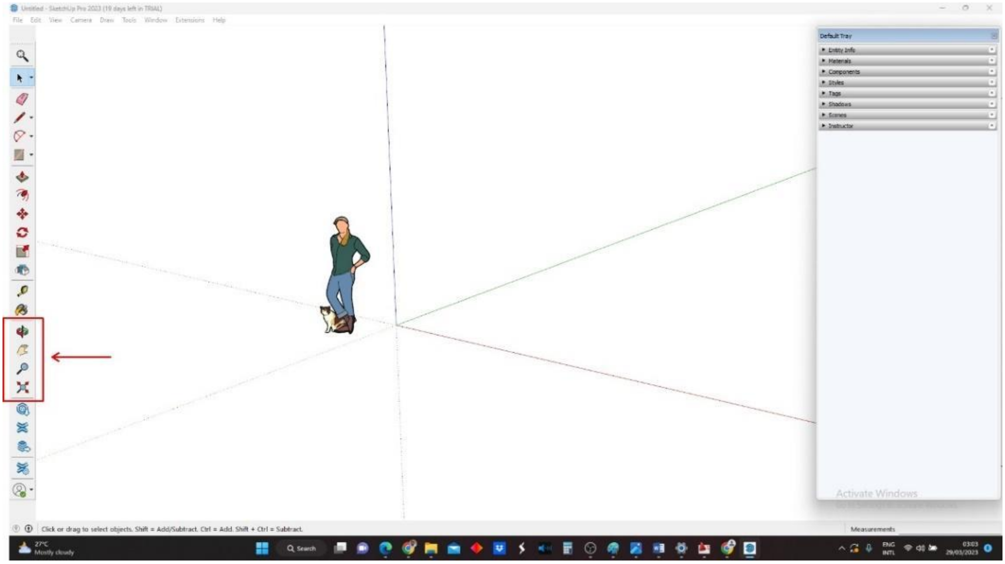


Figure 6. *Users must get to understand the predefined tools of the software.*

Creating and modifying 2D drawings, including basic shapes, lines, and curves. Showing visual elements of line, form, texture, colour, and visual weight, and principles of proportion, order, repetition, and unity are used to create spaces, connect them, and make them visually pleasing to the eye.

If using Google SketchUp, you can import the following 2D file formats: DWG, DXF, .3DS, DEM and KMZ.

Creating and modifying 3D models, including terrain with sandbox tools as the medium. Using aerial photos imported of traced contour lines to transform into Triangulated Irregular Network (TIN).

Materials, textures, creating realistic landscapes, colours, and environments.

You also have the option to choose to design on the Google SketchUp software or import a file from a compatible CAD software such as Autodesk AutoCAD in .dwg/.dwf format.

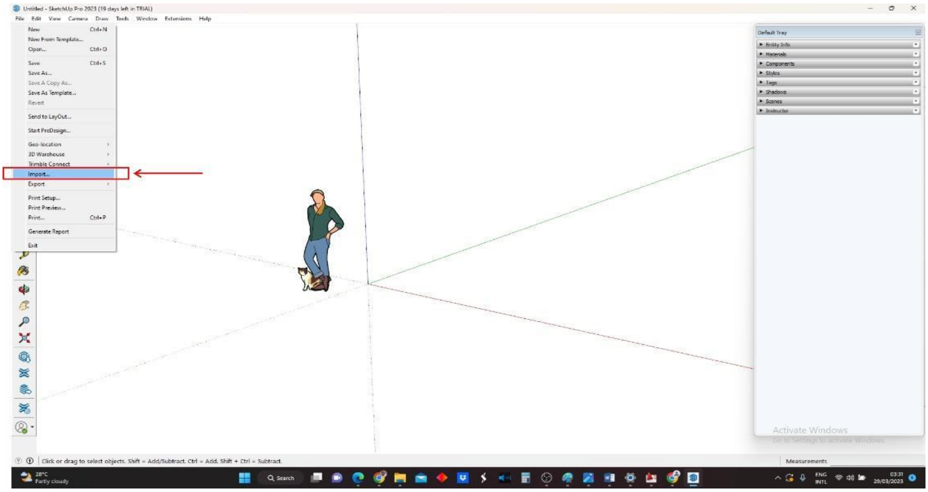


Figure 7: *Drop down window showing the 'import' label.*

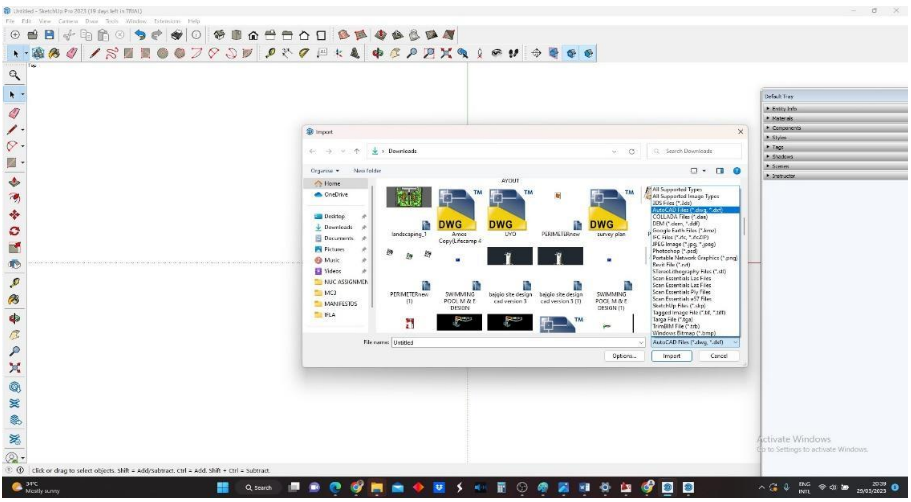


Figure 8: *The format of the file must be selected e.g .dwg,.dwf, .kmz file*

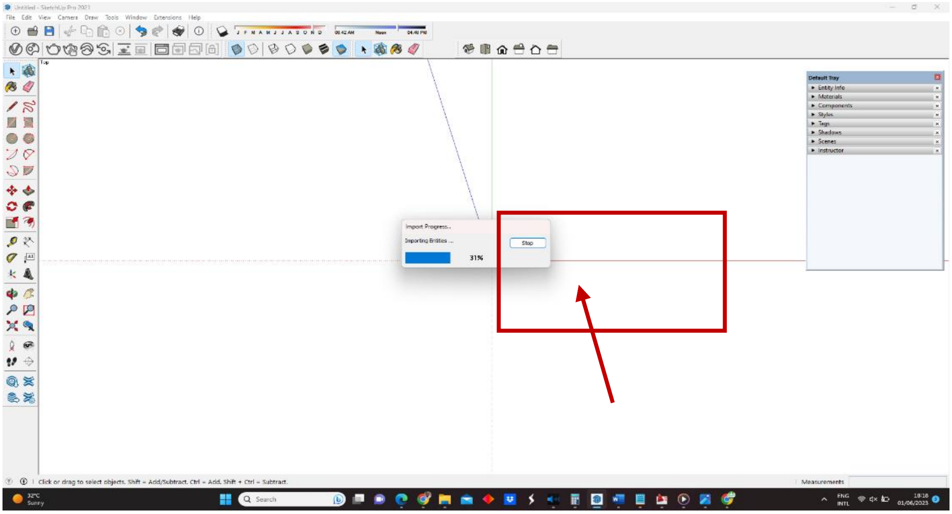


Figure 9: *Shows the import progress of the 2D CAD file into the 3D work space.*

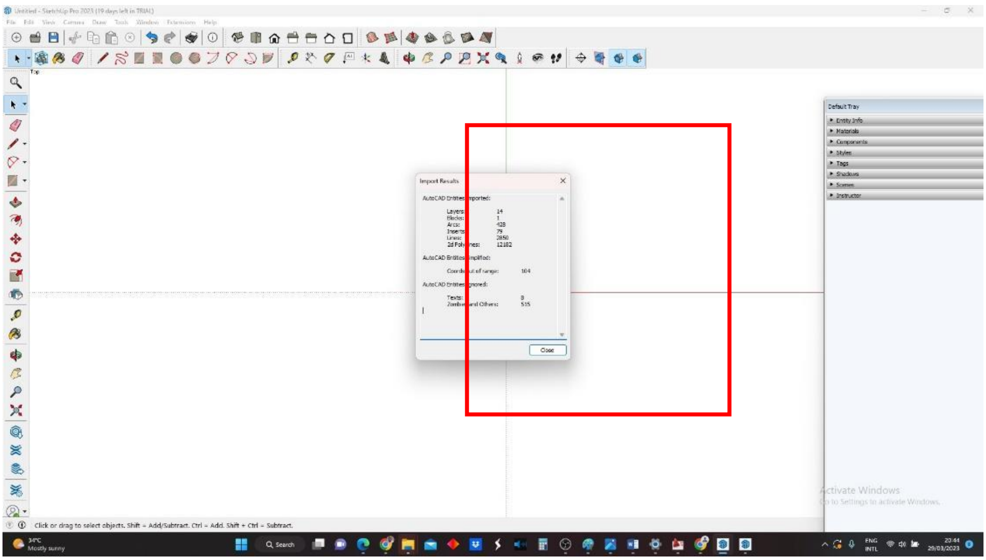


Figure 10: *Files imported come with layers, entities and attributes from 2D plans.*

Visual Styles of the model can be adjusted to other conceptual visualizations. The tool bars below show the illustration.

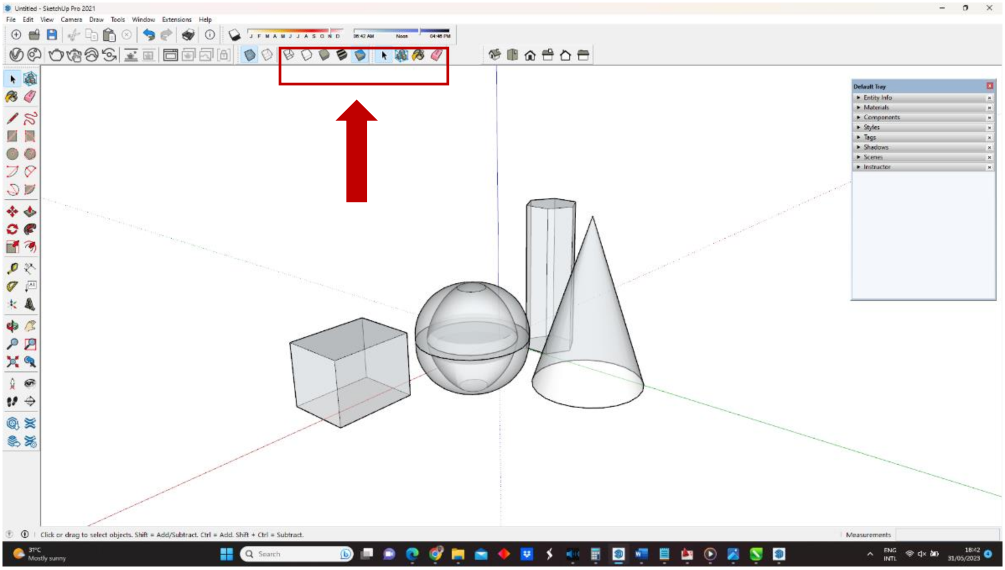
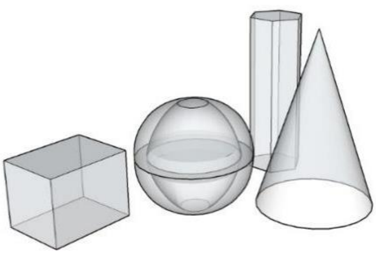


Figure 11: *Shows different visual styles toolbar.*

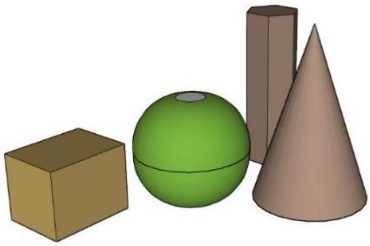
The user can switch between different styles according to the requirements of the project.

For example, **Wireframe/X-ray** displays the wired structure of the drawn 3D object or figure.



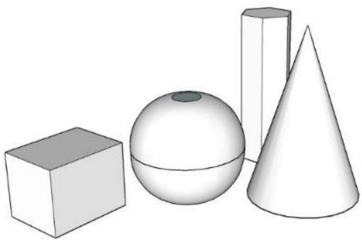
Source: Author’s illustration.

Shaded will display the figure is shaded.



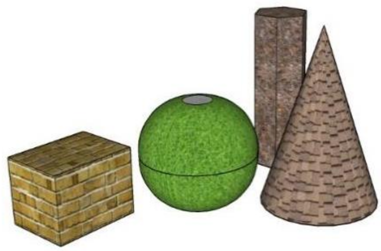
Source: Author’s illustration.

Monochrome displays the model as a single colour.



Source: Author’s illustration.

Shade with textures will display the model with its original shade and texture.



Source: Author's illustration.

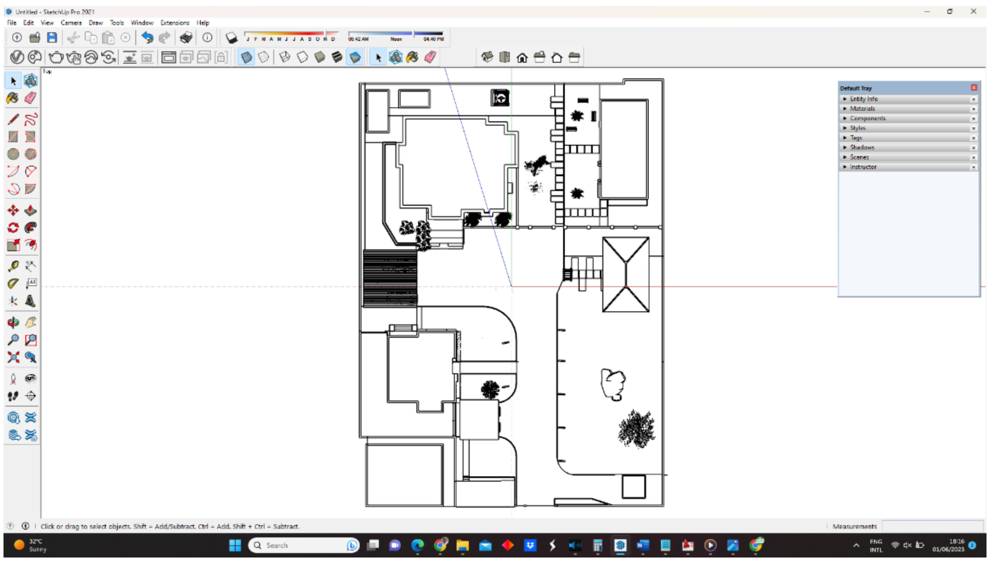


Figure 5: *Shows the imported 2D CAD file the 3D work space.*

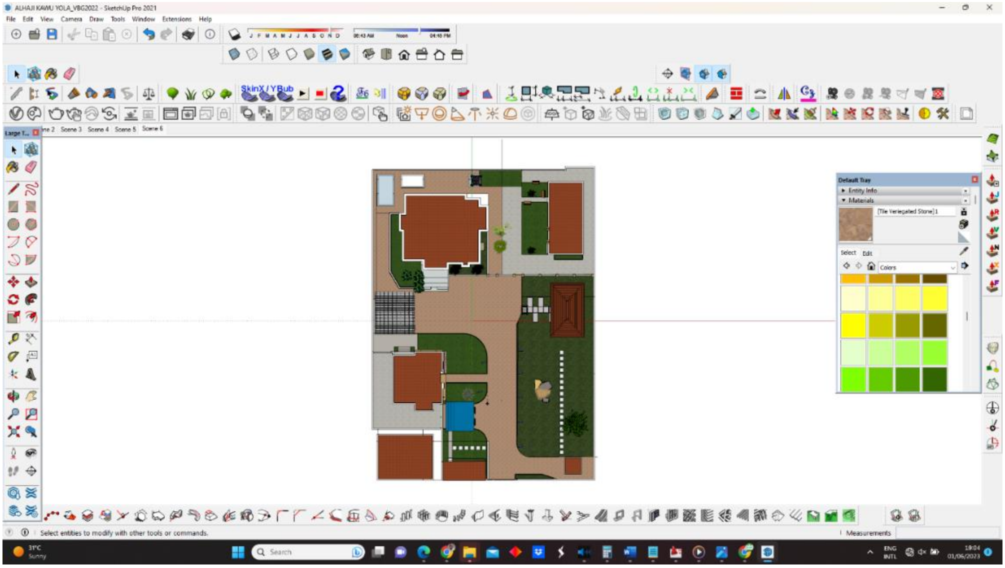


Figure 6: *Apply materials or colours to the floor plan from the materials pallet.*

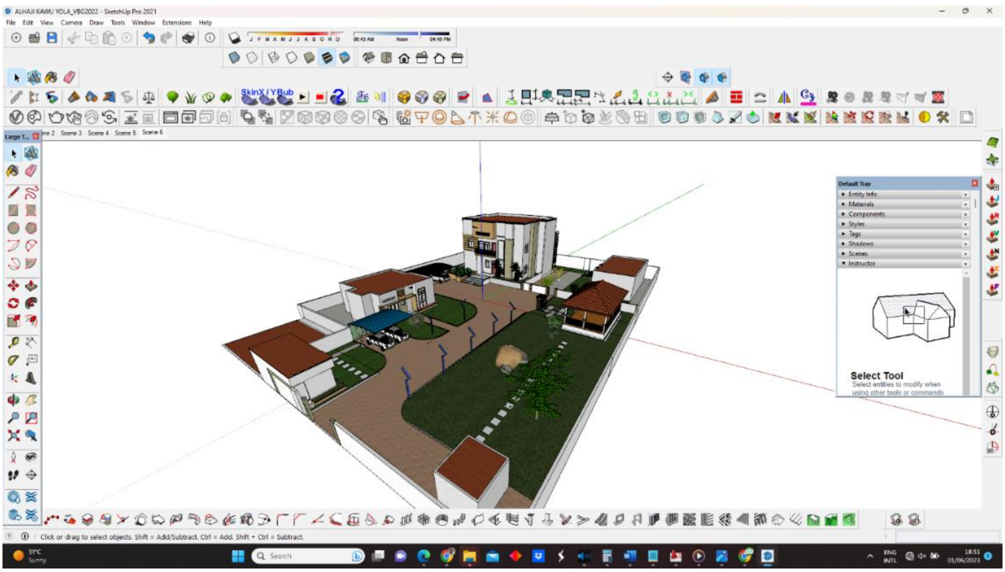


Figure 7: *With a combination of the push and pull tool using the specified measurements a 3D model is generated.*

Landscape Design and Planning in 3D

Start by importing site plan and site survey plan and maps if needed. Students should familiarize themselves with the landscape features on site plans, area and perimeter coverage of landforms and the building line of structures.

Designing landscapes with buildings and topography using (contours) in 3D, including using 3D plugins and extensions to create ponds, berms, hills, slopes etc.

The 'Sandbox tools" are a built-in terrain modelling tool. To enable the Sand box tool, use Extension Manager from the menu bar.

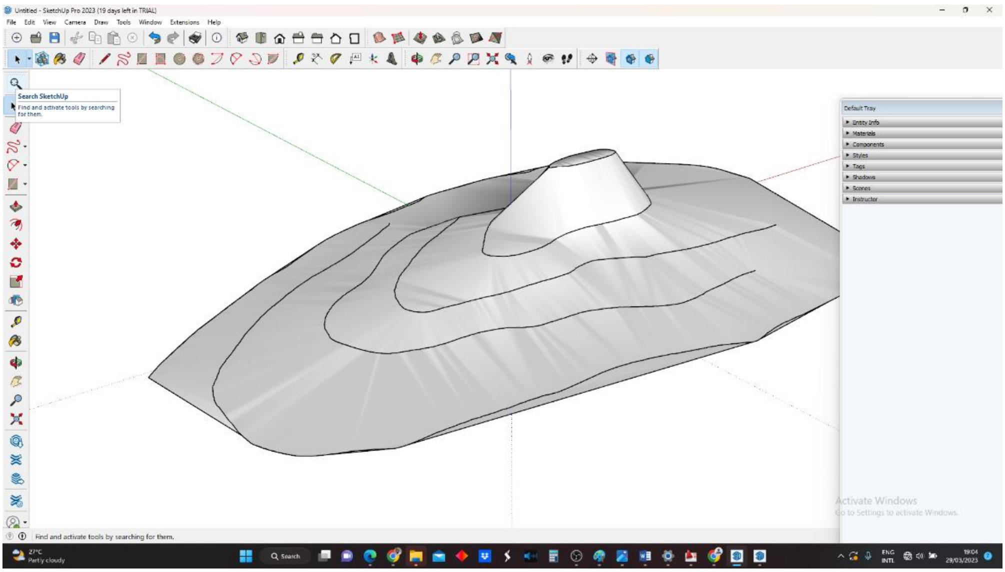


Figure 8. *Terrain generated from contours.*

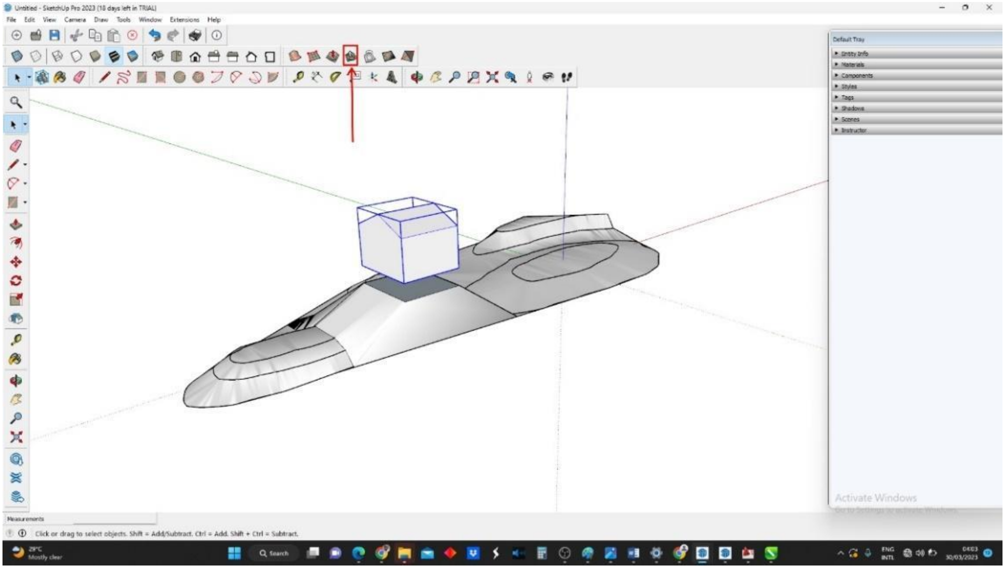


Figure 9: *Building model placed in topography using the stamp tool.*

There are several options to choose from to work with terrain (topography) which include from. Contours (using maps) or from scratch (working in grids).

Applying 3D to Real-World Landscape Architecture Projects in Nigeria

Case studies and examples of landscape architecture projects in Nigeria that used 3D, including project planning, visualisation, and implementation are to be sourced and used.

Best practices and tips for applying 3D to real-world projects in Nigeria, including working with other design professionals, creating project timelines, and managing project budgets.

Overview of the role of 3D in the Nigerian landscape architecture industry, including trends, opportunities, and challenges. Collaboration and communication in 3D design.

Design Studio by collaboration and communication

Exercises and projects designed to practice landscape design with 3D in a studio setting, by developing site plans and survey plans into topographic models for the terrain including the building and other landscape features on the plan in 3D models.

This should evolve around class simulation of working with:

1. Clients and stakeholders
2. (Studio peers, including developing teamwork skills.

Group critiques and feedback sessions to improve designs, including peer review and professional feedback.

Summary

Outline started by introducing the core differences between 2D and 3D CAD in landscape architecture and design. The important role of 3D CAD modelling in landscape design and landscape planning in the visualization of conceived designs and problem-solving implementation etc. Manipulation Survey data to create realistic 3D models. 3D software preference based on complexity and accessibility.

This course will provide students with a strong foundation in 3D software and its application in landscape architecture design, specifically in the Nigerian context. Students will develop critical thinking, collaboration, and communication skills, as well as gain practical experience in designing landscapes in a studio setting. By the end of the course, students will be able to create detailed 2D and 3D models. Develop proficiency in using 3D software for designing landscapes with buildings and topography.

1. Create detailed 2D and 3D models and visualizations of landscape designs using 3D, including site analysis and surveying.

2. Design landscapes with buildings and topography in a studio setting, with a focus on collaboration, communication, and critical thinking.
3. Apply 3D to real-world landscape architecture projects, including case studies and examples of 3D in use.
4. Students will develop skills and style of work to form the basis of their extended study.

Exercises:

Obtain a site layout plan of a private residential plot including the survey plan.

1. Create a terrain landscape using basic contour outlines.
2. Create a 2D layout for buildings, and water pond and planting.
3. Stamp the 2D layout on the terrain (topography).
4. Develop a 3D model of all the objects on the model.
5. Discuss the role of 3D CAD on the landscape design industry in Nigeria.

Reference

Nijhuis, S., & Stellingwerff, M. (2011). 3D-models in landscape architecture. *Envisioning Architecture: Proceedings of the 10th Conference of the European Architectural Envisioning Association*, *September*, 197–208.

Books and Additional Study Resources

1. Ayeni, D.A and Adegunloye, O. (2021). Learning AutoCAD, the Simple Way. University Press Plc. ISBN:978 -9789408924 . On Amazon and Okada Books.
2. Ching, F. D. K., & Juroszek, S. P. (2018). Design drawing (3rd ed.). Wiley.
3. Digital Drawings for Landscape Architecture 2nd Edition Brandley Cantrell & Wes Michaels, Published by Wiley. ISBN-10- 1118693183, Publication date 3rd November, 2014
4. Modelling the Environment: Techniques and Tools for 3D Illustrations of Dynamic Landscapes, Bradley Cantrell 7 Natalie Yates, 1st Edition Publisher Wiley Publication date 27th March 2012, ISBN-10- 0470902949
5. McLeod, V. (2011). Drawing for landscape architecture: Sketch to screen to site. Thames & Hudson.
6. Rendering in SketchUp: From Modelling to Presentation for Architecture, Landscape Architecture, and Interior Design 1st Edition by Daniel Tal. ISBN-978-0470642191.First edition. Wiley. Publication date March 25, 2013.
7. SketchUp for Site Design: A Guide to Modelling Site Plans, Terrain, and Architecture 2nd Edition by Daniel Tal ISBN 978-1118985076. Second edition. Publisher Wiley. February 15, 2016
8. Van der Meer, D. (2018). The power of landscape architecture: Designing the future. BIS Publishers.
9. 3D software and tutorials, available online and in the classroom.
10. Additional resources, including online forums, professional organizations, and industry publications.

BIODATA OF DEBORAH WANYA NENCHI AND ATUMYE AMOS ALAO

Deborah Wanya Nenchi is presently an adjunct lecturer at the Bingham University, Karu, Nassarawa State.

She served 35 years meritoriously in the Civil Service and attained the position of Directorship cadre. Her passion is to create awareness for the landscape architecture profession and education. goals are to make people develop a passion to learn because knowledge is power and the passport to today and the future.

She has a first degree in Geography from Ahmadu Bello University, Zaria (1982), and a Master's in Philosophy in Landscape Architecture from the University of Edinburgh, United Kingdom (1986). She has previously served as the President of the Society of Landscape Architects of Nigeria (SLAN) and a Fellow of the Society, were she pioneered many landscape architecture innovations in the country, and served as Mentor to many graduates of landscape architecture in exploring career opportunities and setting goals.

Wanya is an adjunct lecturer in the Department of Landscape Architecture at Bingham University, Karu, Nassarawa State, a PhD researcher at the Ahmadu Bello University, Zaria. She has several published works and conference paper presentations and sundry signature landscape projects.

Her hobbies are reading, travelling and a passion for nature. She is happily married with four children.

ALAO, Atumye Amos is a registered Landscape Architect and Urban Planner, a certified Project Manager, Health and Safety Environment Professional. He earned a B.Tech. in Urban and Regional Planning from the Federal University of Technology Minna, a Masters in Landscape Architecture from the Ahmadu Bello University, Zaria.

He is Member of the Nigerian Institute of Town Planners (NITP), Town Planners Registration Council (TOPREC), Society of Landscape

Architects of Nigeria (SLAN), Nigerian Institute of Management (NIM) and the Institute of Safety Professionals of Nigeria (ISPON).

He is a practitioner of Therapeutic, Biophilic and Xerophytic Landscape ideologies and has authored a book titled, "Plant Photobook for Greenhorns". He has several scholarly articles to his credit.

He has served as Secretary-General of the Society of Landscape Architects of Nigeria (SLAN) and is presently the 5th elected President Society of Landscape Architects of Nigeria. He also currently serves as the Secretary-General of the International Federation of Landscape Architects Africa (IFLA Africa).

He is a lecturer in the Department of Landscape Architecture at Bingham University, Karu, Nassarawa State and doctoral candidate of Environmental Resource Planning (ERP) at the Department of Geography, University of Abuja.

His hobbies are watching documentaries, reading biographies and gardening.

CHAPTER SIX: INTRODUCTION TO SUSTAINABLE BUILT ENVIRONMENT

Definitions of Concepts Associated with Sustainability

Mike Adebamowo, *University of Lagos* **& Akunnaya Pearl Opoko,** *Bells University of Technology, Ota*

Overview

The built environment has been identified as a major driver of unsustainable practices. Consequently, there is increasing clamour for the adoption of sustainable practices in the built environment. The Architecture profession is a key player in the development of the built environment. In order to contribute to the sustainable development of the built environment, students of Architecture need to understand the core concepts of sustainability.

This text provides a historical background to the evolution of sustainability, its definition and key components. It proceeds to provide an overview of core and emerging concepts associated with sustainability with specific reference to Architecture. It also provides understanding of sustainable architecture, its principles, strategies and methods.

Objectives

The main objectives of this text are to:

1. describe the evolution of sustainability and its link with the built environment;
2. identifying the various concepts of sustainability as they relate to architecture;
3. equip the students to identify and explain the relationship between the components of sustainable architecture;

4. equip the students to identify and explain the relationship between the components of sustainable architecture; and
5. describe the principles, strategies and methods of sustainable architectural design.

Origin of Sustainability

It is possible to connect the origins and evolution of sustainability to environmentalism. This was created in response to resource depletion and pollution caused by the industrial revolution. Carson (1962), who wrote the silent spring, described a world that was void of life due to the dangers of industrial chemicals. The First Earth Day, which was established in 1970, was another important publication that helped to establish the American environmental movement. Earth Day promotes awareness and appreciation for the earth's natural environment. These, along with the Club of Rome report, known as the limits of growth in the 1970s, led to the First United Nations Conference on the Human Environment in Stockholm, 1972. At the Stockholm Conference, an agreement was reached on acceptable behaviour and responsibilities for protecting the environment. The international oil embargo and the energy crisis of the 1970s led to increased interest in energy efficiency and alternative energy sources, including solar and wind power (Pearce et-al, 2017).

Definition of Sustainability

The term "Sustainable Development" actually was first used in 1969 at the world conservation strategy conference (Pham et-al., 2021). The world conservation strategy aims to promote sustainable development by conserving living resources. The Brundtland Report on Environment and Development was the first to popularize sustainable development. This report defines sustainable development as "Development that meets the current generation's needs while not compromising future generations' ability and aspirations". Three components are also called the "critical objectives" **Triple Bottom Line** or three pillars of sustainability are Environment, Social and Economy as shown in Figure 1. Brundtland argued that economic systems and social systems cannot be separated from the "carrying ability of the environment" - that is, that growth and social welfare must be balanced with the conservation of natural resources by the current generation for future generations (Edwards 2010).

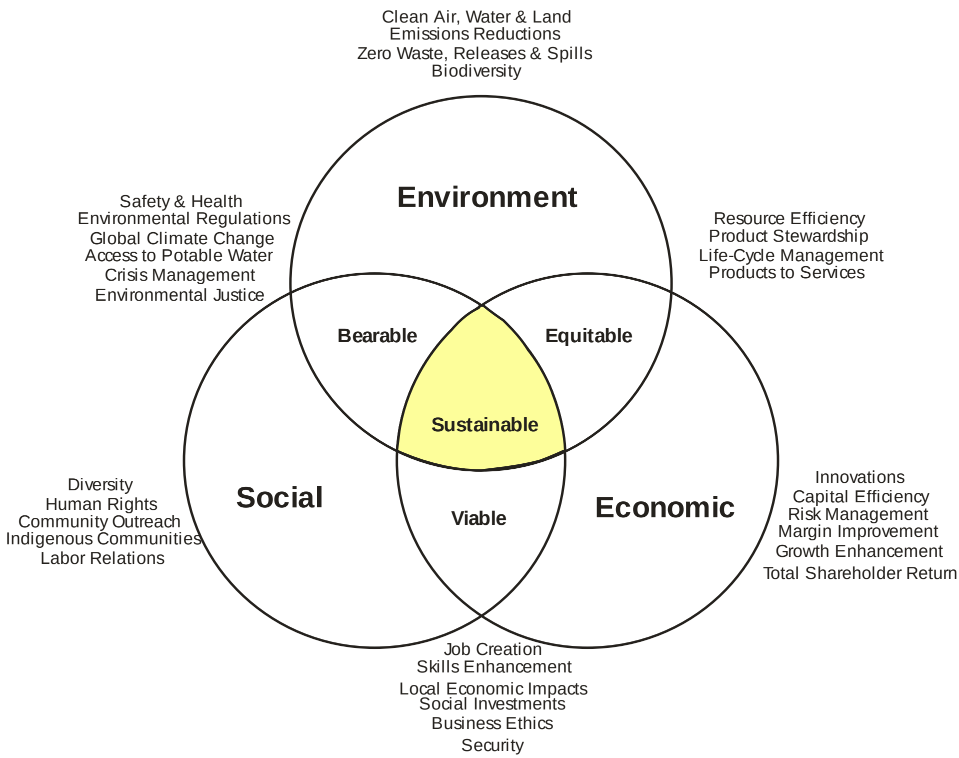


Figure 1: *Triple Bottom Line Factors*
Source: Pearce et-al (2017)

Sustainability requires thinking about the future. As designers, our decisions and actions today will have a major impact on the planet's future. The primary goal of the designer is to improve the long-term quality of human life and support the ecosystem as well. It is therefore imperative to consider future generations when decisions regarding the environment are to be taken. In other words, be 'your brother's keeper'. Sustainability carries a powerful message of 'love'. Love one another and fulfill the holy word that says let no one seek his own, but each one the others' wellbeing.

This is averse to selfish thinking in which people live their own lives, and consider their own needs and wants first before those of others. Everyone has a responsibility to live safely but this must be done in a manner that will not constitute danger to others. When an individual considers only himself, the tendency is that he will be oblivious of the plight of others. For instance, in a buffet, you have the right to take as much as you can, but you must consider the next person. So, you must intentionally decide to leave some layers of meat (for it may not be replaced as quickly as possible); the fact that you have your neighbour in mind signals a message of sustainability. Sustainability is a consideration for those coming behind us.

Concepts Associated with Sustainability in Relation To Architecture

Concept in Architecture

Design concept is the main idea, philosophy or central thought that provides the much needed direction to solving the design problem identified in any given design project. A concept may be one clear single overarching idea or series of similar ideas that connect around a theme. It may easily arise at the start of the project or it may slowly appear later as ideas are tested, experimented and explored. A concept can also be a belief, inspiration, intention, notion, theory, principle, impression or an idea about space, structure, nature and human experience. It can be derived from the design brief, programme, users' needs and aspirations, site context, topography, geometry, structural and environmental domain; social, economic and cultural conditions and its expressed with materials and technology through understanding of design elements and principles.

Vernacular Concept in Architecture

Vernacular Concept in Architecture is an approach of designing buildings that are indigenous, simply utilizing local materials and resources of a place, well tried traditional forms and types with a blend to the climate of the place. Vernacular Architecture is characterized by features that are not only responsive to the environment and climate but also to social, cultural and communal use. The use of local materials focuses more on function rather than beauty. It is also referred to as Folk Architecture and is fitted into the environment by people with native wisdom in accordance with traditional methods. One of the main techniques of Vernacular Architecture is found in the use of timber-frame construction, sun-dried brick wall or Adobe, rammed earth or Atakpame wall, thatched roof, raffia palms etc. (Figures 2-4)

Figure 2: Clay *Houses decorated with low-relief ornament and vibrant designs, Zaria*
Source: ArchDaily (2021)

Figure 3: *Afro-Brazilian two-storey, multi-family (rooming) house, Ilesa*

Figure 4: *Modern Vernacular: Primary School in Gando, Kéré Architecture Source:* ArchDaily

Organic Concept in Architecture

The organic concept in architecture is a way to design buildings that are inspired by, built around, and blend with nature and its natural surroundings. Frank Lloyd Wright, an American architect, coined the term Organic Architecture. This design concept not only strives to integrate buildings with their surroundings but also makes use of natural materials and incorporates landscaping into the design. Some of the main characteristics of organic architecture include simplicity, harmony with surrounding landscape and natural in color and appearance. (Figures 5-7). Organic Architecture aims to create an ecosystem in which building materials and construction components support each other, thereby creating a structure that is part of the natural habitat.

Figure 5: *Falling Waters by Frank Lloyd Wright*

Source: Architecture Digest (2023*)*

Figure 6: *Modern Organ Design: Sydney Opera House*

Source: Kanchwala (2022)

Figure 7: *Mapungubwe Interpretation Centre, Zimbabwe, by Peter Rich Architects*

Source: Re-Thinking the Future (2022)

Bioclimatic Concept in Architecture

Bioclimatic Concept in Architecture refers to a way of designing buildings that are influenced by the local climate, with the goal of providing thermal comfort through the use of environmental resources. Bioclimatic is a combination of two words - Bio (life) and Climate. It employs design strategies that reduce solar radiation and promote natural ventilation and lighting, thus providing comfortable conditions in buildings for the physiological and psychological needs of the occupants. The Bioclimatic Concept uses available natural resources in the design of buildings viz a viz: sun, vegetation, rain, wind etc. It's related to the idea of self-sufficiency and aims at reducing the environmental impact caused by fossil fuels and climate change and improving energy efficiency using passive means. (Figures 8 & 9)

Figure 8: *Unilag Senate Building*

Source: Alumni Association (2021)

Figure 9: *Unilag Senate Building*
Source: Alumni Association (2021)

Passive Design Concept in Architecture

Passive Design Concept refers to a way of designing buildings that uses the natural movement and passive solar heat gain and loss, as well as cooling to maintain comfortable internal conditions. Passive design is based on the principles of circulation, shading, overhangs, and insulation. It also includes double or triple glazing, thermal mass, and insulation. Passive design is the creation of buildings that are extremely tight in cold climates. It also minimizes interior sources of poor air quality like combustion appliances and off-gassing materials. Outside air is provided ventilation. Better building enclosures allow for greater aesthetic freedom and excellent energy performance. (Figure 10)

Figure 10: *The Institute of Venture Design Student Hostel by Olumide Olusanya*

Source: Adebamowo & Ilesanmi (2012*)*

Ecological Concept in Architecture

The Ecological Concept in Architecture refers to a humane way of designing buildings that preserve the environment and ecology, and foster a healthy relationship between humans with their surroundings. This design minimizes environmental damage by integrating with natural processes and the patterns, flows, and cycles of nature. This approach focuses on controlling behaviours that naturally occur, and focusing on aspects of the animal and environment that influence success and failure of behaviour. The concept emphasizes harmony between the built environment and the natural conditions in the surrounding areas. (Figure 11)

Figure 11: *Garden Atrium Apartments by Olumide Olusanya*

Green Concept in Architecture

Green Architecture Concept is the use of resources-efficient and environmentally responsible processes throughout a building's life cycle. From planning, construction to demolition, green architecture aims at reducing the use of materials during construction of buildings. It also seeks to reduce the environmental damage that is caused by the emissions, pollution, and waste of its components. Green architecture ensures that either less waste is produced, or wastes produced are biodegradable and more efficient use of renewable energy is employed. The three main components of green architecture include **reduce, reuse** and **recycle**. Reduce refers to reducing the amount of material used in a building via redesigning. Reuse is the idea of fabricating building components from materials that can be reused again. Recycling refers to the reprocessing of building components at the end of their life cycle into a new material that can then be processed into new parts. (Figure 12)

Figure 12: *John K. Randle Centre, Onikan, Lagos by Si.Sa*

Low-Carbon/Zero-Carbon Concept in Architecture

Low Carbon, Zero-Carbon or Net Zero-Carbon Concept in Architecture is a holistic approach to designing buildings that are energy efficient, environmentally friendly and minimize greenhouse gas emissions from building materials, components and operations. Low-carbon buildings are those that emit very little carbon over their lifetime. Zero-carbon buildings are highly efficient and have no carbon emissions. Net zero-carbon buildings have a significantly reduced energy consumption due to efficiency gains. To achieve a good net zero energy/carbon building design, three measures must be taken into consideration. They are: **Building envelope measures**, **energy efficiency measures** and **renewable energy measures**. Net zero is all about balancing or cancelling out any carbon produced. This is when the amount of greenhouse gas produced is no more than the amount taken away. (Figure 13)

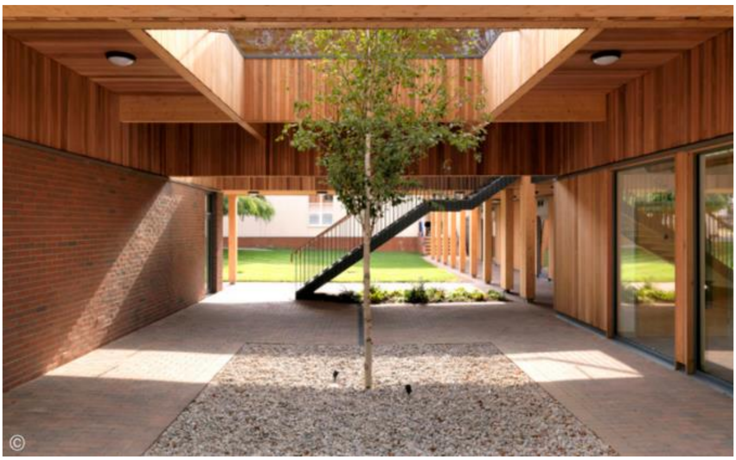


Figure 13: *St. Theresa's 6th Form School by Charles Hosea*

Source: Arch Daily (2022)

Biomimetic Concept in Architecture

This concept entails the usage of nature's biological world as inspiration and as a guide for the creation of new materials. It's a combination of the two words Bio and mimetic. Bio means life or living organisms while mimetic means imitating, mimicking, or representing something. Biomimetic Architecture therefore would mean using the knowledge of living organisms to solve architectural design problems resulting in anything from structural engineering even to lighting with a common goal of sustainability. Biomimetic Architecture operates at three different functional levels. Firstly, at the organism level, where form and function of an organism is applied to the design of the building. Secondly, at the behavioural level, where the interaction between an organism and its environment is applied to the building design. Thirdly, at the ecosystem level, where the interactions of the many parts in an environment are applied to projects of a scale larger than a single building. (Figure 14)

Figure 14: *Eastgate* **Centre, Harare–inspired by termites.**
Source: Livin Spaces (2020)

Restorative Concept in Architecture

Restorative Architecture is one that creates a built environment promoting wellness and economy through conservative and a more meaningful connection to nature. Restorative Architecture is a holistic approach to design which seeks to restore harmony between people, nature, and the immediate environment. It promotes sustainable design, the use of renewable energy and natural resources to ensure a secure, fair, and resilient future. Restorative refers to the restoration of social and ecological systems in a healthy condition. Restorative is a cycle of repair, reuse, and endless use.

Regenerative Concept in Architecture

Regenerative Architecture refers to the use of the natural world as a means and initiator of architecture. It uses the natural and living systems within the immediate site to craft the building blocks of architecture. Regenerative is the ability to allow social ecological systems to remain healthy and evolve. Regenerative refers to a cycle of life that improves and maintains ecosystem functionality. Regenerative design is about creating an environment that has a positive net effect on the natural world.

Resilience Concept in Architecture

Resilience Concept in Architecture is an approach to designing the built environment to sustain probable impact from climate and episodic natural disasters. In other words, it is the intentional design of buildings, landscapes, communities and cities with the aim of responding to natural and manmade disasters, disruptions, pandemic and climatic changes. For instance, the mitigation and adaptation of climate change impacts designing buildings and communities along the coastal region of Nigeria against flooding or heat waves in the hot dry climatic zone of Northern Nigeria. Resilient Architecture therefore can be defined as that which is capable of rapidly recovering from manmade and natural disasters and returning to its original form after the catastrophic disruptions. Also referred to as Climate Resilient Architecture, which would successfully withstand serious damage such as severe flooding or droughts and heat waves.

Circular Economy Concept in Architecture

This concept is aimed at keeping raw materials in a closed loop. It is based on three principles driven by design: (Reducing) Eliminate waste and pollution, circulate (Reuse) products and materials (at their highest value) and regenerate nature. In addition, the concept of

Rethink, Refuse, Reduce, Reuse, and Recycle are ascribed the 5 R's of the circular economy.

The application of Circular Economy concept in Architecture involves design and construction of buildings where the materials and components would undergo the use, deconstruction, reuse, recycle and back to the material for constructions. With the construction industry responsible for over 30% of total waste in Nigeria, the need for a more sustainable circular economy approach is imperative. The concept of a circular economy is about reusing and repurposing rather than demolishing, employing sustainable materials, minimizing waste and energy use and connecting to nature. (Figure 15&16)

Figure 15: *Circular Economy*
Source: Bolland (2023)

Figure 16: *Modular, interactive containerized classrooms – Vetland Junior Grammar School, Agege*

Sustainable Architecture

Many studies have employed various terms to explain this kind of architecture. For example, while there are the early vernacular and organic designs in the 1970s, the bio-climatic and passive designs were trendy in the 1970s and 1980s respectively. In the late 1980s and early 1990s, green and ecological designs were fashionable. However, from the mid-1990s till date, what has been in vogue includes: Sustainable design, low-energy design, zero energy, net energy design, low-zero and net-carbon design. These terms are often used interchangeably to describe environmentally responsive and energy efficient buildings.

Sustainable architecture is an all-encompassing terminology used to describe architectural designs that are based on one or more of the various concepts enumerated above. It begins with incorporating site features and environmental conditions to choosing materials that are ecological and possesses minimum negative environmental impact. Sustainable architectural design integrates green architecture, recycled materials, renewable energy resources, and natural ventilation, reduces heat gains in buildings etc. basically sustainable architecture reduces energy consumption and improves standard of living by incorporating natural materials. (Figure 17).

Adebamowo (2011) states that a building can be designed to be environmentally friendly (e.g., low energy consumption, sustainable resources use) but it may not be sustainable because society rejects it or is too expensive to operate. Pearce et al. (2017) advocate the Triple Bottom Line approach to sustainable construction. Sustainable development should be bearable, equitable and viable. See figure 1. It is worthy to note that technology is playing a great role in all the various kinds of Sustainable Architecture and providing various innovative options.

Figure 17: Makoko Floating School by Nlé Architects

Source: ArchDaily (2020)

Principles, Strategies and Methods of Sustainable Architecture

Three levels of conceptual framework: **Principles**, **Strategies** and **Methods** were developed by Kim and Rigdon (1988) to explain sustainable architecture design. This framework has been modified by the author as illustrated in Table 1 to explain sustainable architecture.

Sustainable Building Assessment Tools

In order to support the implementation of more sustainable practices, the Sustainable Building Assessment Tool was developed. This tool also aims to develop awareness and support for sustainability clients, stakeholder clients, builders etc. The sustainable building assessment tools give some measure of attention to the quality of the indoor environment. LEED (Leadership in Energy and Environmental Design) and BREEAM (BRE Environmental Assessment Method) are the two most widely used tools. Others include Green Star (Australia), Green Mark (Singapore), and Energy Star rating (South Africa) and Green Building Journal (Nigeria).

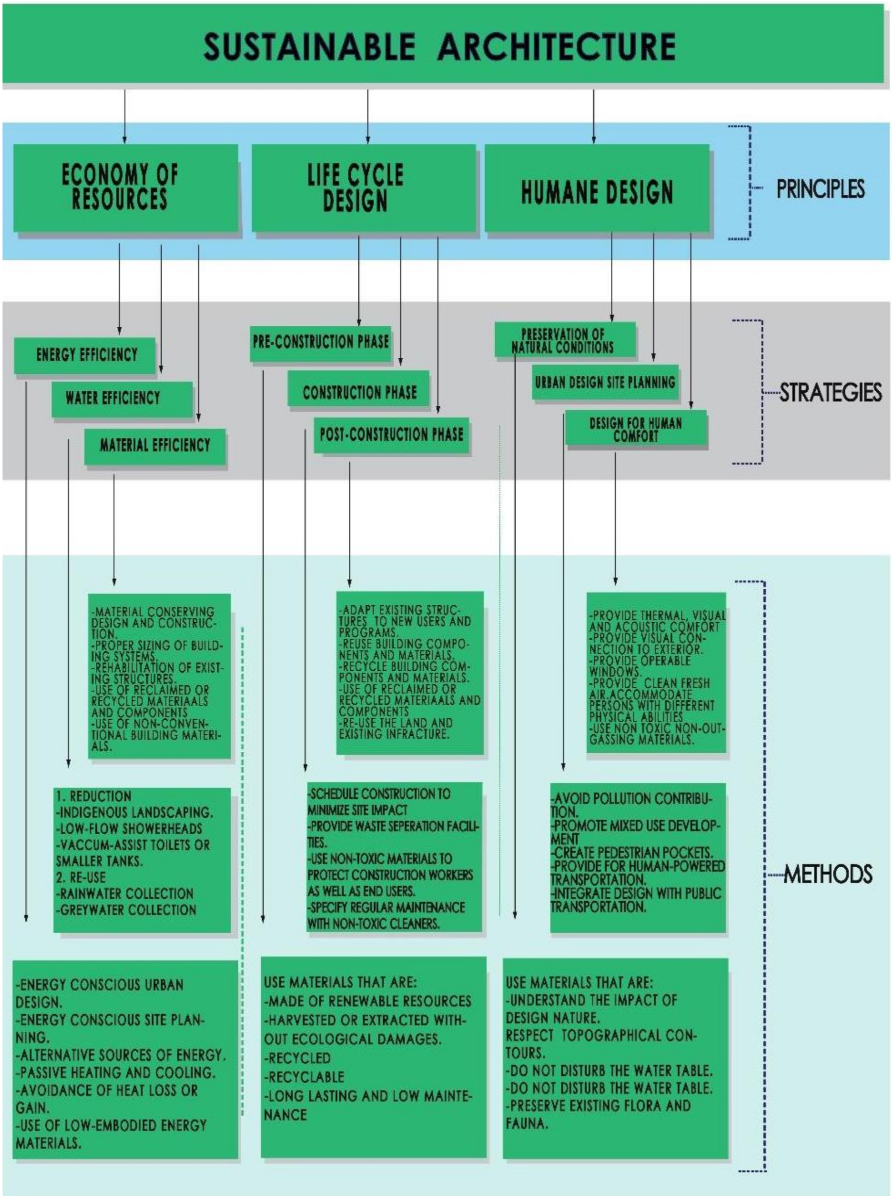
Summary

The chapter provided the origin and definition of sustainability. It also identified various approaches through which the sustainability goals can be realized. It further provided several sustainability concepts relevant to Architecture. In addition, it outlined the components of sustainable Architecture, its principles, strategies and methods. It established that sustainable architecture is not a style but an approach because all the styles form modernism, postmodernism and deconstructivism all imbibe the principles of sustainability into their design.

Exercise

1. What is sustainability?
2. How should sustainability guide the work of designers?
3. Describe three sustainability concepts relevant to Architecture.
4. Explain the relationship between the components of sustainable Architecture.

Table 1: Conceptual Framework of Sustainable Architecture



Source: - adapted from Kim and Rigdon (1998).

References

Adebamowo M.A. (2011):- The Implication of Global Economic Recession on Sustainable Housing in Lagos Megacity. *International Business Research*, vol. 4, no 1, pp. 167-175.

Adebamowo, M. and Ilesanmi, A.O. (2012), "Study of Building Adaptation in Warm Humid Climate in Nigeria", *Open House International*, Vol. 37 No. 4, pp. 72-80. https://doi.org/10.1108/OHI-04-2012-B0008 .drt

ArchDaily (2022), What is Net Zero Architecture, https://www.archdaily.com/977740/what-is-net-zero-architecture

ArchDaily (2021), Maganda, M. *Local Expertise Versus Local Extraction: African Vernacular Architecture and a More Holistic Sustainability*

ArchDaily (2020), Nle Architect's Floating School, https://www.archdaily.com/344047/makoko-floating-school-nle-architects

Architecture Digest (2023), Getty Images: Falling Waters, https://www.architecturaldigest.com/frank-lloyd-wright

Bolland C. (2023), Circular Economy: The cornerstone of sustainability. RPS Group. https://www.rpsgroup.com/insights/consulting-uki/circular-economy-the-cornerstone-of-sustainability/

Carson, R. (1962):- *Silent Spring*, Houghton Mifflin, Boston MA.

Edwards Brian (2010):- *Rough Guide to Sustainability*. RIBA Publishing, London EC2P 2EA.

Encyclopædia Britannica, Exhibiting contemporary vernacular architecture in Zaria, Nigeria. https://www.britannica.com/art/African-architecture#/media/1/756980/127421

Jakepor (2023), Randle Centre For Yoruba Culture and History, https://www.skyscrapercity.com/threads/jk-randle-center-for-yoruba-culture-and-history.2380706/

Kanchwala, H. (2022), ScienceABC – What is Organic Architecture. https://www.scienceabc.com/innovation/what-is-organic-architecture.html

Kim J., Rigdon B. (1998):- Introduction to Sustainable Design *National Pollution Prevention Centre for Higher Education 430E*, University Avenue, Ann Arbour.

Livin Spaces (2020), Biomimetic Concepts, https://www.livinspaces.net/ls-tv/watch-how-the-eastgate-center-in-zimbabwe-cools-itself-without-air-conditioning/

Nwannekanma, B. 2022. Modular, interactive containerized classrooms ,The Guardian. https://guardian.ng/news/lagos-boosts-schools-system-with-first-modular-interactive-containerised-classrooms/

Pearce, A.R., Ahn, Y.H., & HanmiGlobal Co, Ltd, (2017). Sustainable Buildings and Infrastructure: Paths to the Future (2nd ed.). Routledge. https://doi.org/10.9774/gleaf.9781315562643

Pham, D. C., Do, T. N. A., Doan, T. N., Nguyen, T. X. H., & Pham, T. K. Y. (2021). The impact of sustainability practices on financial performance: empirical evidence from Sweden. *Cogent Business & Management*, *8*(1), 1912526.

Rethinking the future – Architectural Styles (2022) 8 Instances of Vernacular architecture influencing Modern architecture in Africa. https://www.re-thinkingthefuture.com/architectural-styles/a2184-8-instances-of-vernacular-architecture-influencing-modern-architecture-in-africa/

The Alumni Association (2021), Notable Places In Unilag, https://www.unilagalumniassociation.org/portfolio-item/notables-places-in-unilag/

BIODATA OF PROFESSOR MICHAEL ADEBAMOWO. B.SC.; M.SC.; PH.D; FNIA

Professor Michael Adebamowo, the Executive Director of University of Lagos Business School is a seasoned architect and sustainable architecture specialist with interest in thermal comfort, architectural science, indoor environmental quality and energy use in buildings. He had his BSc and MSc degrees in Architecture at University of Ife, (now OAU) and later obtained Master of Architecture, (MArch) degree with Distinction at the University of Lagos and Ph.D degree in Geography and Planning with specialization in Building Climatology at Lagos State University, Ojo

Mike Adebamowo joined the service of the University of Lagos in 1995 and has served the University in various capacities, as Head, Department of Architecture Dean of the Faculty of Environmental Sciences and currently a member of the University Council. The erudite scholar has over 40 publications in National and International Journals and one of his publications won the best paper award of Emerald in 2018.

As a Consulting Architect, he has designed and supervised many building projects notable among these are the Golden Park Estate, Lekki, remodelling of Faculty of Arts Building, Unilag; Martinos Event Centre; R&A City Hotel Ikeja; The Summit Hall; Multi-Storey Car Park for Island Club; and The Citadel Church Building and the Redeemers Health Village. All these projects have a positive impact on the environment. He is a member of Network for Comfort and Energy Use in Buildings (NCEUB) UK, member American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), Fellow of the Society of Environmental Toxicology and Pollution Mitigation (SETPOM) and Fellow of the Nigerian Institute of Architects (NIA). He has supervised over 350 Masters and 15 PhD Students successfully and managed research grants.

Sustainability and the Built Environment

Prof. Arc. Evelyn L. A. Allu-Kangkum *University of Jos, Nigeria.*

Overview

As the world population increases, there is greater concern for sustainable development, making the sustainable requirements and expectations from the built environment become more demanding. This is because the built environment is largely responsible for the causal contributor to the greenhouse emissions and this necessitates the global increasing attention towards sustainability in the built environment. Sustainable built environment is a multi-dimensional subject in nature which covers the environment, society, and economy perspectives. Therefore, the knowledge of sustainable built environment would help improve and ensure the global agenda for sustainability.

This text introduces and builds upon previous knowledge of sustainability and the built environment. It also explores and showcases new opportunities and strategies for sustainable choices. Thus, the course equips and guides students in future applications and at the same time serves as advocates for sustainable design.

Objectives

The learning objectives include to:

1. expose students to leading issues on sustainability and the built environment;
2. describe the relevance and importance of sustainability and the built environment;
3. identify the challenges and strategies for sustainability in the built environment;

4. identify the opportunities for sustainable architecture through national and international case studies; and
5. apply sustainable options to building designs.

Introduction to sustainability and the built environment:

Basic definitions of key words are given as follows:

1. **Definitions:**

a. The built environment- This includes all buildings, infrastructural elements and living spaces that are created, or modified, by humans (Sarkis et al. 2014). Thus, the built environment comprises all designed spaces where we live and carry out all our activities.
b. Sustainability – The United Nations 1987 Brundtland Commission Report, referred to as "Our Common Future" notes that, sustainable development is any development that ´meets the needs of the present without compromising the wellbeing of future generations´ (World Commission on Environment and Development, 1987). The Commission’s report describes three pillars/dimensions/perspectives of sustainability as: environmental, economic, and social-political.
    1. The environmental dimensions or component recognizes the interdependence between living systems and finite natural resources.
    2. Whilst the economic dimensions or component relates to man-made resources, the flow of human capital and man-made resources and productive human activity.
    3. Lastly, the socio-political pillar refers to the relationships between human institutions and their systems and the ability for collective decision-making.
    4. Sustainability is only achieved when all three pillars are balancing because achieving any does not amount to sustainability.

a. Sustainability in architecture and construction- deals with discipline related sustainable requirements of the paradigm of sustainability in creative thinking, design, building technologies, innovations, linked with architectural education, knowledge and expertise (Allu, 2018; Celadyn, 2018).

The importance of sustainability on the built environment

The importance of sustainability on the built environment continues to be a concern and its advocacy is global, this is because the built environment has enormous negative impact on the environment – particularly on climate change (Sarkis, et al, 2014; Allu, 2015a; 2015b; Ayarkwa, et al., 2022). Furthermore, the importance of environmental sustainability is significant because it is key in fighting against the climate crisis, excessive energy consumption and resources, and the huge waste generation associated with unsustainable operations (Onyekuru & Marchant, 2011; Opoku, 2016). The solution is to act sustainably in design and construction and to improve the built environment through the applications of Sustainable Development Goals (SDGs) 2030 (Grierson, 2009; Opoku, 2016; Obringer & Nateghi, 2021; Allu-kangkum, 2022). Other interventions suggested are adapting a sustainable framework and creating dynamic modelling (Eromobor & Das, 2013; Allu & Ekele, 2015). Figure 1 shows the 17 itemed SDGs which drive the sustainable agenda globally.

Figure 1. *Sustainable Development Goals (SDGs).*

Source:
https://www.bing.com/images/search?q=sdg+goals+table&form=HDRSC4&first=1

Sustainable Built Environment: Challenges and Strategies.

a. Challenges: a number of challenges were identified to the include the following:
   1. Cost - sustainability requires the use of relatively more expensive materials, technologies with high-cost construction and operations (Wu et al., 2019).
   2. Lack of uniformed Standardization, framework, Certification and lack of consensus on the best practices and appropriate technologies to use (Allu & Ekele, 2015).
   3. Sustainable Materials and Technologies availability are still unfamiliar and limited (Barbosa et al., 2021).
   4. Resistance to Change, long bureaucratic processes and Culture (Graeber, 2015).
   5. Limited sustainable product information (Schoggl et al., 2017).
   6. Long period of processes and complicated technology (Wu et al., 2019).
   7. Inadequate awareness, knowledge and education (Allu & Ebohon, 2015; Ayarkwa, et al., 2022).

b. Strategies for mitigating challenges are suggested to include:
   1. The promotion of economic, social and environmental dimensions at all levels of processes.
   2. Promoting SDGs applications.
   3. Formulate and Sustain policy that will ensure a sustainable built environment.
   4. Education, training and retraining of all stakeholders.
   5. Set sustainable standards, certification and compliance reward system.
   6. Plan to reduce time or long-term goals with short time milestones for sustainable programmes.
   7. Subsidy by the government on sustainable products is encouraged.
   8. Initiate advocacy and capacity building programmes in schools and professional practices.
   9. Showcase and celebrate case studies of sustainable applications within the built environment.

Case studies (sustainability regulations and examples),

National and international case studies of sustainable built environment structures are presented to allow for real life examples, which portrays sustainability as a do- able venture. A few case studies from Nigeria and some continents were selected as examples:

1. Nigeria: examples include Kingsway Tower and Makoko floating school.
2. Africa: First Capital Bank, Lusaka and Gateway Hotel – Umhlanga, South Africa.
3. Asia: Bahrain - Bahrain World Trade Centre 1 and 2 (Bahrain)
4. Europe: The Edge, Amsterdam and Bloomberg London.
5. United States of America (USA) and Canada: Bullitt Center, Seattle- USA and Manitoba Hydro Place, Canada.

Figure 2. Kingsway Tower, Lagos – Nigeria.

Source:https://www.archdaily.com/948253/kingsway-tower-saota?ad_medium=widget&ad_name=more-from-country-article-show (27/03/2023).

Figure 2 is the Kingsway Tower in Lagos Nigeria and is considered to be a sustainable building for the reasons of its use of; passive use of cooling, energy efficient lighting, use of sustainable materials and the use of sustainable construction methods.

Figure 3. First Capital Bank, Lusaka – Zambia Source: https://www.solidgreen.co.za/green-map/

Figure 3 shows the First Capital Bank in Lusaka, Zambia. It is a sustainable compliant building with the following sustainable feature:

1. Sustainable waste management compliant during the construction phase.
2. Maximising on daylight whilst providing daylight glare control.
3. Use of low VOC materials and low lighting zoning power density controls.
4. Users are provided with building users' guide to maximise on the sustainable
5. building features.
6. Provision of fuel-efficient transport and alternative facilities for building users and visitors.
7. Low flush rate sanitaryware for water efficiency and use of non-potable water for their irrigation system.

Figure 4: Gateway Hotel – Umhlanga.

Source: https://hearonearth.wordpress.com/tag/green-building-council-of-south-africa/

The Gateway Hotel in South Africa shown in Figure 4 is another example of a sustainable building and has some sustainable attributes that includes:

1. The leafy facade screen provides solar shading.
2. Minimized air-conditioning requirements.
3. Low-energy light bulbs all through the building.
4. low-emissivity glass serves as the curtain wall glazing.
5. The lifts all have regeneration drive systems.
6. Chilled air is recycled from the hot water heat pumps.

Figure 5. The Bahrain twin towers of the World Trade Center in Manama. Source: https://edition.cnn.com/style/article/green-buildings-world-sustainable- design/index.html

Figure 5 is the Bahrain twin towers of the World Trade Centre in Manama, the capital city. These towers are optimally positioned:

1. To harness the island nation's desert winds as a clean energy source.
2. The three turbines mounted on sky bridges are used to generate electricity.
3. The towers' shapes depict the Arab dhow sailing ships and for aesthetics.
4. Reflective pools at the lower base of the towers help with cooling via evaporation.

Figure 6.: *Bloomberg London.*

Source: https://www.skia.ro/en/blog/top-10-most-sustainable-buildings-in-europe/

Bloomberg London seen in Figure 6 has the following sustainable attributes:

1. It has a 73% lower water consumption rate.
2. It has a 35% less energy compared to other buildings.
3. It also generates 35% fewer carbon emissions.
4. Designed in parts with sustainable wood material and all materials are sustainably sourced.
5. Building materials are sustainably sourced.
6. Uses natural ventilation system
7. Rainwater treatment plant serves in building, walls are adorned with "living" plant wall.
8. Plant wall along with other decorative elements are designed as biomimicry elements.

Figure 7. *Bullitt Centre, Seattle-Washington in USA.*

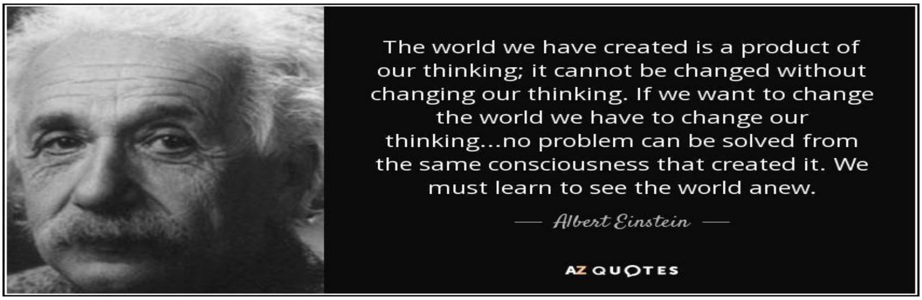
Source: https://rmjm.com/10-examples-of-sustainable-architecture-around-the-world/

Figure 7 is the Bullitt Centre in the USA acclaimed to be the most sustainable commercial building in the world. This centre incorporates all the sustainable features a building can have which includes the following:

1. net-zero energy;
2. net-zero water;
3. net-zero carbon;
4. composting toilets;
5. toxic-free materials;
6. 80% daylighting using high-performance windows; and
7. 100% of the building's energy comes from renewable sources.

These case studies must reflect and promote the agenda for sustainable Development as well as the Sustainable Development Goals (SDGs) are studied to show that a sustainable built environment is achievable and for inspiration. The sustainable applications and strategies adopted by each case study are identified for peculiarities and possible adaptations.

Sustainable Thinking



The quotation from Albert Einstein encapsulates how we must think sustainability to act sustainably, and the best way to train students to think sustainably is from the conceptual mindset through design to construction. Sustainable Thinking explores how sustainable knowledge, values and sustainability can be reoriented towards the way design is processed, actualized, practiced and applied (Sherin, 2017).

Sustainable thinking explores how sustainable values and sustainability are engaged in reshaping the way design processes are practiced and applied. It also explores the ability to think ethically through sustainable means to assess available options, avert the negative impact of unsustainable actions, opportunities and actions (Sherin, 2017). The knowledge gained at this stage and from the case studies, it is expected that the thinking is reoriented from the conventional practices to sustainable practices. Also, the underpins studied would become an integral part of the systemic thinking for the creation of sustainable environments.

Summary

A sustainable built environment is an important tool for a balanced environmental sustainability. The text started with an introduction and definitions of sustainability and the built environment as underpins for the discourse. These include; definitions (built environment and sustainability), understanding sustainability -through its tripoded perspectives/dimensions of environmental, social and economic are explained. The importance of sustainability in the built environment and the challenges therein were established. Some selected examples of case studies across the globe were studied to suggest that despite some challenges, a sustainable built environment is attainable through sustainable architecture. Sustainable Thinking is a crucial part that explores the opportunity to focus on environmentally and socially conscious options for sustainable design creativity and future innovations.

Exercises

Assessment methods would include examination, assignment and test(s).

1. To discuss the importance of a sustainable built environment and its relevance to your future practices.
2. To identify 3 sustainable buildings from Nigeria, Africa and Europe or USA outside the case studies discussed and the reasons for your choice.

REFERENCES

Abraham, M. A. (2017). Sustainable Built Environment. Encyclopedia of Sustainable Technologies, Elsevier, ISBN 9780128047927, https://doi.org/10.1016/B978- 0-12-804677-7.02003-X.

(https://www.sciencedirect.com/science/article/pii/B978012804677702003X). Allu, E. L. A. & Ebohon, O. J. (2015). Assessing the Knowledge and Awareness Level of

Built Environment Professionals in Nigeria. International Journal of Contemporary Applied Science, 2(5), 77- 95. www.ijcas.net/Files/CMSUerOwnFolder/issue/May-2015/06.pdf

Allu, E. L. A. & Ekele, T. O. (2015). Sustainable Urban Built Environment for Nigeria: A Framework Approach. International Journal of Contemporary Applied Science, 2(5), 96-107.

www.ijcas.net/Files/CMSUserOwnFolder/issue/May-2015/07.pdf

Allu, E. L. A. (2015a). Institutional Capacity Building for Climate Change and Sustainability in Nigeria: Reflections on the Responses of Built Environment Professionals. Academic Journal of Sciences, 04(02), 101-106.

www.universitypublications.net/ajs/0402/pdf/H5V536.pdf

Allu, E. L. A. (2015b). Built Environment Professionals' Perceptions of Sustainable Urban Built Environment and the Way Forward for Nigeria. Journal of Arts and Sciences,8(8),1-8. www.universitypublicatins.net/ijas/0808/pdf/DE4C156.pdf Online

Allu, E. L. A. (2018). Sustainable Built Environment Collaborations: Perceptions from the Nigerian Architecture, Engineering and Construction (AEC) Professionals. ARCHSEARCH International Journal of Architecture and Environment, 8(1), 55 – 66. ISSN: 2141-9019. ABU, Zaria.

Allu-kangkum, E. (2022). Global Sustainable Architectural Trends: Top Three Trends in Nigeria and their Implications. Journal of Engineering, Computational &Applied Sciences, 1(1), 25 – 34. SSN: 2795- 3939.

Barbosa, A.P.F.P.L. Salerno, M.S. de Souza Nascimento, P.T. Albala, A. Maranzato, F.P. & Tamoschus, D., (2021). Configurations of project management practices to enhance Cleaner Engineering and Technology 7 (2022) 100455 8the performance of open innovation R&D projects. Int. J. Proj. Manag. .39 (2), 128–138

Celadyn, W. (2018). Postgraduate studies and sustainable architecture. Global J. of Engng. Educ., 20 (1), 54-55.

Eromobor, S.O & Das, D. K. (2013). Dynamic Modelling Approach for Designing Sustainable Green Buildings SB13, Sustainable Building (2013) Creating a Resilient and Regenerative Built Environment 15-16 October 2013, Cape Town, South Africa.2-1 1

Graeber, D. (2015). The Utopia of Rules: on Technology, Stupidity, and the Secret Joys of Bureaucracy. Melville House.

Jeronen E. (2013). Sustainability and Sustainable Development. In: Idowu S.O. Capaldi N., Zu L. Gupta A.D. (eds) Encyclopedia of Corporate Social Responsibility. Springer, Berlin, Heidelberg.https://doi.org/10.1007/978-3-642-28036-8_662

Ayarkwa, J. Opoku, D, J. Antwi-Afari, P. & Li, R. Y. M. (2022). Sustainable building processes' challenges and strategies: The relative important index approach, Cleaner Engineering and Technology, 7, 00455, ISSN 2666-7908, https://doi.org/10.1016/j.clet.2022.100455.

Loftness, V. (2013). Sustainable Built Environment, Introduction. In: Loftness, V., Haase,

D. (eds) Sustainable Built Environments. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-5828 -9_925

Obringer, R. & Nateghi, R. (2021). What makes a city 'smart; in the Anthropocene? A critical review of smart cities under climate change. Sustain. Cities Soc. 75, 103278.

Onyekuru, N. A. & Marchant, R. (2011). Nigeria's Response to the Impacts of Climate Change: Developing Resilient and Ethical Adaptation Options: www.springerlink.com/index/J6857178J6QG5605.pd

Opoku, A (2016). SDG2030: A Sustainable Built Environment's Role in Achieving the Post- 2015 United Nations Sustainable Development Goals. In: P W Chan and C J Neilson (Eds.) Proceedings of the 32nd Annual ARCOM Conference, 5-7 September 2016, Manchester, UK, Association of Researchers in Construction Management, 2, 1101-1110.

Rout, P.R., Verma, A.K., Bhunia, P., Surampalli, R.Y., Zhang, T.C., Tyagi, R.D., Brar,S.K. & Goyal, M.K. (2020). Introduction to Sustainability and Sustainable Development. In: R. Y. Surampalli, T. C. Zhang, M. K. Goyal, S. K. Brar, R. D. Tyagi (Eds.), Sustainability: Fundamentals and

Applications, 1-20. Hoboken: John Wiley & Sons Ltd.

Sakalasooriya, N. (2021). Conceptual Analysis of Sustainability and Sustainable Development. Open Journal of Social Sciences, 9, 396-414. doi: 10.4236/jss.2021.93026.

Schoggl, J.P. Baumgartner, R.J. & Hofer, D. (2017). Improving sustainability performance in early phases of product design: a checklist for sustainable product development tested in the automotive industry. J. Clean. Prod. 140, 1602– 1617.

Sherin, A. (2017). Sustainable Thinking: Ethical Approaches to Design and Design Management. Bloomsbury Publishers. ISBN 9781350034051

World Commission on Environment and Development (1987), Our Common Future, New York: Oxford University Press, 1987.

Wu, Z., Jiang, M., Cai, Y., Wang, H., Li, S., 2019. What hinders the development of green building? An investigation of China. Int. J. Environ. Res. Publ. Health 16 (17), 3140.

BIODATA OF PROFESSOR ARC. EVELYN LAMI A. ALLU-KANGKUM.

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Professor Evelyn Allu-Kangkum is a Fellow of The Nigerian Institute of Architects (NIA), Member of the Architects Registration Council of Nigeria (ARCON) and she is the Chair, Board of Architectural Education (NIABAE). Evelyn is also a member of Association of Architectural Educators in Nigeria (AARCHES) and international Society for Development and Sustainability (ISDS).

Evelyn has had many recognitions/awards, academic and non-academic, within and outside Nigeria. She is an active member of the Gindiri Old Students Association (GOSA) and supports community projects on educational development and other charity organization within and outside Nigeria.

Evelyn is married to Sir. Barrister Cletus T. Kangkum and are blessed with children. For hobbies; she loves humour and enjoys traveling.

Service Life and Life Cycle Assessment of Buildings

Prof E. B. Jaiyeoba. *OAU. Ile-Ife* **& Associate Prof. Pontip Stephen Nimlyat.** *UNIJOS*

Overview

Every human product including built environment products and their components has a service life. The origin of many of these products is traceable to natural resources from the earth's crust. Also, built environment products constitute huge investments to accommodate human activities in comfortable and healthy environments and therefore are often expected to last long to recoup the investment during the service life. The components and elements and the process of coming together to form built environment products will have some effect on the global environment depending on whether they are sourced from renewable or non-renewable resources amongst the abundant resources in nature.

This text deals with the performance of buildings with respect to comfortability, functionality, and cost effectiveness within its life cycle. Life Cycle Assessment (LCA) as a method for determining the totality of the cost to the environment of a component, element or the complete product pre-service life, throughout the service life and end of service life has been discussed.

Learning Objectives.

The objectives of the text are to:

1. define the concept of life cycle assessment (LCA) towards reducing building materials environmental impact;
2. identify the methodology involved in carrying out LCA;
3. equip students with the knowledge and information base for decision making during design and building processes;

4. equip students with professional practice skills in environmental sustainability;
5. describe specific task on LCA assessment such as inventory, impact assessment etc; and
6. discuss the impact of the construction sector on the environment, the need for sustainable buildings, and the parameter driving them.

Narratives on each Topic

Service Life

Every living and non-living thing has a maximum life and as it is commonly put everything that has a beginning must have an end. The time range between that beginning and the end is service life, and many events, occurrences, and happenings are inevitable in any service life. Expectedly, the happenings throughout the service life will be determined to a great extent by circumstances at conception or initiation, especially in relation to buildings and architectural products. A study has shown that the impact of both building, and material service life variations results in a significant reduction in the life cycle embodied energy demand of the building (Rauf, 2022). Service life is suggestive of a cradle-to-grave approach to every situation. For buildings and architectural products, it implies going earlier than initiation to the source of materials, elements, and components of the building to be specified and future projection to their ends if the life of the building they are part of comes to an end.

Life Cycle Assessment (LCA)

Reducing environmental impact and carbon footprint of products whose consumption necessitate commercial and industrial production is to embrace sustainable production methods with minimal release of carbon dioxide and greenhouse gases (GHGs). This sustainable production practice becomes necessary due to climate change awareness. The environmental impact of a product starts from the extraction of the natural resource input to the product, the energy in processing to becoming a finished product, the installation energy in the assembly with other products to make a larger product and energy consumed by the product and the larger product during their service life till the end of life cycle. At the end of life, what happens to the product, or the larger product will continue to have environmental impact, whether disposed of in landfills, recycled to make the same product or a different product or reused. LCA therefore accounts for impact on the environment of a product during the service life of the product and/or larger product and at the end of life disposal. Life Cycle Assessment (LCA) is the major tool for determining the impact of a product on the immediate and global environment.

Life Cycle Assessment (LCA) is often defined in relation to the impact of a product on the environment alone, especially with the problem associated with climate change and the need to 'green' all processes and products towards a sustainable built environment. The process of measuring and reducing the resource consumption burden of buildings and other products including the components and the GHGs generation during whole-life use till the end-of-life is known as decarbonisation. There are embodied and operational aspects of LCA to distinguish between the makeup of the building or product and when in use after completion respectively.

Guidelines for Life Cycle Analysis

Ahmed Samir Ead , Raelynn Appel, Nibin Alex, Cagri Ayranci and Jason P Carey (2021) presented a comprehensive International Organisation for Standardisation (ISO) protocol for life cycle analysis (LCA) based on environmental impact alone according to ISO definition of LCA. Also, because LCA is used in various industries, the exact procedure may vary with different products. ISO 14040 outlines the four steps of LCA to identify the goal and scope of the analysis, compile life cycle inventory

(LCI), complete a life cycle impact assessment (LCIA), and interpret the results.

The goal states the purpose of the analysis which may be to evaluate and compare the environmental impact of two different products and the sector of application, maybe external envelope or internal panel in the building industry. The scope sets a system boundary like cradle-to-grave, that is, production to end-of-life and a functional unit, possibly time-based, so input and output flows of system processes in relation to the environment can be quantified especially in comparative analysis that utilizes the same functional unit. In the building industry the goal of a study may be to compare the environmental impact of multifunctional thermal, acoustic and solar power external panels made of different hybrid materials considering the environmental concerns of the global building industry. The scope of the LCA may cover production, use and end-of-life through 99 years of indoor specified parameters for temperature, humidity, sound decibels and alternative power generation from a defined panel size.

Life cycle inventory (LCI) analysis is the most rigorous stage of LCA. Data either from existing studies or generated primarily on input and output of natural resources, materials and wastes of all processes in the production, use and disposal of the functional unit is collected and documented. All elementary steps of single or grouped operations or unit processes are aggregated in a product system boundary. In addition, all flows of raw materials, water and energy and waste released to the natural environment through land, water and atmosphere and the use of land are tracked and documented. The flows can be visualized in a flow chart organized into a list in an inventory table for further analysis. The alternative to this process approach 'process-LCA' is a simplified method to reduce required data known as 'I/O-LCA'-industry based input/output LCA- using economic databases and environment impact data for modelling and comparing diverse products at national and global levels (Ahmed Samir Ead , Raelynn Appel, Nibin Alex, Cagri Ayranci and Jason P Carey (2021).

The third step is life cycle impact assessment (LCIA). LCIA converts the long list in the LCI into common units of different categories with the possibility of seven ISO standard steps that may not all be taken in the assessment. The 4 steps that must be taken are selection of impact categories and impact category indicators, inventory results classification into categories and characterization. The other 3 steps that may not be part of the assessment are normalization, grouping and weighing. Impact categories recognized by ISO are human health, ecosystem health and resources for 'end-point damage' while climate change and related issues of ozone layer depletion and pollution factors of human toxicity and acidification and sometimes land use as a limited resource for 'mid-point damage'. Qualitative approach is adopted to classify inventory results into impact categories while characterization involves reducing each compact category to a common unit to aggregate a category indicator result which when all listed gives the environmental profile. For the other 3 steps not always adopted, the category indicator results are expressed relative to reference standards for environmental impact interpretation. Grouping ranks the impact of different categories after orderly listing, weighing generates a factor based on determined importance that is used to multiply each indicator for a weighted value Ahmed Samir Ead , Raelynn Appel, Nibin Alex, Cagri Ayranci and Jason P Carey (2021).

Interpretation of results is towards the initial goal and scope of the LCA after the evaluation and analyses and considering the data consistency and reliability and discussions on limitations in the process.

Life Cycle Analysis in Early Design Phase

During design conception, LCA focuses on specification of materials with low embodied and operational carbon in an attempt to limit the cradle-to-gate and cradle-to-cradle environmental burden in a process of carbonization. The impact of global warming caused by Greenhouse Gases (GHG) emission during the material extraction from nature to the manufacturing industry gate of any building element or component is the Global Warming Potential (GWP). Presently, the building industry contributes 39 per cent to the global carbon footprint and to meet the UN Sustainable Development goals LCA is normally carried out at later design stages to meet the green building and sustainability standards and certification. These certifications include Leadership in Energy and Environmental Design, USA (LEED), Building Research Establishment Environmental Assessment, UK (BREEAM) and Deutsche Gesellschaft für Nachhaltiges Bauen, German Sustainable Building Council (DGNB) (Michael Budig , Oliver Heckmann, Markus Hudert,et al, (2021).

The impact of changes at the early design stages can still be done at the least cost. Many digital and computational tools for LCA have been developed for more effective reduction of carbon footprint and performance evaluation of buildings towards more sustainable design. A plug-in for Revit known as Tally extracts necessary building information for LCA for design amendment. According to Bauen et al (2021), the factor of flexibility in design allows for gradual reduction of embodied carbon of the building through adaptability is not accounted for by Tally. Design flexibility allows the use of changeable modular components and changes in use that allows the possibility of reuse of modular components in a circular economy, reduces the need for new materials, promotes material conservation and postpones the end-of-life of buildings and hence lowers carbon impact on the environment.

Bauen et al (2021) demonstrated a workflow for John Habraken type supports and infill open system at early design stage LCA for alternative floor plan variants. The workflow for different 2D schematic floor plans constituting spatial modules in an energy modelling shoebox approach allowed material and construction methods comparison of GWP impact. The floor plans, when made up of modules, allow measurement of material volumes for cradle-to-gate GWP for LCA-based evaluation of preliminary design versions. Further studies intend to extend the workflow to cradle-to-grave by including user needs and possible adaptations in the buildings service life, carbon imprint of changing infill layers and reusability of building components in the GWP assessments.

Applications of Life Cycle Analysis (LCA): the LCA Framework

The traditional LCA is relative to the impact on the environment, especially the effects on climate change indices and long term sustenance of planet earth. In sectors where product impact needs to go beyond the environmental impact to sustainability other inputs such as social and economic factors become important, and the cultural and health factors situates the human factors in the LCA. For example, unavailability of water and water sustainability is crucial in many places around the world. The wastewater treatment sector applies wider impact factors in LCA for wastewater treatment plants (WWTP). In the operation of WWTP, LCA framework is essential for examining the socioeconomic, cultural and human health impacts in addition to the environmental impact in the entire life cycle in a cradle-to-grave approach (Karim M Morsy, Mohamed K Mostafa,Khaled Z Abdalla, and Mona M Gala, 2020). Impacts associated with WWTP include energy balance, land use, water use, eutrophication potential, toxicity-related impact and global warming potential (GWP) among others. Nature-based solutions rather than an activated sludge system with little chemicals and electricity consumption, improving effluent quality and using alternative energy sources are reported to have least impact on the environment. Before adopting GaBi which allows sensitivity analysis percentage deviations from inventory flows apart from having reliable professional database and 4500 life cycle inventory, two other softwares- Simapro and OpenLCA were compared for the study of Egypt's Abu-Rawash WWTP upgrading by Morsy et al (2020).

Applications of Life Cycle Analysis (LCA): Building Sustainability and Environmental Health Impact

Building activities have significant impacts on natural resource depletion through extraction of renewable and especially non-renewable resources, virgin materials consumption, energy consumption in materials manufacture and construction and energy for human comfort during use. Additional environmental impacts include pollution of the environment during the life cycle from extraction and industrial production through construction activities, building use, facility maintenance and rehabilitation up to waste in landfills when service life ends in partial or total demolition. LCA approach was used to investigate whether environmentally friendly buildings or buildings sustainably translate to positive health impacts (Ajayi et al, 2016). Revit software was used to model a classroom block and the life cycle global warming potential (GWP) and human health impacts analysed with green building studio and ATHENA impact estimator tools. The LCA was done for seven other alternative typologies by varying building materials and energy use patterns of the original classroom block. The human health impact indicator was by measuring the particulate matter (PM2.5) in the buildings while the GWP measured in KgCO2 indicated environmental impact; which showed direct relationship for the eight building typologies. This confirms that the more environmentally friendly or sustainable or green a building is the more the positive health effects on the occupants, operatives and neighbours since the less the negative effect on the environment. The result is limited to the environmental health of buildings with implications for sustainable approaches in choice of materials, construction method, building operations and end of life deconstruction of buildings.

Methods of Reducing Carbon emissions

Traditional and vernacular buildings that are built spontaneously around the world by owner-occupiers with readily available local materials, built individually without modern technologies and not in accordance with official building standards are the most sustainable. Building types have been getting bigger due to demand for more space for luxurious living. However, the smaller a building is the lower is the consumption of materials for construction and the energy consumed in operating energy consumption.

The change from the rural and traditional residential pattern and lifestyle led to the decrease of biomass energy and the increase of coal, refined petroleum products like petrol, diesel, liquefied natural gas and electrical power in commercial quantities (Zhixing Luo and Yiqing Lu, 2020). Wood buildings are better than brick, concrete, steel or aluminium in having lower process energy and lower carbon emissions. Also, bamboo buildings have low embodied energy and emit less carbon dioxide to meet the same functional requirements as a typical brick-concrete building.

At the construction stage embodied emissions and transportation emissions are lower for timber than concrete buildings when greenhouse gases (GHGs) emission and energy consumption are compared (Sandanayake et al, 2018). There are better environmental benefits in recycling metal waste than masonry wastes (Wang et al, 2018). In terms of policy, we have to transform to low/no fossil-carbon economies, adopt critical climate change interventions, for example carbon taxation or tax exemption regimes for zero carbon emission operations or carbon trading schemes. And also, the need to have Individualised production of building cooling and heating energy through micro-generation equipment or means especially with alternative energy.

Comparison of ecological materials have been done in recent years as reported by Zhixing Luo and Yiqing Lu (2020). Wooden buildings in the cold regions of China have good energy saving and no obvious thermal performance problems. Bamboo has some disadvantages in extreme cold climates but both timber and bamboo are top performers in hot and temperate regions. Straw is a good ecological material with high adaptability heat insulation performance. Straw when used in filling walls, in straw-clay blocks and prefabricated straw-brick walls has better thermal performance than fired bricks or concrete blocks. Over the whole life cycle replacing concrete with wood reduces carbon emission. From an economic and environmental analysis cork insulation boards, a type of timber is great for retrofitting buildings and cross laminated wood is good for urban homes with low carbon footprint. Agricultural materials like wheat straw have low carbon footprints and some natural materials are carbon sinks. Wooden buildings and wooden intensive buildings are carbon sinks and are said to neutralize or balance carbon emissions in areas of the city.

Approaches to Service life extension and End-of life of Buildings

Running a resource-efficient economy and introducing waste hierarchies are ways of disengaging economic growth from excessive resource consumption and preparing for reuse respectively (Kambiz Rakhshan, Jean-Claude Morel, Hafiz Alaka and Rabia Charef, 2020). The idea is to minimize natural resource consumption in this generation so there will be leftovers for the coming generations according to the definition of sustainable development.

To minimize waste through the whole life cycle of buildings and the service life, many design approaches have been studied. These include design for deconstruction (DfD) (Akinade et al., 2016) and design for manufacture and assembly (DfMA) (Kalyun and Wodajo, 2012). Buildings are known to come to an economic end-of-life when the land value on which it is built is higher in which case it might be rehabilitated for a use that can cope with the value or may have to be replaced by a commensurate building value or use. Most of the buildings to be rehabilitated or demolished lack the DfD or DfMA design approaches and will generate large amounts of waste. The waste are either recycled to recover construction and demolition wastes, sometimes involving industrialised methods and attendant energy and resource needs with emission of greenhouse gases or preferably reused at little or no cost to the environment. Reusing the components or elements of a building means it will be carefully disassembled through deconstruction. Recycling, reuse and design approaches to reduce construction demolition waste are known as reverse logistics.

Service life of historical or sociocultural important buildings or parts thereof may be extended by adaptive reuse at the end of its useful life.

Life Cycle Costing Analysis (LCCA)

LCA brings a consciousness to taking informed design and cost decisions by initiator of projects at the conception stage through life cycle costing analysis (LCCA). LCCA optimizes the decisions on initial capital investment, expected maintenance, operational and management costs in designing service life of buildings or any infrastructure that is an investment or asset. All the cost elements in the LCA of the building, investment or asset up to the disposal cost at the end-of-life is accounted for in the LCCA as a decision making tool.

Life Cycle Cost Analysis is very important in the conception of a project. At a general level, there is a comparison between the initial costs the client or investor is willing to spend for the proposed project based on cost estimates. This cost estimate will have inbuilt the choice of materials, construction methods, procurement process, choice of contractor, construction process, and quality of supervision to completion. The decision to have a reduced initial cost of completing the project through lower quality inputs, processes, and management of the project delivery usually translates to higher future facility maintenance and management costs and may shorten the service life of the project. The energy costs for heating or cooling and other facility maintenance costs are included in the operational costs that may sway design decisions and a pointer to the competence of the built environment professionals (BEPs) on the project.

Summary

In a bid to promote a more sustainable built environmental practice based on sound scientific information, building service life and LCA knowledge base is needed to form part of the architecture higher education curriculum. The subject exposes students to the understanding of how buildings impact on the environment, the principles of LCA, and its application to building evaluation, and the processes involved in carrying out a building LCA.

Exercises

1. Explain how building service life and life cycle assessment (LCA) is used in the built environment.
2. What is benchmarking and is it evaluated for operational energy efficiency?
3. Estimate the total environmental impact of a building that comprises 100 Kg steel and 50Kg glass.
4. Illustrate the iteration process involved in carrying out an LCA.
5. What is life cycle cost analysis (LCCA)?
6. List the various cost elements associated with a building system within the LCCA framework.
7. Evaluate and compare the life cycle costs of two roofing sheets (Aluminum and Shingles) to determine the most cost effective solution over a period of 3 years.

References

Oyedele L.O., Fadeyi M.O., Tham K.W. and Jaiyeoba E.B. (2012), Total Building Performance Approach in Building Diagnostics: Case Study of an Office Building in Singapore. American Society of Civil Engineers Journal; Journal of Energy Engineering 138 (1), 25 – 30

Ajayi S.O., Oyedele L.O., Jaiyeoba E.B., Kadiri K., David S.A. , (2016),"Are sustainable buildings healthy? An investigation of lifecycle relationship between building sustainability and its environmental health impacts", World Journal of Science, Technology and Sustainable Development, 13 (3),190 – 204

Akinade O.O., Oyedele L.O., Ajayi S.O., Bilal M., Alaka H.A., Owolabi H.A., Bello

Rauf, A. (2022). Reducing Life Cycle Embodied Energy of Residential Buildings: Importance of Building and Material Service Life. Buildings, 12, 1821. https:// doi.org/10.3390/buildings12111821

S.A., Jaiyeoba E.B., Kadiri K.O. (2016). Design for Deconstruction (DfD): Critical success factors for diverting end-of-life waste from landfills. Waste Management (2016), Elsevier Ltd.

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CHAPTER SEVEN: ARCHITECTURAL DESIGN STUDIO

Introduction to Architectural Design

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Overview

Architecture is the art and science of designing and constructing buildings and the built environment. Therefore, Architecture is essentially about design and design studio is the bedrock of architectural training. While defining architectural design, certain keywords need to be explained in order to provide the understanding of the design problem, design concept, basic elements and principles of design, design factors and design brief.

The text explores both the three-part process of architectural design and the five step model to illustrate the various views of architectural design in practice and academia. It therefore provides an insight into both the theory and practice of architectural design.

Objectives

the objectives of the text are to:

1. identify the different meanings of architecture and architectural design;
2. describe the various elements and principles of design;
3. discuss architectural design as a problem solving process;
4. examine the various views in theory and practice of the architectural design process; and
5. describe the role of design problem, design brief, design concept and design factors in developing architectural design proposals.

Definition of Architecture

Architecture comes from the Greek word "arkhitekton", 'archi' means 'chief' and 'tekton' means 'builder'. The architect of old is referred to as the Chief Builder. Many famous architects have defined architecture in different ways through different means of physical elements, history, semiotics or theory. For instance, John Ruskin defines architecture as an art for all to learn because all are concerned with it. While Le Corbusier says architecture is the masterly, correct and magnificent play of masses brought together in light. Vitrivius stipulates that elements of good architecture are: - firmitas (firmness), utilitas (commodity) and venistas (delight).

Architecture can simply be defined as the art and science of designing and constructing buildings and the built environment. Therefore, architecture is both a science and an art. The science of architecture then is the body of systematised knowledge that informs the imagination of the architect in the act of making buildings and the built environment.

The science of architecture involves:

1. Physical and applied sciences: - mathematics, engineering and technology and others.
2. Behavioural Sciences: - sociology, psychology, philosophy, economics and others.
3. Environmental sciences: - climatology, geography, planning, landscape and others.
4. Building Sciences: - building systems, materials and construction etc.

Whereas the art of architecture is the knowledge, experience, skill and imagination brought to bear in creative problem solving. The art of architecture involves: - graphic communication, craftsmanship, skill and its application in the sense of great proficiency in executing a plan or action.

What is Architectural Design?

Architectural design is a comprehensive process of solving a design problem through the development of a design concept and using basic design elements and principles in the creation of buildings or reshaping the built environment. This definition brings to light some key words to be explained in order to fully understand what architectural design entails. These are: - 1) Design Problem 2) Design Concept 3) Basic Elements and Principles of Design 4) Design Process 5) Design Factors 6) Design Programming/Brief

Design Problem

Architectural design problems are described as 'wicked problems' according to Rittel and Webber (1973) because they are usually complex and ill defined. There is no one correct or definite solution, no true or false solution. Unlike problems of mathematics or engineering, wicked problems lack clarity in both their aims and solutions as they lack inherent logic that signals the attachment of a solution. In addition, these problems are essentially unique, vary from site to site and it's impossible to be solved in a way that is simple or final. Lastly, these problems have to be analysed and synthesized in a way that a range of possible solutions or design proposals could be developed.

Design Concept

Design concept is the main idea, philosophy or central thought that provides the needed direction to solving the design problem identified in any given design project. A concept may be one clear single overarching idea or series of similar ideas that connect around a theme. It may easily arise at the start of the project, or it may slowly appear later as ideas are tested, experimented and explored.

A concept can also be a belief, inspiration, intention, notion, theory, principle, impression or an idea about space, structure, nature and human experience. It can be derived from the design brief, programme, users' needs and aspirations, site context, topography, geometry, structural and environmental domain; social, economic and cultural conditions and it's expressed with materials and technology through understanding of design elements and principles.

Basic Elements and Principles of Architectural Design

The architect uses a variety of elements and principles in resolving design problems and creating spaces that are functionally and aesthetically pleasing. The elements are the basic units of any visual design which form its structure and convey a visual message while the principles are the rules that guide the action. Design principles standards save the architect from the need to reinvent the wheel for every problem to be solved and provide basic knowledge on design issues to help in decision making.

Basic Elements of Design

The seven basic elements of design are: - 1) Line 2) Shape 3) Colour 4) Space 5) Texture 6) Form 7) Value

Line: A line is an element of art defined by a point moving in space. Lines are used to separate and organize space, outline objects, draw attention and emphasize certain elements. They are probably the most seamless and common elements of design. Lines can be thin and thick; horizontal line, vertical and diagonal; curved, zigzagged, dashed and dotted with all these types conveying different meanings and shaping experiences.

Shape: A shape is defined as a two dimensional area that stands out from the space next to or around it due to a defined or implied boundary or because of a difference of value, colour or texture. Shapes are made of lines and they in turn make objects either geometric, curvilinear or natural forms. Human perception gives meaning to various shapes and directs our attention accordingly. For instance, squares and rectangles are associated with stability and balance while circles and ovals are linked to harmony, love and permanence.

Colour: Colours are electromagnetic radiation at different frequencies having a powerful effect on the human mind and can evoke a complex spectrum of emotions. They convey different meanings to the human mind and this perception is also influenced by our cultural, religion, geographical and professional factors as well as personal preference. They are categorized as primary and secondary colours, warm and cool colours etc.

Space: Space helps to generate flow among lines, shapes and colours. It can be used to describe the way in which the foreground and background combine to create an image that has depth. It can be positive or negative.

Texture: Texture refers to the physical and visual qualities of a surface. It helps to give background, shape or object a more visual appeal in design and creates contrast between objects, balance the elements in design and turn on audience's attention to a central message.

Form: Form is a three-dimensional object with volume of height, width and depth. When a shape acquires depth and becomes three-dimensional, it becomes a form. For instance, a circle is a shape, but its corresponding forms can be cylinders and spheres just like the corresponding form of a triangle can be a pyramid.

Value (Tone): Value or tone refers to the overall range of lightness and darkness; and colour variation within an image. It is used to convey the feeling or mood of an image, either happy or sad; vibrant or dull.

Basic Principles of Design

The 12 basic principles of architectural design are: - 1) Unity 2) Balance 3) Hierarchy 4) Rhythm 5) Variety 6) Harmony 7) Contrast 8) Proportion 9) Emphasis 10) Repetition 11) Pattern 12) Movement

Unity: Unity is the quality of a fundamental work that ensures the harmonious use of design elements such as shapes, sizes, colours etc. for instance, a unified design allows equally important design elements to have the same size or colour thus establishing consistency and a clear visual hierarchy.

Balance: Balance gives a sense of stability and composure that suggests a feeling of satisfaction that things are right. Different kinds of balance are – symmetry, asymmetry, mosaic and radial.

Hierarchy: Hierarchy ensures that the right order is followed while processing design information. Things are structured rationally using a variety of visual parameters like size, colour, contrast, alignment, repetition, proximity, texture etc.

Rhythm: This determines how the eye is led through a design in order to ensure coherence by making use of a variety of direction cues to guide which include directional lines, diagonal lines, perspectives, repetition etc. rhythm is also enhanced with repetition and design can use alteration and gradation to trigger it.

Variety: Variety aims to arouse visual interest especially when there is a need to counteract monotony and excessive unity or when design is too simplistic. Variety employs the use of design elements like lines (varying the weight or angle), shapes (changing sizes or from geometric to amorphous), colours and textures.

Harmony: Harmony helps to achieve visually satisfying design when it is established among all the elements of design.

Contrast: Contrast refers to how different elements are in a design, particularly adjacent elements and the differences make various elements stand out. It helps to emphasize a message or idea in design and can be created by incorporating opposite colours or different sizes of similar shapes.

Proportion: Proportion refers to the size of elements in relation to one another. It helps to give weight of importance to the various elements in design.

Emphasis: Emphasis refers to the part of a design that is meant to stand out. It can be used to convey what is most important and to reduce the impact of other information.

Repetition: Repetition is a way to reinforce an idea and thus unify a design that brings together a lot of different elements. It can be done in several ways e.g., repeating the same colours, shapes or other elements of a design.

Pattern: Pattern refers to multiple design elements working together. It can also mean set standards for how certain elements are designed.

Movement: Movement refers to the way the eye travels over a particular design and the elements are arranged in the order of importance.

Architectural Design Process

Architectural Design is simply the activity of generating proposals that change something that already exists into something that is better. Design can be viewed as a three part process consisting of:

1. Initial State.
2. Method or Process of Transformation.
3. Imagined Future State.

These components also define the functions of the designer as 1) to identify problems 2) identify methods for achieving solutions 3) implement those solutions.

These 3 terms are also referred to as 1) programming 2) generating alternative building designs 3) implementing plans.

The description of the design process as going from an initial state to a future imagined state does not explain fully the activities that are involved. These activities are better described under the five stages of 1) Initiation 2) Preparation 3) Proposal Making 4) Evaluation and 5) Action.

Typical variations from several sources including the Nigerian Institute of Architects (NIA) are shown in Table 1.

Initiation: Initiation involves the identification and definition of the design problem to be solved. It also includes understanding of general problems of the society on the subject matter and stimulating client's aspirations.

Preparation: Preparation involves the systematic collection and analysis of information about the design problem to be solved. This activity is also referred to as 'programming' which leads to building programs (US) or a design brief (Europe and Nigeria). The Initiation and Preparation stages are the initial research that is important to achieve a good design solution.

Proposal Making: Proposal making involves generating ideas and making intuitive decisions. This stage is also called 'synthesis' as a variety of considerations and design factors (as stated below) are brought together to form the preliminary sketch design.

Evaluation: Evaluation of proposal(s) involves comparing the proposed design solutions with the goals and criteria set out in the design brief.

Action: The action stage includes the activities linked with the preparation of the contract documents as well as implementation of the project. The contract documents include the detailed working drawings and specifications as prepared by the Architect, the structural engineering drawings (by Structural Engineer), the Mechanical and Electrical and Plumbing drawings (MEP) by the M & E Engineers and the Bill of Quantities (by the QS). These are the documents to be coordinated by the Architect for tendering and with the exclusion of the BOQ are taken also for building approval processing.

Design Factors

There are factors which influence the design process and eventually the architectural design solutions. These design factors consist of several design issues which are also referred to design considerations. They include issues like circulation, privacy, territoriality, safety, topography, flexibility, visibility, image, energy use, cost etc. each of these considerations is rated when preparing the sketch design, although their relative importance or priority will vary from project to project. The design factors can be grouped as follows: -

1. Spatial Requirements: organization of space in accordance with client's needs; hierarchy of space, relationship and interaction between spaces etc.
2. Client's Image / Value: client is either private, corporate or institutional.
3. Site and Climatic Conditions.
4. Social and Cultural Influences.
5. Material and Construction.
6. Structural Systems.
7. Planning and Building Regulations.
8. Building Services.
9. Human Comfort: visual, thermal, acoustics, indoor air quality and well-being.

10. Time and Cost Budget.

Table 1. (Views of the Architectural Design Process under the Five Step Model)

	Intuition	Preparation	Proposal	Evaluation	Action
H. Rittel, (1972)	Identify the problem	Collect info Analyse info	Creative leap Work out solutions	Test solution	Communicate and implement
J.C. Jones, (1970) (Design method)	Idea	Information Analysis	Synthesis	Evaluation	Optimization
AIA, (Duerk, 1993) (Basic and supplementary Services)		Predesign services	Schematic design Design development		Contract documents Bidding Administration of contract Post design services
RIBA, (1991) Architecture services	Inception	Feasibility	Outline proposals Schematic design Detail design		Production information Bills of quantity Tender action Project planning Operation on site Completion Feedback
Geoffery Broadbent, (1998)	Briefing	Analysis	Synthesis	Evaluation	Implementation Post occupancy evaluation
NIA – Nigerian Institute of Architects NIA Logbook (2014)	Preliminary investigation Project definition	Design brief analysis Outline proposals Cost analysis	Sketch design Presentation drawings Preparation with Engineers and QS		Production of working drawings and specifications Structure drawing inter related Bill of quantities and cost checks

					Tender action Building plan approval Site mobilization to completion

(Adebamowo, 2023)

Architectural Programming or Design Brief

Architectural programming is concerned with collection and organization of information that is required to design. This is also referred to as a design brief. It is at this stage the needs of the clients are stated and the purposes of the building. Some programming is simple, involving only what client clearly states; others are complex and require extended procedures and techniques. The Flow chart below illustrates the programming process.

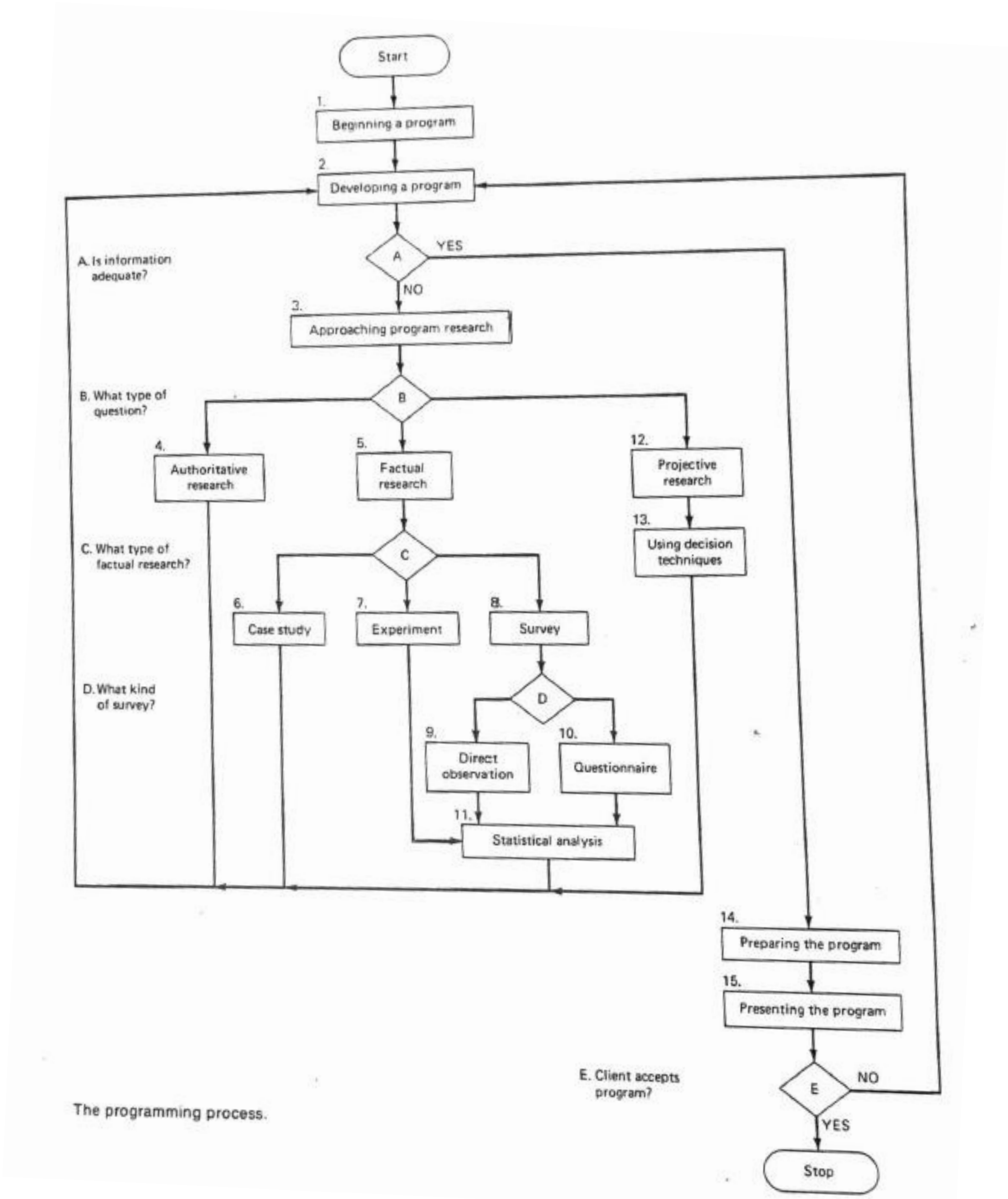

Figure 1. *The Programming Process* (Wade, 1977)

Summary

The text has established the importance of architectural design in the training and practice of architecture as a profession. This was done by exploring architectural design both as a comprehensive process and as an activity of generating design proposals that change something that already exists to something that is better. The 3 –part and 5-step model of architectural design process were discussed and the initial steps which involve research are considered critical to achieve a successful design proposal. However, it is important to note that design is not a strictly sequential process and design problems are wicked problems and a linear step by step method may not yield desired solutions. Therefore, the design process described in the text should not be taken as rigid but rather a guide providing a ray of light to solving the ill-defined nature of design problems and also an attempt to explain the way the Architect goes about the act of designing.

Exercises

1. Differentiate between Architecture and Architectural Design.
2. Why are design problems referred to as wicked problems?
3. What is a design concept and how can you generate a concept for a mass housing scheme?
4. Compare and contrast the 3-part model with that of the 5-step model of architectural design process.
5. What do you consider to be the most important part in the design process and why?

References

Broadbent, Geoffrey (1995), "Architectural Education", In: - Martin Pearce and Maggie Toy ed. Educating Architects, London Academy Editions PP 10-23

Duerk Donna P. (1993), Architecture Programming: Informative Management for Design, New York: Van Nostrand Reinhold

Jones, J.C. (1970), Design Methods: Wiley Interscience

RIBA (2020), RIBA Architects Handbook of Practice Management e-book, RIBA Publishing, https://doi.org/10.4324/9780429347689 retrieved 19 March 2023

Rittel, Horst (1972), "Son of Rittel Think", Design Methods, Group 5th Anniversary Report, PP 5-10

Rittel, H.W., and Webber M.M. (1973), Dilemmas in a General Theory of Planning, Policy Sciences, 4(2), 155-169

Wade, John (1977), Architecture, Problems and Purposes, New York Viley and Sons

BIODATA MICHAEL ADEBAMOWO. B.Sc.; M.Sc.; Ph.D; FNIA

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Mike Adebamowo joined the service of the University of Lagos in 1995 and has served the University in various capacities, as Head, Department of Architecture Dean of the Faculty of Environmental Sciences and currently a member of the University Council. The erudite scholar has over 40 publications in National and International Journals and one of his publications won the best paper award of Emerald in 2018.

As a Consulting Architect, he has designed and supervised many building projects notable among these are the Golden Park Estate, Lekki, remodeling of Faculty of Arts Building, Unilag; Martinos Event Centre; R&A City Hotel Ikeja; The Summit Hall; Multi-Storey Car Park for Island Club; and The Citadel Church Building and the Redeemers Health Village. All these projects have a positive impact on the environment. He is a member of Network for Comfort and Energy Use in Buildings (NCEUB) UK, member American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), Fellow of the Society of Environmental Toxicology and Pollution Mitigation (SETPOM) and Fellow of the Nigerian Institute of Architects (NIA). He has supervised over 350 Masters and 15 PhD Students successfully and managed research grants.

Anthropometrics, Ergonomics and Basic Characteristics of Space and Place

Professor Nghai Ezekiel, *Kaduna State University*

Overview

Architecture aims at making the built environment suitable for human living and as such the science that deals with measurement of the human being. Anthropometrics is necessary if buildings are to be fit for their purpose. Anthropometrics comes with its brother, ergonomics, which deals with the relationship of man and machinery and equipment, for convenient use in order to yield maximum productivity. In doing so, ergonomics relies on anthropometric data to ensure that the machines and the environment fit the person.

The text focuses on the concepts of space and place as used in architecture. Space is discussed as an element or building block of design, while place is the product of design.

Objectives

The objectives are to;

1 define anthropometrics and ergonomics;
2 differentiate types of anthropometry;
3 state the importance of anthropometrics and ergonomics;
4 identify factors that affect anthropometric and ergonomic data; and
5 distinguish between space and place.

Anthropometrics

The science that deals with the study of human beings, their social relationships and their relationship to their environments is called anthropology. One of the branches of anthropology is environmental psychology which deals with the study of man and his environment.

Anthropometrics, which is a branch of environmental psychology, is a word derived from two Greek words, anthropo(s) meaning 'human' and meticos meaning 'of or pertaining to measurement' (Slideshare, 2020). It deals with the measurement of human beings in static and dynamic conditions in order to provide adequate spaces to fit function and comfort. It refers to comparative measurements of the body. It is the study of body dimensions. Human beings interact with their environments, and in order for this interaction to be more meaningful there is need for measurements both of the body size and the part of the environment the interaction occurs in. It is necessary that these dimensions determine room sizes, door sizes, pathways etc. Forms and spaces in architecture are seen as containers of human activities and must therefore be designed according to human dimensions. Del Prado-Lu defines anthropometry as "the science of measurement and the art of application that establishes the physical geometry, mass properties, and strength capabilities of the human body".

In anthropometry three major principles are considered in the design of products:

1. Design for extreme individuals, mainly design for the maximum population.
2. Designing for an Adjustable Range.
3. Designing for the average, mostly being used whenever the use of adjustability is impractical.

Ergonomics

A special field of environmental psychology that has developed from a concern with human factors is ergonomics. Ergonomics stems from the Greek: ergon, meaning 'work' and nomos, meaning 'natural laws' (Slideshare, 2020). Ergonomics is the science of the relationship between man and machinery and the equipment human beings use, and the working environment. According to Phesant (2003), Ergonomics is the science of work: of the people who do it and the ways it is done; the tools and equipment they use, the places they work in, and the psychosocial aspects of the working situation. The main aim of ergonomics is to maximise productivity by minimizing effort and discomfort. Ergonomics, therefore, uses anthropometric data to ensure that the machines and the environment fits the person.

Ergonomics is also seen as the science of adapting the job and/or the equipment and the human to each other for optimal safety and productivity. It is the science of the relationship between man and machinery and the equipment human beings use, and the working environment. Having something that is called ergonomic means that the item has been designed to maximize productivity by minimizing effort and discomfort. Ergonomics is the study of adapting the work environment, particularly tools and equipment, to people. Using design to adapt the environment to the needs of the worker can increase productivity and safety and decrease discomfort and injury.

The basic philosophy of ergonomics is to make any design of furniture which leads to comfortability, physical health, safety, well-being, convenience and brings motivation towards studies (Taifa & Desai, 2017). Ergonomic designs cannot accommodate every user, the extremes will always be special cases to be uniquely accommodated. Human factors are a major influence on the form, proportion, and scale of furniture. These are factors that need to be considered when designing joinery or cabinetry, furniture, planning circulation spaces, workspaces, accessible spaces and to generally make the user comfortable in their interior environment.

The ergonomic approach to design may be summarized in the principle of user-centred design. If an object, a system or an environment is intended for human use, then its design should be based upon the physical and mental characteristics of its human users (insomuch as these may be determined by the investigative methods of the empirical sciences). The objective is to achieve the best possible match between the product and its users, in the context of the (working) task that is to be performed. In other words: ergonomics is the science of fitting the job to the worker and the product to the user.

The human being is the basis of all dimensions. Every furniture that man created are produced according to his/her dimensions. Human dimensions and the relations between those dimensions (proportions) have been studied for a very long time. Anthropometrics deals with this subject and detects those dimensions, because the dimensions and proportions of the human body affect the proportion of the things we handle, the dimensions of our furniture, and the dimensions of the spaces we use.

The fit between form and dimensions of a space and our own body dimensions can be a static one as when we sit in a chair, or lean against a wall, and can be a dynamic one as when we walk up a stairway or move through the rooms of buildings. An architect should plan and design his buildings in accordance with human dimensions in an ergonomic manner. He/she should design the furniture according to human dimensions and design spaces according to those furniture.

Buildings scaled to human dimensions and physical capabilities in an ergonomic manner have architectural elements, such as steps, doorways, railings, work surfaces, seating, shelves, fixtures etc. that fit well to the average person. Moreover, the spaces that are left between these elements should be arranged carefully so that a human being can act and move efficiently between them. The dimensions of these spaces and the circulation areas are determined according to the dimensions of furniture and the standard dimensions of a human being in static and dynamic positions.

History of Anthropometry

The earliest example of anthropometry came from Vitruvius, a Roman architect, who searched into human proportions. He influenced

Leonardo Da Vinci to propound the rules of parts of the human body. This led to the Vitruvius Man, which is mainly translated from Italian to English to mean "The proportions of the human body according to Vitruvius". Da Vinci believed that the ideal man would fit into a circle as shown in fig 1.

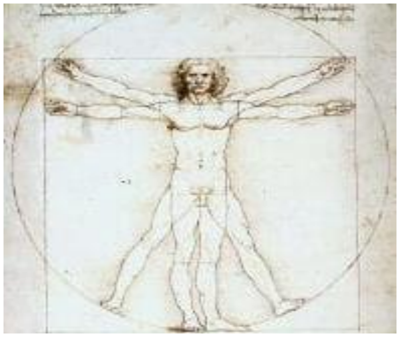


Figure 1. *Vitruvius Man*

Source: https://bedanktvoordevis.files.wordpress.com/2015/06/leonardo-da-

The famous architect Le Corbusier developed a theory of proportion and dimensioning system, named Modulor that is based on human proportions which was based on the average human height as 183 cm. He developed two series of dimensions:

According to the full height of the man, which is 183 cm (red series).

According to the height when he lifted his arm, which is 226 cm (blue series).

Based on this, he developed this system for the serial production of standard furniture and for determining the lengths, heights and widths of inner spaces.

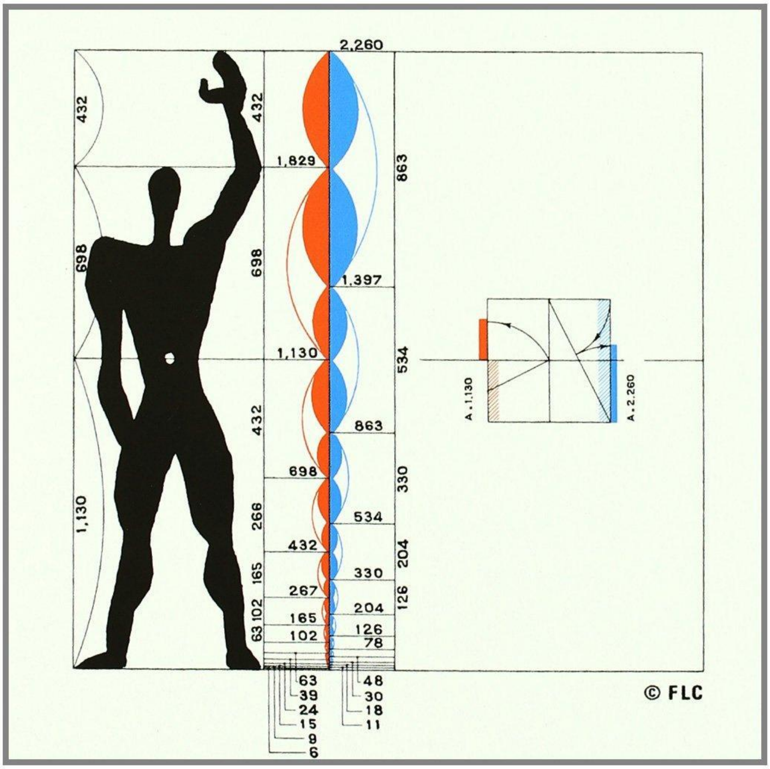


Figure 2: *The Modulor*
Source: https://images-na.ssl-images-amazon.com/images/I/61L1n6-FZ%2BL.jpg

Ching, Roth & Rassmussen (2012), states that these proportional dimensions were used for detecting the following dimensions:

27 cm. - the height of the armchair while sitting

43 cm - the height of the chair

70 cm - the height of the table

86 cm - the height of the countertop

113 cm - the height of the bar

140 cm - the height of the armchair horizontal arm

183 cm - human height

226 cm - human height with arm lifted up

Types of Anthropometry

There are two major classifications of anthropometrics: Static or Structural and Dynamic or Functional (Hedge, 2013).

Static anthropometry – This is also called structural anthropometry, and deals with simple dimensions of the stationary human beings e.g. weight, stature and the lengths, breadths, depths and circumferences of particular body structures. The fit between the form and dimensions of a space and our own body dimensions can be a static one as when we sit in a chair, lean against a railing, or nestle within an alcove space. Skeletal dimensions, measuring distance of bones between joint centres, includes some soft tissue measures in contour dimensions(includes the wobbly stuff that covers our bodies - muscle, fat, skin, bulk). Measures refer to a naked person (with some adjustments)

Dynamic anthropometry – Also called Functional anthropometry – deals with compound measurements of the moving human being. e.g. reach and the angular ranges of various joints. Dynamic fit situations as when we enter a building's foyer, walk up a stairway, or move through the rooms and halls of a building. In a dynamic method, distances are measured when the body is in motion or engaged in a physical activity including reach (e.g. could be arm plus extended torso), clearance (e.g. two people through a doorway) and volumetric data.

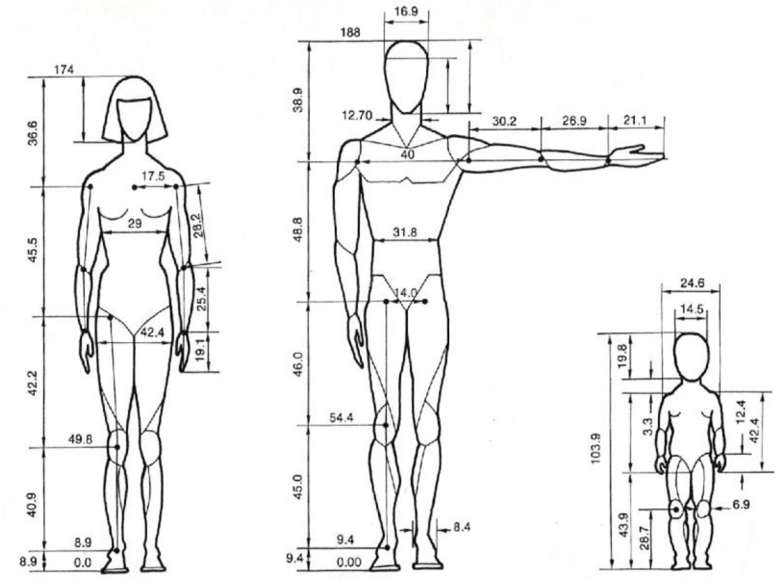


Figure.3. Static and Dynamic Anthropometrics
Source: https://emuarch114.fileswordpress.com/2018/10/arch114_l04.pdf

Importance of Anthropometrics and Ergonomics

Anthropometrics and Ergonomics are of crucial importance to architects as the ultimate basis of the design of most buildings must be the size of the people using them.

Anthropometrics is important in determining the overall design of a building, both interior and exterior. Dimensions should fit human activities.

Anthropometrics in building design ensures that every person is as comfortable as possible. It improves consumer's lives by increasing their comfort when using products. In practical terms, this means that the dimensions must be appropriate, ceilings high enough, doorways and hallways wide enough, and so on.

Ergonomics, when incorporated into industrial machinery and tooling can increase efficiency, productivity and reduce errors and accidents. Anthropometry ensures adequate space requirements for furniture and fittings. It ensures easy manoeuvrability around the building with respect to the design of stairs, lifts, ramps and other features.

Anthropometry may also impact on space requirements for furniture and fittings. For example, a bathroom must have enough space to comfortably fit a bath and sink; a bedroom must have enough space to comfortably fit an average-sized bed; an office building must have enough space to fit desks, air-conditioning units, communal areas, meeting rooms, and so on.

Anthropometry helps you to find out the minimum and exact standard dimensions required for a human being to fit in a bath and perform his regular activity easily. If workplace isn't well-designed to maximize user-comfort and efficiency, it's been shown to result in lower productivity, more absenteeism due to illness, plummeting staff morale and motivation and increased staff turnover. To illustrate it simply, office desks are made to a standard height; office workers are not.

Older people, children, people with mobility issues, wheelchair users and so on may have specific requirements. In particular, good accessibility and easy maneuverability around the building must be considered when designing stairs, lifts, ramps and other features.

As man has to use physical facilities to work, anthropometric and ergonometric measurements improve function and comfort. It makes all persons able to operate particular equipment because personnel are essentially an interchangeable component of any system.

Anthropometric measurements were also used to develop standards for human clearances and manoeuvring space between pieces of furniture or equipment.

Factors Affecting Anthropometric and Ergonomic Data

The difficulty with anthropometric proportioning is the nature of the data required for its use. For example, the dimensions are average measurements and are merely guidelines that should be modified to satisfy specific user needs. Average dimensions must always be treated with caution since variations from the norm will always exist due to the difference between men and women, among various age and racial groups, even from one individual to the next. The dimensions and proportions of the human body affect the proportion of things we handle, the height and distance of things we try to reach, and the dimensions of the furnishings we use for sitting, working, eating, and sleeping. There is a difference between our structural dimensions and those dimensional requirements that result from how we reach for something on a shelf, sit down at a table, walk down a set of stairs, or interact with other people. These are functional dimensions and will vary according to the nature of the activity engaged in and the social situation. Slideshare (2020) gives the following sources of variability:

Age – Body dimensions are related to age. As people grow, dimensions such as height and weight increase but start shrinking at old age.

Sex – Design should take care of differences in body dimensions between sexes. In general, males are larger than females for most body dimensions, and the extent of the difference varies from one dimension to another. Women, however, are larger than men in the four dimensions of chest depth, hip breadth, hip circumference and thigh circumference.

Culture – There are differences in anthropometric measurements caused by differences in nationality and culture. This is reducing due to internationalization of culture.

Occupation – There is anthropometric variability in different occupations. Different occupational requirements must be considered for example, manual labourers, require different space dimensions from those who work in offices. Care should be taken such that anthropometric data obtained from members of one occupation should not be used to design the environments of another.

Secular (Historical) Trends – Equipment used today are more compact than those used in earlier. Designers should consider these trends and project for the future.

Constraints and Criteria used in Anthropometry and Ergonomics

In anthropometry and ergonomics, a constraint is an observable, measurable, characteristic of human beings, which has consequences for the design of a particular artefact.

A criterion is a standard of judgement against which the match between user and artefact may be measured.

Primary criteria include comfort, safety, efficiency, aesthetics, while secondary criteria are varying degrees of primary criteria that must be attained. Pheasant (2003) gives the following constraints and criteria:

Clearance – Designers should provide adequate clearances such as head room, access and circulation space.

Reach - The ability to grasp and operate controls which determine the maximum acceptable dimension of the object.

The limiting user – Consideration should be given to that hypothetical member of the user population who, by virtue of his or her physical (or mental) characteristics, imposes the most severe constraint on the design of the artefact. In clearance problems the bulky person is the limiting user; in reach problems the small person is the limiting user. The design must be done to fit all.

Posture - Postural problems are commonly more complex than problems of clearance and reach—since we may well have limiting users in both tails of the distribution. For example, a working surface that is too high for a small person is just as undesirable as one that is too low for a tall person.

Strength – This implies the application of force in the operation of controls and in other physical tasks. Often, limitations of strength impose a one-way constraint, and it is sufficient to determine the level of force that is acceptable to a weak limiting user.

Adjustability – Adjustable furniture helps us to design to fit every category. Once we have adjustable chairs, desk height can be designed to accommodate about 90 to 95% of users.

Trends – Designers need to consider present as well as future trends.

The variability in the body sizes makes it necessary to take an average of body sizes so that the environment will fit all sizes, but in more specific instances the environment should fit a particular size.

Measurement Techniques

Anthropometry involves the systematic measurement of the physical properties of the human body, primarily dimensional descriptors of body size and shape. Anthropometric measurements require precise measuring techniques to be valid. Specifically, anthropomorphic measurements involve:

Size (e.g., height, weight, area, and volume),

Structure (e.g., height, width, length of various body parts), and

Composition (e.g., the percentage of body fat, water content, and body mass) of humans.

Hedge (2013) explains that distribution of measurements can be represented by three statistics:

Mean (the average)

Median (midpoint at which 50% >, 50%< than value)

Mode (most frequently occurring number).

Workspace Layout

Importance - most important items should be most central and closest.

Function - items with similar functions should be closest together.

Frequency-of-use - position most frequently used items in optimal locations.

Sequence-of-use - position items in optimal locations for sequence of use.

Normal Posture - position items to be accessible from a normal posture.

Tools for Anthropometric Measurements

A variety of specialized tools (as depicted below) are used to obtain anthropometric measurements:

Stadiometers: height

Anthropometers: length and circumference of body segments

Bicondylar calipers: bone diameter

Skinfold calipers: skin thickness and subcutaneous fat

Scales: weight

Space and Place in Architecture

Space and place coexist. Space is emptiness or void, where buildings are built, and trees grow. It is defined as empty land or an open area as it is unoccupied with dimensions of length, of width and of depth (Al-Menshawy, El-Sieedy & Abuzekry, 2021). Space is one of the elements or tools of design. On the other hand, a place finds its existence in space and is seen as a container of man and his activities. In practical architectural terms, space is the site that is void and on which the architect creates a place, a solid container of activities and experiences for man. Thus, the architect creates 'patterns of solids and voids' (Ching, 2015), and in doing so, creates places (solids) and spaces (voids).

Positive space implies form (Place) meanings and attachment a person has for a particular setting Negative Space is void, implying the unbuilt area on a site, the gap between structures on a site. In shaping space, it is necessary to keep contrasting between solids and voids to create the required visual aesthetics (beauty).

Characteristics of Space

Space has a boundary which could be real or imagined.

Space is a container and as such has volume measured by its length, breadth and height.

Space can be organized for better effects.

Characteristics of Place

Place requires closure to define it from space. Closure is provided by planes, bottom plane, top plane and side planes. In other words, places must have form which in turn has openings such as doors that direct entry, defining routes and windows which bring light and regulate views, relate outdoor and indoor.

Place must have activities such as work, social interactions.

Place must have meaning to the individual. A place "is closely involved with the most personal aspects of our lives" (Ballantyne, 2002), such experiences and personal perceptions (Vali & 2014)

Types of Space

Ching (2015) identifies the following types of spaces:

Space between a space – A space may be contained within the volume of a larger space

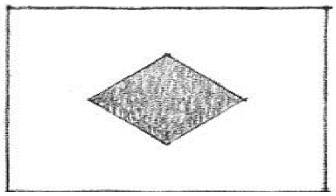


Figure 4: Space within a Space

Interlocking space - The field of a space may overlap the volume of another space.

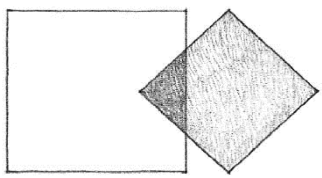


Figure 5: Interlocking

Adjacent spaces - Two spaces may be about each other or share a common border.

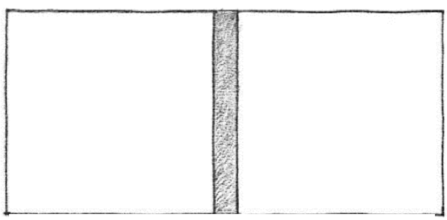


Figure 6: Adjacent Spaces

Linked spaces - two or more spaces linked by a third intermediate space, Two spaces may rely on an intermediary space for their relationship.

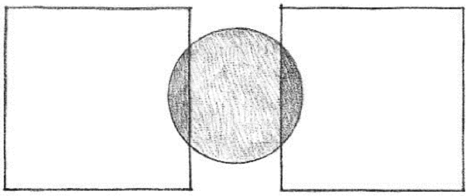
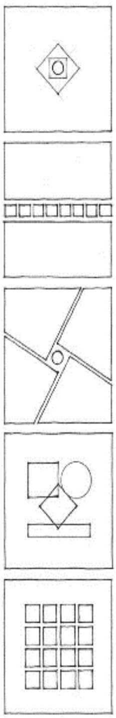


Figure 7: Linked Spaces

Space Organization

Spaces organized within the field of a structural grid or other three-dimensional framework



Centralized Organization
A central, dominant space about which a number of secondary spaces are grouped

Linear Organization
A linear sequence of repetitive spaces

Radial Organization
A central space from which linear organizations of space extend in a radial manner

Clustered Organization
Spaces grouped by proximity or the sharing of a common visual trait or relationship

Grid Organization
Spaces organized within the field of a structural grid or other three-` framework

Figure 8: Organization of space. Source:

Summary

This chapter has discussed the concepts of anthropometrics, which deals with measurements of human dimensions and ergonomics which deals with the relationship between man and machinery and the equipment human beings use, and the working environment. Ergonomics uses anthropometric data to ensure that the machines and the environment fits the person. Both anthropometric and ergonomic data can be static or dynamic. Factors that affect anthropometric data include age, gender, occupation, racial and ethnic group, culture, diurnal and secular (historical) trends. Clearance, reach, posture strength and the limiting user are constraints and criteria for anthropometric data. The chapter concludes with a discussion of space as an element of design, which is seen as an empty site and placed as solids on the site.

Exercises

1. What is the relationship between anthropometry and ergonomics?
2. Discuss two types of anthropometric measurements.
3. Why are anthropometrics and ergonometrics important?
4. Discuss five criteria for variation of anthropometric data.
5. How can our design now take care of future generations of Nigerians, who are getting taller?
6. Undertake an experiment by measuring fellow students in traditional clothes and take an average.
7. Differentiate between space and place.

References

Al-Menshawy, A. El-Sieedy, A. Abuzekry, T. (2021). The difference between the concept of space and of place in urban science. The Egyptian International Journal of Engineering Sciences and Technology, Vol. 35 (2021)1–7. https://eijest.journals.ekb.eg/.

Arch 114 Lecture 04 (nd). Human and Socio-Cultural Factors in Design. Eastern Mediterranean University Department of Architecture. Accessed from https://emuarch114.files.wordpress.com/2018/10/arch114_l04.pdf on 13/03/2023.

Ballantyne, A. (2002). Architecture: A very short introduction. New York: Oxford University Press.

Ching, F.D.K. (2015). Architecture: form, space, & order (Fourth edition). New Jersey: John Willey & Sons.

Ching, Roth & Rassmussen (2012). ARCH 121 – Introduction to architecture I. Week 5: Proportion and Scale. Accessed from https://arch121.cankaya.edu.tr/uploads/files/Week%205-lecture%20notes-21-oct-2012.pdf on 13/03/2023.

Del Prado-Lu, J.L. (2007). Anthropometric measurement of Filipino manufacturing workers. Int. J. Ind. Ergon. 37 (6) (2007) 497–503.

Hedge, A. (2013). Anthropometry and Workspace Design, Cornell University DEA 3250/6510. https://www.yumpu.com/en/document/view/50621855/anthropometry-and-workspace-design-cornell-university-/7.

Pheasant, S. (2003). Bodyspace: Anthropometry, Ergonomics and the Design of Work. (Second Edition). London: Taylor & Francis.

Slideshare (2020). Anthropometric: Basis of architectural design. Assessed from https://www.slideshare.net/iiTCHANJAYVES/1-anthropometry on 13/03/2023.

Taifa, I. W. and Desai, D. A. (2017): Anthropometric measurements for ergonomic design of students' furniture in India. Engineering Science and Technology, an International Journal 20 (2017) 232–239.

Vali, A. P. and Nasekhiyan, S. (2014). The concept and sense of place in architecture from phenomenological approach. Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online). Available at www.cibtech.org/sp.ed/jls/2014/04/jls.htm 2014 Vol. 4 (S4), pp. 3746-3753.

BIODATA PROFESSOR EZEKIEL NGHAI SULAIMAN

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Climate Considerations in Design

Mike Adebamowo, *University of Lagos*

Overview

Buildings are designed to suit the local climate in order for occupants to be thermally comfortable, to use minimal energy to cool the building, to reduce emission of GHG, reduce pollution, maintain good indoor conditions, for cost effectiveness, pleasantries, delight and ultimately for sustainability especially in this era of climate change. Climate determines the optimum orientation of buildings in order to reduce solar heat gains in the tropics and enhance cross ventilation, spacing and grouping of buildings, size, location and types of windows and also specification of building materials and components.

This text deals with climatic elements and their influence on building design. These include temperature, humidity, solar radiation, wind and rainfall. The architect requires a good understanding of how to use the data obtained from these climate elements in order to produce a climate responsive, energy efficient, environmentally friendly and cost effective building that provides occupant wellbeing (comfort, health and satisfaction) and is sustainable.

Objectives

The following are the objectives of the text are to;

1. describe climate and basic climatic data required for building design.
2. identify the general climatic classification systems as the basis for building design.
3. describe the four Nigerian Climatic Zones and their characteristics.
4. discuss the importance of designing with climate with special focus on thermal comfort issues.

5. explore the various design techniques appropriate for each climatic zone in Nigeria.

Climate and Basic Climatic Data for Building Design

The basic properties of the atmosphere around the earth are weather and climate. Weather is an accumulation of atmospheric phenomena that occur over one place for a brief period of time. Climate is the combination of weather conditions over a longer period of time (usually 30 years or more). The essential distinction between climate and weather is made by the element of time.

The architect is particularly interested in climate aspects that impact occupant comfort, energy consumption, building function, and durability. These include temperature changes, extremes and averages, as well as temperature variations between day and night (diurnal temperature range), humidity, sky conditions and incoming and outgoing radiation.

Weather and climate data as recorded at meteorological stations are usually suitable for forecasting weather conditions, aviation and agricultural purposes and not for architectural design purposes. It is therefore the architect's responsibility to obtain climatic information and present it in a manner that is useful for design. (Table 1)

Table 1: Climatic Information

S/N	CLIMATIC INFORMATION	DESCRIPTION
1	**Air Temperature**	The temperature of the air is measured in Degrees Celsius (°C), usually with a mercury thermometer. Temperature conditions on which design work can be based require measurements of monthly mean, monthly mean maxima and minima, monthly extreme maxima and minima temperatures.
2	**Humidity**	The humidity of air can be described as Absolute Humidity (AH) and it's the amount of moisture actually present in the mass or unit value of air. However, the Relative Humidity (RH) is the form of expression that is more useful for design work. This is the ratio of the actual amount of moisture present to the amount of moisture the air could hold at any given temperature and it is expressed in a percentage. Humidity is usually measured with the hygrometer (or the dry and wet bulb thermometer). After the reading of the dry bulb temperature (DBT) and the wet bulb temperature (WBT) are taken, the humidity slide-rule is used to measure the Relative Humidity (RH). You can also measure the RH directly with a digital hygrometer.
3	**Precipitation**	Precipitation is the term used collectively for rain, snow, hail, dew and frost i.e. all forms of water deposits from the atmosphere and measured by rain gauge; expressed in min/day or min/month. It is important to measure rainfall intensity/duration frequency of rainfall expressed as number of days with rain per month, and the direction of driving rain.
4	**Sky Conditions**	Sky conditions are usually described in terms of presence or absence of clouds. It is usually measured in eights; also referred to as oktas or octets. The architect would need to know the time of day and frequency of observations. Sky luminesce values are needed if day lighting in building is to be predicted.
5	**Solar Radiation**	The duration of sunshine which can be measured by a sunshine recorder or solar meter, heliometer etc. and expressed in W/m^2 or J/m^2s. Average daily amounts of solar radiation (MJ/m^2day) for each month of the year would give a fair indication of climatic conditions including seasonal variations.
6	**Wind Measurement**	Wind velocity is measure by a cup-type or propeller anemometer or digital anemometer measured and its direction is measured by wind vane. Velocities are measured in meters per second/s and directions can be grouped as per four semi-cardinal points, NE, SE, SW and NW.

Source: Modified from Evans (1980)

Apart from the climatic information, it is necessary to know the vegetation which typifies the local or site climate. It is an important element in the design of outdoor spaces because, it provides sun shading and helps with the protection from glare

General Climatic Classification as Basis for Building Design

Climate is characterized by several atmospheric parameters: air temperature, precipitation rate, evaporation rate, humidity, cloudiness, solar and long wave radiation, wind speed and direction and air pressure. These attributes are the fundamental properties of a climate.

According to Heerwagen (2004), numerous climate classification systems have been devised during the past century and fall under three principal types which entail those based strictly on climatological data, those founded on the existence of environmental conditions suitable for natural plant growth, and those which evaluate environmental conditions in terms of the ready maintenance of human comfort.

Koppen, a German Biologist developed what has become the most widely used climate classification system. This system is fundamentally based on monthly air temperature averages and seasonal and annual precipitation rates. Five zones are identified namely: 1) Tropical Rainy Climate (Tropical), 2) Dry Climate (Dry), 3) Warm Temperate Climate (Temperate), 4) Cold-Snow Forest Climate (Continental) and 5) Polar Climate (Polar).

The Trewartha climatic classification which was derived from the Koppen Model has been established principally on air temperature and moisture which are two main attributes in building design for comfort. The Trewartha climate classification system which has seven groups and twelve types can be compressed into four distinct climate types: 1) Warm Humid 2) Hot Dry 3) Cold and 4) Temperate.

Nigeria Climatic Zones and Characteristics

Nigeria lies within 4^oN to 14^oN latitudes and 2.5^oE to 14.5^oE longitudes and its climate can be described as tropical with two climatic seasons; the Dry season (November - March) and Rain season (April - October).

Komolafe (1988) proposed a climatological map and a table of the characteristics as shown in Figure 1 and Table 2 respectively. Four climatic zones have been proposed for use in the design of buildings in Nigeria. These zones are Zone 1 – Hot Dry, Zone 2 – Temperate Dry, Zone 3 – Hot Humid and Zone 4 – Warm Humid.

The climatic descriptions of each zone are stated below:-

1. **Zone 1 - Hot Dry:** This is characterized with a mean daily maximum dry bulb temperature during the dry season, which is equal or greater than 35^oC, RH of less than 40%, daily range of temperature between $15\text{-}20^oC$, mean annual rainfall of 528mm to 960mm with height above mean sea level of more than 300m.
2. **Zone 2 – Temperate Dry:** This is characterized with a mean maximum dry bulb temperature greater than or equal to 30^oC during the dry season, RH not exceeding 40%, daily range of temperature less than or equal to 10^oC with annual rainfall from 1077mm to 1399mm with height above mean sea level of more than 300m.

3. **Zone 3 – Hot Humid:** It is characterized with a mean daily maximum dry bulb temperature greater than or equal to 30^oC, RH between 40-70% during the dry season, daily range of air temperature is less than 10^oC with annual rainfall between 1183mm to 1787mm with height above mean sea level between 100m-300m.

4. **Zone 4 – Warm Humid:** It is characterized with a mean daily maximum dry bulb temperature greater than or equal to 30^{o}C during the dry season, RH between 70-100%, daily range of air temperature less than 8^{o}C with annual rainfall between 1185mm to 2788mm with height above mean sea level of less than 100m.

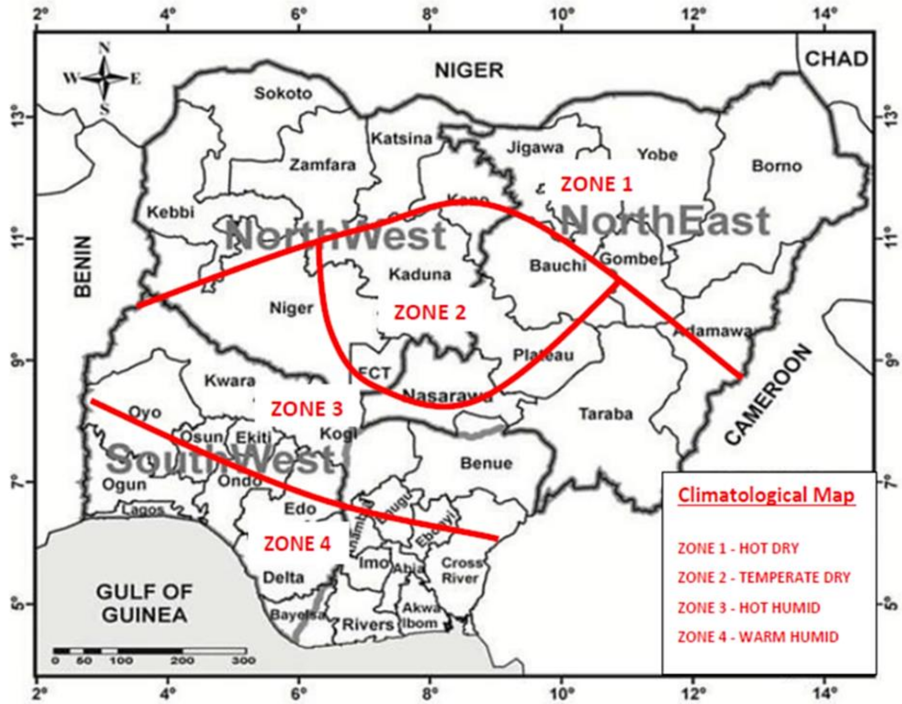


Figure 1: Nigeria Climatological Map
Source: Akande et al (2015)

Table 2: Climatic Zones of Nigeria

S. No.	NAME OF THE STATE	REPRESENTATIVE CITIES	HEIGHT ABOVE M.S.L.	MEAN MAX. DRY BULB TEMPERATURE (^{O}C)	RELATIVE HUMIDITY PER CENT	CLIMATIC ZONE
1.	BORNO, SOKOTO, PART OF KADUNA, BAUCHI, KANO AND GONGOLA	MAIDUGURI, YELWA, KATSINA, BAUCHI, KANO AND YOLA	300m	35 - 40	UP TO 40%	HOT DRY (H.D.)
2.	PART OF KADUNA, ZARIA, ABJA, PLATEAU AND BENUE	ZARIA, JOS, ABUJA	300m	30 - 35	UP TO 40%	TEMPERATE DRY (T.D.)
3.	NIGER, KWARA, OYO, ONDO, ANAMBRA AND IMO	BIDA, ILORIN, LOKOJA, IBADAN, ONDO AND ENUGU	300m 100m	30 - 35	40 – 70%	HOT HUMID (H.D.)
4.	LAGOS, BENDEL, RIVERS, CROSS RIVER AND OGUN	LAGOS, IKEJA, BENIN CITY, PORT HARCOURT AND CALABAR	100m	25 - 32	70 – 100%	WARM HUMID (W.H.)

Source: Komolafe (1988)

Importance of Designing with Climate

It is important for buildings to be designed for occupant wellbeing (comfort, health and satisfaction) and our focus is on thermal comfort which is arguably the most important aspect.

1. Thermal Comfort Requirements

Thermal comfort according to Adebamowo, (2017) is defined as a state of thermal rest, devoid of heat or cold stress. Fanger, (1982) defines it as that condition of mind which expresses satisfaction of the thermal environment. Essentially thermal comfort is a subjective value and it's a function of how the body responds or exchanges heat with the environment.

Various researchers including Nicol et-al, (2020), Chen & Wang, (2021), Deng & Tan, (2020), Medina et-al (2021) and Adebamowo, (2017) agree that four climatic and two personal factors are the dominant variables that affect thermal comfort within a building. The climatic factors are: 1) Dry Bulb Temperature 2) Relative Humidity 3) Air Velocity and 4) Mean

Radiant Temperature. The personal factors are 1) Clothing 2) Metabolic Rate.

The extent to which these factors can be controlled or manipulated to create an optimum indoor environment depends on architectural design, climate zones and a thorough understanding of the thermal properties of the building materials and components.

2. Thermal Comfort Indices

There have been many attempts to develop a single scale that incorporates all factors that impact thermal comfort. These scales are known as thermal comfort models or thermal comfort indices or models. (Table 3)

Table 3: Thermal Comfort Indices

S/N	Thermal Comfort Indices	Abbreviation
1	Effective Temperature	ET
2	Corrected Effective Temperature	CET
3	Equivalent Warmth	EW
4	Operative Temperature	OT
5	Equatorial Comfort Index	ECI
6	Resultant Temperature	RT
7	Predicted Four Hour Sweat Rate	P_4SR
8	Heat Stress Index	HSI
9	New Effective Temperature	NET
10	Standard Effective Temperature	SET
11	Predicted Mean Vote	PMV

Sources: Adebamowo, (2017)

2. Adaptive Thermal Comfort Approach

Many researchers, Nicol et-al, (2020), Yadeta et-al, (2022), Haniyeh et al, (2022), Aqilah et al, (2022) and Parkinson et-al,

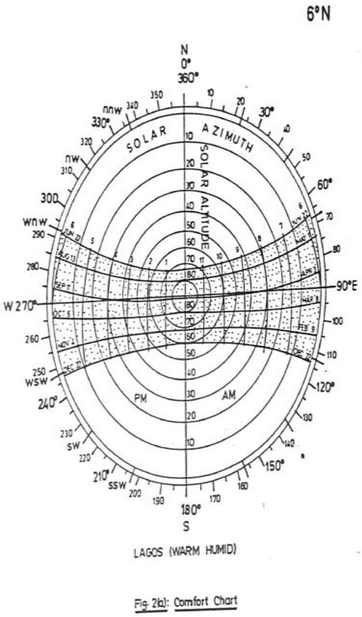
(2020) have shown that comfort does not depend only on the human physiology or heat transfer mechanisms, but also on our social factors and psychological reactions to the environment.

Based on field research of people living in the real world, adaptive thermal comfort was created. It was found that people were more comfortable expressing their comfort levels than they were using climate chambers or laboratory studies. It was discovered that people can adapt to their environment and attain thermal comfort if they have the opportunity and the time.

These actions can be involuntary such as sweating or shivering, or voluntary such as changing their position or activity, clothing, closing a window, drinking cold or warm beverages, or taking a shower or changing the environment. According to the adaptive comfort principle, people will react to discomfort in a way that restores their comfort.

3. Indoor Thermal Control in the Tropics

Comfort charts are used to determine the time and months during which discomfort occurs. The clear part on the chart represents the comfort zone and the shaded portion represents the discomfort zone. The months of the year when shading would be needed are then determined and the appropriate shading device can be applied. Two charts are shown as illustrations for Warm Humid and Hot Dry Zones. Figures 2a and 2b are for Lagos and Maiduguri respectively.



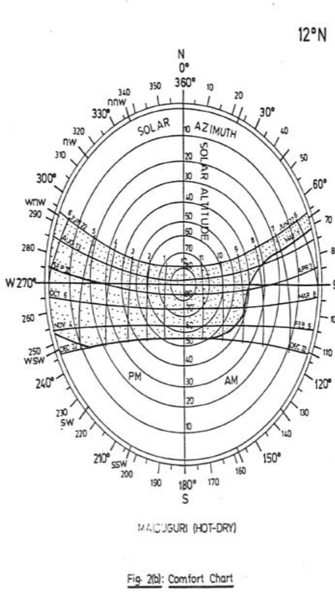


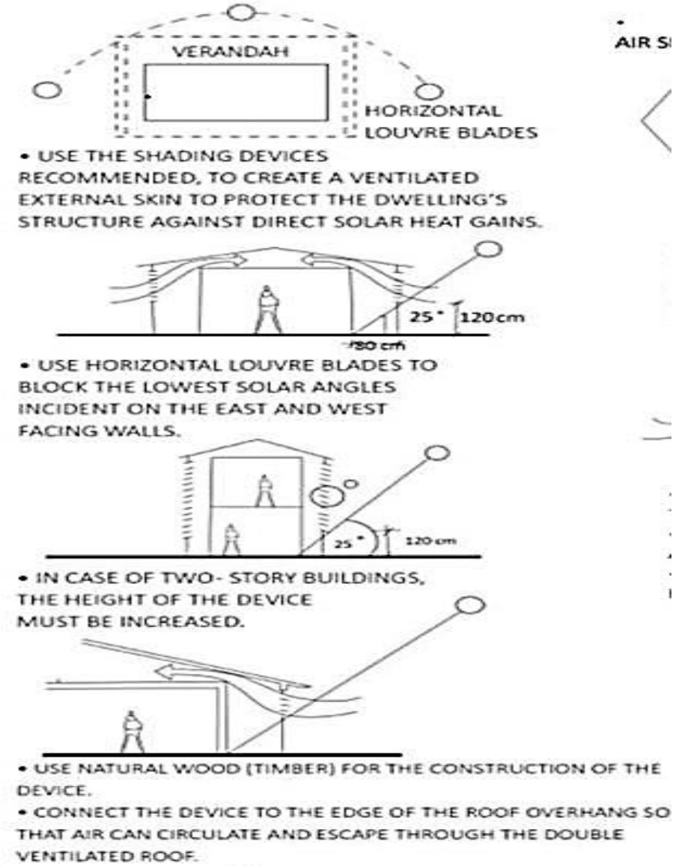
Figure 2a: *Comfort Chart*
Source: Komolafe (1988)

Figure *2b: Comfort Chart*
Source: Komolafe (1988)

Adebamowo, (2007) identified four passive means of controlling indoor thermal conditions in the warm humid environment. They are 1) Solar Control, 2) Ventilation, 3) Thermal Mass and 4) Dehumidification.

1. **Solar Control**
   The sun is the major source of heat gain. Therefore, solar control is the first strategy to be proposed in order to avoid overheated conditions caused by sun rays striking on the building envelope and its surroundings. To avoid internal heat gains and therefore unpleasant thermal conditions, it is necessary to control two types of radiation: a) Direct solar radiation, and b) Indirect long-wave radiation. This can be by proper orientation of the structure and the utilization of effective shading devices. The best orientation to

minimize solar radiation in the warm humid climate is to have the major axis of the building along the east-west line as shown in figure 3.



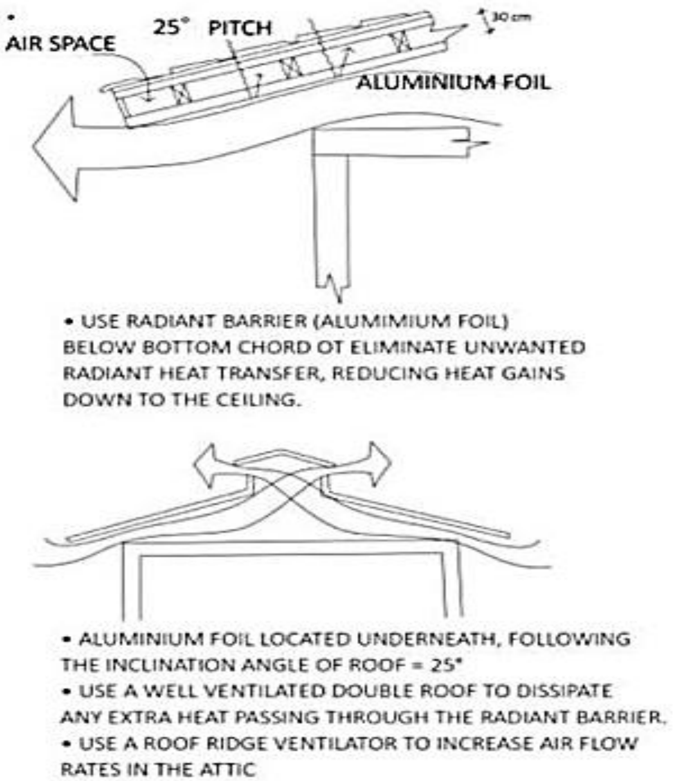
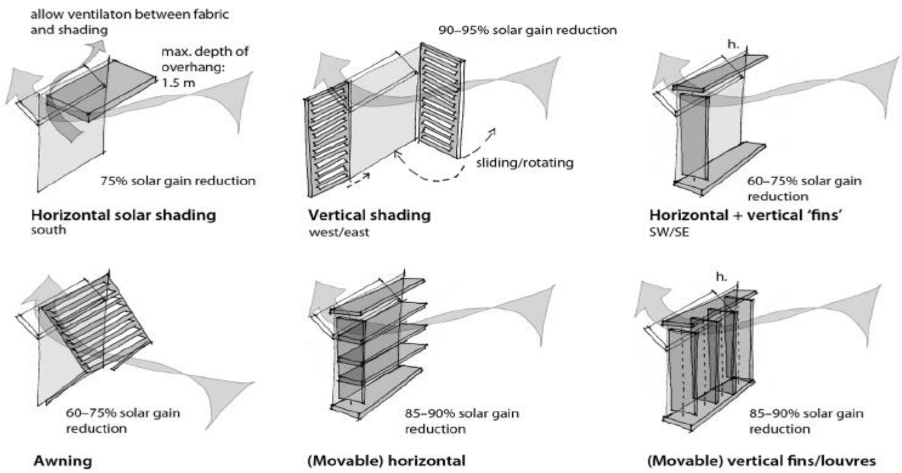


Figure 3: *Means of Solar Control*
Source: Adebamowo, (2017)

Shading devices can be divided into internal and external ones. Internal shading devices such as curtains, blinds and screens are the least effective way of solar control as discovered by Koenigsberger et-al, (1974), Evans, (1980) and Godwin, (1988). External devices can be classified into three basic types: Horizontal devices, Vertical devices and Egg-crate devices as shown in figure 4.

2. Ventilation

Natural ventilation and air movement are related to three distinct functions: (1) supply of fresh air; (2) structural convective cooling; and (3) ventilation for physiological cooling as shown in figure 4.



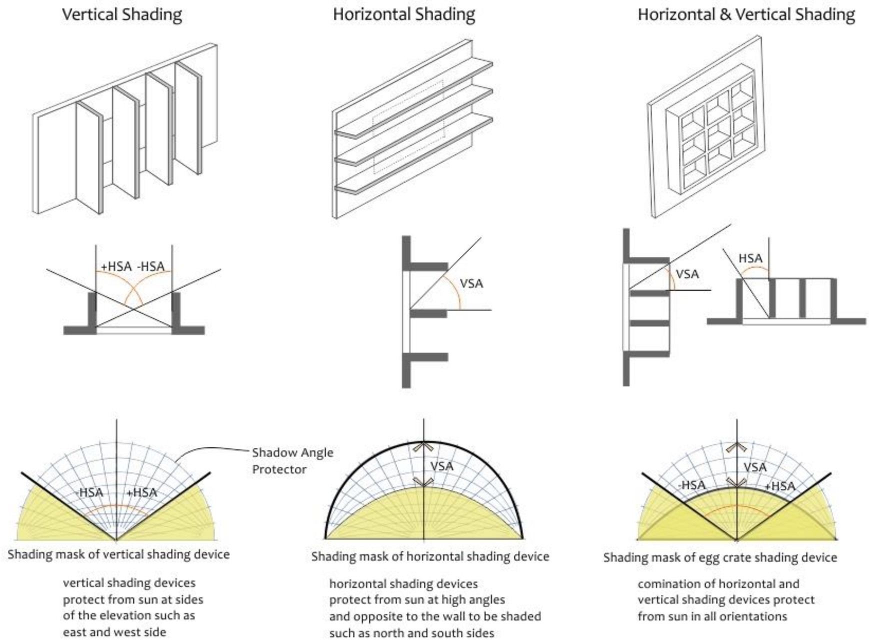


Figure 4: Sun Shading Devices
Source: Adebamowo, (2017)

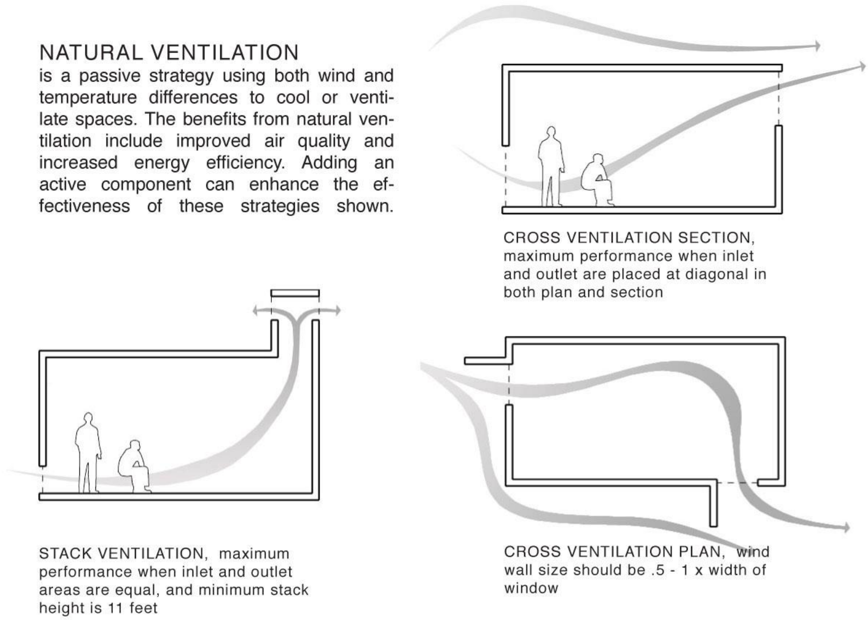
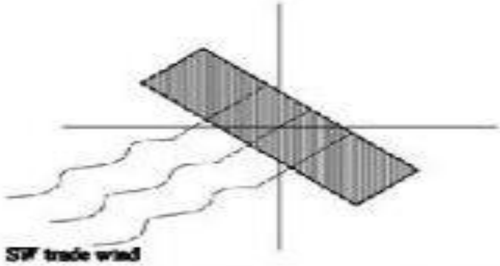


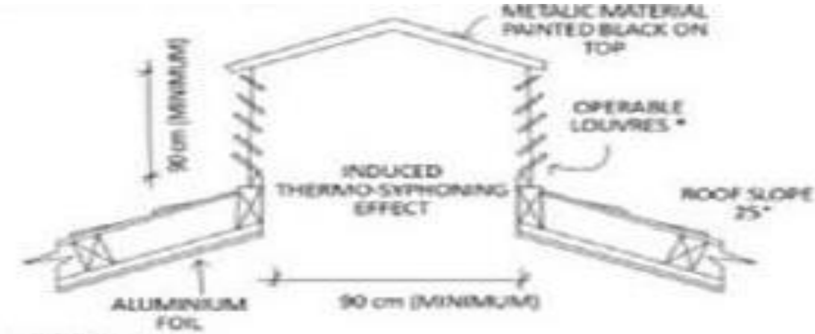
Figure 5: *Means of Ventilation* *Source:* Adebamowo, (2017)

Guidelines and criteria for natural ventilation design as shown in figure 6 include the following rules of thumb:

1. Site design includes the layout, orientation, and location of buildings.
2. Design programs related to indoor air quality, ventilative cooling and other requirements.
3. Design aspects of building include the structure of the building, vertical and plan distributions of spaces, as well as the location and size of openings.
4. The aspect of opening design relates to the selection of screen types and their operational features.



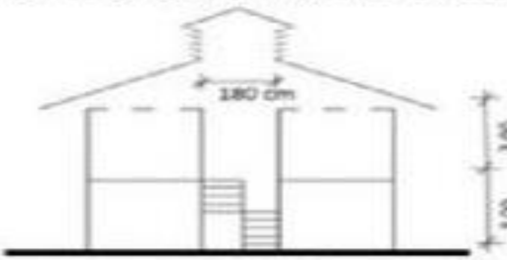
• USE ROOF RIDGE VENTILATORS TO INCREASE THE SUCTION FORCE (-) ON THE ROOF TOP



• DETAIL A

• USE CEILING OPENINGS TO EXHAUST HOT AIR FROM THE INTERIORS

* THEY MUST BE CLOSED DURING COLD PERIODS



• USE THE STAIRCASE AS A VENTILATION SHAFT FOR TWO STORY BUILDINGS.

• INCREASE THE WIDTH OF THE DEVICE TO SUIT THE WIDTH OF THE STAIRCASE (eg180cm)

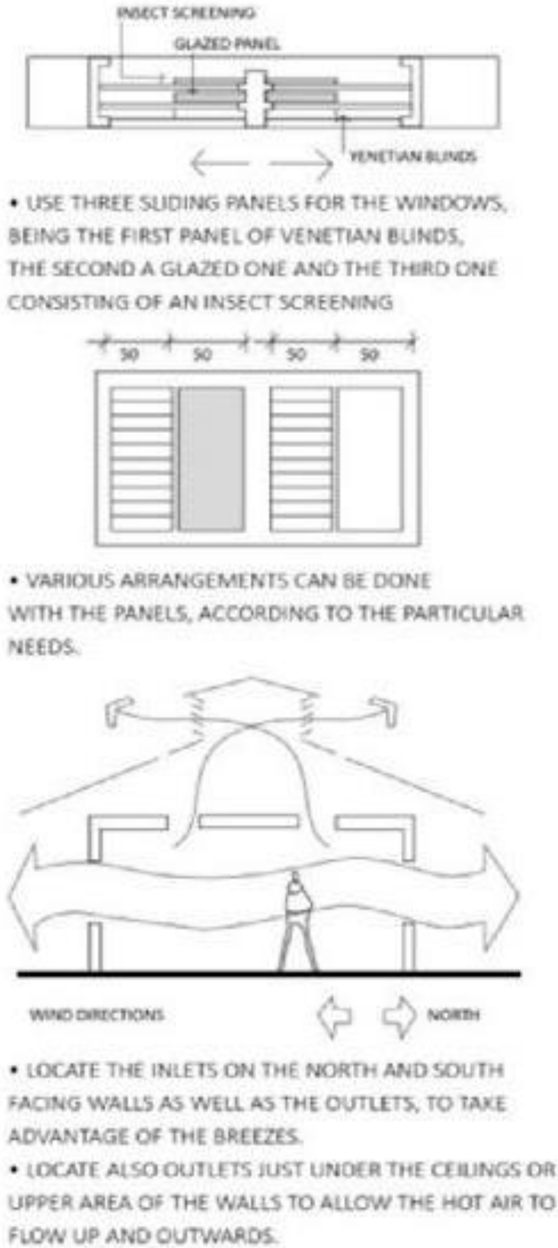


Figure 6: *Design Strategies for Natural Ventilation Source: Adebamowo, (2017)*

3. **Thermal Mass**
   The concept of heat storage is based on the principle that certain materials delay the heat transfer from the outside surface to the interior of the building, as they hold their temperatures for longer periods of time. High thermal mass structures tend to limit internal temperature variations, thus helping to overcome peak temperatures occurring throughout the day.

4. **Dehumidification**
   Whenever the thermal conditions are not favourable and it is not possible to provide humidity control by increasing air movement, supplemental dehumidification is required. Dehumidifiers can reduce the moisture content of the air in buildings when the humidity level becomes excessive. There are various dehumidification methods, but the choice of a particular technique should be based on its compatibility with the passive or hybrid thermal control strategies applied in the building.

Architectural Design Techniques for Each Climatic Zone in Nigeria

Zone 1 – Hot Dry

Discomfort is occasioned by extremes of heat and dryness accompanied by seasonal sand and dust storms. In order to create a comfortable indoor condition, buildings have to be protected from intense radiation from the sun.

Design Techniques are:

1.Compact planning of buildings for mutual shading and minimum exposure of building envelopes.

2.Orientation of buildings so that the longer dimension faces the North-South, while the East-West end should have less fenestration.

3.Courtyard system/form of building is appropriate when further cooled by plants and water, day temperatures are lowered, and humidity is controlled.

4.Extreme green areas rather than paved areas to help absorb heat rather than dissipating heat. Outdoor sleeping areas can be provided.

5.Windows on outside walls should be relatively small and shielded from direct radiation and glare. Ventilation during daytime should be reduced to minimum for wellbeing.

6.External walls should be very thick to ensure time-lag for heat to travel to the interior.

Roofs should have heat storing and reflective upper surface capacity.

Zone 2 – Temperate Dry

Light weight structures with short time lag are appropriate for walls. Clay bricks give better thermal performance than sandcrete blocks. Lightweight or medium-heavy weight insulated roof systems are desirable.

Zone 3 – Hot Humid

Similar to warm humid, the priority is enhancing ventilation and reducing solar heat gain. Lightweight structures are satisfactory with some insulation on the East and West walls. Clay bricks are also preferred to sandcrete blocks. Roofs should be of high pitched roofs with ceiling due to heavy rainfall. Allow natural cooling using shaded ground, evaporative cooling and SW wind. Landscaping, trees and shrubs also help in shading and reducing daytime temperatures.

Zone 4 – Warm Humid

Uncomfortable condition of sweating and sticky skin caused by high temperature and high RH. Buildings should be designed to enhance natural ventilation and reduced solar heat gain.

Techniques to be employed are:

1. Buildings should be dispersed or staggered with free air space to enhance air flow.
2. Elongated structures with orientation that allows for free flow of the SW wind is appropriate; single backed design with open veranda as against double loaded corridors for cross ventilation is desirable.
3. North and South orientation for habitable rooms with minimal or no fenestrations on the East and West walls to reduce solar heat gains.
4. Heat and moisture producing areas should be isolated and separately ventilated in the building.
5. Windows should be large and type to be carefully chosen and be shaded appropriately from solar radiation.
6. Walls should be of lightweight materials with low thermal capacity.
7. Roof should be ventilated and insulated. High sloping roof that drains water quickly is desirable.

All these design techniques are flexible guidelines and not rigid rules as they are subject to particular building types and functions. For instance, thermal mass is good for offices in the tropics but not for residences. Again, as important as natural ventilation is in residences in the humid environment, it may not be appropriate for a shopping mall that requires a controlled indoor condition. Finally, other aspects of comfort like visual, acoustics and other issues like rainfall and moisture control in buildings are important but have not been the focus of this text.

Summary

The text has established the significance of relating buildings with the local climate in order to ensure occupant wellbeing, cost effectiveness and sustainability. It has identified the various climatic classification systems and particularly the Nigerian Climatic Zones and their characteristics. It has further provided guidelines which serve as design techniques for each climatic zone identified in Nigeria. It has been noted that these techniques are not rigid rules but flexible and subject to particular building types and functions.

Exercise

1. Why is it essential to design buildings in conformity with the local climate?
2. Discuss the passive means of controlling the indoor thermal environment in the warm humid zone of Nigeria.
3. Explain the dominant factors influencing thermal comfort within a building.
4. What design techniques would you recommend for the following climatic zones and why? i) Hot Dry ii) Temperate Dry iii) Hot Humid iv) Warm Humid

References

Adebamowo, M.A. (2017), Sustainable Architecture: - A Return to Nature through Biomimicry. *An Inaugural Lecture delivered at University of Lagos, Unilag Press and Bookshop Ltd.*

Adebamowo M.A. (2007):- Thermal Comfort in Urban Residential Buildings in Lagos Metropolis: *Unpublished Ph.D Thesis, Department of Geography & Planning, Lagos State University, Ojo, Lagos.*

Akande, O.K., Fabiyi, O. and Mark, I.C.(2015). Sustainable Approach to Developing Energy Efficient Buildings for a Resilient Future of the Built Environment in Nigeria. *American Journal of Civil Engineering and Architecture*. *3(4),* 144-152 doi: 10.12691/ajcea-3-4-5

Aqilah Naja, H. Rijal, and S. A. Zaki (2022), A Review of Thermal Comfort in Residential Buildings: Comfort Threads and Energy Saving Potential. *Energies, 15, 9012,* https://doi.org/10.3390/en15239012

Chen Y., Wang Y. and Zhou D. (2021), Knowledge Map of Urban Morphology and Thermal Comfort: A Bibliometric Analysis Based on Citespace. *Energy Build, 11(10)*:pp 427- 438

Deng X, and Tan Z. (2020), Numerical Analysis of Local Comfort in a Plan Office under Natural Ventilation. *Indoor Built Environ, 29(7),* pp 972-986

Evans M. (1980):- Housing, Climate and Comfort. *The Architecture Press London*.

Fanger P.O. (1982):- Thermal Comfort. *Robert E. Krieger Publishing Company, Malabar, FL*

Godwin J. (1988):- Architecture, Climate and Environment. *Proceedings of the National Seminar, Nigerian Building and Road Research Institute, pp 86-98.*

Haniyeh Mohammad Pourkarbasi, Iain Jackson, Daniel Nukpezah, Irene Appeaning Addo, and Rexford Assasie Oppong (2022), Evaluation of Thermal Comfort in Library Buildings in the Tropical Climate of Kumasi, Ghana. *Energy and Buildings Vol 268, 112210*

Heerwagen, Dean (2004), Passive and Active Environmental Controls. Informing the Schematic Designing of Buildings. *McGraw Hill NY 10020*

Koenigsberger; Ingresoll T.G, Mayhew A. and Szokolay S.V. (1974):- Manual of Topical Housing and Building**.** *London Longman Group Limited.*

Komolafe, L. Kayode (1988), Design of Buildings for Thermal Comfort in the Different Nigerian Climate Zones- *Proccedings of the National Seminar on Architectural Climate and the Environment NBRRI, Lagos PP 8-23*

Medina J.M., C. Rodriguez, Maria Camila Coronado, and L. Garcia (2021), Scoping Review of Thermal Comfort Research in Colombia. *Engineering and Buildings 11,232,* https://doi.org/10.3390/buildings11060232

Nicol Fergus, Hom Rijal, Hikaru Imegaw, and Rita Thopa (2020), The Range and Shape of Thermal Comfort and Resilience, *Energy and Buildings Vol. 224, 110277,*

Parkinson T., de Dear R.,and Brager G. (2020), Nudging the Adaptive Thermal Comfort Model. Energy Build, 206:109559

Yadeta Chali, Madhavi Indraganti, E. Alemayehu, and Gudina Terefe T. (2022), An Investigation of Human Thermal Comfort and Adaptation in Naturally Ventilated Residential Buildings and its Implication of Energy Use in Tropical Climates of Ethiopia, Science and Technology for the Built Environment Vol. 28, Issue 7, https://doi.org/10.1080/23744731.2022.2048574

Zanibom L.,and R. Albatici (2022), Natural and Mechanical Ventilation Concepts for Indoor Comfort and Well-Being with a Sustainable Design Perspective: A Systematic Review, Buildings, 12, 1983, https://doi.org/10.3390/buildings12111983

BIODATA OF PROFESSOR MICHAEL ADEBAMOWO. B.Sc.; M.Sc.; Ph.D; FNIA

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Mike Adebamowo joined the service of the University of Lagos in 1995 and has served the University in various capacities, as Head, Department of Architecture Dean of the Faculty of Environmental Sciences and currently a member of the University Council. The erudite scholar has over 40 publications in National and International Journals and one of his publications won the best paper award of Emerald in 2018.

As a Consulting Architect, he has designed and supervised many building projects notable among these are the Golden Park Estate, Lekki, remodelling of Faculty of Arts Building, Unilag; Martinos Event Centre; R&A City Hotel Ikeja; The Summit Hall; Multi-Storey Car Park for Island Club; and The Citadel Church Building and the Redeemers Health Village. All these projects have a positive impact on the environment. He is a member of Network for Comfort and Energy Use in Buildings (NCEUB) UK, member American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), Fellow of the Society of Environmental Toxicology and Pollution Mitigation (SETPOM) and Fellow of the Nigerian Institute of Architects (NIA). He has supervised over 350 Masters and 15 PhD Students successfully and managed research grants.

Analysis, Synthesis and Evaluation in the Design Process

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Overview

Design is central to the professional role of the Architect. Understanding the design process is critical to Architecture students. Often, students focus on the end product of the design process rather than on the process. However, the volume of investment in the architectural design product and the importance to the life and well-being of the user/client and the whole society underscores the place of analysis, synthesis and evaluation in architecture. Also, architectural solutions must have three main characteristics; function, durable and aesthetically pleasing. Every action in the design process necessary to achieve these desires is embedded in analysis, synthesis and evaluation. Analysis, synthesis and evaluation go on throughout the design process with a special concentration at the initiation of the design.

This text explores the different stages of the design process including the need for continuous synthesis and evaluation in design.

Objectives

The objectives are to:

1. describe design process;
2. define design analysis;
3. identify analytical issues;
4. discuss synthesis of design;
5. discuss evaluation of design; and
6. apply synthesis and evaluation to design.

Design

Design as defined in the dictionary is specification of an objective or process referring to requirements to be satisfied or conditions to be met so that a problem will be solved. There are several other definitions but in all these definitions, there is this futuristic thing, which tends to what will come (propose/predict) and how to get there (process). Better still design can be viewed in three parts as; initial state, a method and process of transformation and an imagined future state which means "to identify problems, identify methods of achieving solutions and implement those solutions, (McGinty, 1979).

Architectural Design is providing solutions to the space and spatial needs of human activities. It includes the solution to internal activities, external activities (the site), the immediate environment (the neighbourhood/community) and at the level of interaction with other neighbourhoods and communities in the human settlement. Human settlements are in different scales including villages in rural communities, neighbourhoods, towns, cities and agglomeration of cities in a rapidly urbanizing world. Architectural design does not always result in the design of new buildings or facilities. It may result in the evaluation of present available space in terms of utilization or definition or the reconfiguration or rearrangement of sequence or schedule of use or additional spaces as common in facility programming, rehabilitation, renovation, restoration, and upgrading.

Creativity is expected in whatever solution architecture proffers. Creativity is unattainable without a deep understanding of the problem. Explicitly, to design for any human activity the designer must be able to describe every aspect of that activity in detail, because design is innovation, (Taylor, 2018).

User requirements and needs are critical inputs to any design solution. They are the key, the architect works for the client (user), a community (user), or a board (user) so their requirement is the major input for design.

Design Process

The design process is regarded as a creative problem solving tool, (Murtel, 2021). It is a tool that helps to break down large projects into smaller, easier to handle stages. It is very prominent in architectural works, engineering works and manufacturing, helping to deliver finished solutions that customers want and need. It goes through a series of steps from initial concept to realization, which if followed diligently will get the problem solved. In addition, for building types that necessitate a communal architecture approach, the design process includes a participative approach of the community in field studies and information collected as part of the pre-design analysis, synthesis and evaluation. There is always a need to cross-check the data collected and used in analysis, synthesis and evaluation as the design process is cyclical, at any point there is leading new data, to go back and evaluate the new data.

There are different models of design process depending on what is being worked out. A good design process involves all three consecutive stages of analysis, synthesis and evaluation. Examples of models are; a) double diamond model, b) systematic model, c) understand, explore and materialize (consumer/user centric model), etc.

a) Double Diamond Model, follows four distinct steps; Discover, Define, Develop and Deliver.

Discover Stage 1, data is gathered on what are new, user likings, etc.

Define stage 2, looking at possibilities as identified by stage 1, they are set out according to preference. After this the design brief is sieved out, with other challenges are itemized.

Develop stage 3, at this stage, prototypes are developed, tested, revisited and refined.
Deliver Stage 4, feedback is gathered and used to further refine the product (prototypes) before implementation.

b) Systematic model is an architectural design model that consists of the three architecting activities (analysis, synthesis and evaluation). Here architectural analysis examines, filters, and/or reformulates architectural concerns and context in order to come up with a set of architecturally significant requirements, (Zengyang & Paris, 2014)

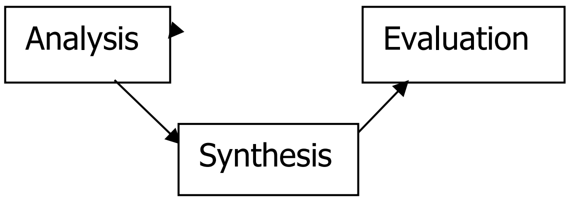

Figure 1. *Systematic Model.*

Architectural synthesis proposes a collection of architecture solutions to address the identified problems from the analysis stage. Architectural evaluation assesses the merits and the demerits of the different possible courses of action as proposed.

c) User centric model (understand, explore and materialize). This is rooted in questioning; question the problem, question the assumptions and also question the implications. It is a powerful tool in tackling all kinds of challenges by reframing the problems in human-centric ways, (Murtel, 2021). They are divided into empathize, define, ideate, prototype, and test. Empathize conducts research in order to develop knowledge about what your users 'do, say, think, and feel'.
Define pinpoints the problem. Then highlights opportunities for innovation.

Ideate is a brainstorming session, where ideas are shared, mixed, remixed and built on others' ideas.
Prototypes are built to tackle representations.
Tests are conducted on the prototypes and feedback is used for refining where necessary.
Implementation of the final visions or products.

Analysis

It is the breaking down of a problem into smaller units or bits in order to understand the smaller units better, (Eden, 2016). That is the separation of an intellectual or material whole into its constituent's parts for individual parts.

Checklist of issues in Analysis

Site and context analysis: size, location relative to access and neighbouring plots and the whole community, other land uses in the neighbourhood, infrastructure such as drainages, electrical supply, and waste disposal.

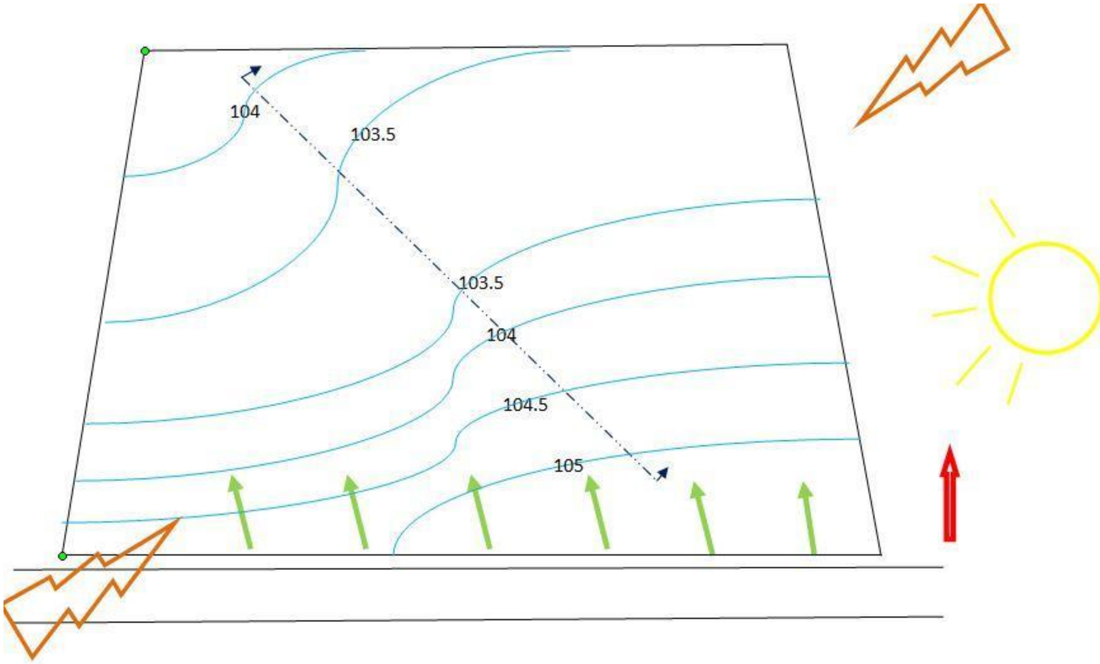

Figure 2. *Site Analysis*.

Site analysis is the art of ordering the man-made and the natural environments to support human activities. In doing this, the site contours (landform) is taken into consideration in positioning of the building, citing necessary utilities; drainage, sewage lines, wastes disposal, water mains, etc. Also, the views around are considered in thinking of the massing of the proposed building, access into the site, etc.

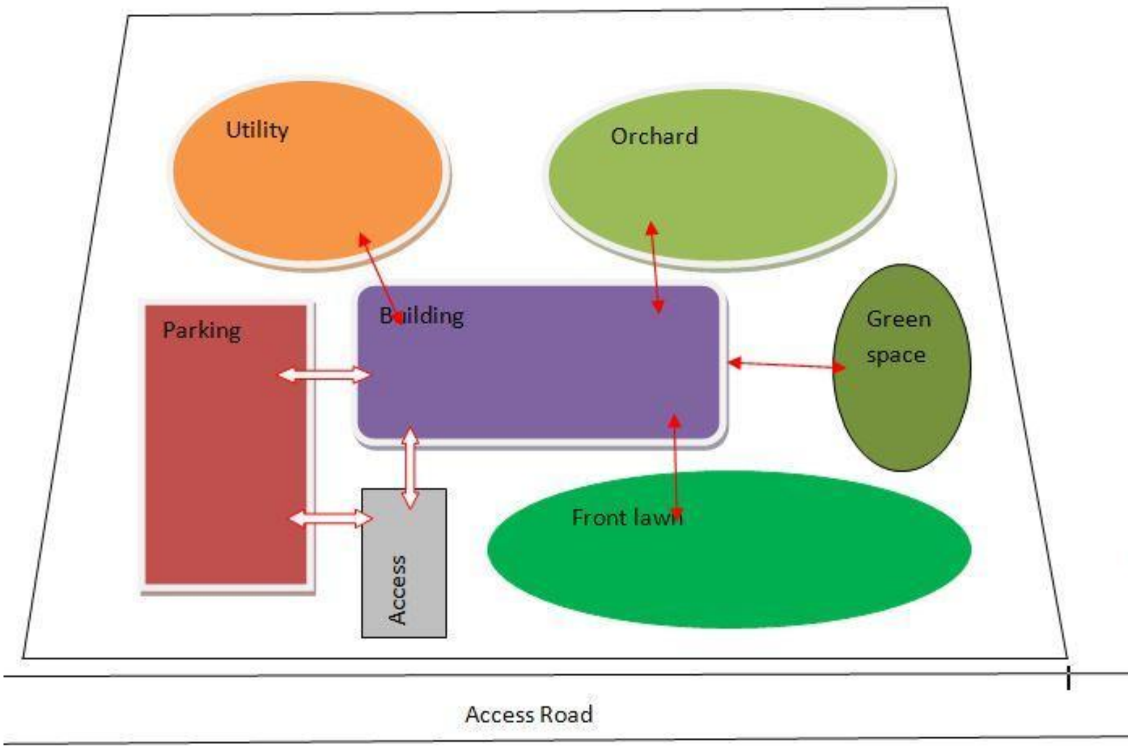

Figure 3. *Spatial Analysis on site*

User requirements entail user needs on physical space, ergonomics, experiential and psychological aspects. User needs; in getting the required physical space size, ergonomics is used to put spaces, internal divisions and furniture to be in tandem for the age and size of the proposed users, which helps in the formulation of the building form.

The size of the plot for design is an issue vis-à-vis the percentage coverage for the building and other things to be provided for on the site. Location of the site; where is it positioned, to know what and what is allowed, what can be accommodated, the size of the building and height restrictions, all come into play in the analysis and the final product.

Neighbourhood context; looking at what obtains in the immediate surrounding including zoning restrictions (easements, height restrictions, set-backs), the building and its impact on the neighbourhood and the impact of the neighbourhood on the building are all to be considered.

Legal information on the ownership of the plot, any legal restrictions and covenants, planning laws, building regulations and future urban development plans. Circulation; the movement of vehicles and humans within, through and around the site is very crucial. Consider the timing of these movement and duration patterns. Future traffic and road developments should also be considered.

Utility lines and infrastructure are very essential and so should be taken into account. Things like drainages, electrical supply, water supply and waste disposal should be treated as a matter of priority.

The site and conceptual climate analysis should be done well. All climate information (rainfall, temperature, humidity, wind direction, and sun path) are to be considered. Natural, physical and sensory features should be handled properly. The topography (contours), trees, rocks, rivers, ponds, drainage pattern, visuals and audible aspects of the site should be considered.

It is good to design with nature, not against it. Outdoor requirements for the site are very critical. It comprises; the driveway (vehicular and pedestrian), pavements, landscaped gardens, parking and drainage.

Materials of construction to be used and construction methods are also very necessary. Care must be taken to work with the clients' budget by using easily and readily available materials and affordable construction methods.

Mode of Analysis

Literature review; every analysis should proceed from a literature analysis of the building type and context. Every studio should be preceded by a comprehensive introduction of the content, design issues, expected output and learning outcomes so the students are driven and motivated to explore all possible analysis, synthesis and evaluation methods. This is especially important in multicultural contexts and critical to internationalizing the curriculum and architectural design studio by giving the students architectural problems in other contexts different from their location, (Asojo, Kartoshkina, Jaiyeoba, & Amole, 2019).

Synthesis

It is bringing back the units or bits into a whole which in essence is the opposite of analysis. It tries to make sense of all the information gathered in analysis mode, aimed at addressing the identified architectural problem. It helps to deduce ideas from the general to the particular which ends in making sketches.

Mode of Synthesis

With the literature review done, the student should be able to determine appropriate solutions to suit the problems at hand. That is formulating a design from the analysis done, by putting them together again individually and collectively. This could be done through the use of bubbles representing spaces and activities in a diagram or flowchart format.

The Bubble Diagram

Bubble diagram is used in trying to synthesize all the analysis done, a proposal for the design. The bubble diagram is done in a not to scale drawing by putting all the activities into spaces in relation to one another with relationship links. These links represent the functional relationship between different spaces or areas within a building and site. It uses simple shapes (circles, squares and rectangles) to represent functions or rooms. These shapes are connected by lines that indicate how the spaces are related to each other; the thicker the line the more the relationship.

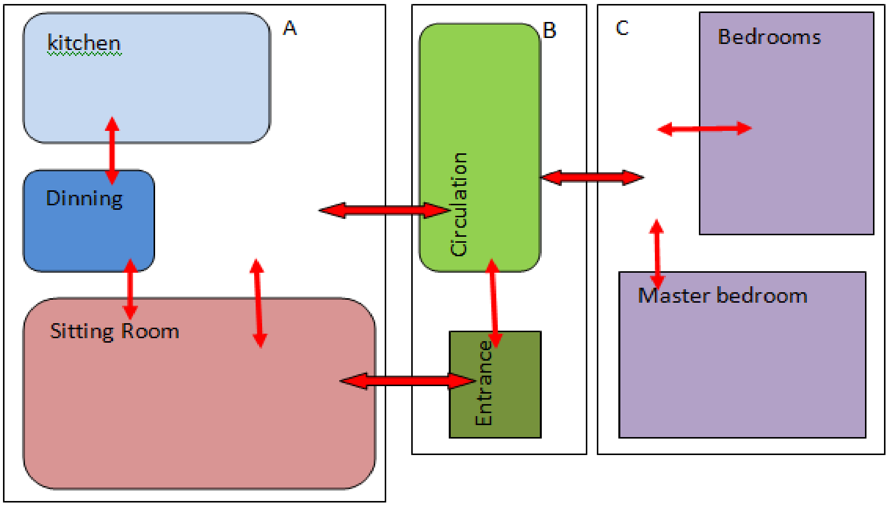

Figure 4. Spatial Analysis within a small residential building. (the interior is divided into three; ABC. A could be said to be the noisy areas in the building, C could be said to be quiet areas and the B is used as a buffer between.)

Evaluation

Evaluation is the process of assessing the merits and demerits of different possible courses of action with a view of drawing a conclusion. It is a supportive tool and aid to decision making. It places each design option side by side showing the merits, benefits, efficiency and effectiveness and even cost implication of each option against the order and then tallies the best option.

Mode of Evaluation

To test the current design made for accuracy whether the performance requirements were actually fulfilled. This test can be carried out by the help of some tools; a) partial evaluation techniques (deals with tangible and quantifiable values) and comprehensive evaluation techniques (deals with all values including tangible and intangible).

Most times in design we deal with tangible and quantifiable values therefore using mostly partial evaluation techniques. These options are often used; i) those that deal with cost and benefits, ii) those that are concerned with cost and effectiveness, iii) those that are based on cost minimization.

Case Studies

Case study is an intensive analysis of an individual unit stressing developmental factors in relation to its context. The main issue is to study an object within its context rather from a distance or in an artificial environment. The study tries to deliberately isolate a small study group, one individual case, and one particular population for in-depth study. It may involve both quantitative and qualitative research methods. To do this, the time available for the research, information available, access to the information, the aim of the research and number of cases to be considered come into play.

Case study is a very good source for the design process where the architecting activities of analysis, synthesis and evaluation take place. It helps the student to source for information on new projects, by availing the student the opportunity to search in-depth of the subject in question with an aim and goal properly placed and so makes informed design decisions.

Issues in case study research

The immediate checklist for case study research includes the needs as stated by the researcher which requires observation, interview and social interaction techniques. The ability to do fast sketching, recollect observations and dimension estimation ability using reconnaissance techniques such as pacing with strides and building material module sizes, for example, the size of floor tiles, ceiling slats or other modularly sized walls, ceiling, floor or roof material are very important. In the entire process, students should be able to show how the information gathered will be analysed and used, that is presentation and analysis of data collected.

Local and International case studies are important to understanding most building types. Depending on the architectural problem under consideration there may be a need to do more international case studies than local ones and vice versa. For example, if the studio title is the design of a nuclear facility or some special healthcare facility in Nigeria more international case studies are needed.

Evidence-Based Design

Evidence-based design (EBD) is the process of constructing a building or physical environment based on scientific research to achieve the best possible outcome, (Hamilton & Watkins, 2009). This could be likened to research informed design (RID), where both of them point to the same thing or have similar outcome 'best design' based on research, (Bentley, et al 2013).

This relies on actual research to attain the best possible solutions. The idea emanated from the health sector as a development of evidence-based medicine that combines individual clinical experiences with known theoretical facts. It connects architectural design to health and has now grown more in the area of Design Science Research that combines knowledge of the sciences, social sciences and built environment research. It is a method that looks backwards through research to contribute to present and future creative and 'best' design solutions. The belief that the environment plays a significant role in the well-being of users and the drive for healing architecture is one of the propellants of the Evidence-based design approach.

Common facilities of those activities are necessarily sequential for example surgical units of health facilities and specialized industrial buildings. It is futuristic Data Driven analysis, synthesis and evaluation for design especially with the advent of Smart Buildings

Simulation of natural and human factors relative to building design. A typical example is wind load effect on high-rise buildings depending on location. The development of digital twins in the design of components, buildings, neighbourhoods and cities is another example of advanced technology and information science applications. Virtual Reality, Augmented Reality and Extended Reality are other technologies transforming the design process now and other developments of these technologies will transform the future.

Purposes of Analysis, Synthesis and Evaluation (ASE)

Research is very important to the professional world and the tools of ASE are of immense value. They bring out ample evidence of a responsibly conducted research, (Rodriguez & Toews, 2005). ASE tends to help bring out better design that is durable, aesthetically pleasing and very functional. Their benefits are innumerable, as follows:

1. Discover foundational ideas of the building type.
2. Discover past concepts and ideas for the building type; for example, privacy and territoriality in student housing.
3. Formulate the concept or idea that drives the project at hand.
4. Arrive at a solution satisfactory and pocket friendly to the Client/User.
5. To have better social-responsive architecture.

6. To have a better human-centred approach.
7. To synchronize the flow of spaces and activities in building types based on procedural and communicating activities.

Having a final architectural product that is a near perfect fit for the context and is a 'public good' A final product that justifies the huge capital investment; which allows for the systemization and computation of design. Whether the design is specific to a present use or flexible for future use will be ascertained. Overall, it must be a creative solution.

Summary

Generally, analysis, synthesis and evaluation of the design process are at the heart of an architecture and architectural education programme. The student should be able to develop an analytical mind to synthesize and evaluate all inputs into and output out of any design adventure.

All architectural problems, in fact all human problems once subjected to proper analysis, synthesis and evaluation of facts on ground builds for better resolution, and that is what is expected with this course.

Exercises

1. Describe a process for collecting information on a Comprehensive Health Centre Design.
2. What theoretical concepts are useful for the synthesis of information on Students Housing design?
3. Illustrate the conceptual ideas in Shopping Mall design based on analysis, synthesis and evaluation of the building type.

References

Addicott, A. (2023) Understanding architecture bubble diagrams, a comprehensive guide.

Asojo, A. O., Kartoshkina, Y., Jaiyeoba, B., & Amole, D., (2019) Multicultural learning and experiences in design through collaborative online international learning (COIL) framework. Journal of teaching and learning with technology. 8(1) 5-16.

Bentley, Y., Richardson, D., Duan, Y., Philpott, E., Ong, V., & Owen, D. (2013) Research-informed curriculum design for master's level program in project management. Journal of management education 37(5) 651-682. doi:10.1177/1052562912458642.

Brogden, F. (1979) Site planning and design. In J. C. Synder, & A. J. Catanese, (1979) *Introduction to architecture.* New York; McGraw-hill book company.

Eden, C. (2016) Analysis, evaluation & synthesis. www.prezi.com

Gonzalez, R. D. A. (2021) Analysis, evaluation and synthesis. www.a01636938.medium.com

Hamilton, K. D. & Watkins, D. H. (2009) *Evidence Based Design for multiple building types*. Hoboken New Jersey. John wiley and sons. ISBN 978-0-470-12934-0

McGinty, T. (1979) Design and the design process. In J. C. Synder, & A. J. Catanese, (1979) *Introduction to architecture.* New York; McGraw-hill book company.

Murtel, J. (2021) The 5 phases of design thinking. www.ama.org.

Rodriguez & Toews, (2005) Training students to be better consumers of research: evaluating empirical research reports. College teaching 53(3)

Synder, J. C. & Catanese, A. J. (1979) *Introduction to architecture.* New York; McGraw-hill book company.

Taylor, N. (2018) Redesigning the intergenerational village: innovative solutions for communities and homes of the future. Design lead.

Watts, S. & Poursani, E. (2022) Bubble diagrams in architecture and interior design. www.study.com.

Zengyang, L. & Paris, A (2014) Architectural debt management in value oriented architecture in economic driven software architecture. www.sciencedirect.com

------------ (2020) Analysis, evaluation and synthesis approaches research paper. www.ivypanda.com

------------ (n. a.) 2.2.1 The analysis, synthesis and evaluation paradigm. www.mankindsoftware.github.io

------------ (2023) 2023 Guide to the design process: kick start your next project. www.monday.com

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CHAPTER EIGHT: ARCHITECTURAL DESIGN TECHNOLOGY STUDIO

Identifying Quality Control Mechanism in Buildings

Prof. Mbina, Anthony Adomi, *University of Uyo*

Overview

Quality control (QC) is a process by which companies or entities review the quality of all factors involved in production. It is further defined as "a part of quality management focused on fulfilling quality requirements". Generally the approach harps on three aspects, namely: Controls, job management, defined and well managed processes, performance and integrity criteria, and identification of records Competence, such as knowledge, skills, experience, and qualifications, and Personnel, integrity, confidence, organizational culture, motivation, team spirit, and quality relationships.

This text focuses on components of quality control, of physical products, such as on-going construction works. End results of services rendered are analysed. Principles of Product inspectors are provided ,with check lists and descriptions of unacceptable product defects such as cracks or surface blemishes. The main thrust of this discuss is to highlight the importance of quality control to an architect.

Objectives

At the end of this section, the reader should be able to:

1. define quality control;
2. identify different types of quality control;
3. evaluate why quality control is important;
4. assess the benefits of quality control;
5. identify the roles of quality control;
6. appraise the responsibilities of quality control;

7. differentiate between quality control and quality assurance; and
8. discuss in details quality control mechanism in buildings

What is Quality Control

Quality does not have a singular definition. Despite the relative meaning of "value," quality control is the process by which products/services are tested and measured to ensure they meet a standard, and to ensure they are as uniform as possible. Quality control helps businesses minimize inconsistencies and improve product quality. Through this process, a business can evaluate, maintain, and improve product quality.

Generally, there are two crucial goals of quality control:

i. to ensure that products are as uniform as possible and

ii. to minimize errors and inconsistencies within them.

Quality control refers to a company's methods for assessing product quality and, if necessary, improving it. There are various ways to perform quality control, including benchmarking, examining manufacturing procedures, and testing products. All of this is done to keep track of significant product differences.

How Quality Control is Carried Out?

Normally, quality testing is part of every stage of a manufacturing or business process. Employees begin testing using samples collected from the production line, finished products, and raw materials. Testing during various production phases can help identify the cause of a production problem and the necessary corrective actions to prevent it from happening again.

On the other hand, customer service reviews, questionnaires, surveys, inspections, and audits are a few examples of quality testing procedures that can also be used in non-manufacturing businesses. A company can use any procedure or technique to ensure that the final product or service is safe, compliant, and meets consumer demands.

Types of Quality Control

Quality is a relative word with many interpretations. Quality control also does not have a uniform, universal process. Some methods depend on the industry. In the food and drug products, for instance, where errors can put people at risk and create significant liability, these industries may rely more heavily on scientific measures, whereas others (such as education or construction) may require a more holistic, qualitative method.

At its core however, quality control requires attention to detail and research methodology. There is therefore a wide range of quality control methods, including:

***Control Charts*:**

A graph or chart is used to study how processes are changing over time. Using statistics, the business and manufacturing processes are analysed for being in control.

***Process Control*:**

Processes are monitored and adjusted to ensure quality and improve performance. This is typically a technical process using feedback loops, industrial-level controls, and chemical processes to achieve consistency.

***Acceptance Sampling*:**

A statistical measure is used to determine if a batch or sample of products meets the overall manufacturing standard.

***Process Protocol*:**

A mapping methodology that improves the design and implementation processes by creating evaluative indicators for each step. There are other quality control factors to consider when selecting a method in addition to types of processes. For example, some companies establish internal quality control divisions when defining what quality control is. They do this to monitor products and services, while others rely on external bodies to track products and performance. These controls may be largely dependent on the industry of the business. Due to the strict nature of food inspections, for instance, it may be in a company's best interest to sample products internally and verify these results in a third-party lab.

Arising from frequent collapse of buildings, there may be a need for such inspections of materials and workmanship to be carried out both externally and on site.

Importance and Benefits of Quality Control

Investments in quality control measures can protect the reputation of a company or service provider and prevent products and services from being unreliable and increase trust on the side of consumers. These processes are determined through rigorous methodology and testing, as well as industry standards and best practices.

Moreover, quality control is necessary because it ensures that a company will look at evidence-based data and research — not just anecdotal observations — to ensure that products are living up to their standard. One essential aspect of quality control is that the process does not just happen once but is a routine evaluation of the product to ensure that it is continuously meeting both the manufacturing standards and consumer demand.

There is no consumer who wants to risk using a product or service that could endanger them or fail expectations. A company's reputation, reliability, and efficiency are therefore all at risk if quality control is overlooked. A product's testing can play a role in marketing and sales as well since consumers may trust it more.

Quality Control Roles and Responsibilities

To be able to ascertain what quality control is, it is critical to understand that it consists of multifaceted responsibilities and roles. Moreover, it should not be confused with quality assurance. Whereas quality assurance looks at the processes used to prevent defects, quality control is focused specifically on the measurement and analysis processes involved with determining product quality.

Quality control uses specific research tools to accomplish fact-finding processes and conduct analyses. A quality control professional is tasked with analysing these measurements against some sort of standard determined by the quality management department, company policies, and industries or regulatory bodies such as Standards Organization of Nigeria (SON). Based on this evidence-gathering, quality control will recommend changes.

We can see from this roadmap, too, how quality assurance and quality control differ. Quality assurance looks at the holistic picture to prevent a product from becoming defective. Quality control, on the other hand, later determines if a product is, in fact, defective or not. Both roles fit under the broad umbrella of quality management.

Thus, an individual in quality control is tasked with communicating results to stakeholders and significant parties. A good quality control specialist will be able to disseminate scientific and research-based thinking to a business community and assist with the problem-solving process. These specialists are a key component of a product's design process, as they determine whether a company's creation is truly acceptable for the market.

Quality Assurance vs. Quality Control

Although the terms quality control and quality assurance are sometimes used interchangeably, they have some key differences. Quality criteria, such as ensuring an item complies with specifications, are the main emphasis of quality control. Quality assurance is the sum of all processes and actions necessary to demonstrate that the requirements for quality are satisfied.

From this distinction, quality specialists may sometimes change their specialization as they progress in their careers from quality assurance to quality control. For upper management, customers, and government inspectors, quality assurance programs and departments make sure that products adhere to all quality requirements and safety regulations. Thus, quality control is a part of quality assurance.

Table 1: Comparison Chart of Quality Assurance and Quality Control

Quality Assurance		Quality Control
Seeks to measure the processes and systems in order to reduce defective products		Seeks to measure the number of quality of the final products.
Often used by management to make decisions on process improvement		It is often used to accept or reject products, or for payment.
Focuses on preventing defects		Focuses on identifying defects
Managerial tool		Corrective tool
Process Oriented		Product oriented
Defines Standards		Ensures Standards are followed
Sets methodologies		Ensure methods are followed
Validation		Verification
Everybody's responsibility		Specific Teams responsibility
Audit		Inspection

What is the importance of quality control in the building industry?

Quality control management in buildings and construction projects is an essential factor to avoid defects in the end product, which could lead to the need for replacements, faults, accidents or any kind of anomalies that will end up having a negative impact on the final result and the customer's experience. Quality control management for construction works and projects is essential, to comply with the parameters and requirements demanded by regulations, to produce high-quality products that guarantee total customer satisfaction and safety, to eliminate waste related to replacements, return of defective products, saving on unnecessary costs, improving technical performance of products and/or efficiency of processes.

Quality control in construction industry is essential, because not only should the tools, equipment and machinery used on site meet strict criteria in terms of quality, standards and be fit for its purpose, but it is equally important to ensure they are correctly maintained throughout the entire project.

This is so because quality control in construction is not just limited to the construction companies. It extends to their trade partners and other stakeholders in the construction supply chain. It involves checking the quality of work done by construction contractors, suppliers, and subcontractors – to even the import of machinery, materials, and equipment used on-site.

Key advantages of quality control in construction:

1. Help alleviate risks, especially regarding the risk of damage or accidents.
2. Ensure the project stays on schedule and remains within budget.

3. Ensure the construction is fit for its intended use and meets the standard set by the client and regulatory bodies.

Construction quality control can be broken down into two broad categories:

- quality assurance and
- quality compliance.

Whereby quality assurance focuses on the quality of the product or service, and quality compliance construction refers to meeting current legal or regulatory requirements.

Construction Quality Control Procedures

There is absolutely no margin for error when it comes to building jobs. Every piece of equipment used needs to be checked for quality and functionality to ensure they can play their part effectively. And that is where quality control procedures come in.

Quality control procedures are the steps a construction company takes to ensure quality in their work. These procedures are essential because they help to improve the quality of the building and reduce risks.

Companies can achieve quality control management in construction by using:

The International Organization for Standardization ISO 9001 – Set of standard created by the ISO to guide how companies should manage their quality management process and meet customer and other stakeholder's needs.

Kaizen – Kaizen is a philosophy and process used in the business world to focus on minor, continuous improvements that lead to dramatic changes over time. It is a process that never ends.

Six sigma – A series of techniques for analysing and improving processes. It focuses on eliminating defects in any process by identifying, measuring and eliminating variables that cause variation in the process.

Construction quality control plan – A document outlining the steps to be followed during construction. It includes the objectives, procedures, timeline and responsibilities of all parties involved.

Quality Control Issues in Construction

The quality control issues in construction can be broken down into three broad categories:

1. Building or Structural Quality Issues

The first category is related to the design of the building or structure. These issues often relate to the structural engineering and design errors such as improper layout, poor materials selection during construction and inadequate design.

2. Quality Issues with Construction Materials

The second category is related to construction materials and processes. It includes poor material selection, poor quality control during production, and improper assembly of components.

Some of the issues with construction materials may include:

The over-consumption and waste generation of these materials during their production process.

The lack of quality control in their manufacturing process resulted in low-quality materials.

The lack of transparency in the supply chain, including subcontractor mishandling and supplier/vendor failures.

Substandard materials do not meet local or international construction product regulations or standards.

3. Poor Workmanship in the Construction Industry

Poor workmanship has been a problem in the construction industry since its inception, and these problems should never be taken lightly. Workmanship negligence and the lack of effort put into quality management in construction can cause costly defects, including damage resulting from corrosion, moulding, plumbing issues, and even injuries, death, and structural damages to the building or site.

Inspections and Quality Control in Construction

The quality control process in construction consists of a series of inspections conducted throughout the construction process. These inspections have to start at the very beginning of the construction project.

Before you start the construction project, all materials and equipment on-site must arrive as intended and meet all relevant standards and requirements. One way to reduce the risks of defective materials or equipment is to inspect the goods – before they are shipped to you. This can be done using the 4 types of quality inspection methods, which includes:

Pre-Production Inspection – Identify quality risks before the production process begins.

During Production Inspection – Filter out issues from the production line while the production is underway.

Pre-Shipment Inspection – Checking the quantity and quality of the goods before they are shipped to you.

Container Loading/Unloading Supervision – Ensuring the products are loaded and unloaded correctly to avoid costly mishandling of goods.

What is the purpose of a construction quality control checklist?

A Quality control checklist is precisely a list, used in the construction sector, whose purpose is to ensure that all critical aspects of quality control are examined carefully and that communication of roles and responsibilities within the team is rapid and unambiguous.

Among the main reasons that push the design teams towards the use of a quality control checklist in the process, are to:

1. create greater awareness of high-risk or high-likelihood problems; and
2. provide a record of inspections which also contains a list of what has been inspected.

Thus, for construction quality control to be truly effective, quality control checklists must be as short and intuitive as possible.

Below are 5 best practices to create checklists that allow you to get the most out of the quality control process:

Do not reproduce the entire technical specification

We know that the technical specification document is important within a project, but it is not necessary to copy and paste it entirely in a quality control checklist because it would make it excessively long and misleading. Synthesis is paramount.

Focus on the most common issues

There is no need to create an excessively long list of items to be audited. Simply enter the issues most commonly envisaged and periodically review the checklist to remove or add any issues.

Maintain Matching Checkpoints

To ensure that the staff involved in the quality control perceive the checklist as a really useful tool and that it speeds them up in their work, it is important that the checkpoints are kept concise and limited to a certain number.

Use the right features for each control point

Each checkpoint has a slightly different purpose from the other, so it is useful to identify the appropriate features for each of them taking into account:

1. the checkboxes used to display the status;
2. how data is collected within fields and tables;
3. observations and comments;
4. images with markup, timestamps and GPS position;
5. direct access to documents, drawings and technical specifications (files or hyperlinks);
6. reference images of the work done correctly to teach/train on what to look for;
7. instructions for inspectors;
8. the reason why an issue has been reported (damage by others, processing, material defect, etc.);
9. the corrective actions necessary to solve a reported problem (repair, replacement, training);
10. priority of the items reported;
11. expiration date of the individual items; and
12. responsible for the work carried out and the problems encountered.

Use the right language

Checkpoints should be as specific as possible, so that the team, inspectors and anyone else reading them have a clear understanding. It is good practice to include specific indicators such as measurements, temperatures and tolerances in order to provide complete and accurate data to future readers. Control points should also be presented in the form of statements rather than questions in order to provide maximum clarity.

Essential Elements of a Construction Quality Control Checklist

The points to be analysed, listed in a quality control checklist, vary according to the type of construction. However, there are some essential elements that will always appear within a good quality checklist, they are:

Product requirements (technical details)

This point represents a fundamental step of the QC (Quality Control) because it is ensured that the material used meets the project requirements. In this phase, aspects such as: material used, weight and size, labels, etc., are generally checked.

Packaging requirements

When the materials are delivered to the site, the very first thing to carry out is the quality control of the packaging protecting the products during transit. In this phase, weight and size of the packaging, labelling, material used for packaging are verified.

On-site product tests and checks

This step is very delicate, it must be carried out carefully and, according to the material to be checked, also with the right equipment. Especially in construction, it is a matter of carrying out checks on building materials and their physical and mechanical characteristics, setting the right type of test, procedure, expected results and tolerances.

Defect classification

Defects or inconsistencies in the product or material are likely to be detected as a result of the on-site inspection. At this stage, it is important to classify the detected defects that according to the Acceptable Quality Limits (AQL) will be accepted on site or not.

Collaboration between the project team, suppliers and QC staff in drafting inspection checklists

This point is often underestimated, but collaboration between the actors involved in the QC process is essential for a clearer and mutual understanding of the requirements on the product, packaging, etc.

Table 2: Approaches to Quality Control

Terminology	Approximate year of first use	Description
Statistical quality control (SQC)	1930s	The application of statistical methods (specifically control charts and acceptance sampling) to quality control.
International Organization for Standardization (ISO)	1947	International Organization for Standardization (ISO) is an independent, non-governmental organization that develops standards to ensure the quality, safety and efficiency of products, services and systems. In addition to producing standards, ISO also publishes technical reports, technical specifications, publicly available

		specifications, technical corrigenda, and guides.
Total quality control (TQC)	1956	Popularized by Armand V. Feigenbaum in a Harvard Business Review article and book of the same name; stresses involvement of departments in addition to production (e.g., accounting, design, finance, human resources, marketing, purchasing, sales)
Statistical process control (SPC)	1960s	The use of control charts to monitor an individual industrial process and feedback performance to the operators responsible for that process; inspired by control systems
Company-wide quality control (CWQC)	1968	Japanese-style total quality control.
Standards Organization of Nigeria (SON)	1971	The standards organization of Nigera (SON), is an organization whose primary function is developing, coordinating, promulgating, revising, amending,

		reissuing, interpreting, or otherwise contributing to the usefulness of technical standards to those who employ them. The organization works to create uniformity across producers, consumers, government agencies, and other relevant parties regarding terminology, product specifications (e.g. size, including units of measure), protocols, and more.
Total quality management (TQM)	1985	Quality movement originating in the United States Department of Defense that uses (in part) the techniques of statistical quality control to drive continuous organizational improvement.
Six Sigma (6σ)	1986	Statistical quality control applied to business strategy; originated by Motorola
Lean Six Sigma (L6σ)	2001	Six Sigma applied with the principles of lean

		manufacturing and/or lean enterprise; originated by Wheat et al.

Review Questions

1. What is Quality Control (QC)?

Quality control is the process by which services/products are measured and tested to ensure they are as uniform as possible and meet a standard. It helps businesses minimize inconsistencies and improve product quality.

2. What are the four types of Quality Control?

The four types of quality control are process control, control charts, acceptance sampling, and product quality control. While a control chart helps study changing processes over time, process control and product quality control help monitor and adjust products as per the standards. Acceptance sampling is a unique type that involves a statistical measure to determine whether a batch or sample of products satisfies the standards.

3. Why is Quality Control important?

Quality control is important to safeguard the company’s reputation, prevent products from being unreliable, and increase trust on the side of consumers. It ensures that the company looks at evidence-based data and research rather than anecdotal observations to ensure that the services/products live up to the standards. It reduces cost and maximizes profit, operational efficiency, and customer satisfaction.

4. What are three examples of Quality Control?

Some examples of quality control are a high-speed car manufacturer runs thorough tests for every component, including manual and automated verifications; websites study the average response time per page for customer interactions and generate tickets when the service gets unacceptably slow; retail store owners employ secret shoppers to test the customer service of their stores.

5. What are the four steps of Quality Control?

The first step for quality control is to set your quality standards and decide which ones to focus on. Secondly, you must establish operational processes to deliver optimal quality and implement them. The third step is to review your results and identify gaps. Lastly, get feedback and make improvisations.

6. What are quality control techniques***?***

Inspection and Statistical quality control (SQC) are the two major techniques of Quality Control. Inspection checks the performance of items as per the pre-decided specifications. It involves periodic checking before, during and on completion of the process. It can be categorized into two types: Centralized and Floor Inspection. Statistical Quality Control relies on laws of probability. It controls the production quality within tolerance limits via sample procedure.

Summary

We all know about the importance of quality in construction. Not only does a quality control procedure in construction minimize the risks of delays, but it also ensures that the project meets their requirements and expectations. One common quality control method in construction is conducting inspections of the materials and equipment used in the construction project. Some companies rely on third party companies that conduct quality inspections on-site for them. It is good practice though if such inspectors are professionals themselves. It will also include inspection of on-going works carried out on site.

References

Wheat, B.; Mills, C.; Carnell, M. (2001). Leaning into Six Sigma: The Path to integration of Lean Enterprise and Six Sigma. Publishing Partners. p. 100. ISBN 9780971249103.

Phillips, Joseph (November 2008). "Quality Control in Project Management". The Project Management Hut. Retrieved 21 December 2012.

Rose, K.H. (2014). Project Quality Management: Why, What and How. J. Ross Publishing. p. 224. ISBN 9781604271027.

BIODATA OF PROFESSOR ANTHONY ADOMI MBINA

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Before joining the services of Ahmadu Bello University, Zaria, Professor Mbina had served in the Physical Planning Unit of the Vice Chancellor's Office in the University of Calabar as an Architect. He has also served as a Local Government Chairman for two years. Mbina is a very committed community leader and holds a chieftaincy title from Enugu/Ebonyi states of outh Eastern Nigeria.

Prof. Mbina's research interests include architectural history, architectural communication and the effect of architecture on the environment. He has published widely in both national and international academic and professional journals. Prof. Mbina is a very humble and patient fellow. He is married with children.

Technical and Environmental Aspects Associated with the Built Environment

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Overview

A school of thought believes that to understand the gradual socio-ecological degeneration of the global environment amidst rapid urbanization and population growth especially in developing countries we have to over exaggerate reality by deploying *apocalyptic urban surrealism* (Japhy Wilson, 2023). The view of *apocalyptic urban surrealism* is that other solutions to the *anthropocene* may come up from painting the reality of seeming helplessness that all human beings and governments around the world find themselves amidst confusing discourses on way forward while still contributing to the destruction of the global environment as if it is an inevitable end.

This text focuses on the environment and contributions of all stakeholders to the built environment process and product as well as the possible interventions by environment professionals (BEPs) and other stakeholders. The premise of this intervention is that built environment products consume between 30 to 50 per cent of the earth's natural resources and contribute significantly to global environmental pollution and climate change problems in their production and subsequent use.

Objectives

The objectives of this work are to:

1. examine the significant climatic factors and their influences on the built environment forms and spaces;
2. determine architectural design strategies to make the built environment adjustable to climate change;

3. integrate passive strategy technologies into the architectural design studio design projects;
4. engage tropical climatic elements as vehicle of design for human comfort; and
5. discuss the likelihood of natural hazards and device in-built architectural technology to combat such occurrences.

Narratives on each topic

The Environment and Human Comfort

The human being is at the centre of all consideration in environmental studies. Perhaps that is why human activities are at the core of most built and natural environment research. Designing for human comfort has recently been extended to the wellbeing and good health of people. Indoor indices affecting human comfort include temperature, humidity, air quality, illumination, sound/acoustics, clean water supply, sanitation, waste disposal. Other factors are the materials and construction of the building including the level of toxicity possible from the building materials and the outdoor indices and eco-physical characteristics. The outdoor indices are often determined by geographical location on earth with peculiar climatic data modified by weather conditions including local topography, vegetation, built and other natural environment elements.

Designing for Designing for Different Climatic Zones: Application of Solar Geometry, Wind, Air Movement and Ventilation

In the similitude of natural objects stimuli-response behaviours, architectural building designs should be treated as a living organism(or living thing); for its characteristic breathing(by ventilation), dynamism(flexibility or change), growth(expansion or settlement) and stimuli-response also responds to climates differently. For Instance, in temperate climatic regions, efforts are always made in preventing air leakage in buildings by airtight methods of conservation. While in the tropical climate, energy saving strategies deal succinctly by excluding hot air from the interior building spaces to ensure users' satisfaction and human comfort in buildings. Therefore, in architectural design technology, it is expedient to hinge the fulcrum of the design studio on the essential tropical factors that govern the functionality of our buildings. Factors like solar geometry (radiation), wind prevalence, air movement, ventilation and lighting (Aderonmu P.A, Adesipo Adeyinka, Onahi Eje I., Amao Daniel. I, Ogbondeminu Joy. E. (2021). Architectural studio Teachers/mentors or coordinators need to lay workable strategies first from the design studio brief, second, during mentoring and consultation processes. During case study exercises, sharp contrast should be shown by the learners between temperate and tropical fitted designs. To enable best practices, knowledge transfer and skills development should be aided by the teachers. Students should be well guided on how to *expose* the *geometry* of their conceptual design forms to the sky i.e tapping useful levels of natural lighting from exterior to the interior spaces. Also, Thermal comfort as a critical success factor in tropical designs could be explained to students via the exposure of design (orientation) in the direction of prevailing winds. Pertinent Issues like fenestrations/openings/window sizes could also become major areas of emphasis during design studio teaching and mentoring. More so, cross ventilation is also an important index to ensure client/users' satisfaction along with sustainability requirements. To achieve this, adequate control of window/opening sizes should be considered along with other contextual factors. Another salient factor perquisite to the tropical architectural design studio pedagogy technology is the holistic integration of solar shading devices (i.e fin blades/walls, cantilevers, overhangs, porches/portico, balconies, window hoods, verandahs e.t.c) into the component parts of the buildings-*passive design methods*.

Acoustics, Noise and Sound

In the architectural design studio, introductory attempts can be made to explain the simple technological indices and terms involved in the application/consideration of Acoustics, Noise, Sound, music and Architecture. Acoustics can be described as a phenomenal art, science and technology that deals with sound production, control, transmission, reception and effects while sound in itself can be described as the disturbance which passed through a physical medium in form of longitudinal waves from a source to a receiver, causing a sensation of hearing. In other words, Noise is the opposite meaning of sound. It is typically described as an unwanted sound.

Music and Architecture

Simple comparison abounds between music and architecture. Some commonalities may be drawn as lessons to enable the inherent meanings between the two (2) phenomenal topics. The following terms and terminologies are common to music and architecture: indices like dynamics, rhythm, frequency, creativity, designs, calibre, patency, originality, propriety, eurhythmy, balance, proportion, scale, symmetry, order, arrangement, tone/tonality, concept, principle, asymmetry etc.

Airtight and Energy Performance in Buildings

In temperate climatic zones, preventing air leakage in buildings, especially artificially ventilated buildings is one step in energy performance and energy conservation. While for the tropical climate, natural ventilation is another step in energy saving. This deals succinctly by excluding hot air from the interior building spaces to ensure users' satisfaction and human comfort in buildings. It is critical in extreme climatic conditions whether cold or hot climates. Heating, cooling and ventilation of building-in-use consume a lot of energy and the production of energy through non-renewable resources is detrimental to the global environment. Ensuring airtightness is good for human comfort in extreme weather, prevents deterioration of building components and materials through moisture, humidity and temperature control thereby reducing maintenance costs and improves energy efficiency. As the built environment enlarges and reduces the natural environment on earth, energy consumption through air leakage and consumption of natural resources for energy production increases. The differential pressure between the inside and the outside of the building envelope results in the simultaneous push and pull of air through openings and cracks. The air movement is measured by reference to standard pressure differentials moderated by the volume of the building, total building envelope surface area and the floor area. This results in air changes per hour (ACH) at 50 MPA standard reference pressure, which is ACH_{50} (Maysoun Ismaiel, Maged Gouda, Yong Li and Yuxiang Chen, 2023). Designers, architectural technologists and concerned BEPs should imbibe solutions and engage in research to minimize air leakage and enhance energy performance of buildings and built environment design.

Performance of Buildings during and after Natural hazards

Natural hazards like earthquakes pose human life risk as well as economic loss considering the huge investment in the built environment. The economic loss and how to mitigate it at conception and design stage, pre-hazard and post-hazard is a continuing debate. In parts of the world where natural hazards are recurrent, the increasing cost of post-hazard recovery is encouraging making existing and most importantly new buildings and infrastructure resistant to earthquakes. Keith A Porter (2021) while pointing out that the public sector rarely has the financial capability to deal with hazard prevention costs on existing buildings rationalized that accepting post-recovery huge spending rather than prevention and reducing the risk through private sector resources were the two options. Porter (2021) further observed that BEPs as consultants and policy makers dwell extensively on past occurrence study rather than solving predictable future problems. Porter (2021) based on a United States study concluded that it is time to build better by adopting building codes that demand slightly higher investment by the private sector in hazard-mitigating construction methods. This puts the long term overriding public interest of scarce funds expenditure after hazards over the short term savings of private developers on initial lower construction cost that all BEPs code of ethics support. Earthquakes being a natural hazard is no respecter of climate or region, over the years, earthquakes have been recorded in Nigeria. Osagie [2008] gave a succinct account of the occurrences of earthquakes and tremors in Nigeria. The first recorded earthquake occurred in Ibadan in 1949 while the first tremor took place in Warri in 1923. There have been other occurrences thereafter. A more recent one was the event that occurred precisely on the 11th of September 2009 at about 03:10:30 am in Abeokuta, Nigeria; where an earthquake of magnitude 4.8 and intensity 7 was recorded; since then, it has remained a real concern in the built environment. National Space Research and Development Agency (NARSDA) researchers corroborated the incident and thereafter articulated the tremor as a sign that Nigeria is not immune from earthquake occurrence(Awoyera, Ogundeji and, Aderonmu.2016).

Building Components Reuse and the Built Environment

Earth's resources are rapidly being depleted by human activities through shelter provision for ever-growing needed land uses in a rapidly urbanizing and developing world. Conservation of earth's resources through material efficiency has become one of the cardinal points of sustainable development. One of the modes of material efficiency in all economic sectors including the construction industry is thinking in terms of waste hierarchy. Waste hierarchy in the context of associating economic growth and resource consumption proffers either prevention of waste or reuse. Studies have proposed design methods to prevent or reuse waste. These include Kalyun and Wodajo (2012)- Design for Manufacture and Assembly (DfMA)- and Akinade et al (2016)Design for

Deconstruction (DfD) respectively to minimise waste throughout the life cycle of new buildings (Kambiz Rakhshan , Jean-Claude Morel, Hafiz Alaka and Rabia Charef, 2020). Rakshan et al (2020) further observed that these methods are new and were not applied in most existing buildings in the world thereby generating a lot of waste during renovation or rehabilitation or at the end of life demolition. Also, recycling is relatively common during construction and demolition waste recovery rather than the preferred reuse in the waste hierarchy. However, recycling is energy intensive in terms of processing compared to outright reuse, though it reduces the amount of waste going into landfills. Recycling also goes through an industrial process that consumes natural resources and contributes to ozone layer depletion through release of greenhouse gases (GHGs) and other emissions.

Components reuse have little or no impact on the environment. Components that may be reused include roof frame, doors, windows, columns and beams in wood and timber, ceiling and roofing slates and sheets, tiles, sandcrete and brick wall units and others recoverable components during renovation/rehabilitation and before demolition. Rakhshan et al (2020) in a review identified economic factors, technical, social and regulatory barriers as significant against reuse of superstructure building materials and should be addressed holistically but the social, economic and regulatory barriers must be given priority.

Prediction of Energy Consumption in Buildings

The challenge of energy cost to the user and energy cost to the environment has necessitated development of prediction tools for energy consumption for all land uses towards achieving energy efficiency and energy conservation. Other means of monitoring and simulating energy consumption include building energy modelling and demand response control. Statistic and artificial intelligence (AI) based, that is, data-driven building energy prediction models are now being developed based on the physical characteristics of buildings and the climatic data of the location amongst other indices. Razak Olu-Ajayi , Hafiz Alaka , Hakeem Owolabi , Lukman Akanbi and Sikiru Ganiyu (2023) in a review found that no data-driven tool is better in all-round performance than all the others though Support Vector Machine (SVM) is outstanding in most reviews, followed by Artificial Neural Network (ANN) and Random Forest (RF) and then Linear Regression (LR) and Autoregressive Integrated Moving Average (ARIMA). The gap identified by Ola-Ajayi et al (2023) include the absence of natural gas predictions, monthly and yearly energy consumption predictions, a condition now being alleviated by smart metres. The future lies in hybrid predictive models based on deep learning methods.

Multi-faceted Sustainability

Sustainability when related to societal development has more meanings than environmental sustainability as reflected in the 17 United Nations Development Goals and their interconnectedness. Climate change as a Global problem has become prominent in terms of activism and discourse on sustainability. The concepts of social and economic sustainability in addition to environmental sustainability becomes necessary when built environment issues and projects are situated in the development of a society. Ja Young Eunice Kim (2023) makes a distinction between green building which is environmentally friendly and will make little negative impact on the environment with ecological orientation. Sustainable buildings have additional qualities related to tradition, culture and heritage, social equity and infrastructure, and a healthy and comfortable environment. Kim (2023) reports that Sustainable Architecture from 2013 shifted from technical outlook to a more cultural-human-nature framework and that sustainable architecture is inclusive of social practice.

Urban Vitality

In a rapidly urbanizing world, the urban vitality concept of Jacobs (1961) in relation to the 17 Sustainable Development goals and the 11th

indicator of having safe, inclusive, resilient and sustainable living spaces becomes critical. Rapid urbanization in the developing world is often not associated with economic development unlike China and other developed world cities. The debate is still ongoing on whether cities can guarantee sustainability, meet up with sustainable development goals and provide adequate quality of life while growing fast. Urban vitality discourse includes economic, social and environmental vitality without excluding cultural vitality in comparison to other cities (Yanxiao Jiang, Yuyang Zhang, Yu Liu, Zhou Huang, 2023). Economic vitality refers to the growth of capital and high skilled workers in a period of rapid growth. Social vitality is the intensity of human interactions and mobility measured by GPS technology while environmental vitality is about how comfortable diverse peoples are considering their physiological and psychological needs and the eco-sensitiveness of the city space. Cultural vitality has inputs of culture, history and tradition of the city, how these influence the activities and meet the needs of people in the city.

The future of vitality research according to Jiang et al (2023) will be based on technological developments in remote sensing added to social perception data and multifactor analysis in the evaluation of urban vitality.

Summary

In summary, for an architectural design technology studio to operate successfully, all its integral parts needed to be synthesised into a holistic entity. In this work, architectural design studio technology must exaggerate the unique factors perquisite to a particular climate (temperate or tropical); in order to design effectively for users' satisfaction and sustainability. More so, human and environment comfort requirements are considerable factors to design effectively. In the tropical climatic context, efforts should be made in the educational training and professional practices to inculcate the culture of a particular climate into its architectural design. In this way, the tropical indices serve as guardians to the technology of building designs. In another view, this work premised its ideology that natural hazard is no respecter of climate or region, therefore, architectural design technologist or Architects should be equipped with combating strategies on one hand and the tools of sustainability on the other hand. Another noteworthy point in this work, is that reuse is recommended for its economic, social and regulatory benefits while recycling is discouraged for its consumption of natural resources, and negative impacts on ozone layer depletion through release of greenhouse gases (GHGs) and other emissions. Finally, this work premised its ideology on the modus operandi that technical or technology issues of architectural designs of buildings and its built environments are collective concerns of all stakeholders with architectural technologists or Architects at the centre.

Exercises

The following exercises are recommended for best practices:

1. Architectural design briefs should be developed by the studio mentors/instructors/teachers in line with the course outlines as specified in the synopsis or syllabus.

2. Quick approach projects should precede and dovetail into the main design studio projects.

   The studio instructors at this level should prepare objective charrette/esquisse/quick approach design studio briefs for students to:

3. investigate and discuss and document various significant-tropical climatic factors and their influences on the built environment forms and spaces;

4. collect information, analyse and synthesize relevant data to determine architectural design strategies/solutions to make the built environment adjustable to climate change;

5. identify and integrate passive strategy technologies into the architectural design studio design projects;
6. itemize and engage tropical climatic elements in their design as vehicle for human comfort;
7. investigate current or recent natural hazards and specify the in-built architectural technology to combat such occurrences.

References

Aderonmu P.A, Adesipo Adeyinka, Onahi Eje I., Amao Daniel. I, Ogbondeminu Joy. E. (2021). Investigating The Daylighting Status and Associated Energy-Efficient Design Strategies in The Selected Museums of Southwest Nigeria. *Archiculture Journal,* University of Jos, Jos, Plateau State, Nig. Archiculture, Vol. 4 (2), December 2021 ISSN (Print): 2636-6747.

P. O. Awoyera, J. F. Ogundeji, P. A. Aderonmu (2016). Simulated Combined Earthquake and Dead Load Lateral Resistance Building Systems using Nigeria Seismic Data. J. Mater. Environ. Sci. 7 (3) (2016) 781-789. ISSN : 2028-2508.

Akinade O.O., Oyedele L.O., Ajayi S.O., Bilal M., Alaka H.A., Owolabi H.A., Bello S.A., Jaiyeoba E.B., Kadiri K.O. (2016). Design for Deconstruction (DfD): Critical success factors for diverting end-of-life waste from landfills. Waste Management (2016), Elsevier Ltd.

Kambiz Rakhshan , Jean-Claude Morel, Hafiz Alaka and Rabia Charef (2020)

Osagie E.O., Pacific J. Sci. Technol. 9 (2008) 546 – 551

BIOGRAPHY OF JAIYEOBA, EMMANUEL BABATUNDE

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CHAPTER NINE: BUILDING STRUCTURES

The Relationships Between Structures and Architectural Design

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Overview

One of the main characteristics of architectural products of which buildings are the major one is stability. Stability can only be guaranteed through a perfect coordination of structures and architectural design. A lack of proper coordination can result in failure and disaster of unquantifiable proportion since many lives may be lost. This is unlike professionals whose mistakes may lead to a loss of one life which is bad enough. This underscores how important a good knowledge of structures is to all designers and especially architectural designers.

This material equips students with basic knowledge of structural elements ,considerations made by the architect in designing buildings that are stable unless and can withstand all expected and unexpected natural forces and superimposed loads from human activities. In design, everything required for the building to be permanent is considered in both structural and architectural design

Objectives

The objectives of this chapter are to:

1. describe the interface between architectural design and structural implications;
2. explain the basic ideas of structures for architectural design;
3. explain the latest developments for structural stability in buildings;

4. examine the intricacies of complex structures; and
5. describe the various elements of structure and architectural design.

Considerations in Architectural Design with Structural Implications

Permanent buildings are able to resist inclement weather and climate, natural disasters such as flooding, landslides, cyclones, tremors and earthquakes and other environmental factors such as pollution, extreme heat, extreme rain and ice fall amongst other unimaginable natural occurrences. Occupants should also be protected against animal and human threats. The desire to make buildings to fulfil these requirements may lead to special structural and architectural design for various building types with implication for cost and value of the final architectural product.

Structural and architectural design solutions are also known to respond to these special environmental and social requirements of buildings over the ages. Human beings' desire for more durable and structural stability led to the use of stone and bricks instead of ordinary soil for construction and the natural occurrence of flood at the banks of rivers led to constructing houses on stilts (Sobczyk, Wiesenhutter, Noennig, & Wallmersperger, 2022)

Basic Ideas of Structures for Architectural Design

Unreinforced masonry construction cannot withstand lateral forces. Masonry construction can only bear compressive loads and little or no tensile, bending or shear loads. This is the reason masonry construction is mostly used for one-level buildings or bungalows especially for residential use. Masonry walls are not expected to bear point loads of beams. Lintel over windows and doors and other low span openings not greater than 2.4 metres are usually supported continuously over masonry walls on minimum 0.6m on the side of openings. In areas with seismic activities, that is tremors, unreinforced masonry construction is unsafe.

Latest Developments for Structural Stability in Buildings

Introduction of Smart materials

The response to the unpredictability of environmental factors in the midst of extremes of weather and climatic conditions including climate change and depleting natural resources is deploying intelligent solutions. One of the intelligent solutions is the introduction of materials that can detect environmental changes and respond to them, known as smart materials, to building construction. Smart materials can also detect seismic activities with information science and digital technologies.

Design for Seismic sensitivity

Anti-tremor and earthquake design details feature ductile detailing that allow inelastic deformations and controlled dissipation of imposed kinetic energy to sustain the integrity of existing structure and avoid considerable damage or outright failure of overall structure. However, the cumulative and residual deformations in the ductile components and joints usually require repairs or replacement in successive tremors or recurring earthquakes. The effect on day-to-day human activities in the building during a post-earthquake rehabilitation, the overall economy and the required capital for facility rehabilitation, maintenance or redesign is better imagined as an alternative to losing the whole structure. The cumulative effect on city and regional economies if the earthquake occurred over a large area slows down post-earthquake recovery (Zhong & Christopoulos, 2022).

To alleviate this, a Performance Based Seismic Design (PBSD) for each structure that utilizes the performance objectives and life cycle analysis factors to arrive at the permissible level of damage to a corresponding level of seismic hazard. More research on PBSD now intends to raise the performance level of structures during seismic hazards at reasonable initial construction cost. According to Zhong and Christopoulos (2022) progress made in this research is isolation damping systems to supplement ductile detailing in dissipating seismic energy and ensure minimal service disruption in addition to safety of lives. The latest research results are developments on self-centering structural systems that dissipates seismic energy during earthquakes and returns the structure to the pre-earthquake structural status without residual displacement.

Design of Tall Buildings

Tall buildings and the content- living and non-living are prone to vibrations due to natural factors like wind, super winds (for example cyclones), tremors and earthquakes. The wellbeing of this content, especially human beings and structure itself is the most important consideration in architectural design and structural design. Structural design that bears maximum responsibility in this regard means that structural advice starts from the conception of such projects.

Case studies of complex structures

Membrane Structures

These are long span structures over large spaces, for example Denver airport in the US (see Figure 10-1), that are flexible enough to vibrate or relax when exposed to dynamic loading (Liu, et al., 2021). The cover over the flexible membrane structure that is likely to fail under impact load is polyvinyl chloride (PVC) fabric membrane. The flexibility of the membrane structure due to little stiffness of the lightweight and long span structure can be tested easily in rain and wind storms. The vibration response to these and other impact loading like hailstones affects the structural stability and may actually lead to structural failure. More research like (Liu, et al., 2021) are presently extending the loading consideration for membrane structures from wind loads to impact loads like hailstones and other unexpected impact loads.

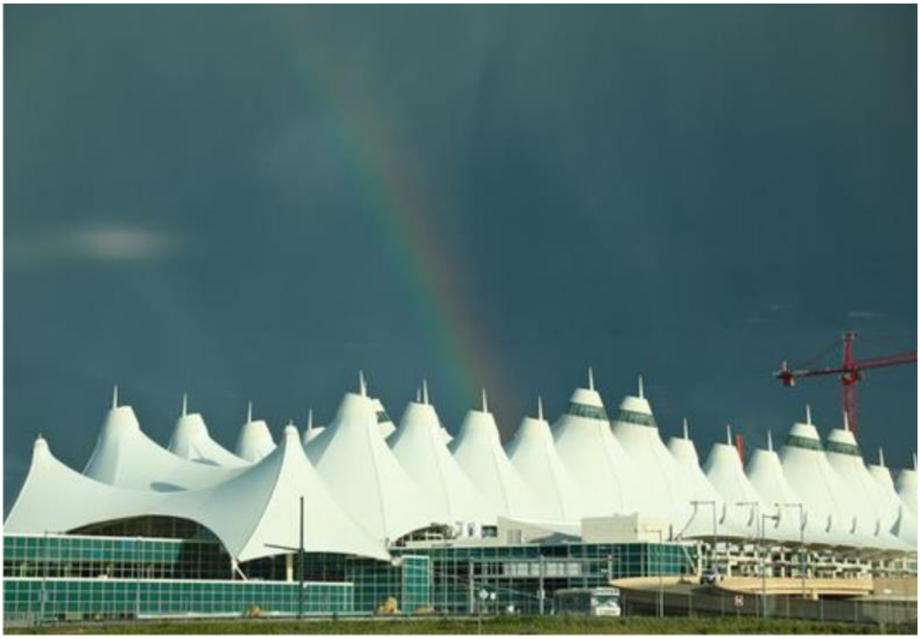

Figure 10-1: *Denver Airport, USA*

Source: (100) Pinterest

Adaptive or Active Structures

Most conventional structures are designed to be static or passive. Active structures transform to different forms, shapes and uses in response to stimuli such as weather, movement, solar exposure and air conditioning or respond to sensor, algorithm and actuator controls. Examples include retractable roofs, transforming elevations in 2 or 3 dimensions and movable bridges. Active structures may be hybrid in terms of components, methods, functions and technologies that may translate to different forms of loading, structural systems and materials (Marker, Jirasek, Schmidt, & Bleicher, 2022). Marker, Jirasek, Schmidt, and Bleicher (2022) proposed a hybrid roof concept that is stable but simultaneously adaptable to static and dynamic loads through elastic kinetic control elements.

Design Precepts from Nature

The history of Architecture and Engineering have featured borrowing from nature and getting inspiration from nature. Nature has provided designers with metaphors and proven to be a compendium of solutions to many human problems beyond providing metaphors (Selçuk, Nur, & Güneş, 2022). The concepts of sustainability and digital technologies on architectural design and production have transformed architecture in the 21st century. Forms, structural formations in nature have inspired designers and researchers but digital technologies have now made the effectiveness of natural solutions more evident. For example, the formation of tree-like structures in architecture as popularized by Frei Otto relating branches, leaves, trunk, roots as a natural construction and load distribution metaphor as a 'minimum path system' in his book "Finding Form: Towards an Architecture of the Minimal" (Otto & Rasch, 1995) was analysed through parametric tools by (Selçuk, Nur, & Güneş, 2022). Nature provides architecture and structural solutions as seen in biophilic, sustainable and eco sensitive and ecological building designs.

Structure and Architectural Design by the Elements

1. Structures and Architectural Design

The relationship between all stakeholders in the building industry is geared toward the production of buildings that are stable and have adequate strength. Strength has to do with the ability of the building to withstand the effects of various forces that may act upon it, whereas stability ensures that the building has the ability to maintain its configuration while resisting loads (forces) that may be incident on it (Khodadadi, 2022).

The two main participants envisaged in architectural and structural designs here are the architect and engineer respectively. The architect provides the spatial designs for the proper functioning of the building and the engineer articulates the structural requirements for the spaces to perform their designed roles. It can also be inferred that architects think in the ways of form, function and aesthetics and the engineers do in the ways of form and functionality. Put differently, the architect is visually driven, and the engineer is mathematically driven. To the architects, design is drawing and to the engineers, it is calculation.

The relationship between architectural and structural designs has over the ages advanced in accordance with the prevailing technological prowess, however, three possible models have been identified thus: exposure, concealment and celebration. There are situations where the structural system is exposed at the expense of the architectural design, concealed by the architectural design and exploited as a design feature by way of celebrating its elements (Ching, Onouye, & Zuberbuhler, 2009). The Guggenheim Museum, Bilbao, Spain (1991-97) designed by Frank Gehry is a good example of a relationship where the structural system is concealed (Fig. 10-2). The Los Manantiales, Xochimilco, Mexico, 1958 designed by Felix Candela is an example of the relationship where the structural system (thin shell concrete) is celebrated (Fig. 10-3). The SS: Sergius and Bacchus, Istanbul, Turkey, 527-36 AD portrays the relationship where the structural system (masonry-bearing wall) is exposed (Fig. 10-4).

Figure. 10-2: *The Guggenheim Museum, Bilbao, Spain (1991-97)*

Figure. 10.3: *The Los Manantiales, Xochimilco building, Mexico*

Figure. 10.4: *The SS. Sergius and Bacchus building, Istanbul, Turkey, 527-36 AD*

2. Foundation, Substructure and Superstructure

Buildings generally comprise three main components: foundation, substructure, and superstructure (Fig.10-5). According to Kultermann and Spence (2022) and Ching, Onouye, and Zuberbuhler (2009) the primary function of a building's foundation is to safely support and anchor the superimposed loads and transmit to the earth. The substructure is the lower part of the building that is below the surface of the ground level. It basically harbours the foundation system which provides the base upon which the load of the building is anchored to ensure stability and strength. The basement can be construed to be part of the substructure except that it is meant to provide accommodation. The superstructure is the part of the building above the surface of the ground carrying the building envelope and its support systems.

The design of the foundation system is carried out by the engineers after the architectural design of the building has been by the architect. The choice of the foundation system is dependent on a number of factors among which are: the architectural design of the building; size and type of building to be constructed; site and context; climate; soil; available and prevailing expertise, moisture conditions, legal constraints (codes) and budget. The foundation of the building can either be of the shallow or deep type. Shallow foundations are considered when loads are anticipated to be transmitted directly below the substructure which has stable soil of adequate bearing capacity and close to existing ground level. Examples of shallow foundation include pad, strip (continuous footing), or raft foundations. They may take any of the following geometric forms: point (column footing); line (foundation walls and footings) and plane (mat foundations – raft). Deep foundation is chosen when unsuitable soil conditions are prevalent and it is required to transfer the loads to a more appropriate bearing stratum of rock or dense sands and gravels well below the substructure (Ching, Onouye, & Zuberbuhler, 2009). A typical example of the deep foundation is the pile foundation.

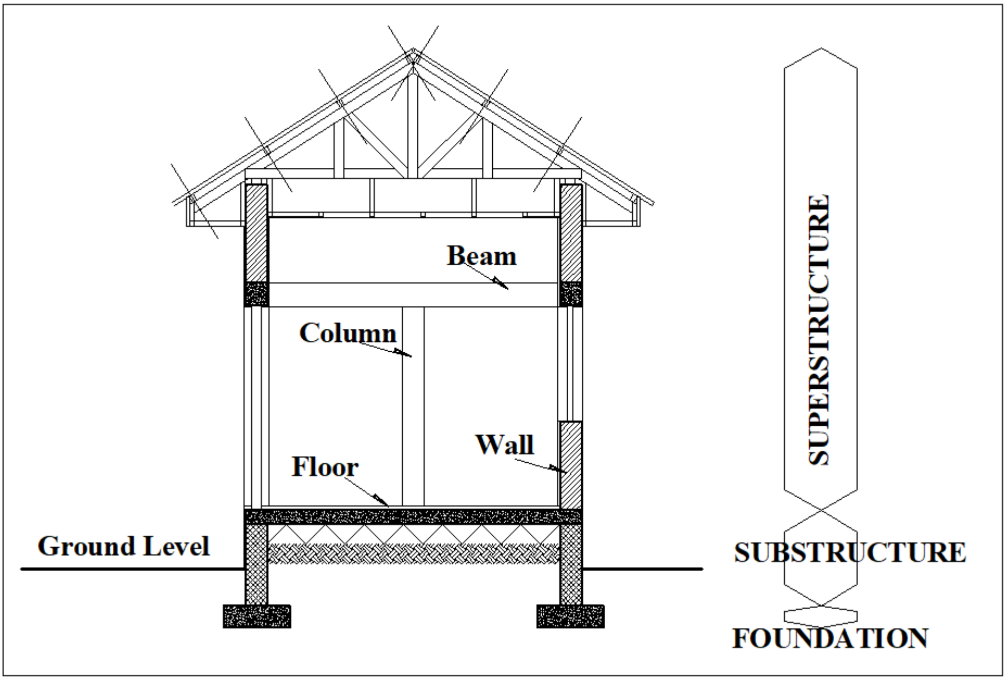

Figure. 10.5: *The three main components of a building: foundation, substructure, and superstructure*

3. Elements of the Superstructure

Wall

There are two types of wall structural system: Load bearing and non-load bearing. A load bearing wall has the ability to support imposed loads whereas a non-loading wall is merely for partitioning purposes as it does not support any loads. Walls can be made of masonry, concrete – in-situ and precast, wood, metal, etc.

Floors

Floors are horizontally spanning members of a building which provide the basic parameter for the usage of the space. It is designed in such a way to support its own weight and other imposed loads. Materials for its construction can be of concrete, wood, steel, etc.

Columns

Columns are vertical structural members that are rigid, relatively slender structural members of a building designed basically to resist compression (Ching, Onouye, & Zuberbuhler, 2009; Dabby & Bedi, 2012). They are classified as being short, long or intermediate in sizes. They are subject to failures by crushing and buckling. Short columns fail by crushing, long by buckling and intermediate by partly crushing and partly buckling. They can be constructed with reinforced concrete, wood, steel, etc. They carry loads downwards to the foundations and ground.

Beams

Beams are horizontal structural members that support loads. They are designed to carry down loads to the stable bearing stratum through the columns. They run perpendicular to its length, by resisting bending (Dabby & Bedi, 2012). There are four classifications of beams: simple, fixed-end, continuous and cantilevered. They are subject to failure by deformation thereby creating deflection. The type, size, and location of the loads on the beam as well as the type of and location of the supports determine the extent of deformation a beam may likely experience.

Roofs

Roof structures are horizontal spanning systems of a building meant to provide protection over the internal spaces. They may take the form of being pitched or flat, gabled or hipped, broad or sheltering, or rhythmically articulated (Ching, Onouye, & Zuberbuhler, 2009). The structural design of the roof does take into consideration its own weight (dead load) and all others imposed on it, especially from the elements of the weather – snow and rain. It is expected that its structural design is to align with those of the columns and wall systems to enable the seamless transmission of its loads to the foundation.

References

Ching, D. F., Onouye, S. B., & Zuberbuhler, D. (2009). *Building structures illustrated: patterns, systems, and design.* New Jersey: John Wiley & Sons .

Dabby, R., & Bedi, A. (2012). *Structure for architects: a primer .* New Jersey: John Wiley & Sons .

Khodadadi, A. (2022). *Basic concepts of structural design for Architectue students .* Portland State University Library. doi:10.15760/pdxxopen-31

Kultermann, E., & Spence , S. W. (2022). *Construction materials, methods, and techniques: building for a sustainable future.* Boston, USA: Cengage Learning .

Liu, C., Wang, F., Deng, X., Pang, S., Liu, J., Wu, Y., & Xu, Z. (2021). Hailstone-induced dynamic responses of pretensioned umbrella membrane structure. *Advances in Structural engineering, 24*(1), 3-16. doi:https://doi.org/10.1177/1369433220940149

Marker, P., Jirasek, R., Schmidt, T., & Bleicher, A. (2022). Development, realization, and experimental validation of an active hybrid roof structure based on elastic kinetic and rigid-body transformation. *International Journal of Space Structures*, 1-18. doi:10.1177/09560599221134286journals.sagepub.com/home/sps

Otto, F., & Rasch, B. (1995). *Finding form: towards an architecture of the minimal.* Bayern : Deutscher Werkbund.

Selçuk, S. A., Nur, B. G., & Güneş, M. (2022). Tree-like structures in Architecture: revisiting Frei Otto's branching columns through parametric tools. *SAGE Opem*, 1-22. doi:10.1177/21582440221119479.journals.sagepub.com/home/sgo

Sobczyk, M., Wiesenhutter, S., Noennig, R. J., & Wallmersperger, T. (2022). Smart materials in architecture for actuator and sensor applications: A review. *Journal of Intelligent Materials Systems and Structures, 33*(3), 379-399.

Zhong, C., & Christopoulos, C. (2022). Self-centering seismic-resistant structures: Historical overview and state-of-the-art. *Earthquake Spectra, 38* (2), 1321-1356.

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CHAPTER TEN: BUILDING COMPONENTS AND METHODS

Basic Building Components

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Overview

Adequate knowledge of the basic components that make up buildings is very vital to the understanding of how to design and erect buildings; the various options available in terms of the design and materials; what details are included in a typical building, and the workability of the building. It is also important to know how to achieve safer and aesthetically pleasing buildings; understand how to schedule projects to meet the deadline provided by the owner.

This text equips students with knowledge of the three essential building components: foundations, walls, and roofs; their different types, design, and construction methods as well as the materials that can be used in their construction. It also enhances the students' knowledge of the performance requirements of these components and the International building codes and regulations associated with the material, design, and construction of walls and roofs.

Objectives

This chapter is designed to ensure that students are able to:

1. identify the different types of foundations, walls, and roofs in buildings;
2. explain the conditions in which the different types of foundations can be used in buildings;

3. draw and label the different types of foundations, walls, and roofs in buildings;
4. identify the different materials for foundations, walls, and roofs;
5. describe how foundations, walls, and roofs are constructed;
6. mention the key sustainability issues considered in choosing walls and roofing materials; and
7. identify the local and international building codes and regulations associated with the material, design, and construction of walls and roofs.

Foundations

Buildings have two main components: the sub-structure and the superstructure. Whereas the sub-structure is the part below the ground that is not usually seen, the superstructure is that part of the building which is above the ground and can easily be seen. Foundation is the lowest part directly in contact with the ground (sub-structure) that supports and holds the upper part of the building (superstructure) and helps to transmit its loads directly to the ground. What roots are to trees is what foundations are to buildings. The foundation's lowermost part in direct contact with the subsoil is called the footing. It is the footing that transfers load from the superstructure directly to the soil.

Functions of foundations

Foundations in buildings serve the following basic functions.

1. Hold up and hold together the superstructure of the building.
2. Reduce the load intensity by distributing it over a larger surface area of the soil.

3. Help to transfer load and distribute it evenly to avoid unequal (differential) settlement of the foundation and avoid damage to the superstructure.
4. Anchor the building to the ground, thereby preventing horizontal movement resulting from lateral or horizontal forces such as wind, earthquake, and water current.
5. Prevent damage to the superstructure due to soil movement resulting from shrinkage and expansion of the subsoil made of clay or made-up soil.

Basic Features of a Good Foundation

According to Emmitt and Gorse (2005), the basic functional requirement of a foundation is strength and stability. Given this, the following are some of the basic features of a good foundation.

1. It should be able to support the self-weight and imposed loads of the building.
2. The foundation footing should be rigid enough to withstand any form of excessive differential settlement.
3. Settlement of the foundation should be within acceptable limits to minimise any threat to the superstructure.
4. The foundation depth should be adequate to ensure that seasonal variations in the soil conditions will not have any significant effect on the building.

Factors that Determine Foundation Depths

Generally, several factors determine the depth of foundations. These include:

1. Availability of a favourable soil-bearing capacity.

2. Depth at which the soil type experiences variation in volume due to seasonal changes.
3. Frost penetration depths and levels of fine sand and silt soils.
4. Possibility of future excavation near the project site.
5. The depth of the groundwater table on the site.
6. The depth of topsoil and level of made-up soil on the building site.
7. The expected load on the building (Chudley & Greeno, 2014).

Types of Foundations in Buildings and Methods of their construction

Classification of foundations has its origin in Terzaghi's theory of foundation classification. By this theory, a shallow foundation is one that has a depth that is less than or equal to its width, and a deep foundation is one that has a depth that is larger than its breadth. This means that the classification of foundations is based on their depth in the soil and the ratio of their depths to their widths (See Figure 1).

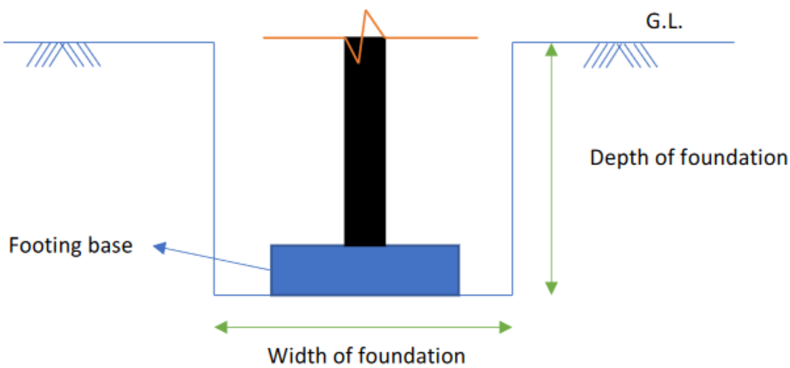


Figure 1: *Section of a foundation showing the width and depth*

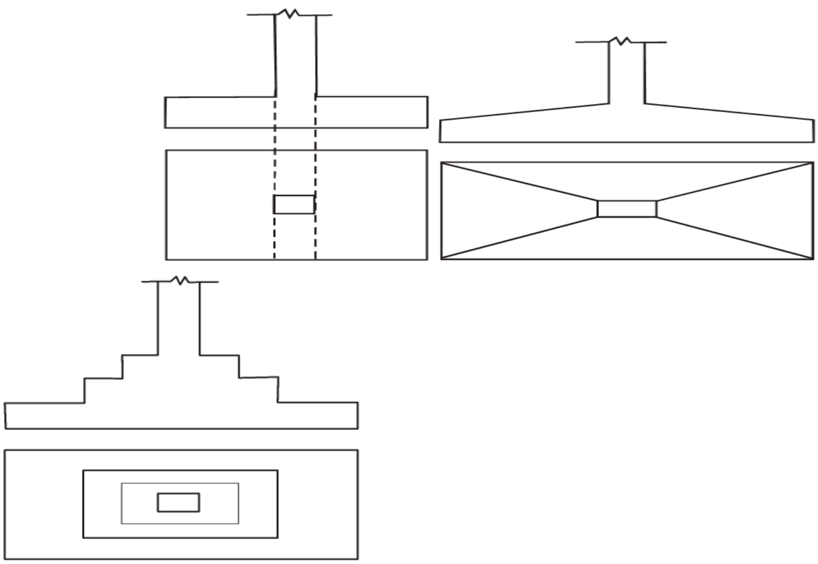
Based on Terzaghi's theory of foundation classification, we have two main types of foundations in buildings. These are shallow foundations and deep foundations.

Shallow Foundations

These are foundations whose widths are greater than or equal to their depths. According to Rajput (2020), examples of shallow foundations include the following:

Isolated footing

This is also known as the pad foundation. It consists of isolated footings of rectangular and square shape that are separated from each other and supports structural components like walls or columns (Chudley & Greeno, 2014). It is the most common and economic type of foundation used where the soil has a good capacity to support loads. The wideness and deepness of a pad foundation are determined by the soil condition (i.e. load bearing capacity) and expected load on the building. Isolated footing can occur in three ways: plain isolated footing; slopped isolated footing and stepped isolated footing as shown in Figure 2 (a, b & c).



(a)Plain Isolated footing (b)Sloped Isolated footing (c) Stepped isolated footing

Figure 2: *Graphic illustrations of plans and sections of isolated footings*

2. Combined footing

In this type of foundation, two or more columns have their footings placed close to each other to the extent that their footings overlap forming a combined footing (Figure 3). This is used when having individual footing for each column is not possible due to site restrictions or when the loads are heavy and the distance between the columns is smaller. The shapes of the footings can either be rectangular, trapezoidal, or combined column/ wall footings.

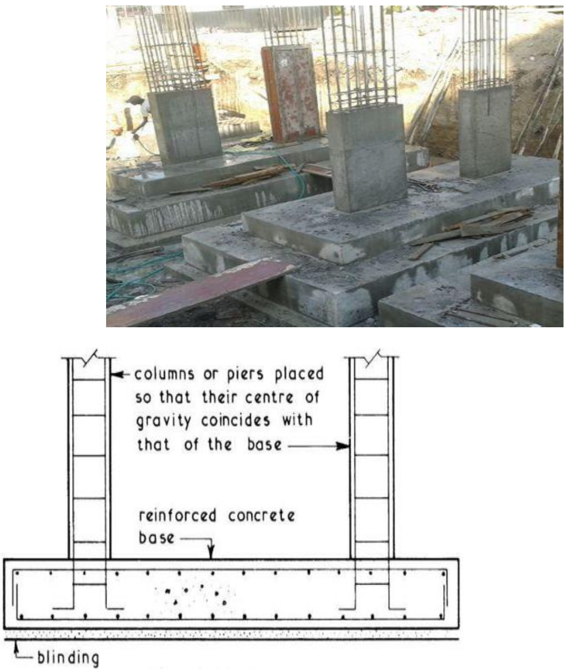


Figure 3: *Combined footing*

Source: Constro Facilitator ,2021. Source: Chudley & Greeno ,2014.

Strip foundation

Strip foundations, which are also known as wall footings are used to transfer loads continuously from walls of concrete and timber frames (see Figure 4).

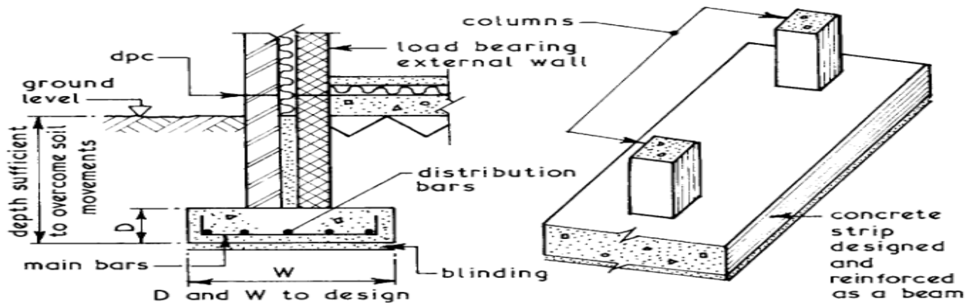


Figure 4: *Strip foundation;* *Source* **:** Chudley & Greeno, 2014.

The size and position of the strips are determined by the overall thickness of the wall. The width of the footing is generally between 2 and 3 times the thickness of the wall. We use strip foundations, particularly where the soil has a good load-bearing capacity. They are used in low-rise or medium-rise buildings and retaining walls where strip foundations of mass or reinforced concrete are economical. The different types of strip foundations are conventional strip, deep strip or trench fill, reinforced concrete strips, and continuous columns.

Cantilever or Strap footing

When two independent columns' independent footings are joined by a beam known as a strap beam, a shallow foundation of this kind is created. The strap beam that connects the two individual foundations provided below the two isolated columns is not allowed to come in contact with the foundation soil or subsoil as shown in Figure 5.

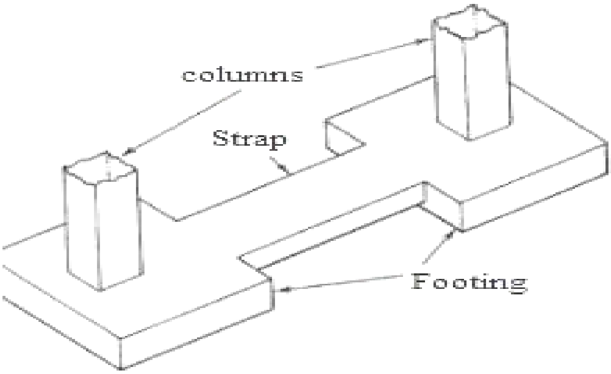


Figure 5: *Plan of cantilever or strap foundation*

Mat or Raft Foundations

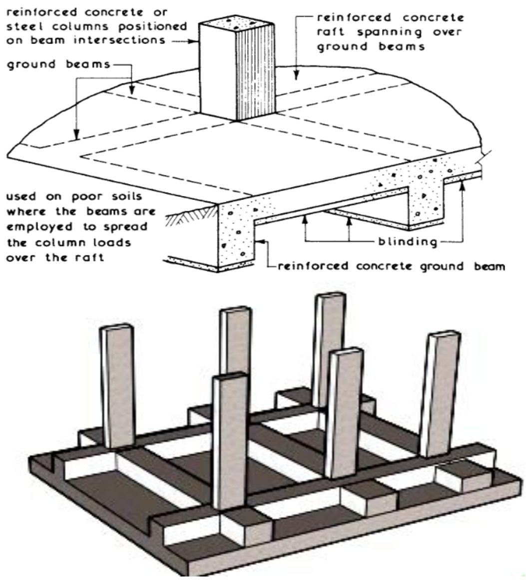
These are made up of solid slabs that support columns or walls underneath them. This foundation type is used mostly where there is compressible ground such as very soft clay soil, alluvial deposits and made-up soil with very low load-bearing capacity and strip, pad or pile will not likely provide a stable foundation (Emmitt & Gorse, 2005). The raft foundations are normally used to provide a very large surface area to spread the load of the building, and thus prevent uneven settlement of the foundation. The advantages of raft foundation are that it requires less excavation, good for soils with low bearing capacity, the load from the upper part of the building is spread over a large surface area of the ground and helps to reduce differential settlement of soil. However, a lot of reinforcement and skilled workers are required for the construction of raft foundations, which can increase the cost of the project.

Types of Raft foundations

There are three major types of raft foundations used in buildings. These are:

1. Beam and slab raft foundation. This consists of reinforced concrete inverted T-beams and slabs that cover the whole area of the foundation. The inverted T-beams run in both directions and at the points where they meet are columns that carry the load from the upper part building. The entire arrangement of slab and beams form a unified structural entity. It is used when the loads carried by columns are heavy and the spacing of the columns is relatively wider. The beams are usually arranged parallel to each other in both directions and at the meeting point of any two beams is a column as shown in Figure 6.

They are two types of beam and slab raft foundations. The first is the raft foundation with down-stand beams and the second is the raft foundation with up-stand beams (Chudley & Greeno, 2014). The raft foundation with the down-stand beam has the ribs of the beams below the raft slab, hence, the raft slab doubles as either the basement floor slab or the ground floor slab. The raft foundation with up-stand beams has the ribs of the beams above the raft slab. This is disadvantageous, firstly, because of the need to provide a ground floor slab, and secondly, it constitutes some challenge in dealing with the cells provided by the up-stand beams.



(a) raft foundation with down-stand beams **(b)** raft foundation with up-stand beams

Figure 6: *Beam and slab raft foundation*

2. Flat raft foundation. This is made up of thick reinforced concrete slabs that cover the entire space of the foundation and are strengthened by layers of bars running perpendicular to each other beneath the top surface of the mat and another layer above the bottom. The slab usually supports the columns which are placed close to each other as shown in Figure 7.

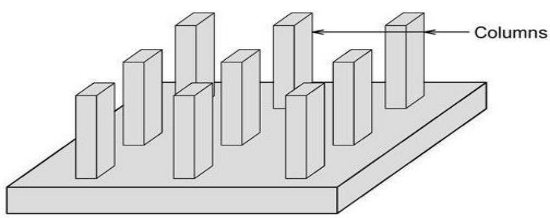


Figure 6: *Graphic illustration of Flat Raft foundation*

3. Cellular raft foundation: This has two-way beams at the foundation with a solid slab placed above and below (Figure 8).

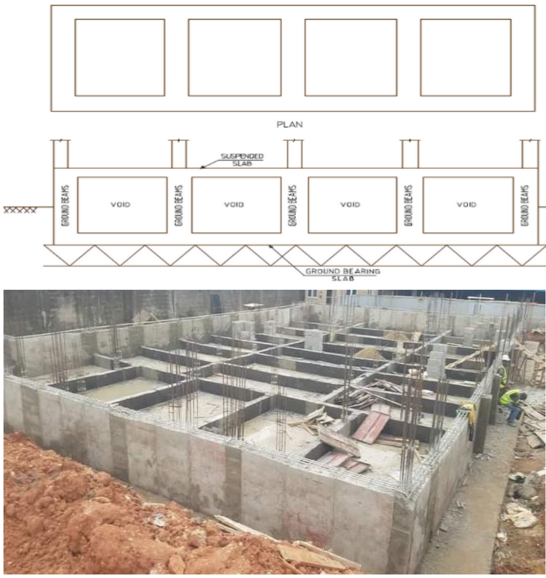


Figure 8: *Cellular raft foundation;* *Source*: Omotoriogun , 2021.

Both the upper and lower slabs are connected by intermediate beams, making the foundation look like an I-beam structure. The top slab can be covered using precast soffits or other types of permanent formwork and it is filled with lightweight infill blocks. The cellular raft foundation is normally used where there is heavy mining activity; the soil has bearing capacities, and there is a need to check soil uplift pressure.

Deep Foundations

These are all foundations in which the ratio of their widths to depths is less than one. They are used to transfer the load on buildings down through the upper weak layer of topsoil to the stronger strata of subsoil. There are generally three types of deep foundations in construction, but the pile foundation is the most common type used in buildings. The three types of deep foundations are 1) pile foundation: used in buildings

2) pier foundation, used in bridges and fly-overs to resist heavy traffic loads, and 3) drilled shaft or caisson foundation which is used where the pile foundation is not enough to bear the heavy load of the structure such as bridges and dams under the water.

Pile foundations

A pile foundation consists of several columns built or inserted into the ground to transfer the loads on the building to a lower subsoil level (Chudley & Greeno, 2014). It is used where hard strata are available below the limit in which the shallow foundation is not economical, and piles are used for the purpose of transferring loads from the building to a hard surface in the ground (Figure 9).

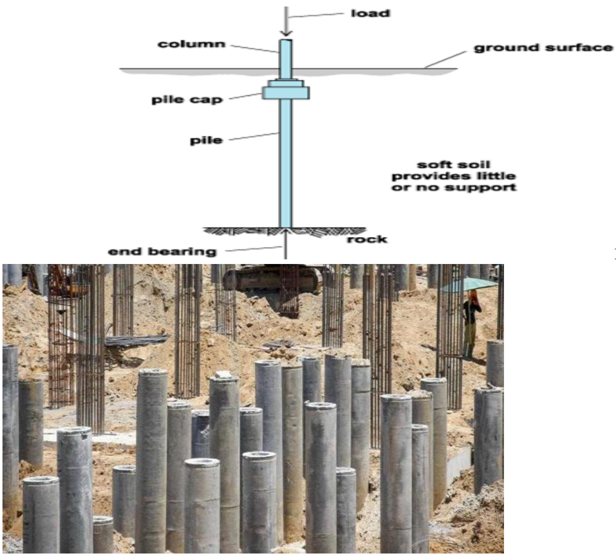


Figure 9: *A typical pile foundation*; Source: Constro Facilitator, 2021.

Pile foundations are used where there is shrinkable clay soil, deep-rooted trees, sub-soil is soft, and the existence of uncertain bearing capacity of soil a few meters below the topsoil (Emmitt & Gorse, 2005). They prevent the building from experiencing uplift due to lateral loads from wind and earthquake forces; and limit uneven settlement of the foundation. Pile foundations could be pre-fabricated or cast-in-situ and can be constructed using timber, steel, concrete, reinforced concrete, or a combination of any two of these materials.

(a) **Steel piles**: These are made up of H-piles, pipe piles, and sheet piles made of rolled steel sections. These piles have a shoe at the lower end for ease of driving and to prevent rusting epoxy coating is recommended.

(b) **Concrete piles**: These occur in two main types: precast and cast-in-situ. Pre-cast (prefabricated) piles are cast in a factory or prestressed and then transported to the site. The cast-in-situ piles are constructed on-site by boring holes through into the soil and then filling them up with concrete. For reinforced concrete piles, the already prepared cages are filled with concrete after inserting the steel reinforcements.

(c) **Timber piles:** These are prepared from wood that is straight and devoid of defects and cracks. Timber piles are usually provided with steel shoes to prevent damage during driving. For durability, a coating of creosote oil or bitumen coating is usually recommended.

(d) **Composite piles:** Composite piles are made up of two different materials, such as concrete and timber and concrete and steel. It is a common practice to place the concrete in the upper part, while the lower part is made up of steel or timber.

Modes of load transfer in pile foundation

There are three modes of load transfer in pile foundations (Rao, 2010). These are end bearing mode, friction mode, and combined end bearing and friction mode (see Figure 10).

(1). End-bearing or Point-bearing piles. This transfer loads to a hard stratum some depth below the ground level based on the bearing capacity of hard strata. They behave as columns and transfer loads with the same mechanism as structural columns in a building.

(2). Friction or floating piles: Unlike end-bearing piles, friction piles do not require a hard stratum to be able to transfer loads as they transfer loads via friction with the surrounding soil. The load to be transferred must be equal to skin friction between the piles and the surrounding soil. This type of pile is also referred to as floating piles because they do not have contact with a hard stratum of the soil. They are used when getting to the hard strata is not economical because of their depth.

(3). Combined end bearing and friction piles: They transfer load using a combined mechanism of end bearing and skin friction mechanisms as previously explained.

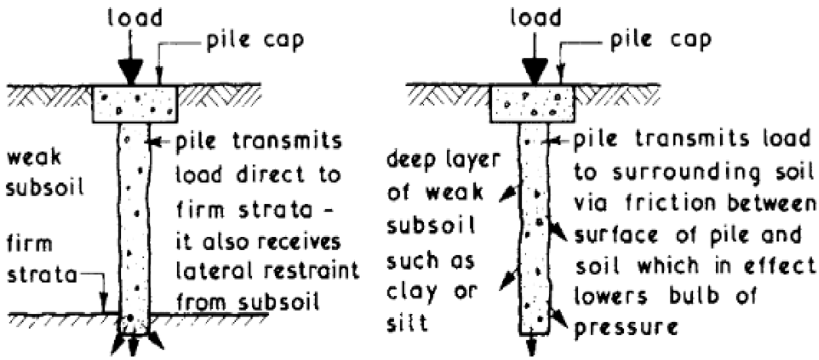


Figure 10: *Modes of load transfer in pile foundations Source*: Chudley & Greeno, 2014

Foundation Design Principles

The purpose of a foundation is to have a reliable structural arrangement that ensures that loads on the building are transferred to the sub-soil safely and economically without any form of vertical and horizontal movement capable of threatening the structural stability of the building. Therefore, the foundation design procedure includes the following steps:

1. Evaluation of the site conditions with respect to the soil investigation report.

2. Estimation of the anticipated loads on the building at all times.

3. Choose the appropriate type of foundation taking cognizance of the following factors

a) Soil condition (i.e. bearing capacity).

b) Type of building (e.g. residential, institutional, commercial, etc.).

c) The anticipated load on the building in its entire life span.

d) The cost implication of the foundation.

e) The duration of the building contract.

f) Buildability of the foundation.

g) Materials to be used.

4. Size the members of chosen foundation bearing in mind the loading condition, soil bearing capacity, and form of movements the building might likely experience in the future (Chudley & Greeno, 2014).

Walls in Buildings

A wall is an element used to divide or enclosed spaces or to form the external covering (envelope) of the building. It is part of the building structure that supports a load and offers security, shelter, and soundproofing.

Types of Walls and their functions in Buildings

Based on their functions walls are divided into the following types (i) load-bearing walls (ii) non-load-bearing walls (iii) cavity walls (iv) shear walls (v) partition walls (vi) panel walls (vii) veneered walls and (viii) faced walls

Load Bearing Walls

Load-bearing walls are force-resisting or load-carrying elements that carry their own weight, and, vertical and lateral load on the superstructure from the floors, beams, slab, and roofs. Load-bearing walls are designed as interior or exterior walls. Load-bearing walls are in different types namely: (i) precast concrete wall (Figure 11) (ii) retaining wall (Figure 12) (iii) masonry wall (Figure 13) (iv) pre panelized load bearing metal stud walls (Figure 14) (v) engineering brick wall (Figure 15) and (vi) stone wall (Figure 16).

Figure 11: *Precast Concrete Wall*

Source: Kingdom Precast (2023)

Figure 12: *Retaining wall*

Source: PERI Nigeria (2023)

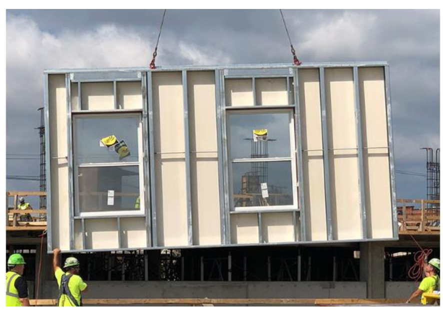


Figure 13: *Masonry Wall* **Figure 12**: *Pre-panelised metal stud Walls*

Source: Richard (2018) *Source*: All Steel mid-rise (2023)

Figure 15: *Engineering brick Wall*
Farad Contractors (2010)

Figure 16: *Stone Wall*
Dream Civil (2022)

Non-load/Structural Bearing Walls

These are walls that do not carry any load outside their weight. They are mostly used as internal walls to divide the spaces in buildings into smaller spaces for different activities. They are built with lighter materials such as plywood, metal sheets, and others, and hence are cost-effective. Any non-load-bearing walls can be removed from the building without endangering the structural stability and safety of the building. The types of walls in buildings that are not designed and constructed to carry loads include (i) hollow concrete blocks when used in multi-story buildings (Figure 17) (ii) façade bricks (Figure 18) (iii) hollow bricks (Figure 19) and brick facing walls (Figure 20).

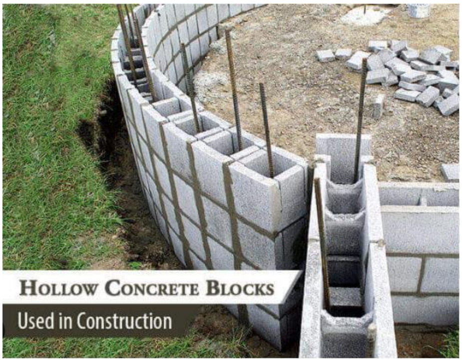


Figure 17: *Hollow Concrete Block*
Patel (2020)

Figure 18: *Façade Bricks*
Farad Contractors (2010)

Figure 19: *Hollow Bricks*
Alamy (2022)

Figure 20: *Brick Walls*
Source: Earth Bricks Venture (2023)

Cavity Walls

Cavity walls are made of two leaves or skins with a void or cavity between them. The outer wall is normally connected to the inner wall separated by an air space. Cavity walls improve thermal and acoustic insulation while excluding moisture from entering the interior spaces of the building through the wall. They are fire-resistant and economically cheaper than other solid walls (see Figure 21).

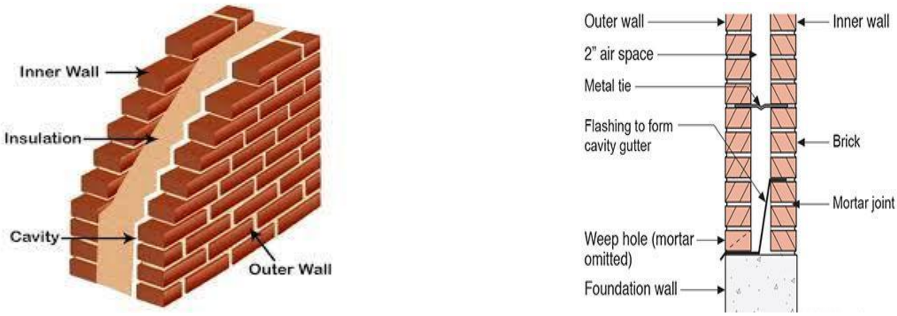


Figure 21: *Cavity wall*

Shear Walls

These are framed walls meant to transfer lateral loads from exterior walls, floors, and roofs to the foundation. Shear walls are very important in high-rise buildings to provide bracing due to their very high stiffness and strength. They act as a beam cantilevered out of the foundation and their strength comes from their thickness Shear walls are usually made up of wood, concrete, or masonry. They are very good at resisting seismic (earthquake) and wind loads (see Figure 22).

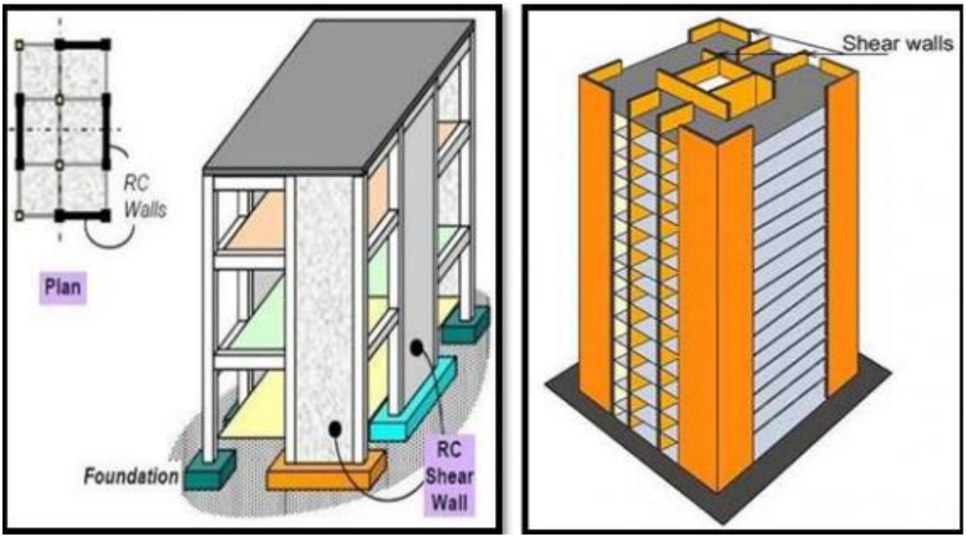


Figure 22: *Reinforced concrete shear wall in building* *Source:* Murty C. V. R (2005)

Partition Walls

Partition walls are used to subdivide large spaces into smaller ones in buildings. They can be constructed with different materials such as bricks or stones and are stable and strong to support their self-weight and those of wall fixtures. They have high soundproof and fire-resistant properties.

Panel Walls

Panel walls are not designed to support additional loads except their self-weight. Both nails and adhesive are used to install the panel. The paneling design possibilities include rustic, boards, and frames. They can be manufactured from hardwoods or economical pine. Prior to installing panel walls, the space should be painted.

Veneered Walls

These are single, non-load-bearing exterior brick, stone, or artificial stone walls. They have an air space behind them and are called anchored veneer. They are usually light-weighted and take a shorter time to construct.

Faced Walls

These have facing and backing made of two different materials held together by a binding material to ensure they act as a unit. They create a streamlined look and they are easy to install. Figure 23 shows a faced wall with two bricklayers at the front and a fiberboard at the back. The bricks and fiberboard are held together by concrete.

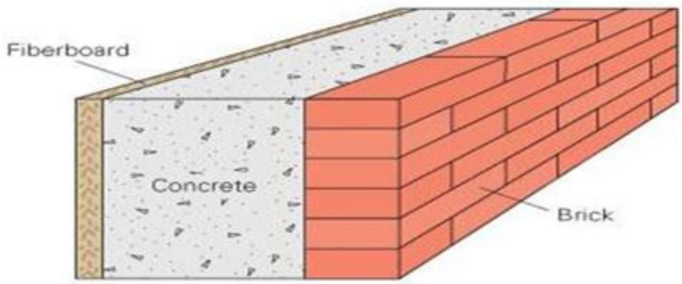


Figure 23: *A faced wall of fiberboard and brick held together by concrete*

Materials for Construction of Walls

There are different ways to construct walls with different materials. Walls can be formed of individual units of materials such as bricks, clay or concrete, or stones, usually in courses joined together with binding materials such as mortar. Monolithic walls are formed of materials set in layers or as sheets and can be made of conventional earth materials or concrete, or even wood. The earth walls are affordable and sturdy if put on a stable base and shielded from the rain by a rendering or wide roof overhangs.

A frame wall is built as a series of relatively tiny, mostly wooden, elements placed closely together to form a load-bearing unit with a face or sheathing on one or both sides. A membrane wall is created as a sandwich of two thin skins or sheets made of reinforced plastic, metal, asbestos-cement, or any other suitable material attached to a core of foamed plastic. It can also be achieved using framed or earthen materials comprising light sheeting that is fastened to the face of the wall and forming the enclosed elements. This is often referred to as cladding.

Factors that determine the type of wall to be used

The following factors determine the type of wall in a building (i) the availability and cost of the materials (ii) the availability of a skilled workforce to use the material (iii) climate and (iv) the type of building and its function.

Sustainability Issues in the Choice of walling materials

The sustainability issues associated with the choice of wall materials include the following:

1. The source of the materials and energy required its extraction, processing, and transportation to the site.
2. Level of CO_2 emission involved in the production of wall materials.
3. Initial and maintenance costs of the wall.
4. Thermal insulation properties of the material for the thermal comfort of building users.
5. Aesthetics of wall materials.

International and Local Building Codes and Regulations Associated with the material, design, and construction of walls

International Building Code (IBC): Chapter 14 of the IBC is on Exterior Walls. It covers the fundamental requirements for exterior walls, such as the types of wall coverings that should be used, how they should be installed, and the weather and fire-resistant properties of walls.

*Nigeria's National Building Code 2006***:** Section 10 of the NBC is on building materials and components requirements. This section covers the requirements of various materials used in building construction and establishes the expected quality of such materials to be characterised by their durability, functionality, aesthetics, resistance to fire, and grade.

Roofs in Buildings

The roof is a covering on the top of a building that protects occupants and interior spaces against elements of weather such as rain, snow, sunlight, wind, and temperature.

Performance Requirements of Roofs

The following are the basic functional requirements of roofs.

1. Have enough strength and stability to support the self-weight and imposed loads.
2. Adequately protect the building and its occupant from rain, sun, wind, etc.
3. Be durable against the adverse effects of the elements of weather.
4. Be water-proof and have good drainage features.
5. Adequate thermal insulation properties.
6. Have adequate fire-resistant property.
7. Provide adequate insulation against sound.
8. Have provision for natural daylighting if required.
9. Should be accessible for maintenance.
10. Provide adequate security.
11. Be aesthetically pleasing (Emmitt & Gorse, 2005).

Types of roofs

The choice of any roof type for a building is a function of climatic conditions and material availability. There are three main categories of roofs. These are:

1. 1. Pitched or sloping roofs: Pitched or sloping roofs have their sides inclined to the horizontal plane and with a pitch of over 10 degrees used in different kinds of buildings
2. 2. Flat roofs or terraced roofs: These are roofs with a pitch ranging from 0 degree to 10 degrees. Flat roofs can be used on buildings of any size and shape.
3. Curved roofs: These have curved surfaces and are used to create aesthetic effects. They can take different forms such as cylindrical and parabolic shells and shell domes, doubly-curved shells (e.g. hyperbolic, paraboloids, and hyperboloids of revolution, and folded slabs and prismatic shells). They are used in different building types, including civic buildings, sporting facilities, factories, and others.

Different Roof forms

Roofs have different forms, but the common forms are shown in Figure 24.

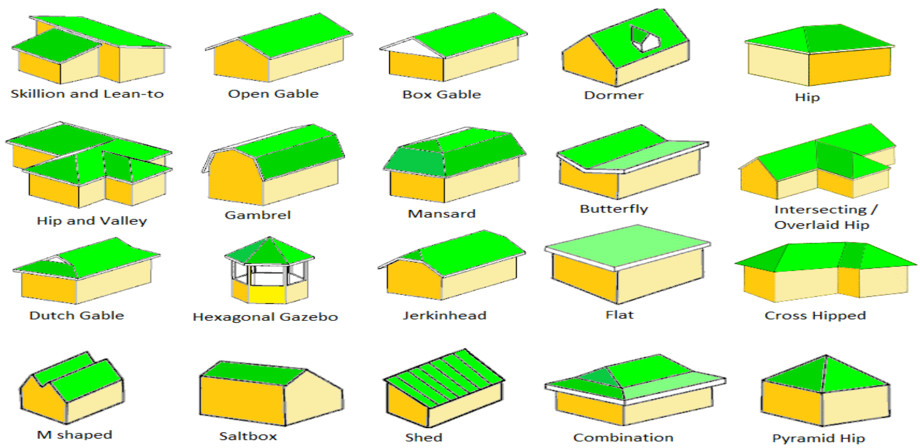


Figure 24: *Roof forms* *Source*: Rahman (2021)

1. Lean-to or shed roof. It is the most common type of roof that slopes on one side only.

2. Gable Roof: This has slopes in two directions. The slopes meet at the ridge and the ends face form a vertical triangle.

3. Hip Roof: This is formed by having the four sloping surfaces in four directions. The end faces form slopping triangles.

5. Mansard Roof: This is similar to a hip roof with slopes at the face. However, each slope has a break resulting in sloping ends.

7. Gambrel Roof: Like a gable roof, it slopes in two directions but each slope has a break and at each end, there is a vertical face.

6. Butterfly Roof: This is formed by two lean-to roof meeting at the valley.

8. Flat roof: This has a slope of less than $10^{o.}$ The slope required for the rainwater to drain off easily and rapidly. Flat roofs serve as terraces for different activities.

9. Shell and domes roofs: These are roofs with curved geometry with a pleasing appearance.

10. Clipped gable roof: This is also known as Jerkinhead or bullnose roof. It has the shape of a gable, with two sides meeting at the ridge with bent-in peaks. Small hips are created at the ends of the ridge.

11. Dutch gable roof: This is a combination of gable and hip roofs. The main roof structure is hip but with a miniature gable roof (gablet) placed on top of the hip roof.

Materials for construction of roofs

Roof materials consist of those used as roof structures and those used as roof coverings. Roof structures are mostly timber, steel, and concrete. The different materials that can be used as roof coverings include the following:

1. Eco-friendly or green roofing materials**:** These include materials made of trees and plants such as thatch, grasses, timber
2. Shingles: This is the generic term for roofing materials with sections overlapping each other. Examples include asphalt shingles and asphalt roll
3. Clay and concrete tiles: Made from clay and concrete materials that are very durable.
4. Membrane roofing. Made of large sheets connected to form a continuous surface (e.g. Polyvinyl chloride (PVC) roofs,)
5. Concrete or fibre cement: This is made of cement reinforced with fibre material
6. Reinforced concrete: Consists of cement and steel and is mostly used for flat and curved roofs. There are three main categories, precast/prestressed, cast-in-situ, and shell roofs.
7. Metals roofs: These are corrugated metal sheets **(**e.g. galvanised iron, copper, aluminium, copper, stainless steel).

Determinants of the choice of roof types and materials

Several factors determine the choice of roof types and materials (Mijinyawa, Adesogan & Ogunkoya, 2007). These include

1. Durability and ability of roofing material to withstand weather conditions.
2. Properties of the material such as weight, thickness, durability, slope, and shape.
3. Eco-friendliness of the material (e.g. energy efficiency, embodied energy).
4. Cost of the material (initial and maintenance costs inclusive).

5. The desired aesthetic quality.
6. The type of roof (i.e. pitch and slopes of the roof).

Sustainability Issues in the Selection of Roofing Materials

The sustainability issues associated with the selection of roofing materials are concerned with how green, or eco- / environmentally friendly the materials are in terms of the sources of their raw materials; how there are manufactured; their performance over their lifetime; and how they are disposed of at the end of their lifespan. Given this, in choosing roofing materials, the following sustainability issues should be considered.

1. The source(s) of the raw materials used in producing the materials: Renewables sources are preferred.
2. The quantity of energy used in their production and transportation to site and assemblage (embodied energy). Preference should be given to locally sourced materials to reduce energy consumption and CO_2 emission during production and transportation and construction process.
3. Ability to reflect and insulate from heat to reduce heat gain into the building. For energy efficiency, light in coloured and highly reflective materials is recommended.
4. Durability: Be sure that the roofing material requires less frequent maintenance and that no toxic products are required to maintain it.
5. Biodegradability of the material: Highly biodegradable materials are preferred to reduce the amount of waste in the dump site.
6. Recycled content: Check to see if the roofing material contains recycled content. The higher the percentage of recyclable content the more sustainable.

7. Cost, including initial and maintenance costs.

International and Local building codes and regulations associated with the material, design, and construction of roofs

International Building Code (IBC): Chapter 15 of the IBC deals with 'Roof Assemblies and Rooftop Structures. It provides the basic requirements for roof construction in buildings. It identifies the requirements for roof coverings and the need to use weather-protective and fire-resistant materials for roof construction.

National Building Code 2006: Part 2, Section 5, of the National Building Code which is on the construction process by elemental classification deals with the design and construction requirements for the various building components including the roof. It specifies the types of materials for roof construction for durability and fire protection. Standards for roof coverings are also specified in the NBC (2006).

Building Regulations*:* Local building regulations deal with the quality and standards in the use of any specified materials or methods of erection or conformity with any specification, standard specification, code of practice, or standard method, these guides establish the specific materials and techniques of erection of structures. Relating to the material, design, and construction of roofs, building regulations specify the standards that buildings must adhere to as preventative measures against fires or other emergencies, including the resistance of buildings against the outbreak and spread of fires.

Summary

This section of this book dwelt on three basic building components: foundation, walls, and roofs. The Chapter was broken into three parts. The first part focused on identifying and explaining the various components of building foundations, their functions, and design requirements. It went on to describe the different types of foundations, their construction methods, the materials used in their construction, and the condition in which they can be used in buildings. The second part focused on walls. It identified and described the different types of walls, their construction methods and material, and the sustainability issues considered in the choice of walling materials. It concluded by identifying the two international and local building codes and regulations associated with the material, design, and construction of walls. Last but not the least dwelt on roofs. The discussions were on performance requirements for roofs, types of roofs, roof forms, materials for roof construction, factors that influence the choice of roof types and materials, and sustainability issues in the selection of roofing materials. The Chapter ended with the identification of international and local building codes and regulations associated with the material, design, and construction of roofs.

Exercises

1. Identify the two main types of foundations that you know.
2. Identify different types of shallow and deep foundations explaining the conditions in which they can be used in buildings.
3. Describe the factors that determine the choice of foundation for buildings.
4. Identify and describe the different types of walls in buildings.
5. Identify and explain the sustainable issues considered in the choice of walling and roofing materials.
6. Survey the buildings in your university and document the various types of walls and roofs used.
7. Identify the performance requirements of foundations and roofs.
8. Identify the materials that can be used in the construction of foundations, walls, and roofs.

9. Mention any two local and international codes and regulations associated with the material, design, and construction of walls and roofs in buildings.

References

Chudley, R., & Greeno, R. (2014). *Building Construction Handbook* (10th Edt). Taylor & Francis Group: New York.

Constro Facilitator (2021). Different types of Foundations are used in Buildings and Structures. Retrieved from https://constrofacilitator.com/different-types-of-foundation-used-in-building-and-structures/ on 15 March 2023.

Emmitt, S. & Gorse, C. (2005). *Barry's Introduction to Construction of Buildings*. Blackwell: Oxford.

International Code Council (2018). International Building Code. International Code Council, Inc.: Illinois

Mijinyawa, Y., Adesogan, S. O. & Ogunkoya, O.G. (2007). A survey of roof failures in Oyo State of Nigeria. *Journal of Building Appraisal*, 3:52-58.

National Building Code (2006). Federal Ministry of Housing and Urban Development: Abuja.

Omotoriogun, V. (2021). Cellular Raft Foundation -Worked Example. Structures Centre. Retrieved from https://structurescentre.com/designing-a-cellular-raft-foundation/ on 12 March 2023.

Rajput, R. (2020). Types of Foundation: definition, diagram, uses, or applications. *Eye on Structures.* Retrieved from *https://eyeonstructures.wordpress.com/2020/11/02/types-of-foundation-definition-diagram-uses-or-applications/ARTICLE.* On 7 February 2023

Rao, N.S.V.K. (2010) *Foundation Design: Theory and Practice*. Wiley: New York

Rahman, F.U. (2021). Types of Roofs. The Constructor. Retrieved from https://theconstructor.org/question/what-are-the-common-roof-types/ on 3 March 2023.

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Construction Site Management

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Overview

Construction projects are complex endeavours because of their many components, variety of materials and labour that go into them. They also consume huge sums of money. It is very important therefore that projects are delivered on time, to a stipulated standard of quality and within the clients' budget. The construction phase of a project consumes most of the resources that go into projects. The need therefore for projects to be properly managed at this stage cannot be overemphasised.

This text on construction site management provides an overview of the principle of construction site management and how this can be effectively applied, taking into consideration important aspects of construction site management like construction site management plans and construction site layouts. It also identifies some of the relevant tools and techniques used in construction site management and highlights the roles of the construction site manager.

Objectives

The objectives include the following:

1. describe the processes involved in construction site management;
2. discuss the importance of construction site management;
3. equipping students with some strategies for effective construction site management;
4. list issues to be considered while preparing construction site management plans and construction site layouts;
5. identify the tools and techniques used in construction site management; and
6. identify the roles of the construction site manager.

The Construction Site

The construction site is the piece of land on which construction activities take place. Construction activities including roads, dams and buildings. A construction site is therefore a building project site when the construction activity is a building. Usually, a piece of land is not yet a construction site until it is handed over to the contractor.

Construction Site Management

Construction Site Management (CSM) is the organisation and controlling of activities on a site in order to ensure that the project is accomplished within the time allotted, to the designed standard and within the client's budget. It benefits a project in the following ways:

It helps to organize workflows to ensure that tasks and activities proceed in a systematic way thereby maximizing space utilization, minimizing duplicate handling of materials and streamlining human and vehicular circulation.

It optimizes resources including materials, machinery, time and money for a more efficient project delivery;

It reduces losses due to idling of machinery and workers, theft, damages and wastes;

It enhances better-quality project delivery by predefining project's quality metrics and ensuring adherence to same;

It ensures timely project delivery via greater adherence to project milestones and deadlines;

It prevents, mitigates and manages risks and accidents on construction project sites by early identification and resolution of challenges;

It enhances project workers' performance and productivity by ensuring safety and well-being of the worksite, resolution of conflicts, facilitating internal communications and collaboration;

It boosts project profitability through improved transparency, accountability, budget accuracy and forecasting based on data-driven decisions;

It provides a good database by proper documentation and record keeping.

Construction Site Management Plans

Due to the contractual implications of construction projects, it is important to clearly state how the project will be executed. This will include identifying the roles of all the stakeholders, the procedures and protocols that will guide the process in line with prevailing regulations. These are formally documented in a Site Management Plan (SMP).

A site management plan thus, removes ambiguity as to how a project will be organized, executed and controlled in order to achieve its designed quality, time and budgetary deliverables within a context of workers' safety and well-being. A good site management plan will reduce conflicts and avoid costly mistakes.

The Construction Site and its Layout

The contractor organises the site before actual construction starts, this will involve erecting temporary facilities that will be needed for smooth site operations. In order to organise the site properly, the contractor must be familiar with the site - its features, conditions and adjoining properties. He must also study the project drawings, especially the site plan in order to know the portion of the site that has been earmarked for the project. Facilities to be provided on site include access roads within the site, parking lots, accommodation (office and residential) for consultants and contractors; welfare facilities; site security posts; off-loading and storage areas for materials and machinery; fabrication and testing facilities; signage; emergency routes and muster points.

A good site layout will consider the site (endowments, size, shape conditions, constraints and risks); accessibility and zoning of facilities to ease circulation, avoid conflicts and overcrowding; safety and health considerations for all stakeholders; adequacy of facilities in terms of sizing and positioning; availability of temporary on-site services; and storage locations to avoid double handling, theft and damage.

Construction Site Management Techniques

Due to the complexity and quality deliverables of construction projects, site managers and supervisors often rely on some tools and techniques to enable them to effectively manage their project sites. Increasingly, software packages are incorporated into these tools and techniques to make them more efficient.

Gantt Charts are one of the simplest, versatile and easy to use project management tools. They bar charts in horizontal format. They are used for project planning, resource scheduling and progress monitoring. Their usefulness has been enhanced by project management software like "Project Manager" which creates interactive project plans.

Work Breakdown Structure (WBS): It is a technique, which breaks down the entire project into smaller bits that are less overwhelming but easier to manage. Each bit of the work is graphically represented with the timelines indicated to highlight critical dates. Work Breakdown Structures are usually used in conjunction with other techniques like critical path method (CPM) or the Program Evaluation Review Technique (PERT).

Project Network Diagrams: These management techniques graphically represent the interactions between project activities using a series of arrows connecting to boxes (nodes). Each network shows the day when an activity will start and end. With the network diagrams, it is easy to monitor progress of each project activity. Variations of the network diagram include the precedence diagramming method (PDM) and arrow diagramming method (ADM).

Kanban Boards: this management tool uses a board and moveable cards to represent and track activities. Each card can be prioritised to improve workflow and maximise resources. Kankan boards enable the project to visualise each activity in the context of others. Thus, appropriate decisions can be made concerning each activity and the project as a whole.

Risk Matrix: A risk matrix helps site managers to project the possibility and likely magnitude of risks (or otherwise) the project may encounter, in order to avert or limit their impact. Risks may be internal arising from strategic, operational, financial or technical decisions. They may also be from the external context.

Timesheets: Timesheets are typically used to calculate wages of site workers. They document the number of hours each person has worked in a given period. They also provide useful project data required for current project reviews and design of future projects.

Project dashboard: This unique one-stop page visually presents vital information on the project's progress and performance (cost-related, task-related, workload and other resource management metrics) in the form of charts and graphs. It is also useful for project management audits.

Project Reports: These come in various forms like the weekly or monthly status reports, progress reports, workload reports, risk, cost-benefit analysis and project variance. Project reports provide useful information on the progress and performance of projects.

Agile Project Management: Agile Project Management is a project management technique, which allows projects to be managed in an iterative manner within short durations of work called sprints. Each sprint starts with planning using tools like task lists and kanban boards.

Programme evaluation and review technique (PERT): this management technique utilises both network diagrams and simple statistical methods in conjunction with Work Breakdown Structures to highlight interdependent activities. Information is presented graphically as a network where arrows sequentially represent activities and nodes represent events. From the network, it is possible to know the earliest and latest times a project can start and finish.

Critical Path Method: The Critical Path Method combines the network diagrams, Work Breakdown Structures and Gantt charts to determine the project timeline and define its critical path. Activities on the critical path are very important to the timely completion of the project. Any delay in completing them translates to project delay.

3.0 The Construction Site Manager

Although construction project managers may be involved on projects at earlier stages of a project, this section considers their roles at the construction stage. The construction stage ideally starts after the tendering stage when a contractor has been selected and the project is ready to proceed to the execution stage. The project construction stage can be divided into four main phases as identified in Table 1. These are the initial, planning, execution and closeout phases.

Construction project managers are responsible for the success of projects at the construction stage. They supervise, direct and monitor the operations on construction projects. Prior to mobilisation to site, the construction project manager needs to put some things in place to avoid disruptions and delays when work starts on site. These initial preparations will include familiarisation with the project parameters, documents and site as well as regulatory requirements and standards that may affect project outcome. Ensure that there are no discrepancies within and between the consultants' documents.

Table 1: Construction Stage Phases

Phase	Initial	Planning	Execution and monitoring	Closeout
Highlights	Familiarisation with project documents, site and regulatory requirements Establish project parameters Recognise threats, risks, quality and other protocols Construct initial construction plan	Clarify project parameters and processes Assess risks Refine project plans Scheduling Procurement plans	Manage project parameters Monitor and control risks Manage project execution	Assess project performance Identify lessons learned Archive project documentation

They are usually employed by the client or project owner. Therefore, the duties and degree of authority exercised by the construction project manager are often agreed with the client. He/she must however, have sufficient freedom in order to effectively perform. The construction project manager performs several roles. They ensure that projects meet the three main project criteria of time, budget and quality (Zain, et al, 2021). They ensure that construction projects are completed to the desired quality standards, within the specified time and the approved budget of the client or project owner. They also ensure that activities are organised and undertaken in ways that do not jeorpadise the health, safety and well-being of everyone on site and adjoining properties. This also includes ensuring that risk factors are identified and appropriately addressed. The very nature of construction projects make them prone to danger. The construction manager should ensure that everyone working on site is not only aware of proper safety measures but make sure that safety protocols are enforced by the workers and the contractor. Some safety devices that can be used at construction sites include head protection hats, eye protection devices, respiratory protection devices, hand protection devices, foot protection wears, body protection clothing, special protective equipment, floor & roof opening/covers, safety signs and banners, fall protection, traffic control devices, fire safety devices.

Construction managers are usually not resident on site but undertake their work through regular visits to the project construction site. However, on large projects, a representative of the project construction manager may be resident on site to serve as a principal point of contact. Whatever happens, success demands that they must be abreast of all site activities.

Planning is critical to the successful construction of projects. It saves money and time while facilitating safety and minimising conflicts and risks. Studies have shown that poor planning of construction projects as a major cause of project delay (Zain, et al, 2021). Therefore, the construction project manager ensures that construction project tasks are streamlined and structured in such a way that site activities proceed in a seamless manner (Shibani and Sukumar, 2015). Planning involves breaking down the entire project into its smaller component tasks and distributing them within the project period, taking into consideration critical activities, project milestones, and the resources required to accomplish them. These resources include money, materials, machinery and work force. Good planning requires a thorough knowledge of the construction process. It is expected to provide predefined quality assurance and control methods and metrics, cost management plans, safety plans, communication strategies, risk assessment and management strategies that will guide the construction process.

Two major activities take place during the project execution phase. These are the actual construction of the project and monitoring to ensure that construction tasks are carried out as earlier planned. It is important for the construction manager to ensure appropriate staffing who are adequately aware of their tasks and how those tasks should be done. Although arrangements for procuring project resources should have been made earlier, not all of them will be procured prior to construction phase. This could be because of funding constraints, storage facilities and the nature of the resources. Therefore, during the execution phase, the construction manager will be involved in the procurement of materials and equipment either directly or indirectly in order to ensure that the right quality and quantity of resources are procured. Other roles of the construction manager at this phase will include directing, coordinating and controlling. To monitor the progress of work, the construction manager can use key performance indicators. Appropriate performance indicators are developed and then used to track project costs, time and quality.

As shown by Shadan and Fleming (2012) in Figure1 the construction project manager interacts with a variety of stakeholders involved in the realisation of projects. These include project owners, consultants, contractors and subcontractors, specialist suppliers, site workers, staff of regulatory agencies, trade unions and owners of adjacent properties. He/she therefore needs good communication skills. According to Shibani and Sukumar, (2015) communication for project managers is their ability to listen, understand and persuade others.

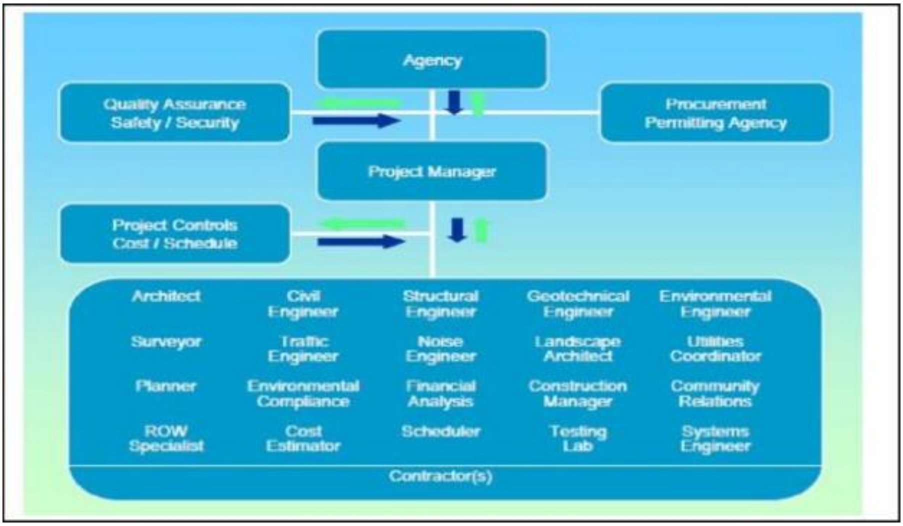

Figure 1: *Construction project with a project manager Source*: Shadan and Fleming, 2012.

In the course of executing projects, changes may occur either due to unforeseen circumstances, change in client's needs, tastes, or availability of relevant new information. Flexibility helps the construction manager to effectively respond to such changes as they occur. In addition, there may be discrepancies or ambiguities in the contract documents that need the attention of the consultants and contractors in order to be resolved. It is therefore imperative for a good project construction manager to build a culture of collaboration. Documentation is important throughout the construction process. This provides data for better decision making on the current project and relevant information to guide future projects. Proper documentation can provide very important information in the case of disputes. As rightly reported by Shibani and Sukumar, (2015) conflicts are frequent on construction projects. This is because of the complexities of activities, work force and resources involved in the realisation of projects. The project construction manager may be required to act as an arbitrator in disputes especially arising between subcontractors and others associated with the construction process. Transparency and clarity in communication are important characteristics of a good project construction manager who intends to reduce conflicts and maintain a conducive environment for a motivated, happy and productive workforce.

Towards the end of the project, there is a need for the construction project manager to prepare a snag list with which to cross check and confirm that no aspect of the work is left undone. At the end however, there is a need for the construction project manager to review the project from the beginning to the end. This is in order to identify factors that may have positively or negatively affected the progress of the project. He/she should also ensure that some relevant documents on the project are prepared. These include the final inspection report, punch lists, as built drawings, operation and maintenance manuals, warranty documents and certificate of completion.

There are now construction project management software like the Microsoft Project and Project Manager, which the construction project manager can use to organise his work for greater efficiency.

Summary

This chapter focused on providing basic introductory knowledge on how to manage construction project sites. It highlighted the need for construction project management and factors to be considered in setting up the site. It also briefly introduced several construction project management techniques employed at the construction stage of projects. It went further to identify the phases of the construction stage and the various roles the construction project manager is expected to play, highlighting some personal traits that would assist him/her in performing the roles. At the end, some exercises are provided to test the understanding of the students.

Exercises

1. Enumerate seven benefits of project construction management.
2. Highlight five criteria that influence the layout of a project construction site.
3. Briefly discuss five project construction management techniques.
4. Identify four personal traits that will assist the project construction manager to successfully undertake his/her roles.
5. Discuss three reasons for project documentation by the project construction manager.

REFERENCES

Jimoh, R. A. (2012). Improving Site Management Practices in the Nigerian Construction Industry: The Builders' Perspective. *Ethiopian Journal of Environmental Studies and Management.* 5(4) DOI: 10.4314/ejesm.v5i4.5

Shadan, K. and Fleming, P.E.G. (2012).Construction Project Management Handbook. FTA Report No. 0015. Federal Transit Administration Office of Research, Demonstration and Innovation U.S. Department of Transportation, Washington, DC 20590 http://www.fta.dot.gov/research

Shibani, A. and Sukumar, D. (2015) The Role of the Project Manager in Construction Projects in India. *Chinese Business Review*, 14 (6): 298-324 URL: http://dx.doi.org/10.17265/1537-1506/2015.06.003 DOI: 10.17265/1537-1506/2015.06.003

Zain, S. I., Hamid, A. R. A., Bah, A. U., Hatem, Z. M., Ba-Hutair, A. A. M. A., Zadran, B. G., Abba, N and Islam, M. S. (2021). Ineffective Site Management Practices and Their Impacts on Project Performance. The 6th Proceeding of Civil Engineering of the School of Civil Engineering, Universiti Teknologi Malaysia. pp.501-518. DOI: 10.13140/RG.2.2.14697.21600

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CHAPTER ELEVEN: HISTORY OF WORLD AND TRADITIONAL ARCHITECTURE

Cultural Influences on the built form

Prof. Ephraim E. Edem, *University of Uyo*

Overview

Amos Rappaport in his revolutionary publication, House form and Culture (1968) argued that culture should and indeed play a determining role in housing. It relates the form that housing takes to the culture in which that housing is built. He went on to comment that earlier theories were generally confined to principal explanations of the physical (climate, materials and available technology, etc). His basic hypothesis is that "house form is not simply the result of physical forces or any single causal factor but is the consequence of a whole range of socio-cultural factors seen in their broadest terms" (Rappaport, 1963). In primitive societies everyone is capable of building his own dwelling, with the average family having all the technical knowledge that is needed. This means that the needs of the dwelling are understood perfectly with certain ways of doing or not doing things.

This text focuses on the house form and factors that drive the evolution of form. Socio cultural and economic forces are discussed. The relationship between form and culture as well as tradition are identified. Factors that influence the changing pattern of house forms are discussed.

Objectives

The objectives are to:

1. identify the influences or forces that act on the built form;
2. identify the varieties of the built forms in different regions and communities in the world;

3. distinguish between culture and tradition in any given society; and
4. to describe the relationships between culture and architecture and environment and design and establish cultural influences on the built form.

Culture and Architecture

The Concept of Culture

There are many different definitions of the word culture.

1. One defines it as a way of life typical of a group of people.
2. Another defines it as a system of symbols, meanings and memory transmitted through symbols.
3. A set of adjustable changes for survival related to ecology and resources.

Increasingly these three views are seen not as being in conflict but complementary. Thus, designed environments of particular cultures are settings for the kind of people which a particular group sees as standards and the particular lifestyle which is significant and typical, distinguishing the group from others. In creating such settings and lifestyles, an order is expressed, a set of memorable symbols, and some vision of an ideal are given form – however imperfectly. Finally, both the lifestyle and symbolic system may be part of the group's adjustable changes within their ecological setting (Rappaport, 1979).

In a discussion of the relationship between the individual and society, C, Norberg – Schulz explains how satisfactory cultural integration depends on the existence of a common – symbol system.

1. From birth we try to orientate ourselves with the environment and establish a certain order called culture. The development of culture is based on information and education and therefore depends on the existence of common symbols – systems. The culture integrates the

single personality into an ordered world based on meaningful interactions.

2. From the earliest times man used language as his basic form of communication, a system whereby words have a meaning understood by all within an ordered grammatical framework. The inadequacy of words to express certain meanings has led to the development of non-verbal communication systems whose purpose is to assist and extend understanding of aspects of experience. Science, the arts and music each extend our understanding of the world by means of constructions not possible within language alone, and architecture gives meaning to aspects of life that cannot adequately be conveyed by words.

3. Architecture has always played a leading role in the way an individual may be identified within a culture and certain styles evolved during the later Middle Ages which were concerned with status within the social hierarchy. This has been discussed in chapter one of this book.

4. Whatever culture is or does one can question the utility of that concept in trying to understand built form and how it is used. It can be suggested that culture is both too global and too abstract to be useful. It is often helpful to clarify excessively abstract and broad concepts by "breaking" them down and then studying the components and their various interrelationships with each other and with other variables (Low, S. M. 1982). One cannot "design for culture" but any specific parts of environments for specific components of culture. In response to "culture" being too global, a sequence from culture, through worldview, values, images/schemata, lifestyle to activity systems can be proposed, suggesting that the last two offer useful starting points.

5. In response to the concept being too abstract, it is possible to make it more operational by discovering the social manifestations of culture which are potentially observable, such as family and kinship, status and other roles, rituals, food habits and many others. These can be and can be related to the built environment, influencing the latter and being

influenced by it. Starting with these more specific, more concrete expressions of culture offers another way of relating it to built form. (Rappaport, A. 1983)

6. In any case, these and other successive definitions, clarifications, and "breaking down" of the concept of culture enables us, at least, in principle, both to understand and analyse cultural aspects of environment – behaviour relationship and to "design for culture".

Environment and Design

Environment can be understood as a system of settings within which human life takes place. These systems, the components which make them up and the linkage and separations in space and time, their meaning, etc. are highly variable culturally and need to be discovered rather than assumed (Rappaport, A. 1983).

Secondly, the environment can be understood in a variety of ways, given that it consists not only of things, but also of people. At the very least, then, it is a set of relations between people and people, people and things and things and things. More specifically, various versions of this have been proposed but the one useful here is that which combines design and environment, which states that the design of the environment is the organization of our things: space, time, meaning and communication (Rappaport, A. 1983). It then becomes possible to consider, discuss and investigate the implications of each for a given culture. This does, of course, raise the question of what "design" means.

Design is anything humans do to alter the face of the earth and anything they build is design – not just what professionals do. Specifics therefore become crucial, whether about culture or the environment, for example, space organization (and form) are not the same as shape and, in most cases, more important (Rappaport, 1986). In some cases, however, shape may be more important, for example, in terms of identity, religion, cosmology, etc.

According to Langer (1953), a culture is made up, factually, of the activities of human beings. It is a system of interacting actions, a continuous functional pattern. As such it is, of course, intangible and invisible. It has physical ingredients – artifacts; also, physical symptoms – the ethnic effects that are stamped on the human face, known as its "expression", and the influence of social conditions on the development, posture and movement of the human body. But all such items are fragments that "mean" the total pattern of life only to those who are acquainted with it and may be reminded of it. They are ingredients of culture, not its image.

The architect creates the image: a physically present human environment that expresses the characteristic rhythmic functional patterns which constitute a culture. Such patterns are the alternation of sleep and waking, venture and safety, emotion and calm, austerity and abandon; the tempo, and the smoothness or abruptness of life.

Langer continues this argument by asserting that an environment, the created space of architecture, is a symbol of functional existence. She explains that this has nothing to do with convenient arrangement or provident planning. To Langer, the work of architecture does not suggest things to do but embodies the feeling, the rhythm, the passion or humility or fear with which things at all are done. That is the image of life which is created in buildings; it is the visible semblance of an ethnic domain, the symbol of humanity to be found in the strength and interplay of forms.

There can be no society without a culture and no culture can exist without people practicing it. All events of large significance take place within the setting of a culture and indeed derive their significance from the culture in which they find themselves. In order to properly grasp the meaning of culture there is need to know what tradition is because both terms (i.e. culture and tradition) are often used interchangeably. According to Rappaport (1979) "Given a certain climate the availability of certain materials the constraints and capabilities of a given level of technology, what finally decides the form of a dwelling and moulds the space, and their relationship is the vision that people have of the ideal life of the family as dwelling unit. The family should reflect beliefs, family and clan structure, socio-cultural organization, ways of gaining a livelihood and social relations amongst individuals". This emphasizes culture as the behavioural pattern of a people. Culture is not restricted to certain specialized fields of knowledge. It includes ways of behaviour derived from the whole range of human activity. It includes not only the techniques and methods of art, music and literature but all those methods used to make pottery, sewing, clothing or building houses. This again, emphasizes the concept of culture as the common denominator of the factors that make up people's civilization.

The concept of culture is all-embracing. It embodies varied aspects of man's living pattern. The cultured man in the ambit of tradition is sophisticated, sensitive and educated. An architect in the course of his training absorbs these attributes. Izomoh (1994) opined that architecture also developed from merely sheltering to the provision of spaces within the houses and immediate environments for social-cultural activities.

Hornby et al (1996) defines tradition as handing down from generation to generation of opinions, beliefs, and custom. Again, each tradition comprises loosely correlated aesthetic, social, economic, political and ethical codes of behaviour and members variably share ideologies, habits, customs, procedures and technologies.

Activities of each society help the people to establish their pattern of living. This then results in distinctive expressions in all spheres that are referred to as culture. While culture is about intellectual, social and spiritual development and exhibiting it as a trait of a specific people, tradition is essentially the retention of what has been developed over time be it social, intellectual or spiritual. Tradition goes further to preserve the traits so developed for posterity. In other words, culture evolves ideas and exhibits them, but tradition has the duty of retention and transfer of such cultural values to new generations.

Summary

A culture is made up, factually, of the activities of human beings. It is a system of directing and actions, a continuous functional pattern. As such it is, of course, intangible and invisible. It has physical ingredients – artifacts; also physical symptoms – the ethnic effects that are stamped on the human face, known as its "expression" and the influence of social conditions on the development, posture and movement of the human body. But all such items are fragments that "mean" the total pattern of life only to those who are acquainted with it and may be reminded of it. They are ingredients in a culture, not its image.

The architect creates its image; a physically present human environment that expresses the characteristic rhythmic functional patterns which constitute a culture. Such patterns are the alternation of sleep and waking, venture and safety, emotion and calm, austerity and abandon; the tempo and the smoothness or abruptness of life.

Culture is one of the important factors which affected architecture in ancient Greece at a particular time. Attitudes developed in the areas of religion, philosophy, science, mathematics, technology and art which led to an architecture which represented the main ideas of the culture.

Although we can understand Greek civilization through the combined media of say art, philosophy and literature, architecture, by its special role, draws these together so that they become embodied in buildings. The cultural forces are encapsulated in architecture, and it is not coincidental that this architecture and the cultural values which it represents have endured to the present day.

This expression of cultural forces in buildings has happened throughout history and in our own time, the glass skyscraper represents vital features of the twentieth century, symbolizing our technological capacity and key concerns much as did the pyramids, the Greek temples or Gothic Cathedrals.

Exercises

1. Briefly explain the meaning of the word culture.

2. Name, at least, three buildings in Nigeria where cultural forces are seen to be at work.

3. In what ways does culture influence the built form?

References

Baker, G. H. (1996); Design Strategies in Architecture – an approach to the analysis of form. Van Nostrand Reinhold. New York.

Edem, E. E. and M. M Okonkwo (2010). Ibibio Architecture; the People and Place, Published (Monograph) Published by the Journal of Architectural Educators in Nigeria (AARCHES-J) No.1, 2010.

Second Edition (2012) Published by CAPE, Enugu – Nigeria in Amazon.com

Edem, E. E. (2010): Architecture in Ibibio land: In search of style for Historical Documentation of a People's Material Culture. Unpublished (Ph.D) thesis, Abia State Univesity, Uturu (2010).

Hornby, A. S. R. Gatenby, E. V. and Walkfield, H. (1996). Advanced learners Dictionary of current English (2nd Ed.) Oxford University Pras.

Low, S. M. (1982). Professional Culture: The Boundary between theory and practice in Design. NIE Education Resources Centre (ERIC). No. ED 219890. Washington DC. US Department of Health, Education and Welfare.

Langer, S. K. (1953). Feeling and form: A theory of Art London.

Noberg – Scbulz, C. (1980). Genius Loci, Towards a phenomenology of Architecture. New York.

Rappaport, A. (1969). Houseform and Culture, New Jersey, prentice and Hall.

Rappaport, A (1979). Cultural origins of Architecture. Introduction to Architecture (Snyder, J. C. and Cantonese, A. J. (ed) McGraw-Hill Company.

Rappaport, A (1980), "Gross Cultural Aspects of Men-Environments Studies" in Human behavior and Environment, Vol. 4: Environments and Culture, ed. Altman, I. Rappaport, A and Wohwill New York. Pletnum.

Rappaport, A (1983). "The effect of Environment on Behaviour," in Environment and Population; Problem of Adaptation. New York. Praeger.

Rappaport, A. (1986). "Culture and Built Form: A reconsideration" Keynote Address at Conference on Built Form and Culture Research. University of Kansas, Lawrence, Kansas.

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CHAPTER TWELVE: FLUID MECHANICS, HYDROSTATICS AND STABILITY

Fluid Mechanics, Hydrostatics and Stability

Professor Gyang Yakubu Pam, *Ahmadu Bello University*

Overview

Fluid mechanics is concerned with the behaviour of fluids in motion and at rest. A knowledge of the basic principles and concepts of fluid mechanics is required for the analysis of any system in which a fluid is the working medium. Some examples are: i. the design of ships, submarines, aircrafts and automobiles,

ii. the design of turbines, fans, compressors, pumps, fans, blowers, which are classified as fluid machinery,

iii. the design of pipeline systems. Fluid mechanics is an aspect of applied mechanics involved with statics and dynamics of fluids.

This text focuses on the behaviour of fluids and the fundamental laws of applied mechanics and thermodynamics, which include: i.) the conservation of mass, ii.) the conservation of energy, iii.) Newton's second law of motion, and equations that are found in solid-body mechanics and thermodynamics. It relates ship stability fluid mechanics

Objectives

The objectives include:

1. discuss the fundamental principles of fluid mechanics;
2. identify the factors to be considered in the design of ships, submarines, aircrafts and automobiles;
3. describe basic design of ship components such as turbines, fans, compressors, pumps, fans, blowers;

4. discuss the basic principles of hydrostatics and stability; and
5. identify the design of various pipeline systems.

Fluids

A fluid is any substance that deforms continuously when subjected to a shear stress no matter how small it may be. A fluid at rest, therefore, has no shear stresses acting on it and all forces acting on it are at right angles to the planes upon which they act. Fluids are either liquids or gases.

A liquid deforms to take up the shape of any container into which it is placed. Developing a free surface if such a container is located in a gravity field, under normal conditions of temperature. A liquid is almost incompressible.

A gas on the other hand will deform and expand to occupy the entire volume when placed in a container without forming a free surface. Compared to a liquid, a gas is easy to compress.

An ideal fluid is one that has no viscosity. Such a fluid does not exist.

Dimensions and Units

Dimensions are physical quantities like mass, length, time and temperature, which are all measurable. These measurable quantities are divided into: *primary* quantities and *secondary* quantities. The primary quantities are a small group of dimensions from which secondary quantities can be formed.

Units are names and magnitudes assigned to primary dimensions adopted as standards for measurement. For instance, the primary dimension of length may be measured in units of metres, feet or miles. These units of length may be converted from one to another through unit conversion factors (5280 feet = 1,609 metres = 1 mile). The system of dimensions that is adopted for this text, is the one that has mass [M], length [L], time {T] as primary dimensions. In the International system (SI) of units, the unit of mass is the kilogramme (kg), the unit of length is the metre (m), the unit of time is the second (s) and the unit of temperature is the kelvin (K). Force is a secondary dimension with unit, the newton (N), defined from the second law of Newton as

$$1\ \mathrm{N} \equiv 1\ \mathrm{kg} \times 1\ \mathrm{ms}^{-1}$$

Density

Density is the quantity of matter contained in a unit volume of a substance.

Mass density

As a continuum and not with the properties of individual molecules, the mass density at a point is determined by considering the mass δm in an infinitesimal volume δV surrounding the point. δV is larger than x^3, where x is a linear dimension that is larger than the mean distance between molecules. Mathematically,

$$\rho = \frac{\delta m}{\delta V}$$

Mass density has units of kilogramme per cubic metre (kgm^{-3}) and dimensions, ML^{-3}.

At a pressure of $1.013 \times 10^{-5}\ \mathrm{Nm}^{-2}$ and temperature of 15°C, the mass density of water is 1000 kgm^{-3} and that of air is 1.23 kgm^{-3}.

Specific weight

Specific weight w is defined as the weight in a unit volume of a substance. The specific weight varies from point to point depending on the local value of acceleration due to gravity g. From Newton's second law of motion, Weight in a unit volume = Mass in a unit volume x g

$$w = \rho g$$

Specific weight has units of newton per cubic metre (Nm^{-3}) and dimensions of $ML^{-2}T^{-2}$.

Specific gravity

Specific gravity s is the ratio of mass density of a fluid to that of some standard mass density. For liquids, the standard mass density chosen is that of water at 4°C at atmospheric pressure.

$$s = \rho_{liquid} / \rho_{water\ at\ 4\ ^oC}$$

Specific volume

Specific volume is the reciprocal of density, which is the volume per unit mass of fluid.

Viscosity

Deformation can be caused by shearing forces, i.e., forces that act tangential to the surface, as shown in figure 1.1. The material originally MNOP deforms to MN'O'P under the action of a shearing force, F. Shear stresses develop only in a moving fluid. This happens because the fluid particles move relative to each other with different velocities. This distorts the original shape of the fluid. Fluids normally flow past solid boundaries. The particles in contact with such boundaries stick to them and hence, have the same velocity as the boundaries.

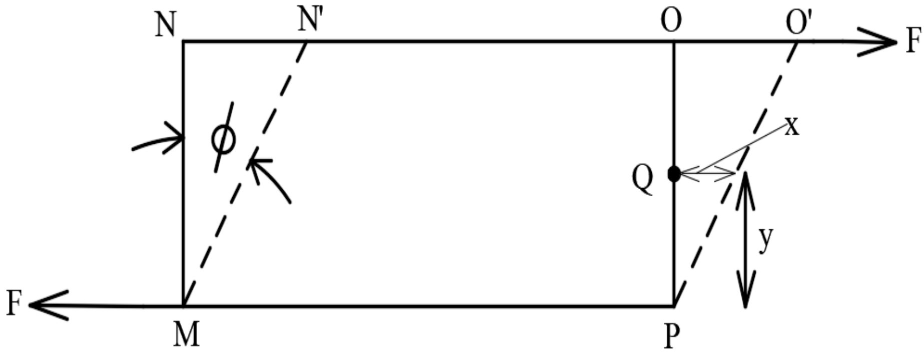

Figure 1.1. *Deformation resulting from a shear force.*

Considering successive layers of the fluid parallel to the boundary as depicted in figure 1.2, the velocity of the fluid will change from layer to layer as *y* increases, where *y* is distance away from the boundary.

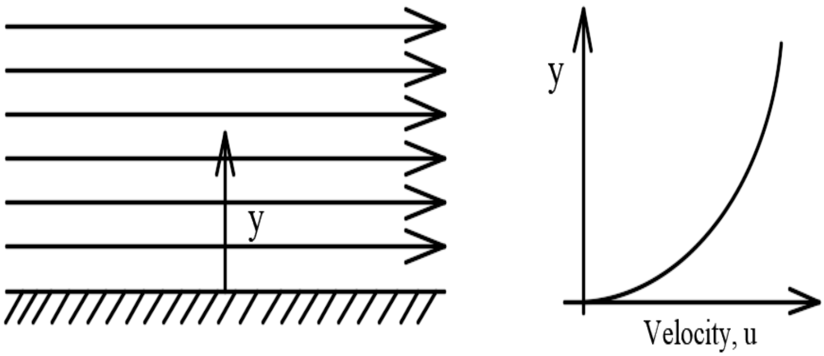

Figure 1.2. *Change of velocity with distance from a solid boundary*.

For fluid element MNOP in figure 1.1, with thickness *z* at right angle to the paper, the shearing force will act over an area, *A*, equal to NO x *z*. The shear stress τ, is the force per area *F/A*. The deformation, which is the angle ϕ is the shear strain, is directly proportional to the shear stress from experiment in a real fluid. In a real fluid, as opposed to a solid which has a fixed shear strain ϕ, the shear strain will continue to increase with time and the fluid will flow.

Consider a fluid particle at Q in figure 1.1that is a distance y from MP, which moves a distance x in a time t. For small angles, the shear strain ϕ is

$$\phi = \frac{x}{y}$$

The rate of shear strain, $\frac{d\phi}{dt}$, is

$$\frac{d\phi}{dt} = \frac{x}{yt} = \frac{\left(\frac{x}{t}\right)}{y} = \frac{u}{y}$$

Where $u = \frac{x}{t}$ is the velocity of the particle at Q.

Since from experiment for a real fluid, the shear stress is proportional to the shear strain, then

$$\tau \propto \frac{u}{y}$$

$\frac{u}{y}$, which is change of velocity with y, can be written in differential form $\frac{du}{dy}$ and is the velocity gradient. So,

$$\tau \propto \frac{du}{dy}$$

or

$$\tau = \mu \frac{du}{dy} \quad .$$

(1.1)

Where, μ is the dynamic (or absolute) viscosity of the fluid.

The relation in equation (1.1) is Newton's law of viscosity and all fluids that obey it are known as *Newtonian fluids*.

Newtonian fluids are defined as fluids where the applied shear stress is directly proportional to the velocity gradient, which has been shown to be the rate of deformation. *Non-Newtonian fluids* are those in which the applied shear stress is not directly proportional to the rate of deformation.

Dynamic viscosity

Rearranging equation (1.1),

$$\mu = \frac{\tau}{\frac{du}{dy}} = \frac{\frac{Force}{Area}}{\frac{Velocity}{Distance}} = \frac{Force\ x\ Time}{Area}\ or\ \frac{Mass}{Length\ x\ Time}$$

Units: newton seconds per square metre (Nsm^{-2}) or kilogrammes per metre per second ($kgm^{-1}s^{-1}$). In the Absolute Metric system of units, the basic unit of dynamic viscosity is called a poise (P) (10 P = 1 $kgm^{-1}s^{-1}$).

Dimensions: $ML^{-1}T^{-1}$

Kinematic viscosity

The ratio of the dynamic viscosity, μ, to the mass density, ρ, is the kinematic viscosity, υ.

$$\vartheta = \frac{\mu}{\rho}$$

Units: Square metres per second (m^2/s). In the Absolute Metric system, the basic unit of kinematic viscosity is called a stoke (St) (1 St = 100 mm^2/s).

Dimensions: L^2T^{-1}

Surface Tension

Molecules that make up any substance attract one another, and these attractive forces make the material cohesive. For a liquid, with molecules in constant motion, a molecule within the body of the liquid is attracted equally in all directions by other molecules surrounding it. However, a molecule located at the surface of a liquid experiences upward and downward attractions that do not balance, being pulled inward towards the bulk of the liquid, in a direction perpendicular to the surface. This resultant force is what creates the defined surface exhibited by liquids and causes the surface layer to be in a state of uniform tension, known as surface tension. Surface tension σ is measured as the force acting across the length of any line drawn on the surface. It acts in the plane of the surface, normal to any line in the surface and is the same at all points. Surface tension is constant at any one temperature but decreases with increase in temperature.

Compressibility

Solids, liquids and gases are compressible when a force is applied uniformly all over the surface of a given mass of the material. The volume V will reduce to $V - \delta V$, if the pressure increases from p to $p + \delta p$. The volumetric strain due to the pressure is the change in volume divided by the original volume.

The bulk modulus K of the material is given by:

$$Bulk\ modulus, K\ = \frac{Change\ in\ pressure}{Vlolumetric\ strain}$$

or

$$\frac{Change\ in\ volume}{Original\ volume} = \frac{Change\ in\ pressure}{Bulk\ modulus, K}$$

Hence,

$$\frac{-\delta V}{V} = \frac{\delta p}{K} \;\Rightarrow\; K = -V\frac{\delta p}{\delta V}$$

The negative sign is there because the volume decreases with increase in pressure. In the limit, as $\delta p \rightarrow 0$

$$K = -V\frac{dp}{dV}$$

(1.2)

Considering the specific volume, which is the volume per unit mass and hence, the reciprocal of the mass density,

$$v = \frac{1}{\rho}.$$

(1.3)

Differentiating equation (1.3),

$$v d\rho + \rho dv = 0$$

$$dv = -\left(\frac{v}{\rho}\right)d\rho$$

Substituting for v from equation (1.3)

$$dv = -\left(\frac{1}{\rho^2}\right)d\rho \quad .$$

(1.4)

Putting the values of v and dv from equations (1.3) and (1.4) into equation (1.2)

$$K = \rho\frac{dp}{d\rho}$$

(1.5)

Vapour pressure

In the space above the free surface of a confined liquid, exist water molecules that had sufficient energy to escape from the attraction of the surrounding molecules in the liquid. Some of these molecules will condense and return, but others will take their place. An equilibrium will eventually be attained where the number of molecules of liquid above the free surface is a constant. As one molecule is leaving the liquid, at the same time another molecule from space is condensing. Those molecules produce a partial pressure known as the vapour pressure in space.

The degree of evaporation increases with an increase in temperature and hence, the vapour pressure will increase. Boiling occurs when the vapour pressure is equal to the pressure above the liquid. By increasing or decreasing the pressure, boiling can occur at temperatures above or below the boiling point at atmospheric pressure. Water boils at a temperature of 120^{o}C at 2.7 bar and boils at 72^{o}C at 0.34 bar.

Cavitation

A flowing liquid can have areas where the pressure is low. If the pressure in such areas falls below the vapour pressure, there will be local boiling and vapour bubbles will be created. This phenomenon is called cavitation and can result in problems if the flow of liquid sweeps these bubbles into areas of higher pressure where they will collapse (condense) suddenly. If this occurs in contact with a solid surface, a most destructive action on the surface can occur because of the large force with which the liquid hits the surface. Cavitation reduces the performance of turbines, pumps and other hydraulic machinery. It can cause local erosion of metal parts of hydraulic machinery.

Cavitation can also occur if there is air entrained in a liquid, since the solubility of gases in a liquid decreases with decreasing pressure. Air bubbles will be released in the same way as vapour bubbles with the same damaging effects.

The Perfect Gas

At temperatures in excess of the critical temperature of a fluid and at low pressures, the vapour of a fluid approximately obeys the equation,

$$P = \rho RT \qquad (1.6)$$

Where R is the gas constant and has units of kJ/kgK and dimension of $L^2T^{-2}\Theta^{-1}$.

No gas in existence obeys this law absolutely. An imaginary gas which obeys equation (1.6) is called a perfect gas. Equation (1.6) is called the equation of state of a perfect.

Avogadro's hypothesis states that at the same pressure P and temperature T, all gases have the same molecules per unit volume, hence mass density ρ is proportional to the relative molecular mass M (kg $kmol^{-1}$). The quantity MR will therefore be constant for all perfect gases, and is called the universal gas constant R_o. R_o has a value of 8.314 kJ $kmol^{-1}K^{-1}$.

$$R_o = MR \qquad (1.7)$$

Summary

This chapter has completed a review of some of the fundamental concepts that will be required in the study of NARC 103 – Fluid Mechanics, Hydrostatics and Stability. Some of these are definition of a fluid immersion and units, properties of fluids like density, specific gravity, viscosity and vapour pressure. Some interesting phenomena, such as Newtonian fluids, compressibility, cavitation and the perfect gas were also introduced.

Exercises

1. What is a fluid?
2. What are the primary dimensions and letters that represent them?
3. Define specific weight.
4. What is a Newtonian fluid?
5. Define Surface Tension
6. What is the relationship between kinematic viscosity and dynamic viscosity in equation form?

References

Fox, R.W., McDonald, A.T. and Pritchard, P.J. *Introduction to Fluid Mechanics.* Sixth Edition, 2004, John Wiley & Sons Inc.

Giles, R.V., Evett, J.B. and Liu, C. *Fluid Mechanics and Hydraulics*. Third Edition, 1994, Schaum's Outlines Series, Mcgraw-Hill Companies

Eastop, T.D., and McConkey, A., *Applied thermodynamics for Engineering Technologists*. Fifth Edition, 1993, Pearson Education.

Mayhew, Y.R. and Rogers, G.F.C., T*hermodynamic and Transport Properties of Fluids*, S.I. Units, Fifth Edition, 2004, Alden Press, Osney Mead, Oxford.

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