EFFECTIVE ACOUSTICS IN CATHEDRALS: A DESIGN OF A CATHOLIC CATHEDRAL FOR AWGU DIOCESE, ENUGU STATE, NIGERIA

BY

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GOU/U22/ARC/192

DEPARTMENT OF ARCHITECTURE
FACULTY OF NATURAL SCIENCE AND ENVIRONMENTAL STUDIES
GODFREY OKOYE UNIVERSITY, ENUGU

JULY, 2026

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A PROJECT PRESENTED TO THE DEPARTMENT OF ARCHITECTURE, FACULTY OF NATURAL SCIENCE AND ENVIRONMENTAL STUDIES, GODFREY OKOYE UNIVERSITY, ENUGU

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF SCIENCE (B.Sc) IN ARCHITECTURE

SUPERVISOR: ARC. DR. CHUKWU CHINECHETAM

JULY, 2026

APPROVAL

This research project entitled "Effective Acoustics in Cathedrals: Design for a Catholic Cathedral for Awgu Diocese, Enugu State, Nigeria" was carried out by Ifeanyi Peter Ugwu in partial fulfilment of the requirements for the award of the degree of Bachelor of Science (B.Sc.) in Architecture in the Department of Architecture, Godfrey Okoye University, Enugu, Nigeria.The project has been examined and approved for its contribution to knowledge and for meeting the academic requirements of the Department of Architecture.

Arc. Dr. ChukwuChinechetam _____ **Signature** _____ **Date**
(Supervisor)

External Examiner _____ **Signature** _____ **Date**

Arc. Dr. ChukwuChinechetam _____ **Signature** _____ **Date**
(Head of Department)

CERTIFICATION

I hereby certify that this research project entitled "Effective Acoustics in Cathedrals: Design for a Catholic Cathedral for Awgu Diocese, Enugu State, Nigeria" was undertaken by Ifeanyi Peter Ugwu under my supervision in accordance with the regulations governing the award of the Bachelor of Science (B.Sc.) Degree in Architecture at Godfrey Okoye University, Enugu.To the best of my knowledge, this work is original and has not been submitted, either wholly or in part, to any other institution for the award of any degree or professional qualification.

Ifeanyi Peter Ugwu **Signature** _____ **Date** _____
(Student)

Arc. Dr. ChukwuChinechetamSignature _____ **Date** _____
(Supervisor)

DEDICATION

This work is dedicated first and foremost to Almighty God, whose unfailing grace, wisdom, strength, and guidance made every stage of this academic journey possible.

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First and foremost, I give all glory, honour, and thanksgiving to Almighty God for His abundant grace, protection, wisdom, and strength throughout my academic journey. Without His guidance and countless blessings, the successful completion of this research would not have been possible.

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I am deeply grateful to my parents and family for their unwavering love, prayers, financial support, encouragement, and countless sacrifices throughout my education. Your belief in my abilities has continually inspired me to strive for excellence.

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ABSTRACT

Acoustic plays a very significant role in designing of places of worship because sound reception quality from preacher, prayer, music and other liturgical activities is heavily determined by the acoustic quality of the space. Ironically, acoustic aspect is one that receives least design consideration in most Nigerian church structures. In consequence this phenomenon manifest in terms of poor speech intelligibility, excessive reverberation, improper sound distribution and extensive application of amplification electronic equipment.The purpose of this paper is to investigate the implementation of Architectural acoustics in the design of a Catholic Cathedral for Awgu Diocese in Enugu State, Nigeria.This study was designed as a descriptive architectural research that included a wide literature review, case study analysis, and site investigation. The local case studies of St. Theresa's Cathedral, Abakaliki, and selected Nigerian cathedrals were compared and contrasted with the international ones of SagradaFamília, Notre-Dame Cathedral, and St. Peter's Basilica. These case studies have been useful in understanding the interrelationships between building form, material choice, spatial organization, and acoustics. Literature and case study findings were synthesized and used to develop a design proposal for Awgu Diocese based on the 21st-century cathedral.Effective acoustics cannot be realized only by amplifying the sound, but must be addressed at the very beginning of an architectural design, the study revealed. The geometry and ceiling configuration of a building, the dimensions of rooms, the type of interior finishes, and acoustic materials all have a significant effect on speech intelligibility, sound distribution, and reverberation. The findings also indicated that with the use of a good building design, orientation and natural ventilation, and careful space design, worship environments can be made functional and enriching.From this, a design for a cathedral was created, incorporating the symbolism of the cross and the bishop's miter to symbolize the Church's universal message of the Christian faith and the bishop's pastoral role within the Church. The proposed design will combine the elements of acoustics, Catholic liturgical needs, environmental responsiveness, and contemporary architecture to create a worship space that improves the clarity of speech and is conducive to the use of sacred music and active participation of the congregation.The study brings a conclusion that architectural acoustics is not a secondary consideration in the design of a worship space, but it should be considered as a primary design consideration. From the conceptual design stage, acoustics can be combined with the design of the space so that cathedral environments can be visually inspiring, environmentally responsive, acoustically efficient, and functional for the spiritual and functional needs of current and future generations. The study is expected to help Church Authorities, students, and researchers, as well as Architects in planning and designing worship spaces in Nigeria and other similar environments.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Acoustics is the science of sound, its production, propagation, reception, and perception in an environment. In architecture acoustic involves not only noise prevention, but also space acoustics performance. It affects the intelligibility of speech, music appreciation, users' comfort, and the emotional feelings of occupants. Inadequate acoustics can lead to excessive reverberation, echo, distortion of sound, and unequal distribution of sound, which may have a negative impact on communication and spatial experience (Long, 2014).

The acoustic requirements of worship spaces are special since they are required to be able to accommodate speech and music. At the religious services, there will be sermons, prayers, scriptural readings, responses of the congregation, choir, and instrumental music. Therefore, there is a delicate balance to achieve between hearing and music in these spaces. For sacred music, reverberation can be extended to improve a warm and resonant sound quality, but for speech, it is desirable to have a shorter reverberation time to ensure the discernibility of speech (Barron, 2019).

The cathedral is one of the most important types of worship architecture in the catholic world. On the interior, cathedrals feature large spaces and high ceilings, wide naves, vaults, domes, and reflective building materials (stone, marble, and plaster). All these features enhance the majestic spatial qualities and help to form the acoustic context. It has been demonstrated that these architectural traits can lead to longer reverberation times that enhance choral and organ music, but can also decrease intelligibility when not adequately controlled (Long, 2014; Algargoosh, 2016).

Today's Catholic worship places greater emphasis on an active role by the congregation and effective communication. Nowadays, the use of the spoken word is more prominent in liturgical

practice than in past centuries. Therefore, the design of the cathedral needs to consider a compromise between retaining the acoustic properties conducive to sacred music and maintaining adequate speech intelligibility for large congregations (AcousPlan, 2025; ISO 3382-1).

The interior of the church buildings in Nigeria is designed with little consideration given to acoustics, but with a focus on capacity, aesthetics, symbolism, and structure. This frequently results in echoing, sound coverage issues, speech clarity, and too much reliance on electronic amplification devices. These challenges are further compounded by the ever-increasing congregational growth and the current manner of worship, which is becoming more and more multimedia-driven.

Field observations of the existing cathedrals in the south-eastern part of Nigeria have shown that many of these churches are able to effectively house large congregations, but are forced to implement electronic amplification technologies to address the acoustic challenge, instead of architectural measures. This dependency can lead to further problems like feedback, level imbalance, and higher maintenance needs.

Currently, the Catholic Church has a cathedral in the Awgu Diocese, which houses about 1,800 worshipers. The continued growth of the diocese, however, has led to the need for the development of a new complex for the cathedral. This is an opportunity to involve acoustic concepts in the early design stages, ensuring that the acoustics in the building are part of the design process and the worship environment is made to aid speech and music acoustically from an architectural perspective, not just with technological interventions.

Plate 1.1: A view of St. Michael's Cathedral, Awgu, Enugu.

Source: Author fieldwork, 2026

The aim of this study is, therefore, to investigate the principles of architectural acoustics in the design of a cathedral and utilize the results to design the proposed Catholic Cathedral for the Awgu Diocese, Enugu State. The study's purpose is to help fill the gap between traditional cathedral architecture and the present-day acoustical requirements, while still providing a design that enables meaningful worship experiences and retains the sacred quality of Catholic cathedral architecture.

1.2 Statement of the Problem

Acoustic problems still exist in many churches of today, especially in developing countries like Nigeria in the Catholic Church. This is a design problem occurring when little consideration is paid to the acoustics of a worship assembly. As a result, buildings are built without regard to acoustic parameters like reverberation, reflection, diffusion, absorption, and speech intelligibility.

The most frequent side effect is a lack of clarity in speech. Many listeners, who are not near the altar, struggle to hear the sermon, prayer, and the reading of the scriptures because the sound waves of the reflection of the word overlap, and so the individual is unable to understand the message. This directly attacks one of the church's key roles to communicate, teach, and engage spiritually.

A major issue is the reverberation or uncontrolled echoes. Reflective, rigid materials like concrete, marble, glass, and ceramic finishes, along with large enclosed spaces, can allow sound to continue for longer than desired after the sound has stopped. Reverberation can enhance sacred music but can also be a problem when it becomes too much reverberation, which can muddy speech and diminish the overall acoustical quality of the performance (Barron, 2019).

Music performance is also impacted. The acoustic balance may be poor or over-amplified during Choir presentations and instrumental accompaniment, thus resulting in a loss of the desired richness. This dilutes the emotional and spiritual impact of worship events.

We find poor acoustics is rife in the Awgu Diocese and churches across the board – it seems a great number rely solely on electric systems as the only way to compensate for the issues. These systems are effective at improving audibility but often lead to poor distribution of sound and are prone to technical problems, maintenance issues, and acoustic feedback.

Technology is not the problem; poor application of acoustic principles in the design of architecture is. Even a high-end sound system can't overcome the shortcomings if they are not considered in the planning and design process.

This study tackles this challenge by studying the potential of architectural design strategies for successful acoustic performance within a catholic cathedral with a view towards minimizing reliance on mechanical interventions to provide an effective acoustic solution whilst improving the worship experience.

1.3 Aim and Objectives of the Study

Aim of the Study

The purpose of this study is to explore the acoustic principles in the worship spaces and the application of these principles in the design of a Catholic Cathedral that defines the effectiveness of acoustics in the Awgu Diocese, Enugu State.

Discuss the concepts of architectural acoustics applicable to the church worship space.

Objectives of the Study

The purpose of this study is to address these questions:

1. Which of the following are crucial to the design of a Catholic cathedral?
2. What are some common acoustical problems of the old Cathedrals?
3. How can an architect and materials be used to achieve effective acoustics in a Catholic Cathedral?
4. What can be done to incorporate acoustics into the design of a cathedral for Awgu Diocese

1.4 Research Questions

This research is important because it deals with an important yet underutilized concept in church architecture, acoustics.

1. The study offers insights for architects into the interplay between the shape of the building, spatial organization, and material selection, and their effect on sound behavior. Creates a process that is aesthetically beautiful, functional, and very easy for anyone to follow.
2. The outcomes will also be utilized in forming and implementing Catholic church environment in the manner to effectively and proactively involve people, create richer spiritual experience. The Catholic Church services will sound clearer by delivering sermons better, music fuller and prayers clearer.

3. In addition, the study can help reduce dependency on sound systems for amplified music by prescribing architectural changes.
4. The study would contribute to knowledge of architectural acoustics in Nigeria places of worship which currently has a nascent level of literature.

1.5 Significance of the Study

The relevance of this research is that it addresses a neglected and yet significant aspect of church architecture-namely acoustics.

Provides designers with a better understanding of how building form, spatial organization, selection of construction materials and the acoustic characteristics of the building interact. Encourages integrated design, one which considers all aspects - appearance, usability and function. The findings will also allow Catholic Church to build places of worship where communication, participation and spiritual engagement will be more effective. Better acoustics will help to make the sermons more audible, prayers more understandable, and musical performances more fantastic. The study also contributes to minimizing the unnatural reliance on electronic sound systems by providing architectural solutions that naturally enhance acoustic qualities.

The study is of academic interest in the field of architectural acoustics in the worship space, especially in Nigeria, where few studies have been conducted in this field.

1.6 Scope and Delimitation

This study is mainly aimed at the design of a catholic cathedral for the Awgu Diocese with a special focus on the aspect of good acoustics.

The study pursues:

i. Architectural acoustic principles.
ii. Cathedral design characteristics.

iii. Acoustic behavior of worship spaces.

iv. Effects of building form and geometry on sound.

v. Effects of construction materials on acoustic performance.

vi. Case studies of selected local and international cathedrals.

vii. Application of research findings to a proposed cathedral design.

1.7 Organization of the Report/Thesis

This study has been structured into five chapters.

In the introduction of the study (**Chapter One**), the background of the study, problem statement, aim and objectives, research questions, significance, scope, and definition of terms are presented.

The literature review and the case studies are presented in **Chapter Two**, which includes information on architectural acoustics, cathedral architecture, acoustic materials, the effects of building forms on sound, and relevant local and international case studies.

The study area is described in **Chapter Three**, where the geographical setting, historical development, climate, vegetation, the characteristics of the population, and site selection criteria are discussed.

Chapter Four outlines the research methodology, data collection procedures, and methods of analysis.

Chapter Fivepresents findings, conclusions, recommendations, and design implications.

Chapter Six: Conclusion and Contribution to Knowledge.

1.8 Definition of Special Terms

Acoustics: The science of sound and its behavior within different environments.

Architectural Acoustics: The branch of acoustics concerned with the control and behavior of sound within buildings (Long, 2014).

Reverberation: The persistence of sound after the source stops, caused by multiple reflections from surrounding surfaces.

Reverberation Time (RT60): Time needed for the sound energy in space to fade 60 dB when the sound source is removed. One of the key factors determining acoustic quality.

Sound Absorption: The process through which materials convert sound energy into heat, thereby reducing reflections.

Sound Reflection: Bouncing of sound waves off a surface.

Sound Diffusion: The scattering of sound energy in multiple directions to promote uniform sound distribution.

Speech Intelligibility: How easily it is to hear and understand speech.

Echo: A bounce back of sound due to a delay.

Nave: The central part of a church, the aisles of which are occupied by people.

Apse: A rounded or polygonal head or room at the end of a church decorated with a high altar, such as the one at the end of a church.

Cathedral: The main church in a diocese where the bishop's seat is, or where it was at one time.

CHAPTER TWO

LITERATURE REVIEW AND CASE STUDIES

2.1 Review of Related Literature

2.1.1 Concept of Architectural Acoustics in Worship Spaces

Architectural acoustics is the study, control, and quality of a space's acoustical characteristics. Acoustics in worship settings can have a profound impact on how well people are able to hear, understand, and appreciate worship, music, and other sounds. Cathedrals have to be capable of supporting both speech and music, but in the same space and at the same time, unlike theatres or lecture halls, where one or the other is supported (Long, 2014).

Reverberation time, speech intelligibility, sound diffusion, sound reflection, and sound absorption are the most common measures of the acoustic quality of a worship space. A good cathedral should also offer adequate reverberation to enhance sacred music and good speech clarity for sermons, prayers, and liturgical readings (Barron, 2019).

Recent research indicates that the acoustics of a church can have a direct impact on the perception of sacredness and spiritual involvement by worshipers. In religious buildings, sound is not only a tool for worship, but it is also an integral part of the worship experience (Lokki et al., 2022).

2.1.2 Effects of Shape and Form on Acoustics in Worship Spaces

This is because the geometry of a building has a significant influence on the way sound moves through the building. The reverberation time, the pattern of sound reflection and speech intelligibility depend on the type of architecture.

A. Rectangular Form

The rectangular plan has continued to be one of the most acoustically effective plans for worship areas. The sound moves regularly from the altar to the congregation, which leads to a relatively even spatial distribution of sound.

Merits

I. Good speech intelligibility.

II. Predictable sound reflection patterns.

III. Easier integration of sound reinforcement systems.

Demerits

I. May create flutter echoes between parallel walls.

II. Requires acoustic treatment to reduce repeated reflections.

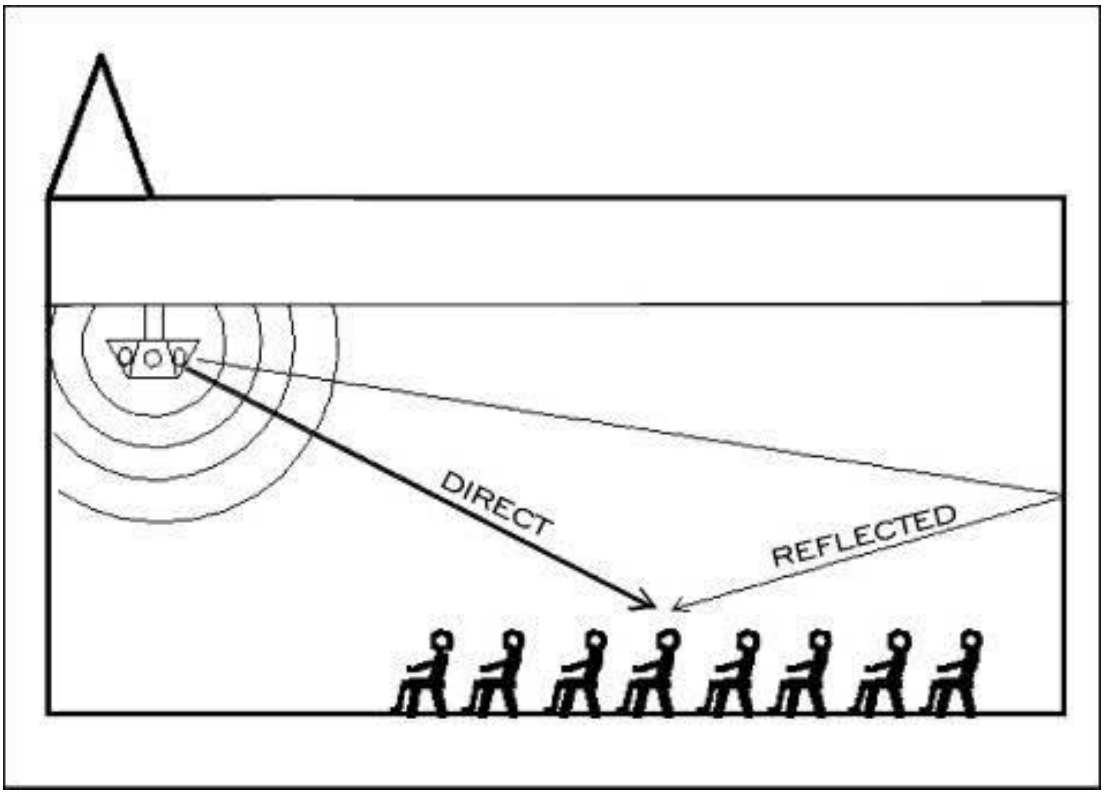

Figure 2.1: The sound reflection pattern in a rectangular worship place.
Source: https//www.acousticsciences.comasc-articlesauditorium-acoustics-102-reflections-make-all-the-difference

B. Fan-Shaped Form

Fan-shaped churches started becoming popular after the Second Vatican Council, because they improve the visual and also the physical connection between the congregation and the altar.

Merits

I. Better sightlines.

II. Reduced sound travel distance.

Demerits

I. Can produce uneven sound coverage.

II. Side-wall reflections may be weakened.

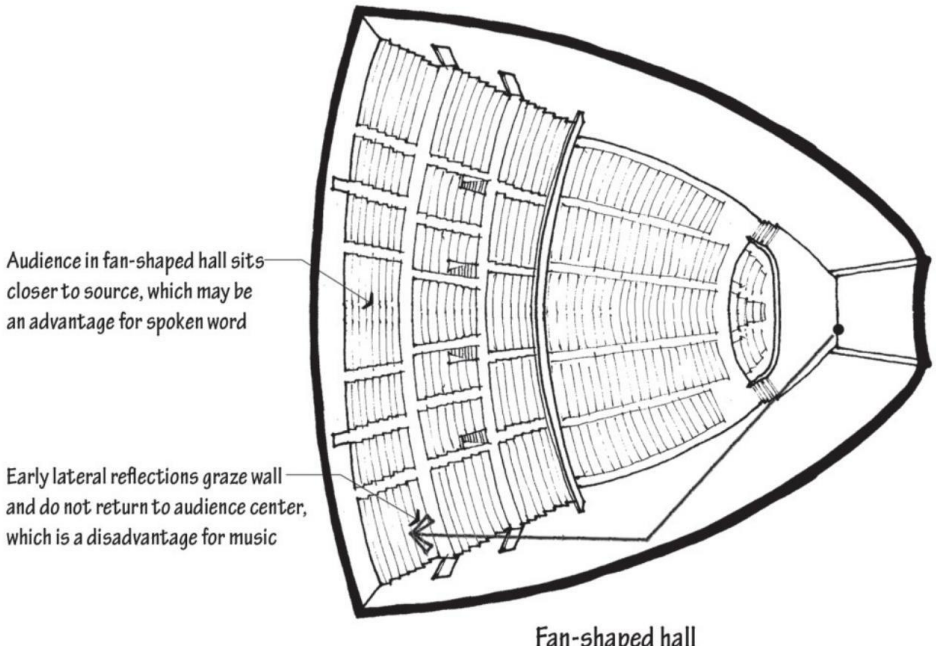

Figure 2.2: The acoustics in a fan shaped worship space.
Source: https://www.academia.edu/figures/6119758/figure-2-plan-view-of-the-reverse-fan-shaped-hall-ermann

C. Reverse Fan-Shaped Form

A reverse fan-shaped church is a church with a wide sanctuary and a narrow back to the congregation. The form is a focus toward the altar and can enhance the sound projection if it is designed correctly.

Merits

I. Strong visual focus on the altar.

II. Improves speech intelligibility.

III. Promotes more even sound distribution.

Demerits

I. May cause sound focusing if poorly designed.

II. Limits seating flexibility.

III. Requires careful acoustic treatment to prevent echoes.

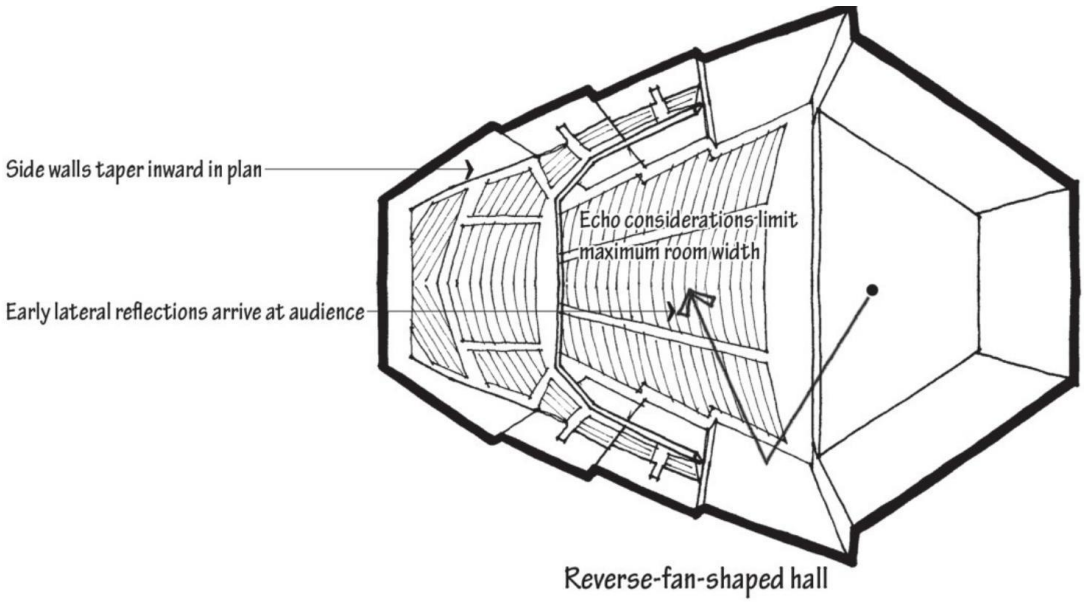

Figure 2.3: Acoustic behavior in a reverse fan-shaped worship space.
Source: https://www.academia.edu/figures/6119758/figure-2-plan-view-of-the-reverse-fan-shaped-hall-ermann

D. Domes, Vaulted Ceilings and Curved Surfaces

Domes and vaulted ceilings are traditional features of cathedral architecture.

Merits

I. Enhance sacred musical resonance.

II. Create a sense of grandeur and spaciousness.

Demerits

I. May produce focal reflections and echoes.

II. Can significantly reduce speech clarity.

For a few European major cathedral studiesdomegeometris show areas of intense acoustic reflection which need specific acoustical treatment (lvarez-Morales et al.2014).

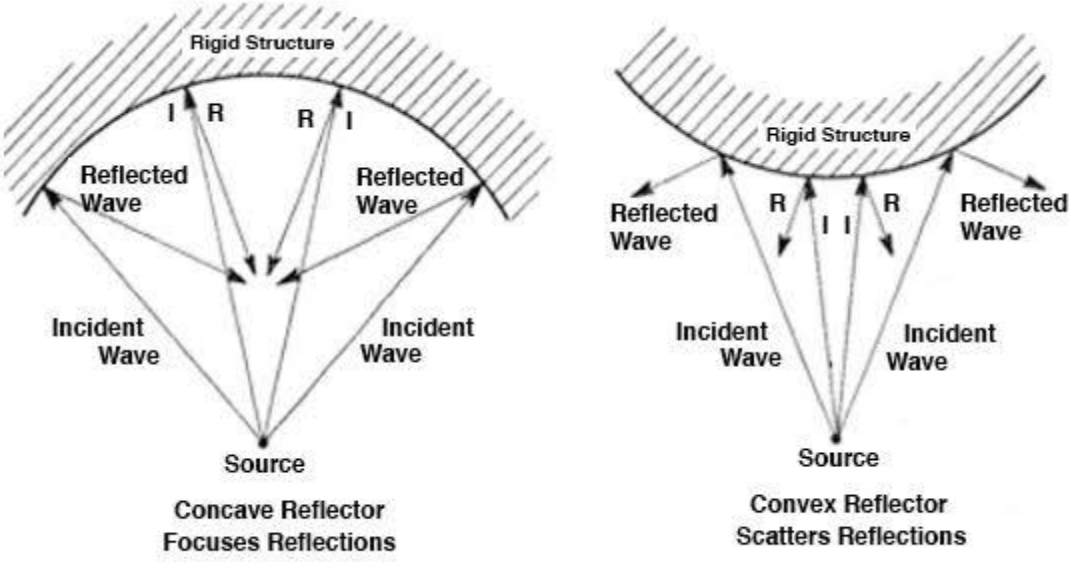

Figure 2.4: The influence of curvilinear surfaces in the transmission of sound.
Source:https://www.sfu.ca/sonic-studio-webdav/cmns/Handbook%20Tutorial/Sound-Environment.html

2.1.3 Effects of Acoustic Materials in Cathedrals and Worship Spaces

The type of material chosen will greatly affect the sound since each surface either reflects sound,absorbsit,or diffuses it.

Stone and Marble

The use of stone and marble finishes in traditional cathedrals is fairly typical.

Effects

i. Strong sound reflection.

ii. Long reverberation times.

iii. It also includes good quality backing forchoirand organ.

iv. Decreased Speech intelligibility when overused.

Timber

Timber has average sound absorption and diffusion.

Effects

I. Improves warmth of sound.

II. Reduces harsh reflections.

III. Enhances speech clarity.

Upholstered Seating

In modern cathedrals, padded seating is common.

Effects

I. Controls reverberation.

II. Improves speech intelligibility.

III. Maintains more consistent acoustics regardless of occupancy.

Acoustic Panels

Contemporary worship spaces increasingly use acoustic wall and ceiling treatments.

Effects

I. Reduce excessive reverberation.

II. Improve clarity of speech.

III. Minimize echo formation.

Stained Glass

Stained-glass windows remain a defining feature of cathedral architecture.

Effects

I. Reflect sound rather than absorb it.

II. Contribute to reverberant environments.

III. Require balancing with absorptive materials elsewhere.

2.1.4 What Makes a Church Building a Cathedral?

Many people mistakenly assume that a cathedral is simply a large church. However, size alone does not determine cathedral status.

A cathedral is often confused with being just a large church. But size is not the only criterion for a cathedral. The cathedral is the main church of a diocese with the seat of the bishop (the cathedra). The word cathedral comes from the Latin word cathedra (chair, seat). The Code of Canon Law (Catholic Church 1983, with revised applications and diocesan guidelines in effect until 2025) defines a church as a church that is the seat of the bishop's chair and serves as the administrative and liturgical center of a diocese.

Typical features of a cathedral include:

I. The bishop's cathedra.

II. Main altar.

III. Nave.

IV. Sanctuary.

V. Choir.

VI. Sacristy.

VII. Baptistery.

VIII. Administrative offices.

Therefore, a church may be architecturally impressive yet not qualify as a cathedral if it is not the seat of a bishop.

2.1.5 Overview of the Study Area: Awgu Diocese

The Catholic Diocese of Awgu is situated in the south of Enugu State and Awgu is its headquarters. The diocese is presently running St. Michael's Cathedral, in Awgu, which seats around 1,800 worshippers at the major liturgical occasions. The diocese is experiencing a steady increase in the Church's population and the building of a new complex for the cathedral is currently under consideration to increase capacity and enhance facilities.

The proposed cathedral project offers a chance to integrate contemporary acoustics from the beginning, making sure the new building promotes both speech and music, and has the sacred architectural character that is required of a Catholic cathedral.

2.2 Case Studies

2.2.1 Local Case Study One: St. Theresa's Cathedral

Plate 2.1: Facade of St Theresa's Cathedral, Nsukka.
Source:https://commons.wikimedia.org/wiki/File:St._Theresa_Cathedral.jpg (accessed 2026)

Plate 2.2: Indoor look of Holy Ghost Cathedral, Enugu.
Source: Author fieldwork, 2026

Background

St. Theresa's Cathedral is the official seat of the Bishop of Nsukka, and the cathedral church of the Catholic Diocese of Nsukka. The cathedral has a strong role in the administration of the diocese and in Catholic worship in the region. Major Religious Ceremonies, Ordinations, Conferences, and Diocesan Celebrations are held here. The building is an important example of modern Catholic architecture in the southeast region of Nigeria.

Location

The cathedral is located in Nsukka Urban, Enugu State, Nigeria. Its strategic location within the town makes it easily accessible to worshippers and visitors from across the diocese.

Facilities Contained

I. Main worship hall.

II. Sanctuary and altar.

III. Choir loft.

IV. Sacristy.

V. Administrative offices.

VI. Bell tower.

VII. Parking facilities.

Merits

I. Large internal volume supports choral music.

II. High ceiling enhances sound projection.

III. Strong reverberant character suitable for liturgical music.

Demerits

I. Reduced speech intelligibility in rear seating areas.

II. Dependence on electronic amplification.

III. Excessive sound reflections from hard surfaces.

Major Design Considerations

I. Longitudinal cathedral layout.

II. High roof structure.

III. Large congregation capacity.

IV. Symbolic Catholic architectural expression.

2.2.2 Local Case Study Two: Holy Ghost Cathedral, Enugu

Plate 2.3: Exterior view of Holy Ghost Cathedral, Enugu.
Source:https://soluap.com/holy-ghost-cathedral-enugu/ (accessed 2025).

Plate 2.4: Interior view of Holy Ghost Cathedral, Enugu.
Source: Author fieldwork, 2026

Background

Holy Ghost Cathedral serves as the seat of the Archbishop of the Catholic Archdiocese of Enugu. It is one of the most important Catholic cathedrals in southeastern Nigeria and functions as the spiritual and administrative center of the archdiocese. The cathedral hosts major religious ceremonies, including ordinations, diocesan celebrations, conferences, and national Catholic gatherings.

Location

The cathedral is located along Ogui Road in Enugu North Local Government Area of Enugu State, Nigeria. Its central location within Enugu metropolis makes it highly accessible to worshippers and visitors.

Facilities Contained

The cathedral complex contains:

I. Main worship auditorium (nave)
II. Sanctuary and altar
III. Bishop's cathedra
IV. Choir section
V. Sacristy
VI. Confessional rooms
VII. Administrative offices
VIII. Meeting halls
IX. Clergy offices
X. Parking areas
XI. Landscaped open spaces

Merits

I. Large worship space enhances sound propagation.

II. High ceiling improves sound projection.

III. Supports congregational singing and choral performances.

IV. Relatively uniform sound distribution throughout the nave.

V. Modern sound reinforcement systems improve audibility.

VI. Spacious interior supports large liturgical gatherings.

Demerits

I. Hard materials contribute to excessive sound reflection.

II. High reverberation levels may affect speech intelligibility.

III. Traffic noise from the surrounding urban environment can penetrate the building.

IV. Acoustic performance depends heavily on sound system calibration.

V. Echoes may occur during low occupancy periods.

Major Design Considerations

I. Large seating capacity for diocesan functions.

II. Clear visibility of the altar and sanctuary.

III. Monumental architectural appearance.

IV. Natural ventilation is suitable for a tropical climate.

V. Adequate daylight penetration.

VI. Functional zoning of liturgical and administrative spaces.

VII. Efficient movement and circulation patterns.

2.2.3 Local Case Study Three: St. Theresa's Catholic Cathedral, Abakaliki

Plate 2.5: Exterior view of St. Theresa's Catholic Cathedral, Abakaliki.

Source: https://mindtrip.ai/attraction/abakaliki-ebonyi-state/saint-theresas-catholic-cathedral/at-aivicTT7Catholic Diocese of Abakaliki Archives (accessed 2026).

Plate 2.6: Interior views of St. Theresa's Catholic Cathedral, Abakaliki.
Source:
https://www.facebook.com/groups/298549307726102/posts/1651275039120182/Catholic Diocese of Abakaliki Archives (accessed 2026).

Background

St. Theresa's Catholic Cathedral is the cathedral church of the Catholic Diocese of Abakaliki. It serves as the bishop's seat and the principal center for Catholic worship and diocesan administration within Ebonyi State. The cathedral accommodates major religious events, diocesan celebrations, pastoral programs, and liturgical ceremonies.

Location

The cathedral is situated in Abakaliki, the capital city of Ebonyi State, Nigeria. Its location within the urban center makes it a prominent religious landmark and easily accessible to worshippers.

Facilities Contained

The cathedral complex includes:

I. Main worship hall
II. Sanctuary and altar
III. Bishop's cathedra
IV. Choir loft
V. Sacristy
VI. Chapels
VII. Confessionals
VIII. Administrative offices
IX. Meeting rooms
X. Clergy support facilities
XI. Parking spaces
XII. Landscaped surroundings

Merits

I. Spacious worship area promotes good sound distribution.

II. Elevated roof structure enhances sound projection.

III. Suitable reverberation for sacred music.

IV. Supports choir performances and congregational singing.

V. Amplification systems improve speech audibility.

VI. Effective separation of sanctuary and congregation improves sound organization.

Demerits

I. Hard finishes contribute to excessive sound reflection.

II. Longer reverberation times may reduce speech clarity.

III. Acoustic quality varies across different seating areas.

IV. Large interior volume can create sound delays.

V. Dependence on electronic amplification for effective performance.

Major Design Considerations

I. Accommodation of large congregations.

II. Liturgical emphasis on altar and sanctuary.

III. Natural ventilation and thermal comfort.

IV. Daylighting through large openings.

V. Symbolic and monumental architectural expression.

VI. Functional integration of worship and administrative spaces.

VII. Flexibility for diocesan ceremonies and events.

2.2.4 Foreign Case Study One: St. Peter's Basilica

Plate 2.7: Exterior views of St. Peter's Basilica, Vatican City, Rome.
Source: https://vatican.museum/vatican-city-early-access-tour-of-the-sistine-chapel?srsltid=AfmBOorDwmpM6-cPAc-XD39DwsOv4BhyE0bOhUBmAojlRNzS9cSjbVA7(accessed 2026).

Plate 2.8: Interior views of St. Peter's Basilica, Vatican City, Rome.
Source:https://www.facebook.com/ArchiDesiign/posts/interior-of-st-peters-basilica-vatican-city-rome-italyphoto-by-asim_broadsword-i/2971366566351912/ (accessed 2026).

Background

St. Peter's Basilica is one of the most important churches in Christianity, and it's considered the spiritual heart of the Roman Catholic Church. Built between 1506 and 1626 on the traditional site

of Saint Peter's burial, one of Jesus Christ's twelve Apostles and the first Pope. The building was designed and developed by several famous Renaissance architects, such as Donato Bramante, Michelangelo, and Carlo Maderno. Basilica is known to the world for its monumental dome, excellent architectural grandeur, artistic treasures, and splendid interior spaces. It is a significant pilgrimage site and is the venue for important papal ceremonies that are attended by Catholics from all over the world.

Location

Vatican City, a sovereign state surrounded by the city of Rome, Italy, is where St. Peter's Basilica is found. The basilica is situated at a central point on the western end of Saint Peter's Square. It is part of the Vatican complex - the seat of the Roman Catholic Church. The strategic position plays an important role in its religious, cultural, and historical value.

Facilities Contained

I. Main basilica.
II. Papal altar.
III. Chapels.
IV. Sacristies.
V. Museum spaces.
VI. Pilgrim facilities.

Merits

I. Exceptional musical resonance.
II. Strong support for choir and organ performances.
III. Monumental sound experience.

Demerits

I. Very long reverberation times.

II. Speech intelligibility challenges without amplification.

Major Design Considerations

I. Massive dome structure.

II. Monumental scale.

III. Pilgrimage capacity.

IV. Symbolic religious significance.

2.2.5 Foreign Case Study Two: Notre-Dame Cathedral

Plate 2.9: View of the exterior of Notre-Dame Cathedral on Île de la Cité, Paris, France.
Source:https://www.westend61.de/en/photo/WD04897/france-paris-ile-de-la-cite-view-to-notre-dame-cathedral (accessed 2026).

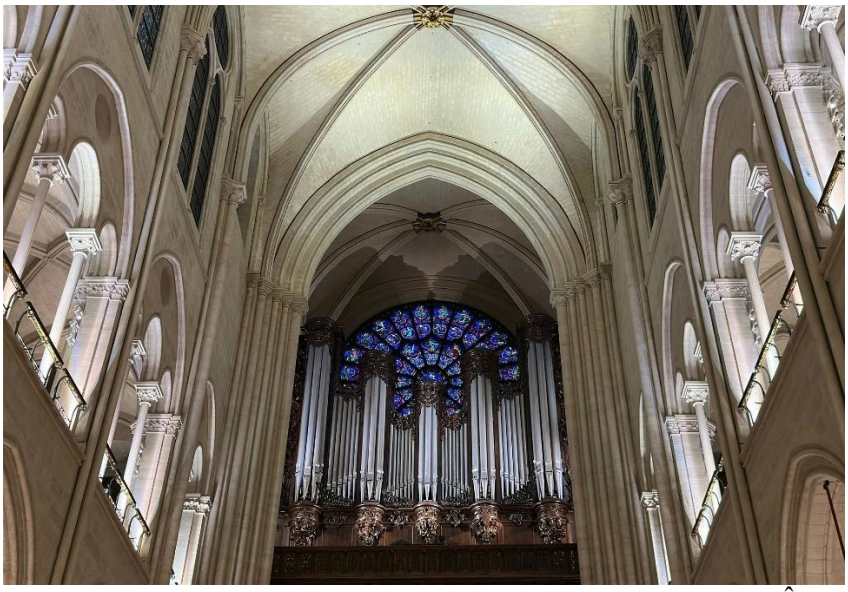

Plate 2.10: The interior of the Notre-Dame Cathedral on the Île de la Cité in Paris, France.
Source:https://www.pariscityvision.com/en/notre-dame-entrance-audioguide-cruise

Background

One of the most popular examples of French Gothic architecture, Notre-Dame Cathedral is one of the most recognizable cathedrals in the world. Work started under King Louis VII in 1163 and was to last nearly 200 years. The cathedral is famous for the flying buttresses, ribbed vaults, stained glass rose windows and decorative sculptures. Notre-Dame has been a place of religious worship, national ceremonies and cultural events in France throughout its history. Although extensively damaged during the fire in 2019, much work has been done to preserve its architectural and historical value.

Location

The Notre-Dame Cathedral is located in the historic center of Paris on an island in the River Seine, called Île de la Cité. It is located in the center of Paris and is one of the most visited religious and cultural sites in Europe. The cathedral's location on the banks of the river makes it even more visible in Paris.

Facilities Contained

I. Main nave.

II. Choir area.

III. Chapels.

IV. Bell towers.

V. Administrative facilities.

Merits

I. Excellent choral resonance.

II. Rich reverberant atmosphere.

III. Strong sacred acoustic character.

Demerits

I. Long reverberation affects speech clarity.

II. Requires electronic reinforcement during large events.

Major Design Considerations

I. Gothic architecture.

II. Rib-vaulted ceilings.

III. Longitudinal plan.

IV. Heritage preservation requirements.

2.2.6 Foreign Case Study Three: SagradaFamília

Plate 2.11: Ventilated view of the outside of SagradaFamília, Barcelona, Spain.
Source:https://en.wikipedia.org/wiki/File:SF_maig_2_cropped.jpg (accessed 2026).

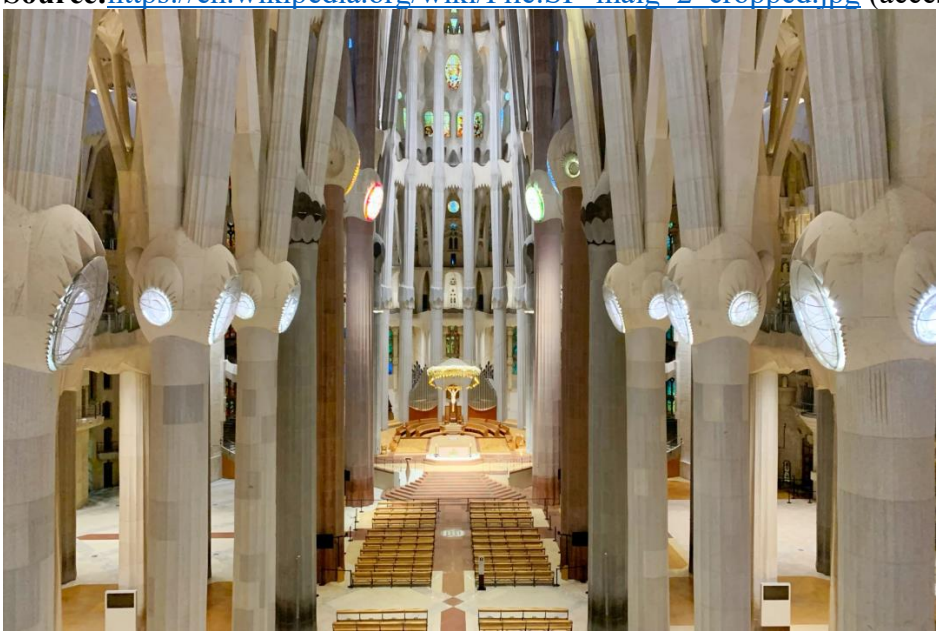

Plate 2.12: Inside of the church SagradaFamília in Barcelona, Spain.
Source:https://www.afar.com/magazine/sagrada-familia-now-offers-after-hours-tours-how-to-book (accessed 2026).

Background

A key building in the history of modern architecture, SagradaFamília is one of the most innovative and influential religious structures in history. The building was started in 1882, and in 1883, it was continued by the renowned Spanish architect AntoniGaudí. Gaudí transformed it into a masterpiece, a synthesis of the Gothic, the Art Nouveau, and the nature-inspired, unique structural and symbolic forms. Its towers, complex facades, geometric shapes, and the use of natural light are all hallmarks of the basilica. While the building continues to be completed, SagradaFamília has emerged as one of the world's most visited architectural monuments and is a testament to religious devotion and architectural creativity.

Location

Also known as the Holy Family, SagradaFamília is situated in the Eixample district of Barcelona, in the autonomous region of Catalonia. The basilica is located in a prominent urban area, and it is one of the most important landmarks in the city. The city of Barcelona provides it with many advantages, which make it an active place of worship, but also a great international tourist center.

Facilities Contained

I. Main worship hall.
II. Chapels.
III. Towers.
IV. Choir areas.
V. Visitor facilities.

Merits

I. Modern acoustic integration.
II. Enhanced speech intelligibility.

III. Balanced reverberation performance.

Demerits

I. Complex geometry requires sophisticated acoustic management.

II. Large volume still presents reverberation challenges.

Major Design Considerations

i. Biomorphic architecture.

ii. Advanced structural systems.

iii. Natural daylighting.

iv. Integrated acoustic engineering.

2.3 Summary of Literature Review and Case Studies

The literature surveyed verifies that acoustics plays an important role in the design of a Cathedral. It is important that the combination of speech and music in the worship space is appropriate in terms of their effectiveness. Acoustic performance depends on the building geometry, ceiling volume, the shape of the ceiling and the material type.

The review is also a confirmation of the different sound characteristics of the various forms of architecture. Rectangular shapes tend to perform better in speech and domes or vaulted ceilings better in music, but will not perform as well in speech.

The case studies show that reverberation and excessive use of electronic sound reinforcement are some of the common acoustic problems in both local and international cathedrals. But with new structures like the SagradaFamília, modern acoustic concepts have been successfully applied with traditional cathedral structures.

The results thus confirm the necessity of a Cathedral design for Awgu Diocese which makes conscious use of the acoustic properties from the initial stages of design work. This will enable a

worshipping atmosphere to foster liturgical activities, engage members of the congregation and give an enriching spiritual experience to the worshippers.

CHAPTER THREE

THE STUDY AREA

3.1 Geographical Location and Setting

Enugu state has seventeen Local Government Areas (LGAs), including Awgu, which is found in the south-central region of Nigeria. It is located approximately between latitude 6°00'N and 6°19'N, and longitude 7°23'E and 7°35'E. The town is the administrative headquarters of Awgu Local Government Area, and it is strategically located within the Catholic Diocese of Awgu.

Awgu abuts Udi Local Government Area in the North, Oji River Local Government Area in the East, Aninri Local Government Area in the South, and Enugu South Local Government Area in the North East. The area is well connected to major urban centers with roads that provide access to and connect the area to the metropolis of Enugu and neighboring communities, making the area relatively accessible to citizens and visitors.

Several benefits of the proposed cathedral project could be addressed at this location. Awgu is not as becoming as a highly urbanized center where noise pollution is a big concern. The availability of land also provides opportunities for future expansion, landscaping, parking facilities, and other supporting facilities necessary for a Diocesan Cathedral.

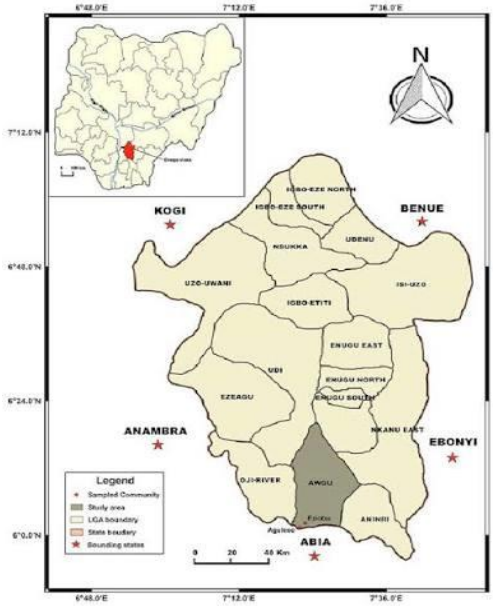

Figure 3.1: Map of the Awgu area in Enugu State.

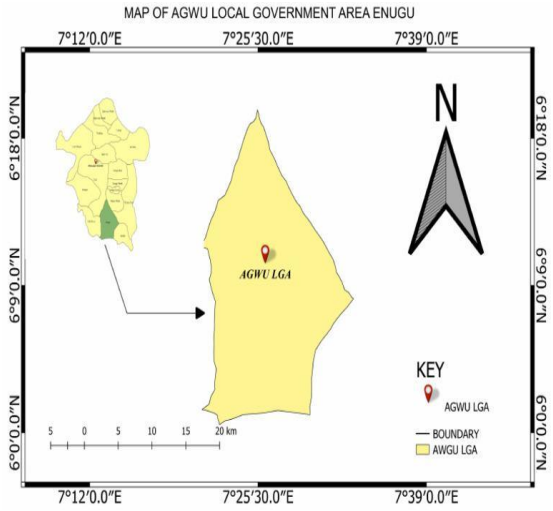

Figure 3.2: Administrative Map of Awgu Local Government Area.

Source: Enugu State Government GIS maps (2026).

3.2 Site Selection Criteria

The selection of a suitable site for a cathedral requires careful consideration of functional, environmental, cultural, and acoustic factors. A cathedral is not merely a place of worship but a major religious, administrative, and social landmark within a diocese.

The following factors were used to choose a site.

Accessibility

The site should be accessible from all over the diocese. To ensure the ability to attend large events and celebrations within the diocese, good road networks and transportation links are required.

Topography

A relatively flat site decreases construction costs and engineering issues. Gentle slopes may be desirable for good drainage and heightened visibility.

Environmental Quality

The location of the site should be away from sources of excessive noise like roads, industries, markets, transport terminals, etc. Too much outside noise may impact worship activities and acoustics in the Cathedral (Rindel, 2018).

Land Availability

The land should be adequate for the site of the cathedral building, as well as for future expansion, administrative buildings, residences for clergy, parking, landscaping and open space for assembly.

Climate Responsiveness

The design should consider building orientation to optimize access to natural ventilation, daylight, and thermal comfort, and minimize heat gain and exposure to prevailing winds.

Their significance and importance within their culture and religion.Their religious and cultural meaning.

The location should be a symbolic area and should have the potential to convey the Catholic community's identity and aspirations, with a cathedral as the spiritual heart of the diocese.

3.3 A brief history of the study area

Awgu culture has a long and storied history, inextricably woven into the fabric of Igbo culture. Historically, pre-colonial society was defined by factors such as kinship structures, age grade associations, agricultural cycles and systems of community governance.

Today the mainstay for the majority of the people is agricultural cultivation. The most common crops for agricultural cultivation include, for instance, the various vegetables, yams and sweet potatoes, and sweet potato as well as the cassava tubers. This kind of favorable and fertile soil as well as climatic conditions in that period were fundamental to the settlement of land in that place. Christianity was brought to the region in the colonial era by the efforts of Catholic missionaries and other Christian churches. The Catholic Church slowly emerged as one of the most influential institutions in Awgu, in the areas of education, healthcare, social development, and religious life. The Catholic Diocese of Awgu was also established in the area, which further enhanced the religious significance of the area. Through the years, the number of Catholic people in the diocese has increased significantly, and so have the needs for a larger worship space to serve a growing number of people who want the diocese to hold larger gatherings and special liturgical celebrations.

There is an existing cathedral in the diocese with a seating capacity of about 1800 worshippers. But, with the growth of the population and greater activities of the diocese, a new cathedral complex is currently being built. This development is an opportunity to use contemporary architectural and acoustic design to create a contemporary worship space.

3.4 Physiography, Climate, and Vegetation

Physiography

The terrain of Awgu is undulating with hills, ridges, valleys, and gently sloping plains. The area is part of the Udi-Nsukka Plateau system, which predominates the topography of much of Enugu State.

The topography of the area is varied and provides for the development of impressive architecture, as well as scenic scenes. Construction activities are reasonably supported by the terrain, but care should be taken in the planning of the sites and the design of drainage on the steeper slopes.

For large-scale development, including cathedrals, the physiographic features will affect the design of foundations, the grading and drainage plans of sites, and the landscaping plans.

Climate

Awgu falls within Nigeria's Tropical Wet and Dry Climate Zone (Köppen Classification: Aw), characterized by distinct wet and dry seasons (NiMet, 2024).

Two major air masses influence the climate:

I. The Tropical Maritime Air Mass (moist south-west winds)
II. The Tropical Continental Air Mass (dry north-east winds)

Annual temperatures generally range from 24°C to 33°C, while relative humidity remains high for most of the year. Below is a table (Table 3.1) of the climate characteristics of Awgu.

Table 3.1: Climatic Characteristics of Awgu

Climatic Element	Characteristics	Design Implications
Climate Type	Tropical Wet and Dry (Aw)	The building should respond to both rainy and dry seasons.
Rainy Season	April – October	Provide steep roof pitches, wide overhangs, efficient drainage, and moisture-resistant finishes.
Dry Season	November – March	Incorporate shading devices, natural ventilation, and heat-resistant materials.
Average Temperature	24–32°C	Encourage passive cooling through orientation and cross ventilation.
Annual Rainfall	Approximately 1,500–2,000 mm	Rainwater harvesting and adequate stormwater drainage should be provided.
Relative Humidity	Moderate to High	Use durable materials resistant to dampness and mould.
Prevailing Wind	South-West (wet season); North-East (dry season)	Orient openings to enhance natural ventilation while minimizing dust infiltration.
Vegetation	Derived Savannah with patches of tropical vegetation	Preserve vegetation for shading, cooling, and acoustic buffering.

Source: Nigerian Meteorological Agency (2024); Enugu State Ministry of Lands and Urban Development (2024).

Climatology

Awgu experiences two major seasons:

A. Rainy Season (April – October)

The rainy season is characterized by:

I. Heavy rainfall.

II. High humidity levels.

III. Increased cloud cover.

IV. Reduced solar intensity.

Design Implications of the Rainy Season

For cathedral design, the rainy season necessitates:

I. Steep roof pitches to facilitate rapid rainwater runoff.

II. Large roof overhangs to protect walls and openings from rain splash.

III. Effective drainage systems to prevent flooding and erosion.

IV. Durable moisture-resistant construction materials.

V. Proper waterproofing of roofs and foundations.

VI. Covered walkways for pedestrian movement during rainfall.

From an acoustic perspective, rainfall noise on roofs can interfere with speech and worship activities. Therefore, roofing systems should incorporate sound-insulating materials to reduce rain-generated noise.

B. Dry Season (November – March)

The dry season is characterized by:

I. High temperatures.

II. Low rainfall.

III. Increased solar radiation.

IV. Harmattan conditions between December and February.

Design Implications of the Dry Season

The dry season requires:

I. Adequate natural ventilation.

II. Large openings positioned to capture prevailing winds.

III. Shading devices to reduce heat gain.

IV. Use of thermally efficient building materials.

V. Landscaping strategies that reduce surrounding temperatures.

For worship spaces, maintaining thermal comfort during the dry season is important because excessive heat can negatively affect occupant concentration and overall comfort during services.

Vegetation

Awgu lies within the Derived Savannah-Tropical Rainforest transition zone of southeastern Nigeria. The natural vegetation consists of:

I. Tall trees.

II. Shrubs.

III. Grasses.

IV. Agricultural farmlands.

Although human activities have altered portions of the original rainforest, significant vegetation remains throughout the area.

Vegetation plays several important roles in cathedral design:

I. Provides natural shading.

II. Improves microclimatic conditions.

III. Enhances visual aesthetics.

IV. Functions as a natural acoustic buffer against environmental noise.

Trees and landscaped green belts around the proposed cathedral can help reduce external noise intrusion while contributing to a serene worship environment.

Plate 3.1: Picture of Mmaku hill, Awgu, showing vegetation characteristics of Awgu.
Source: *https://i0.wp.com/outravelandtour.com/wp-content/uploads/2019/08/Mmaku-hill-Awgu-Enugu-State-12.jpg?ssl=1*

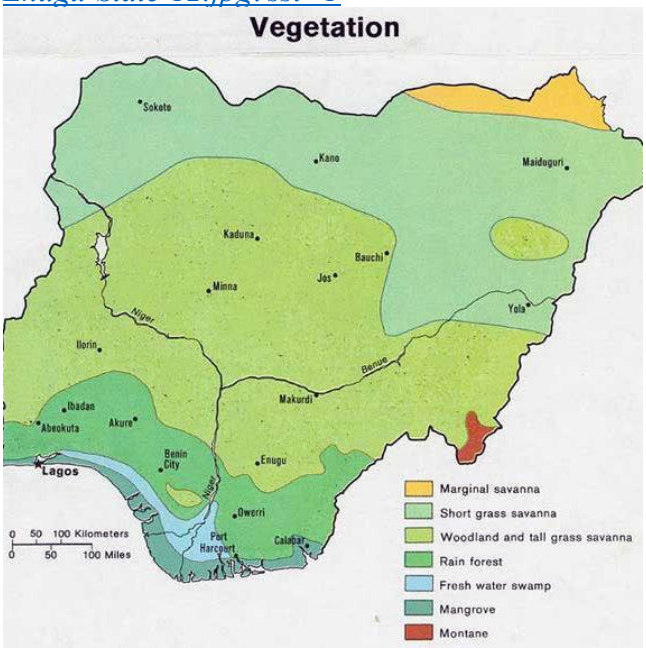

Figure 3.3: Typical physiographic characteristics of Nigeria
Source: Nigerian Environmental Reports (2024–2025).

3.5 Population, Culture, and Economic Development

Population

According to the National Population Commission (2006 Census), the Awgu Local Government Area had a population of approximately 390,681 persons, as shown in Table 3.2 below. Recent

projections by the National Bureau of Statistics and demographic growth estimates suggest that the population has increased significantly and is currently estimated to exceed 500,000 people. The continuous population increase has implications for religious infrastructure development in the context that providing religious infrastructure, including the provision of worship facilities, is able to accommodate large congregations.

Table 3.2: Population Data for Awgu Local Government Area

Population Indicator	**Description**
Local Government Area	Awgu
State	Enugu State
Population (2006 Census)	390,681
Estimated Current Population	Over 500,000
Major Ethnic Group	Igbo
Predominant Religion	Christianity (predominantly Catholic)
Major Occupations	Farming, Trading, Civil Service, Artisanship, and Small-scale Enterprises

Sources: the National Population Commission (2006) and the National Bureau of Statistics (2024).

Culture

Awgu is largely inhabited by Igbo people and has the cultural practices prevalent in the southeast of Nigeria. There is an emphasis on traditional values like living in a community, respecting elders, being hospitable, and having a sense of family. Christianity, especially Catholicism, has a major influence on cultural and social activities in the area. This connection between faith and local

identity remains strong and is further enhanced through religious festivals and diocesan events, as well as through community gatherings.

Economic Development

Food production is still the largest industry in Awgu. The common agricultural products are:

I. Yam.
II. Cassava.
III. Maize.
IV. Cocoyam.
V. Palm produce.
VI. Vegetables.

Other economic activities include:

I. Small-scale trading.
II. Civil service employment.
III. Artisanship.
IV. Transportation services.
V. Educational services.

In recent years, infrastructural development, educational institutions, healthcare facilities, and religious organizations have contributed significantly to the socio-economic growth of the area. The anticipated completion of a new Diocesan Cathedral will further boost development by drawing visitors to Awgu, promoting local businesses, providing employment opportunities associated with the construction of a cathedral and adding to the religious and cultural heritage of Awgu community in Enugu State.

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1 Research Design

The type of research in this study is descriptive research, which is a combination of literature review, case study analysis, and architectural design research. This approach is selected because of the nature of the research problem, which is aimed at understanding the relationship between architectural design and acoustic performance of the cathedral buildings, and the application of the knowledge gained to the design of the proposed Catholic Cathedral for the Awgu Diocese in Enugu, Nigeria.

The literature review part of the study serves as the theory on which the study is based. It entails the review of scholarly books, academic journals, conference papers, technical reports, and other relevant publications concerning architectural acoustics, the design of worship spaces, the design of cathedrals, the behavior of sound, the acoustic properties of materials, and environmental design. Here the review will explore existing literature, theory, and practice relating to religious building acoustics.

Moreover the study adopts a case study approach and the cathedrals involved include local and foreign cathedrals respectively. Local cases: St Theresa's Cathedral Nsukka, Holy Ghost Cathedral Enugu and St Theresa's Cathedral Abakaliki and Foreign cases: SagradaFamlia Cathedral, Barcelona, Notre-Dame Cathedral, Paris and St Peter's Basilica, Rome.

The cathedrals were chosen on the basis of their architectural value, acoustical properties, and their relevance to this study. These buildings are only some of those analyzed and can offer interesting insights into the application of acoustics in worship spaces across various cultural and geographical settings. The following table (Table 4.1) is a summary of the case study.

Table 4.1: Summary of Case Studies

Case Study	Location	Key Merits	Key Demerits	Design Lessons for Proposed Cathedral
St. Theresa's Cathedral	Nsukka, Enugu State, Nigeria	Large internal volume supports choral music; high ceiling enhances sound projection; strong reverberant character for liturgical music.	Reduced speech intelligibility at rear seating, dependence on electronic amplification, and excessive reflections from hard surfaces.	Adopt a longitudinal layout while improving speech clarity through controlled ceiling geometry and acoustic finishes.
Holy Ghost Cathedral	Enugu, Nigeria	Large worship space promotes sound propagation; good support for congregational singing; relatively uniform sound distribution; modern sound reinforcement.	High reverberation; hard interior finishes; traffic noise intrusion; dependence on sound systems; echoes during low occupancy.	Combine passive acoustic treatment with electronic reinforcement and provide acoustic buffering from external noise.
St. Theresa's Catholic Cathedral	Abakaliki, Ebonyi State, Nigeria	Good speech clarity; balanced reverberation; effective congregation participation.	Minor reverberation in large gatherings; localized echoes in some areas.	Integrate balanced acoustic materials and maintain clear visual and acoustic focus on the sanctuary.
St. Peter's Basilica	Vatican City	Exceptional musical resonance; excellent support for choir and organ music; monumental acoustic experience.	Very long reverberation time; reduced speech intelligibility without amplification.	Balance reverberation with speech clarity and avoid excessive interior volume without acoustic control.
Notre-Dame Cathedral	Paris, France	Excellent choral resonance; rich reverberant atmosphere; strong sacred acoustic character.	Long reverberation affects speech clarity; electronic reinforcement is required during major services.	Preserve the spiritual quality of reverberation while incorporating passive measures to improve speech intelligibility.
SagradaFamília	Barcelona, Spain	Modern acoustic integration; enhanced speech intelligibility; balanced reverberation; excellent daylight integration.	Complex geometry requires sophisticated acoustic management; large volume still presents reverberation challenges.	Integrate acoustics into the architectural concept from the earliest design stage, combining symbolism with environmental performance.

The analysis in this section has been done by the author based on the selected local and international case studies.

Moreover, the study is based on the architectural design research method. This allows the results of literature and case studies to be applied to developing solutions that can be implemented in practice. The ultimate goal is to create a cathedral design proposal that meets the different needs and requirements for acoustics and other functional, liturgical, environmental and design goals.

4.2 Data Needs and Sources

The research needs a broad spectrum of information concerning cathedral architecture, the acoustics of the worship space, environmental conditions, and properties of the research area. Data required are those relating to the principles of acoustics, the acoustic requirements to worship spaces, planning requirements for cathedrals, building forms and how this influences sound behavior, architectural materials and their acoustic properties, climate, population characteristics, and environmental factors which influence the design decision.

Both primary and secondary sources of data are employed to get this information. Primary data is acquired by direct observation of selected cathedral buildings and the study area. The site visits allow the architectural characteristics, spatial organization, material use, environmental conditions, and the observable acoustic characteristics to be examined. Where possible, photographs and field notes are used to document important findings.

The secondary sources for data are published and unpublished sources such as textbooks, academic journals, conference proceedings, dissertations, government journals, church journals, meteorological journals, online architectural journals, and databases. An effort has been made to exclusively include literature published in the last 14 years (2012-2025) to ensure that the study is based on recent design practices and knowledge in the fields of architecture and acoustics.

The combination of primary and secondary sources makes the research more reliable and comprehensible as it gives both a theoretical and practical context of cathedral acoustics and architectural design.

4.3 Population of Study and Sampling Procedure

The population for this study is comprised of cathedral buildings, worship facilities, architectural precedents which give information on acoustic performance and cathedral design. It also covers the users of worship space including clergy members, church administrators, choir members, and worshippers whose experiences help to provide an understanding of acoustic performance in worship spaces.

A purposive sampling technique is used as it is suitable for this study. In this method, the researcher can choose the sample cases intentionally that have characteristics which are relevant to the objective of the research. The criteria used to select the cathedrals were their architectural significance, information about them, acoustical properties, and relevance to the proposed cathedral project for Awgu diocese.

Purposive sampling is appropriate for this research because it is not about the representation of the buildings in the sample, but about obtaining detailed information about buildings that can provide lessons for cathedral design. Narrowing the field of countless design solutions and acoustic possibilities by providing illustrative examples, on which to hang the design of the suggested project.

4.4 Methods and Instruments for Data Collection

The study obtained information by literature review, observation, recording images and searching in the internet. Literature review will form the theoretical foundation to gain insight into fundamental of architectural acoustics, the principle of the architecture of a cathedral and the

design concept for religious premises. The selected literature will include relevant books, journals, proceedings from conferences, and reports of technical expertise. The trends of the field are to be determined.

The second most important data collection method is direct observation. In direct observation, direct observations will be taken on the shape of building forms, building material finishes, circulation routes, and any architectural elements that would have an influence on acoustic performance, within a selection of cathedrals and in the study area. This methodology produces first hand data and supports secondary data.

A photographic documentation is made to cover also significant structural and environmental aspects and characteristics. The photographs serve as useful aids as reference in the analysis, design, study. The help to relate to other aspects of the buildings which are hard to express with mere written language.

Other information sources are acquired from online searches, the official Church websites, the library, online journals, an architectural index, an government agency research, geographic information systems and many more resources, providing current data, historical data, and geographic map data and aerial views.

Data collection devices Observation sheets, field notebooks, cameras, portable data loggers, maps, imagery obtained by satellite imagery, documents related to architectural publications are among the data collection devices which organize and collect data gathered by the research process.

4.5 Methods of Data Analysis and Presentation

The analysis of the data of the present study utilizes qualitative and comparative analysis. Qualitative analysis of the data from the study, from relevant literature as well as case study and

field observation will be utilized for interpretation. The process helps in identifying the principal issues and trends as well as concepts of design and design principles of cathedral acoustic.

Special attention is paid to the correlation between building form, choice of materials, spatial layout and acoustical performance of the worship space. The objective is to analyze the effect these components can have on reverberation, the distribution of sound within the space, how users perceive the sound in the worship space and how they benefit from clarity of speech in the worship space.

This study further compares between the selected case studies; similarities and differences between them. We are looking for the acoustical properties, concept, plan, capacity, function and construction materials of each case. This comparison would guide the design by drawing the attention towards effective and less effective solution for the new design.

The outputs from literature, climatic assessment, site investigation and case studies have been amalgamated in this section to develop a series of design criteria for the Catholic Cathedral, Awgu Diocese that would facilitate the attainment of appropriate standards of function, environment, liturgy and appearance as well as the design requirements in terms of acoustics.

The findings of the study are communicated by descriptive discussions, tables, photographs, maps, diagrams, and architectural drawings (as needed). These presentation methods are used to clearly communicate the research findings and to generate a logical basis for the final design proposal.

CHAPTER FIVE

DESIGN SYNTHESIS AND DEVELOPMENT

The design proposal included in this chapter is the result of the investigations conducted in the previous chapters. The review found that the acoustics of a cathedral depend greatly on many architectural factors like the form of the structure, the spatial configuration of elements within the cathedral, its shape of ceiling and ceiling features, the nature of the interior surfacing and finishes, the chosen materials and the form and proportion of the space itself. The case studies provided examples of how many of our modern cathedrals make use of powerful electronic amplification systems, but the finest spaces for worship were often found to make most of passive acoustic features (Barron, 2019; Long, 2014).

From the study area evaluation, it can be further ascertained that Awgu has positive Climatic, Environmental and Topographic characteristics conducive to build a functional and environmentally conscious Cathedral. The relative serenity, tropical climatic situation and the availability of land make it possible to infuse in the design; Natural ventilation, Landscaping and Exterior buffer to external noise.

So the findings from the literature review, the case study, the site visit and environmental report, have then been synthesised into an architectural scheme for the construction of a Catholic Cathedral, which would allow for liturgical services to be held and offer good acoustics. Acoustics has not been considered as something which will be added to, it is something which has been involved from the outset. This integration reflects the holistic approach of contemporary building design practice and architectural acoustic design (Cox &D'Antonio, 2017).

5.1 Design Brief

The project is about a design of Catholic Cathedral which is proposed to serve as the spiritual, administrative, and ceremonial headquarter for Catholic Diose of Awgu in Enugu State to serve the entire Catholic population in the Diose.

The proposed development meets the needs of the growing Catholic population in the diocese and the space constraints of the present cathedral, which is able to cater for about 1,800 people. The new cathedral will be larger and more functional than the current building, and will also have improved acoustics, to allow for up to about 2500 congregants to attend services on a regular basis, and support additional attendees for larger diocesan celebrations.

The design brief is not limited to the provision of a Worship Hall. The cathedral complex is designed as a unified religious campus, which allows for the implementation of liturgical, administrative, educational, and social functions. The proposed facilities are: main cathedral, Blessed Sacrament Chapel, daily Mass Chapel, parish offices, diocesan administrative offices, meeting rooms, catechetical classrooms, clergy support facilities, landscaped prayer gardens, parking facilities, and other supporting facilities.

With the main aspect of acoustics of buildings as the primary concern of this research, special consideration is paid to a balance between speech intelligibility and musical reverberation. The design thus eliminates unnecessary echoes and ensures a good distribution of sound and less reliance on electronic sound reinforcement without losing the atmosphere of solemnity and sacredness that is appropriate to a Catholic cathedral.

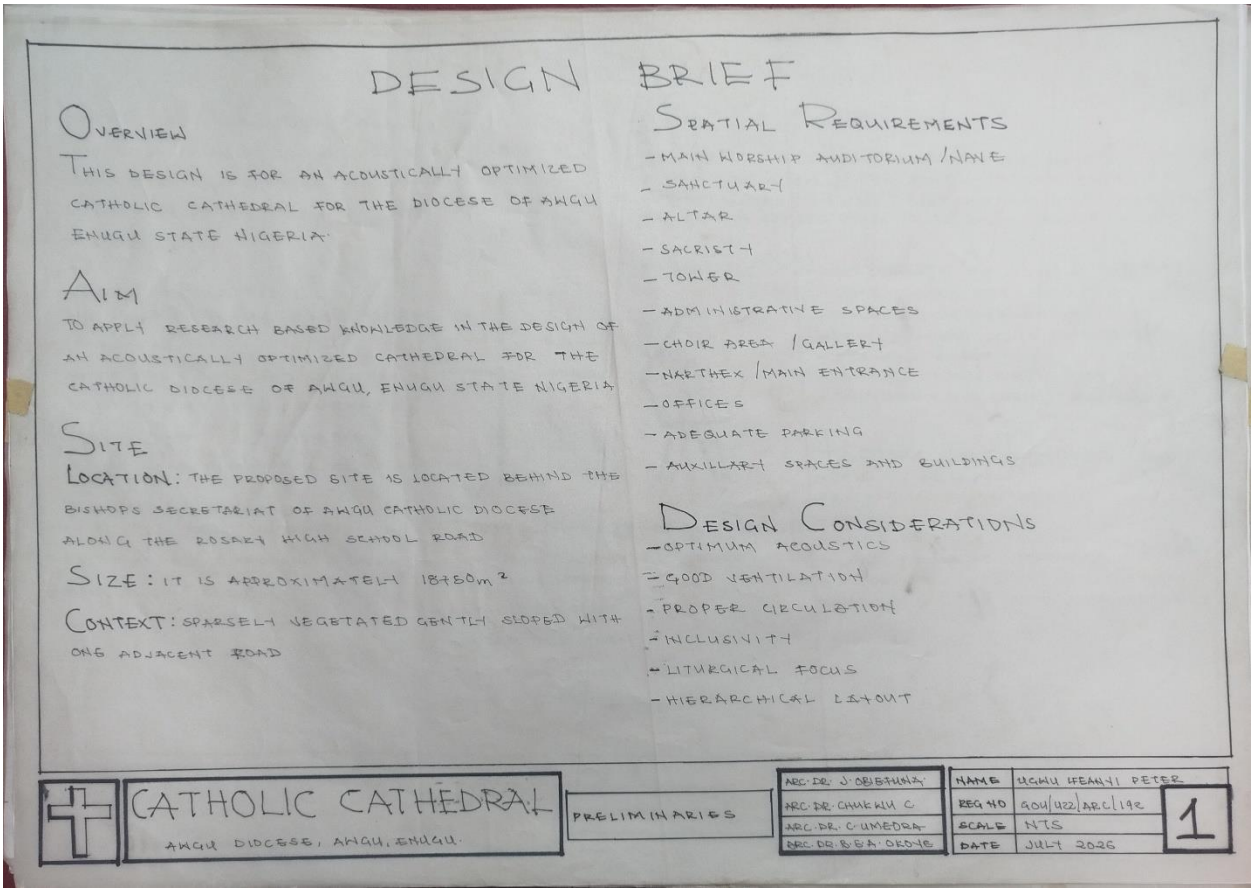

Figure 5.1: The Design Brief Sheet

Source: Author

5.2 Design Requirements for Activities and Planning Data

The design criteria used to plan the cathedral were the catholic liturgical requirements, architectural planning standards (Table 5.1), anthropometric data, ergonomic principles, access, and requirements of building rules.

Table 5.1: Space Planning Requirements

Space	Principal Activity	Key Planning Requirement
Main Worship Hall	Congregational worship	Unobstructed sightlines, even sound distribution, and adequate seating spacing
Sanctuary	Celebration of the Eucharist	Visual prominence, elevated platform, excellent acoustics
Choir	Choral music	Direct sound projection towards the congregation
Blessed Sacrament Chapel	Personal prayer	Quiet environment with minimal external noise
Administrative Offices	Church administration	Privacy, daylight, and natural ventilation
Multipurpose Hall	Meetings and social events	Flexible layout with adaptable seating
Parking Area	Vehicle circulation	Safe access, convenient drop-off, and pedestrian separation

Source: Neufert (2012); Long (2014); Author's Design Proposal.

Liturgical Requirements

The sanctuary is the center of Catholic worship, and consequently, the most prominent position in the church building. It can be used for the high altar, the bishop's cathedra, the ambo, the seats of the celebrants, the altar assistants, and the choir. Clear sight and good sound projection to the congregation, thanks to its location.

Anthropometric Considerations

Pew size, aisle widths, circulation in the sanctuary, size of stairs, ramps, seating arrangements, and more were determined by anthropometric standards. There was sufficient room between pews for movement and efficient usage of floor space. The design and functionality of entrances, ramps, wheelchair spaces, and sanitary facilities were designed with universal accessibility in mind. A few of the anthropometric standards that were itemized in this study are shown below in Table 5.2 and Figure 5.2.

Table 5.2: Anthropometric Standards for Worship Spaces

Design Element	**Recommended Standard**
Seating Width per Worshipper	500–600 mm
Pew Row Spacing	900–1,000 mm
Central Aisle Width	2.4–3.0 m
Side Aisle Width	1.5–2.0 m
Wheelchair Space	900 × 1,200 mm
Ramp Gradient	1:12 (maximum)
Main Entrance Width	1.8–2.4 m
Emergency Exit Width	Minimum 1.5 m
Sanctuary Platform Height	450–600 mm
Recommended Ceiling Height	12–20 m
Comfortable Viewing Distance to Altar	30–35 m
Standing Clearance	Minimum 750 mm

Source: Neufert (2012); ISO 3382-1 (2023); Long (2014).

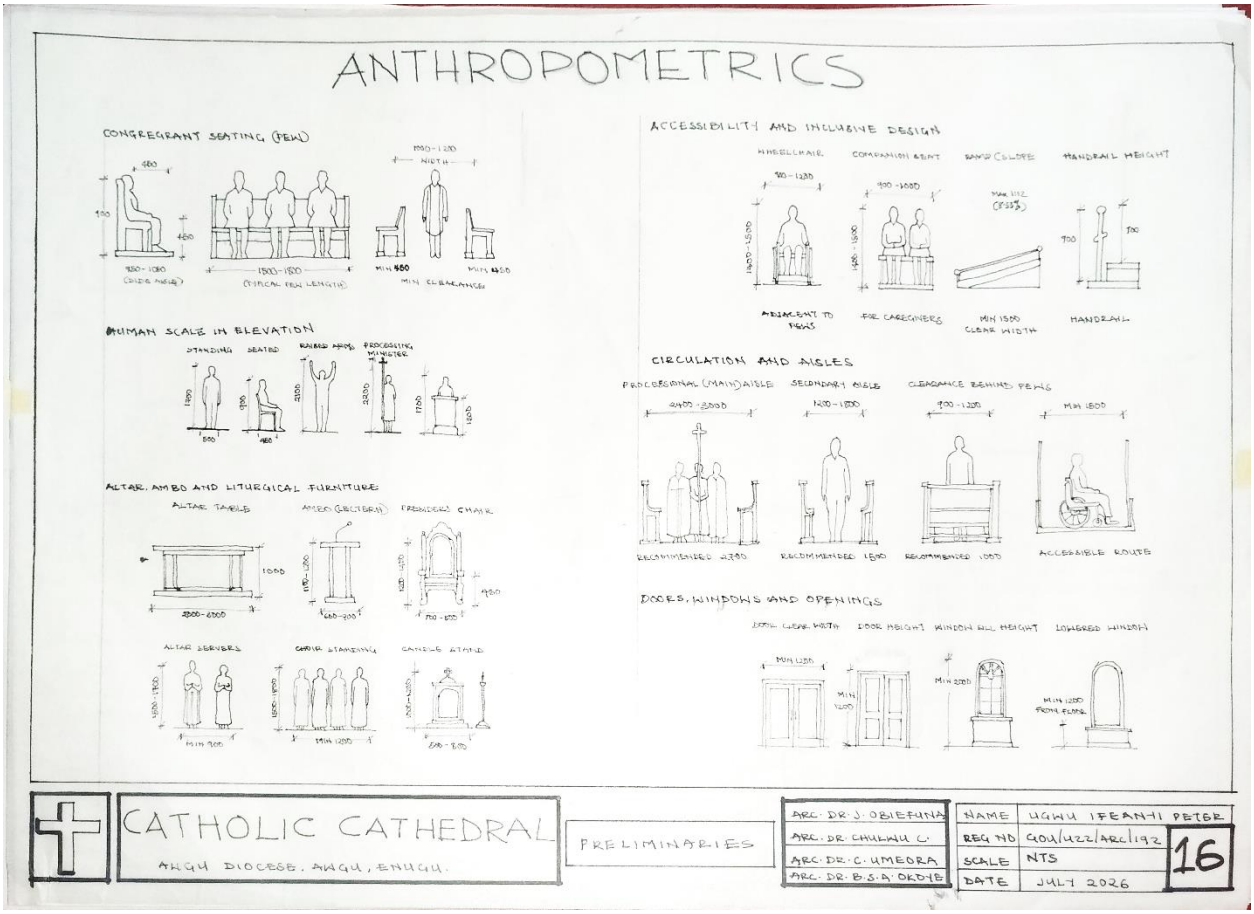

Figure 5.2: The Anthropometrics Sheet
Source: Author

Acoustic Requirements

The acoustic requirements are outlined in the list below and Figure 5.3

I. Longitudinal worship layout to promote even sound propagation.

II. Non-parallel internal wall surfaces to reduce flutter echoes.

III. Moderately sloping or raked ceiling/floor geometry to improve sound reflection.

IV. Timber ceiling finishes for controlled diffusion.

V. Upholstered seating to stabilize reverberation under varying occupancy levels.

VI. Acoustic wall treatments strategically positioned to reduce excessive reflections.

VII. Isolation of noisy service areas from the worship space.

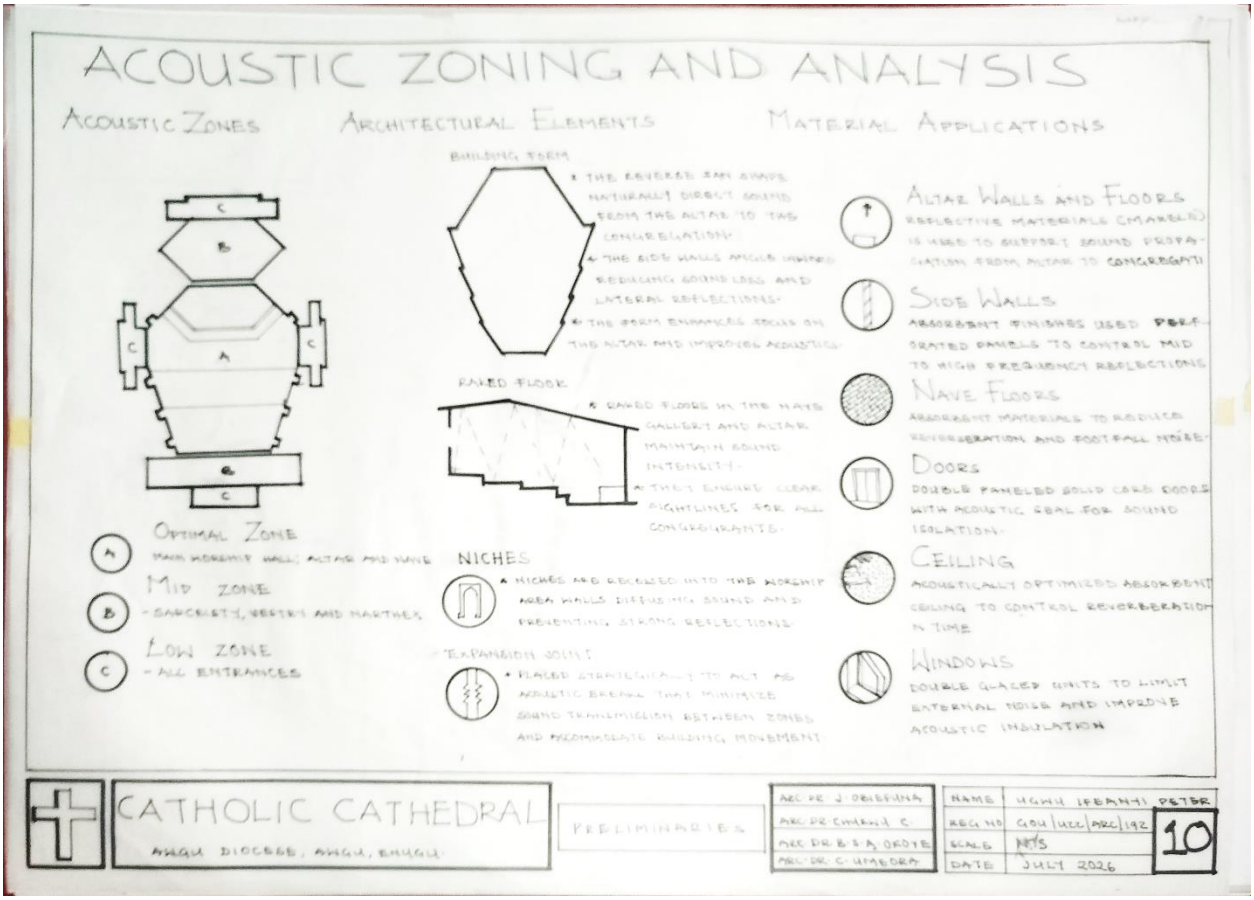

Figure 5.3: Acoustic zoning and analysis sheet

Source: Author

5.3 Schedule of Accommodation

The accommodation program (Table 5.3) was created based on the requirements of the dioceses, the use of liturgical functions, and lessons learned from the case studies.

Table 5.3: Schedule of Accommodation

Space	**Quantity**	**Proposed Area (m²)**
Main Cathedral (Nave)	1	4,800
Sanctuary	1	350
Blessed Sacrament Chapel	1	180
Choir	1	180
Sacristy	2	80
Baptistery	1	70
Confessional	4	12 each
Bishop's Office	1	40
Parish Priest's Office	1	35
Administrative Offices	2	25 each
Conference Room	1	120
Multipurpose Hall	1	700
Library/bookshop	1	120
Public Convenience Blocks	4	45 each
Generator House	1	35
Security Post	1	25
Parking Area	200 Vehicles	2500
Landscaped Prayer Garden	1	As Required

Source: Author's Design Proposal (2026).

5.4 Special Considerations

This study has several themes that are directly addressed by the proposed cathedral. Acoustic performance is the first thing to be taken into account. The research has revealed that churches tend to over-reliance on electronic sound systems, so the design is focused on passive acoustic control. The geometry of the building, ceiling profile, wall finishes, and interior finishes have been carefully chosen to optimize speech intelligibility and sufficient reverberation for sacred music. Climatic responsiveness is the second factor to be considered. The building faces the site towards the opposite side of the sun to reduce the amount of unwanted heat gain the building receives and to increase natural ventilation. Wide overhangs on the roof, openings for clerestory light and ventilation, and landscaping help to create a thermally comfortable indoor environment in Awgu in the Tropical wet and dry zone. Thirdly, the Cathedral is symbolically important, and this is also taken into consideration in the design. The vertical emphasis, the tower elements, and the central sanctuary allude to the Catholic liturgical tradition and resonate with the cathedral as a landmark in the Awgu Diocese. Lastly, there is the flexibility to expand in the future by keeping the site layout flexible to allow further developments and growth in congregation numbers without compromising on existing activities.

5.5 Site Inventory and Analysis

The proposed site has a number of positive attributes in terms of cathedrals.

The gently rolling land allows for good drainage and a visually strong architectural composition. Vegetation helps to improve the environment and provides a natural sound barrier to external noise.

Access from the surrounding communities should be easy at the site for major diocesan events. Distinguished road and pedestrian movement systems, making them safer and less congested.

The prevailing wind direction, as indicated by the environmental analysis, is favorable for cross-ventilation, thus providing a better environment for worship, as well as the quietness of the surrounding environment, which minimizes external noise interference during worship. This building information was a direct reflection of the location of the Cathedral, parking area, administrative buildings, and the open spaces of the landscape.

The research results show clearly that there is not just one architectural element that is important for the development of good cathedral acoustics, but several.

It was found in the literature that a building's layout with the longitudinal axis is generally acoustically better than a centralized one in terms of speech clarity, while a dome or vault is acoustically better in terms of musical resonance, but requires acoustical treatment.

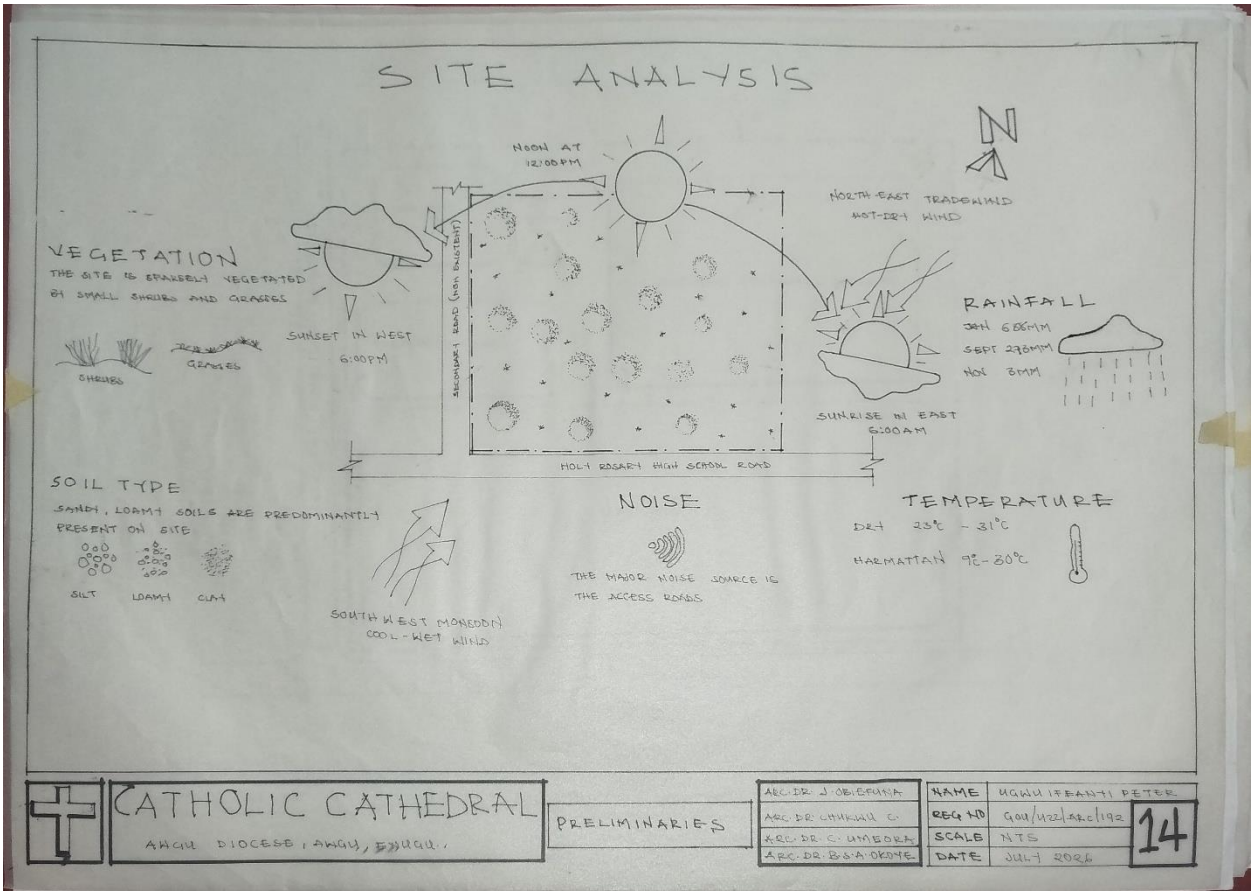

Figure 5.4: Site analysis sheet
Source: Author

5.6 Data Analysis and Presentation

The common issues identified in the local case studies included reverberation, the need for more electronic amplification, and sound distribution issues. On the other hand, the international case studies showed that the use of passive acoustic principles in combination with the latest technologies can have a dramatic effect on worship environments.

Based on these findings, the following changes were made to the longitudinal plan, the geometry of the ceiling, the type of materials, and integrated acoustic treatments in the proposed design.

The Catholic Church's miter and the cross were employed in these elements to symbolize the religion. All these concepts form the backbone of the building's aesthetic value, and in the process the Church's spiritual identity and its position as a sacred institution.

5.7 Design Concept and Design Proposal

The main focus of the picture is the cross, which symbolizes the Church of Christ and the fullness of the Christian Gospel. The central part of the Christian Gospel, is what the Christian faith means; redemption, universal access, sacrifice, mission and ministry, sharing of the Word of God with all the nations of the world. It also makes the cathedral a sacred worship place and a manifestation of the Christian faith in Awgu Diocese.

The bishop's miter is placed above the cross, symbolizing the bishop's episcopal authority, as the chief shepherd and spiritual leader of the diocese. The positioning of this above the cross reminds us of the bishop's pastoral care role in the Church of Christ, as he is called to lead, teach, and serve the faithful in line with the teaching of the Gospel. These two symbols embody the unity of the Church and the Church's ordained leadership.

The form of the cathedral is thus built around the synthesis of the symbolic elements. The composition is well balanced, with expressive verticals and a modern rendition of the Catholic church architecture, which makes it a landmark of great spiritual value and well differentiated.

The sanctuary is visually and liturgically the central part of the building, and the interior is designed to allow for an unobstructed view and sound from the sanctuary to every part of the worship space. Light from the natural world comes in through clerestory glazing and stained-glass windows that flood the interior with light and enhance the sacral ambiance, and diminish the need for artificial illumination for daytime worship.

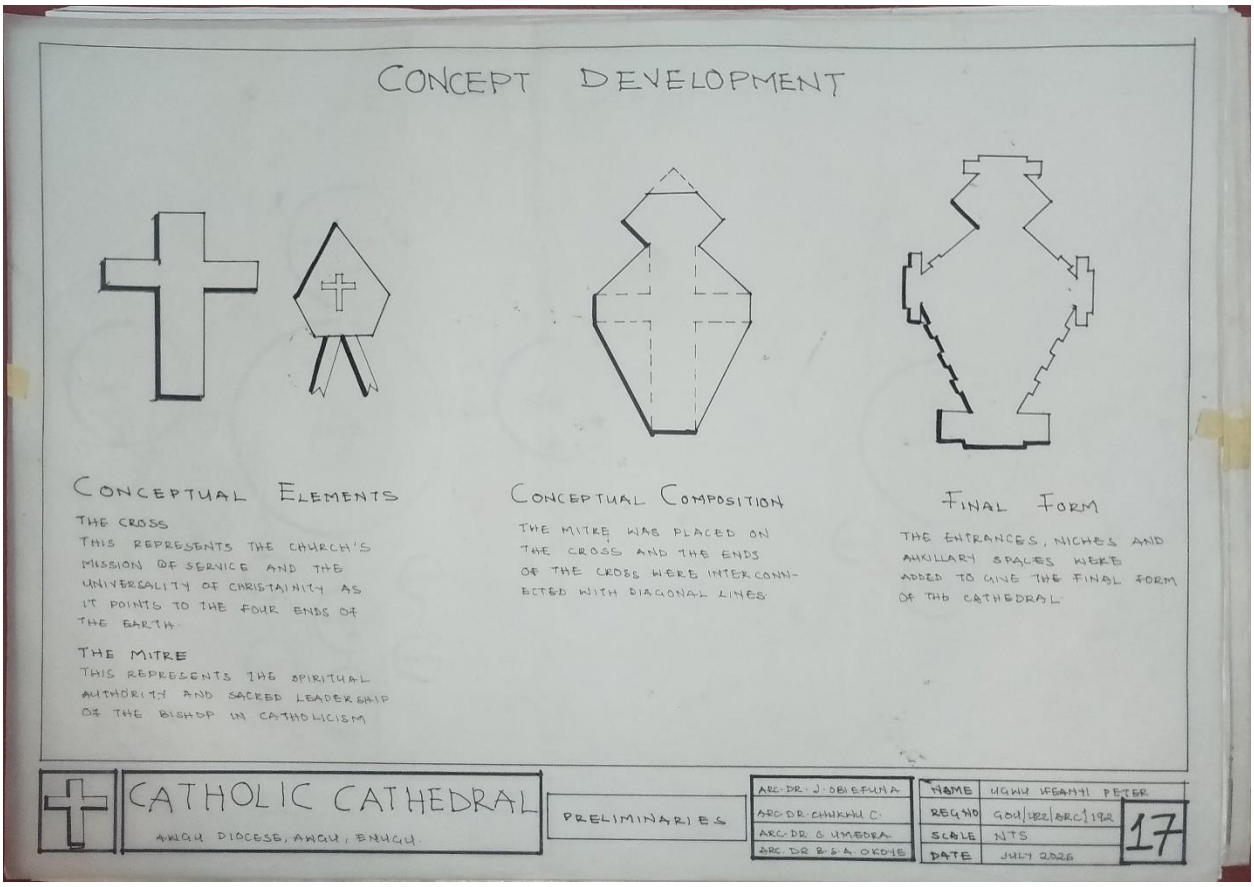

Figure 5.5: Concept development sheet

Source: Author

From an acoustic point of view, the proposal integrates:

I. balanced reverberation,
II. controlled sound reflections,
III. sound diffusion,
IV. selective sound absorption,
V. acoustically responsive ceiling geometry,
VI. optimized seating layout,
VII. carefully selected interior finishes.

Electronic sound reinforcement is incorporated as a complementary system rather than the primary means of achieving acoustic quality.

5.8 2D and 3D Presentation Drawings

The completed design proposal is displayed through use of a number of architectural drawings and three-dimensional visualizations. Those for a presentation will include:

Here are the presentation drawing

I. Location plan

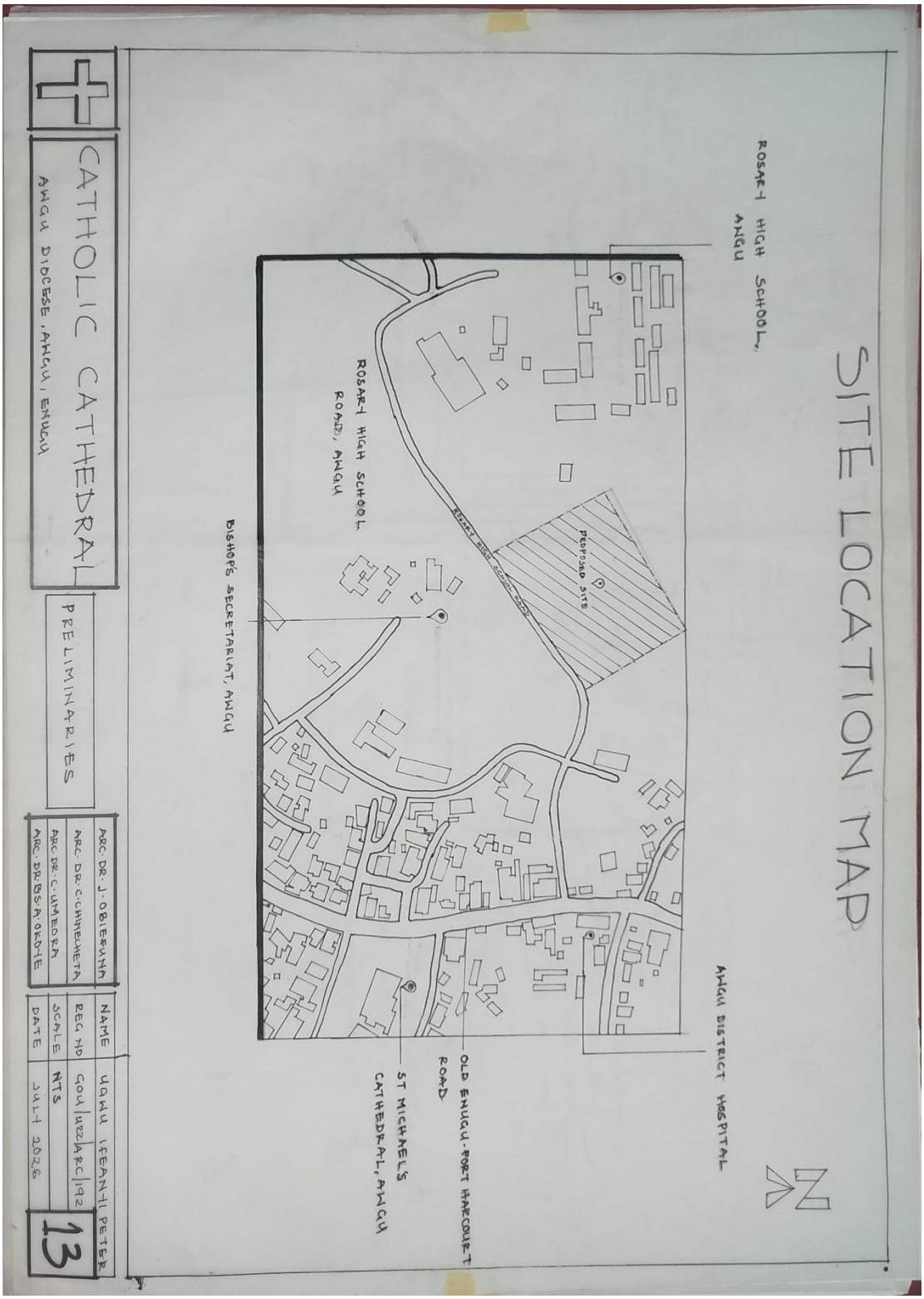

Figure 5.6: Site location map

Source: Author

II. Site plan

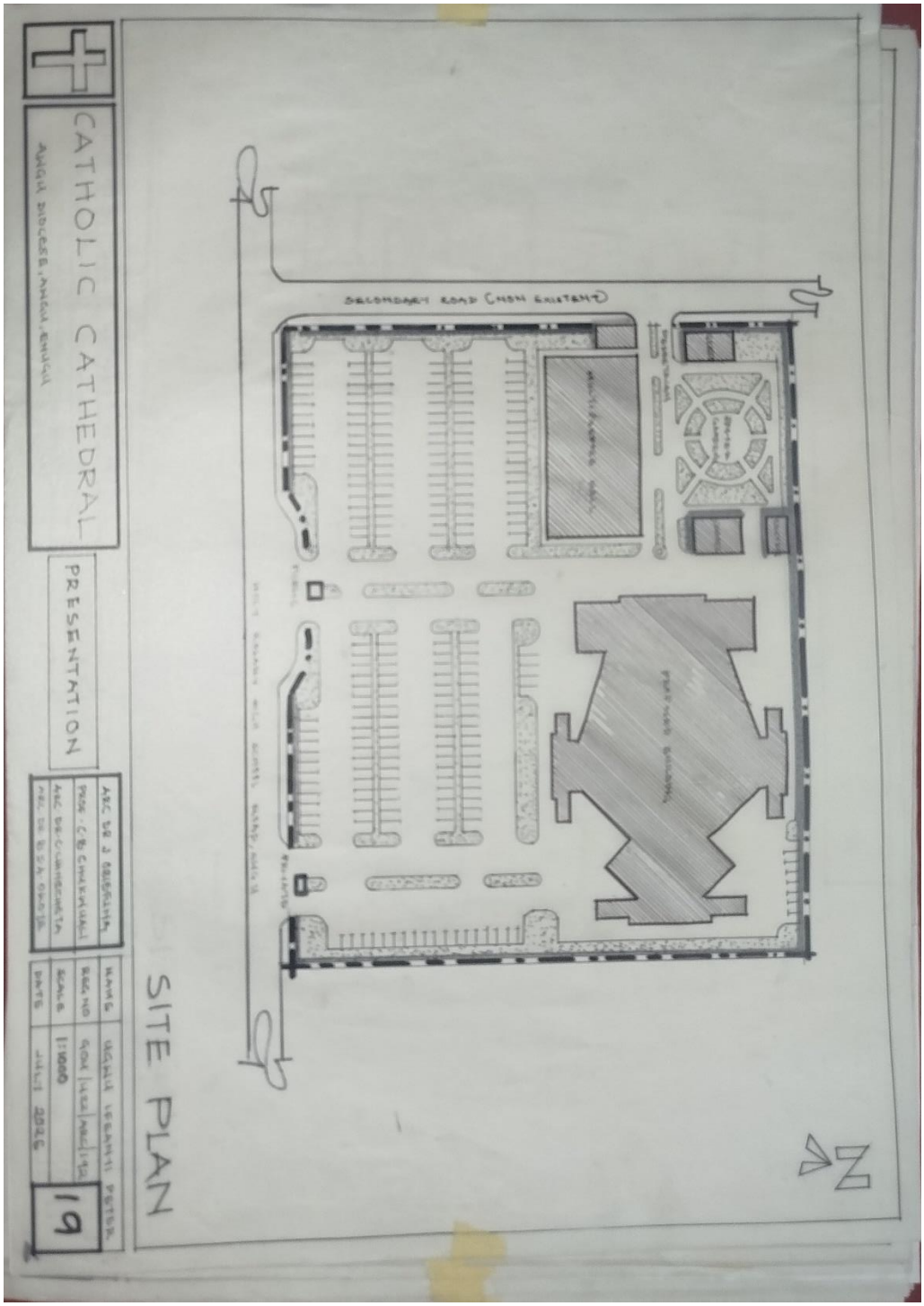

Figure 5.7: Site plan

Source: Author

III. Floor plans

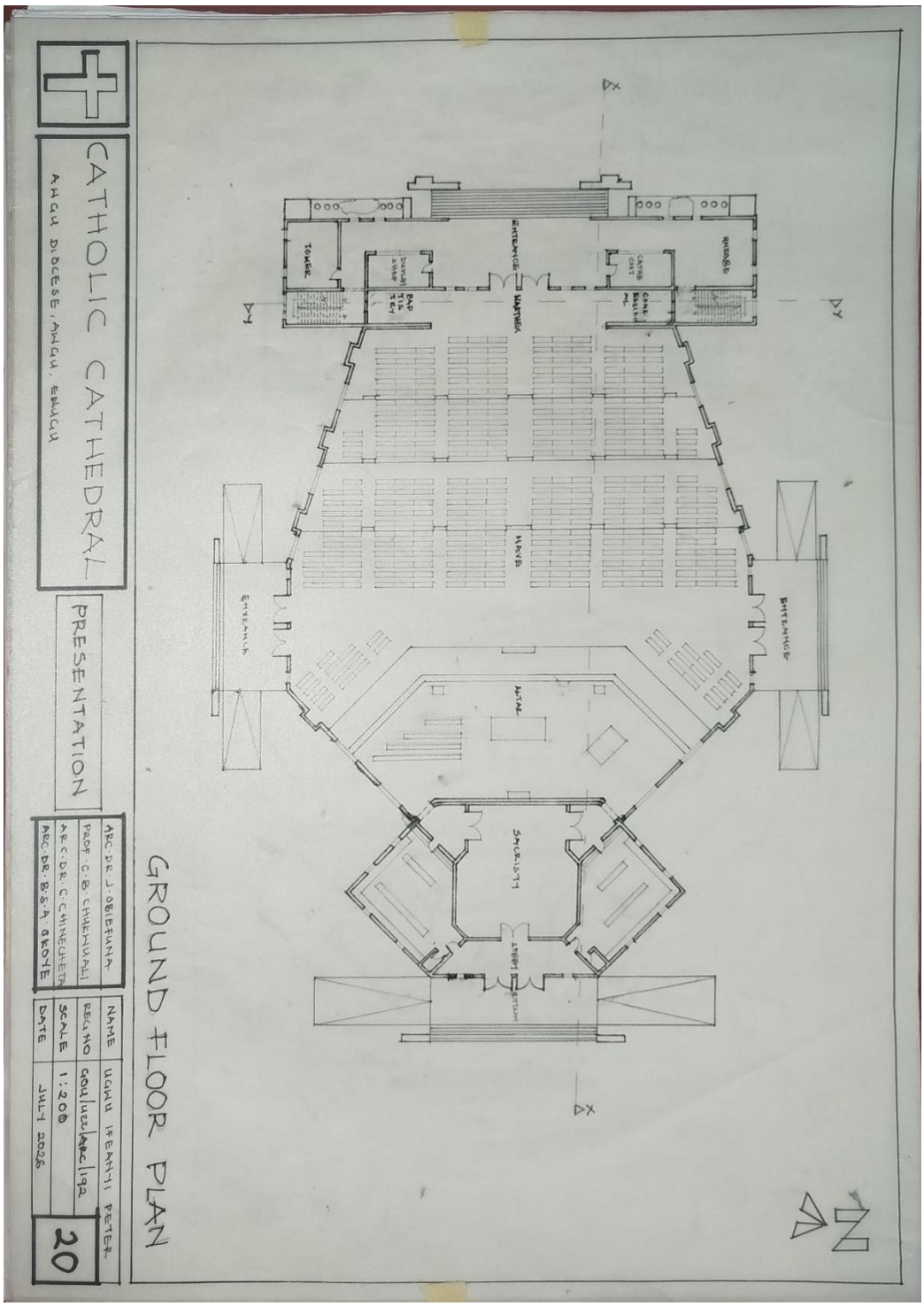

Figure 5.8: Ground floor plan

Source: Author

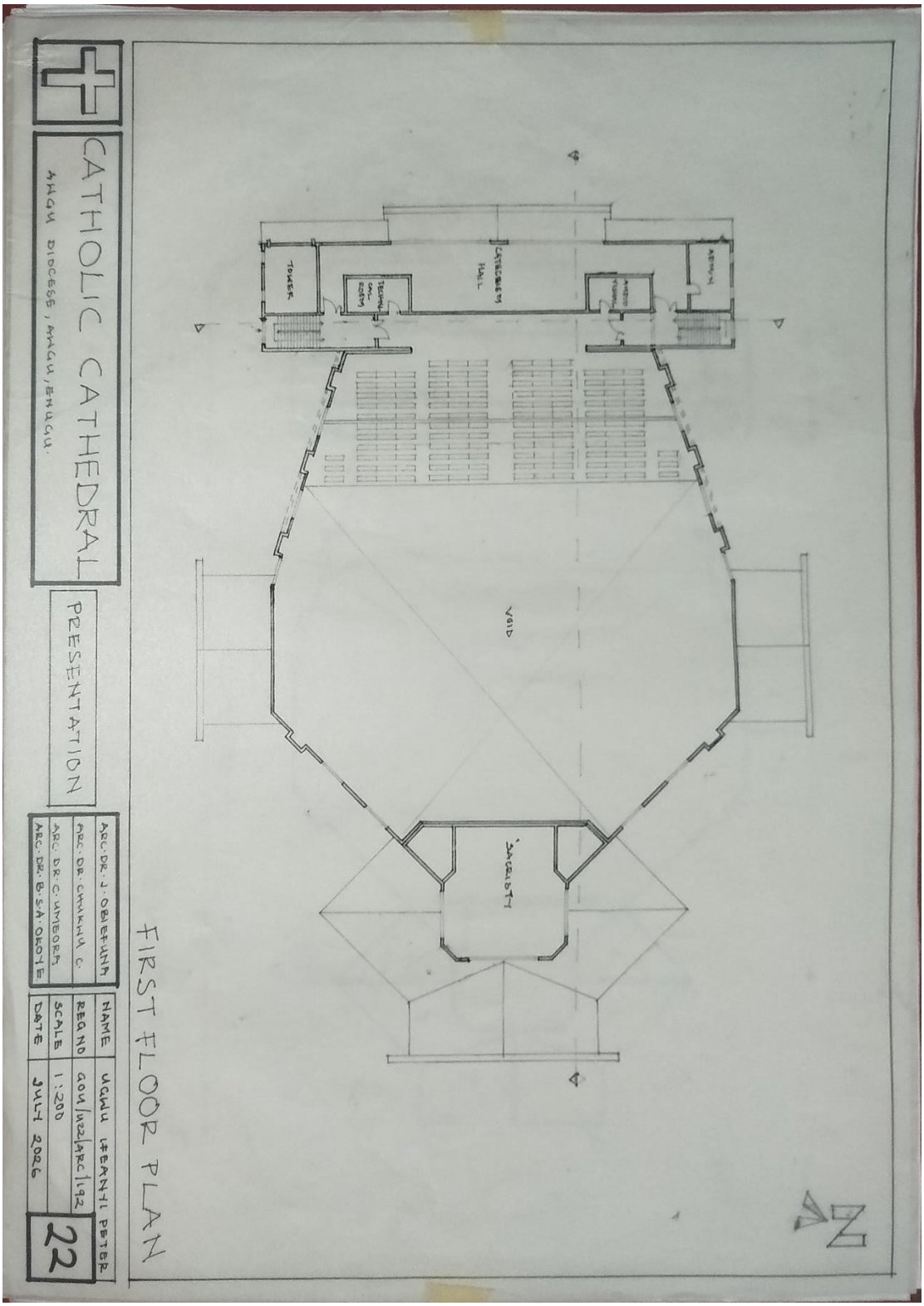

Figure 5.9: First floor plan

Source: Author

IV. Roof plan

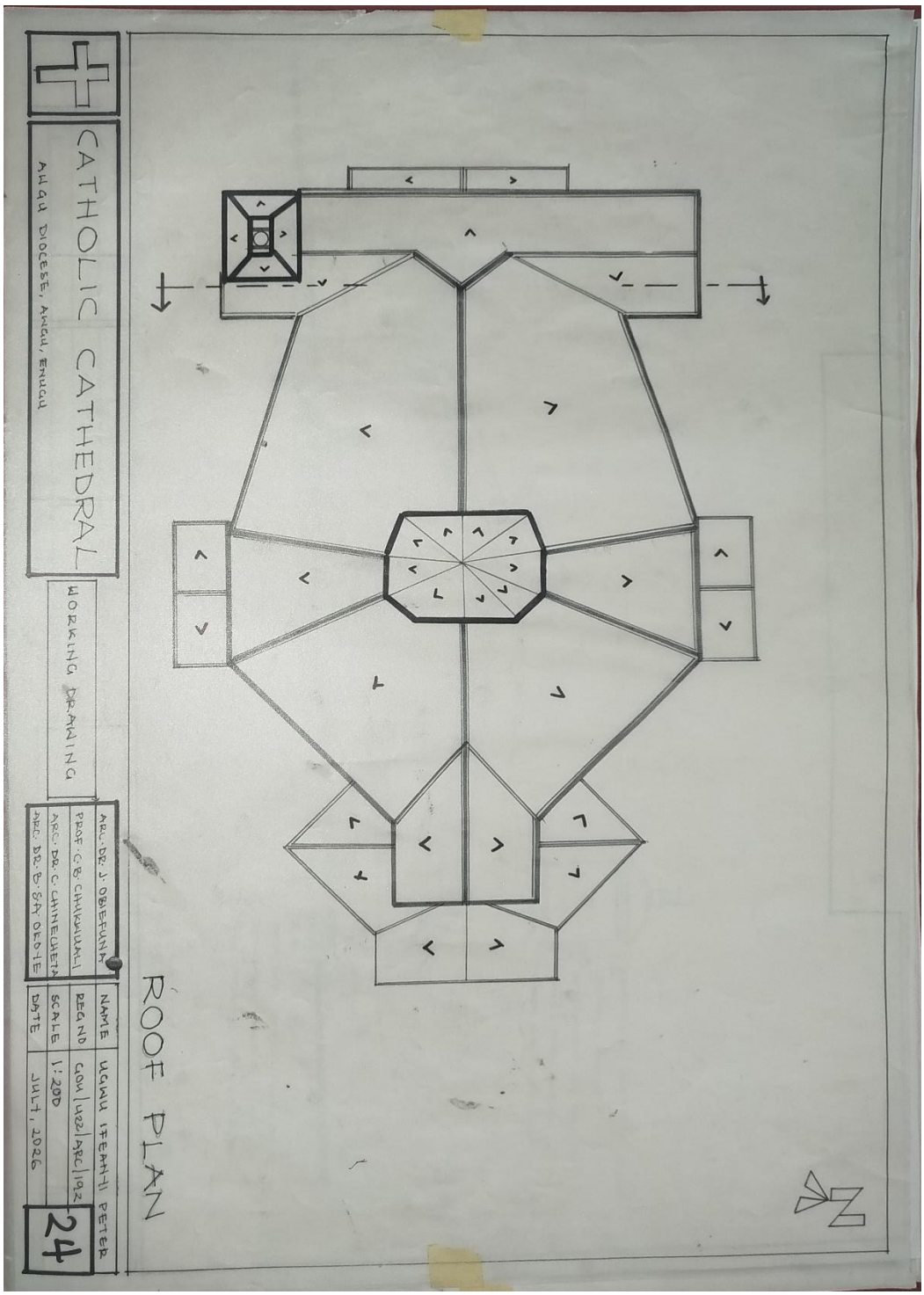

Figure 5.10: Roof plan

Source: Author

V. Elevations

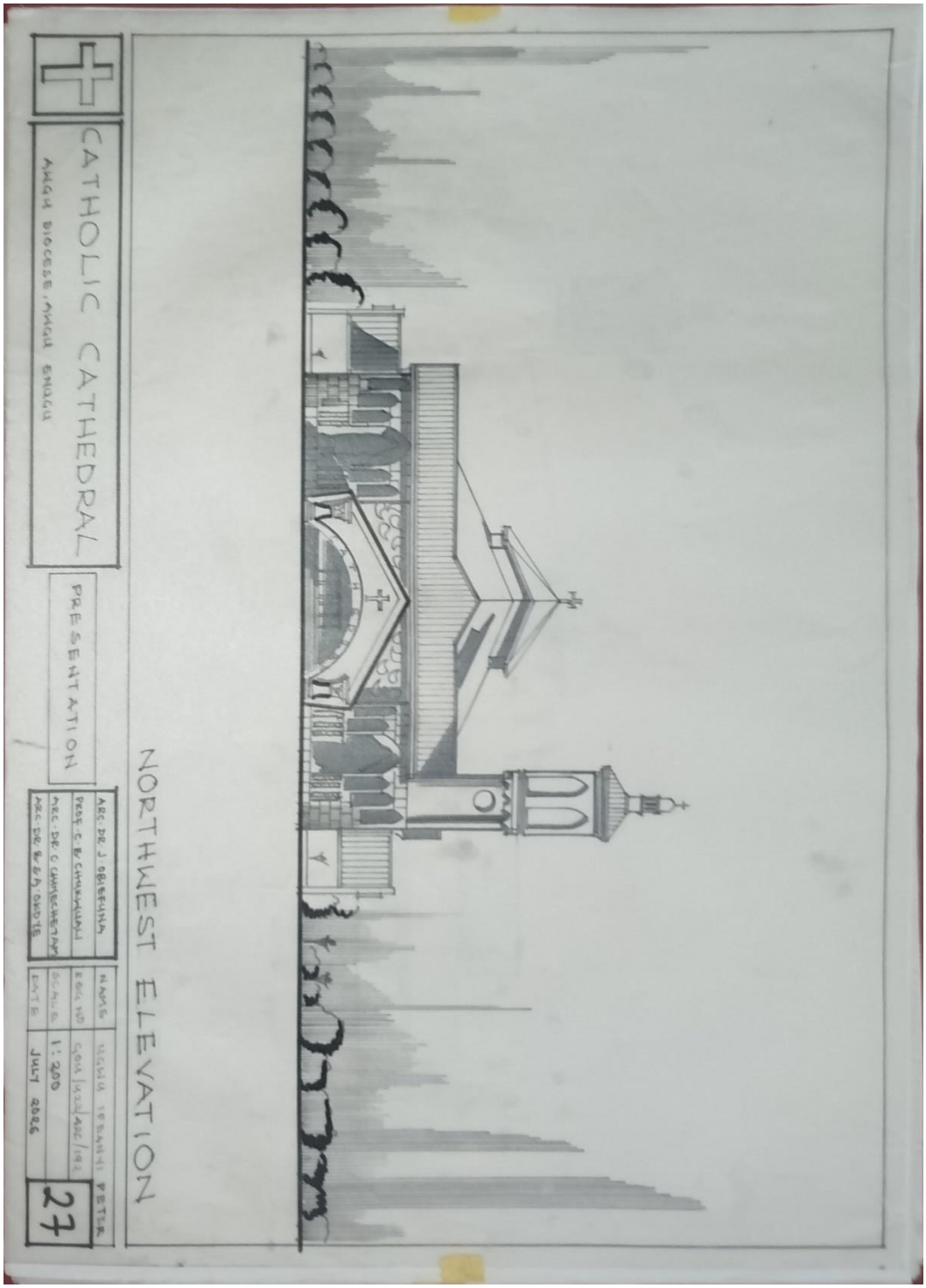

Figure 5.11: Northwest elevation

Source: Author

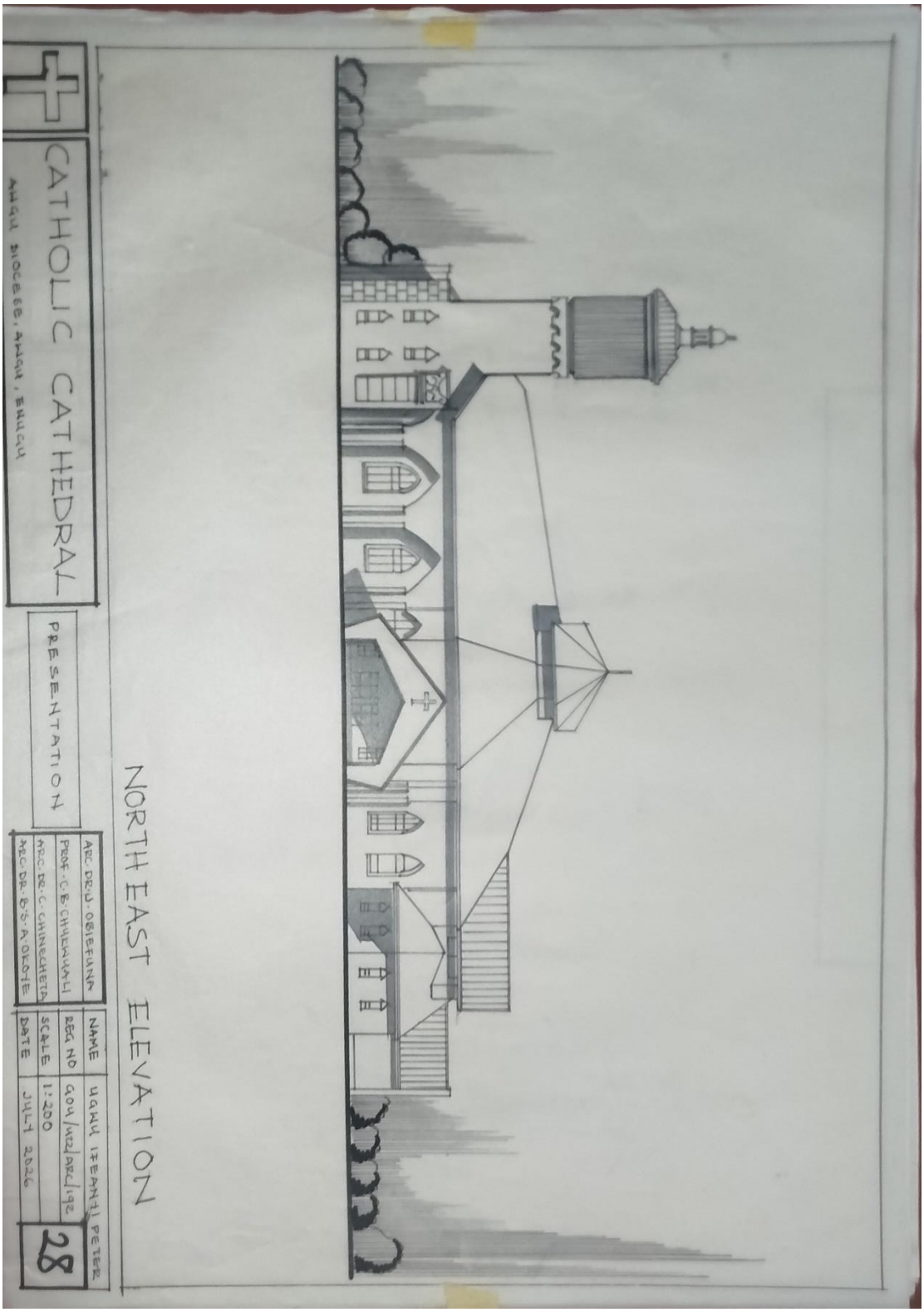

Figure 5.12: Northeast Elevation

Source: Author

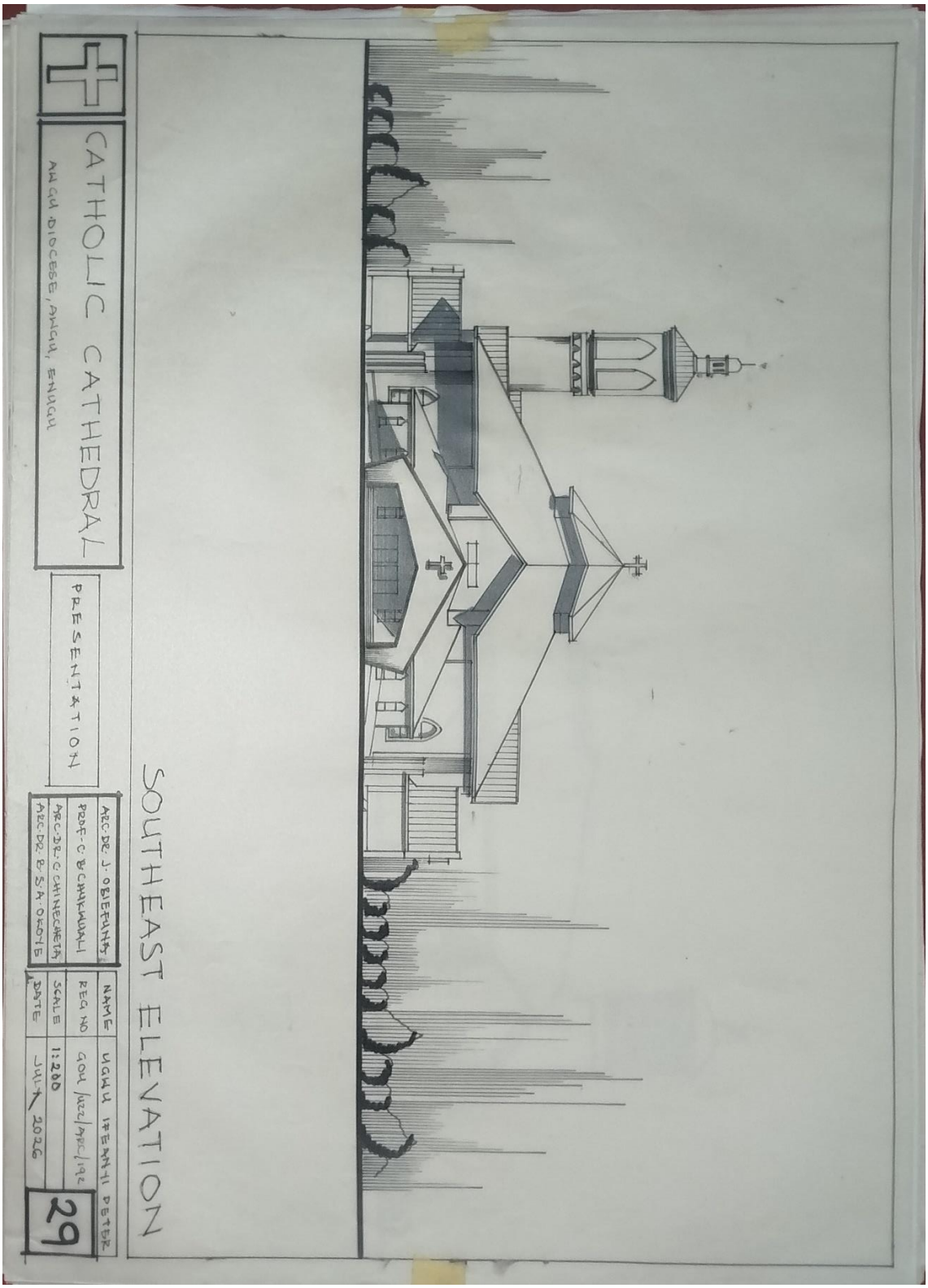

Figure 5.13: Southeast elevation

Source: Author

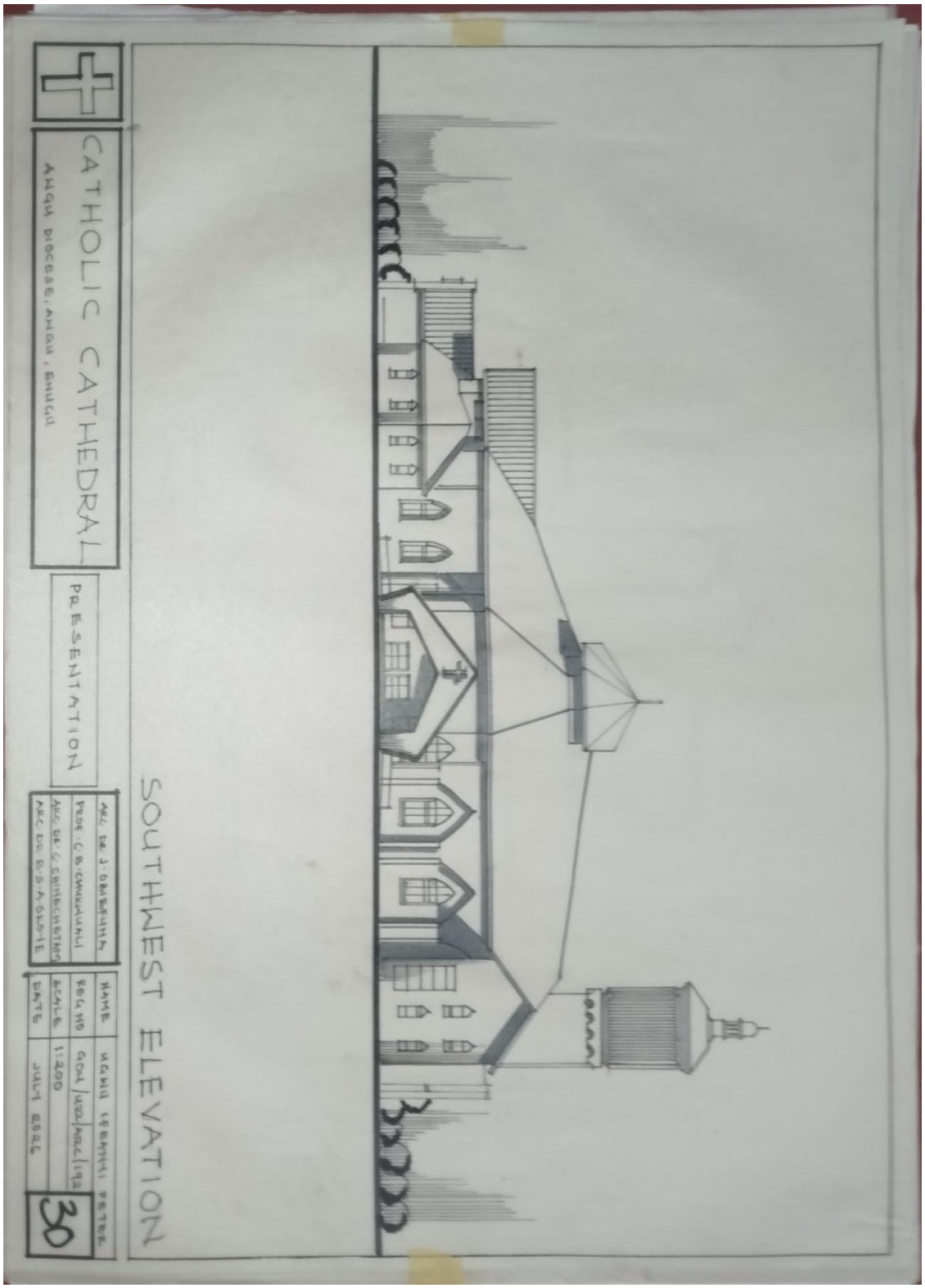

Figure 5.14: Southwest elevation

Source: Author

VI. Sections

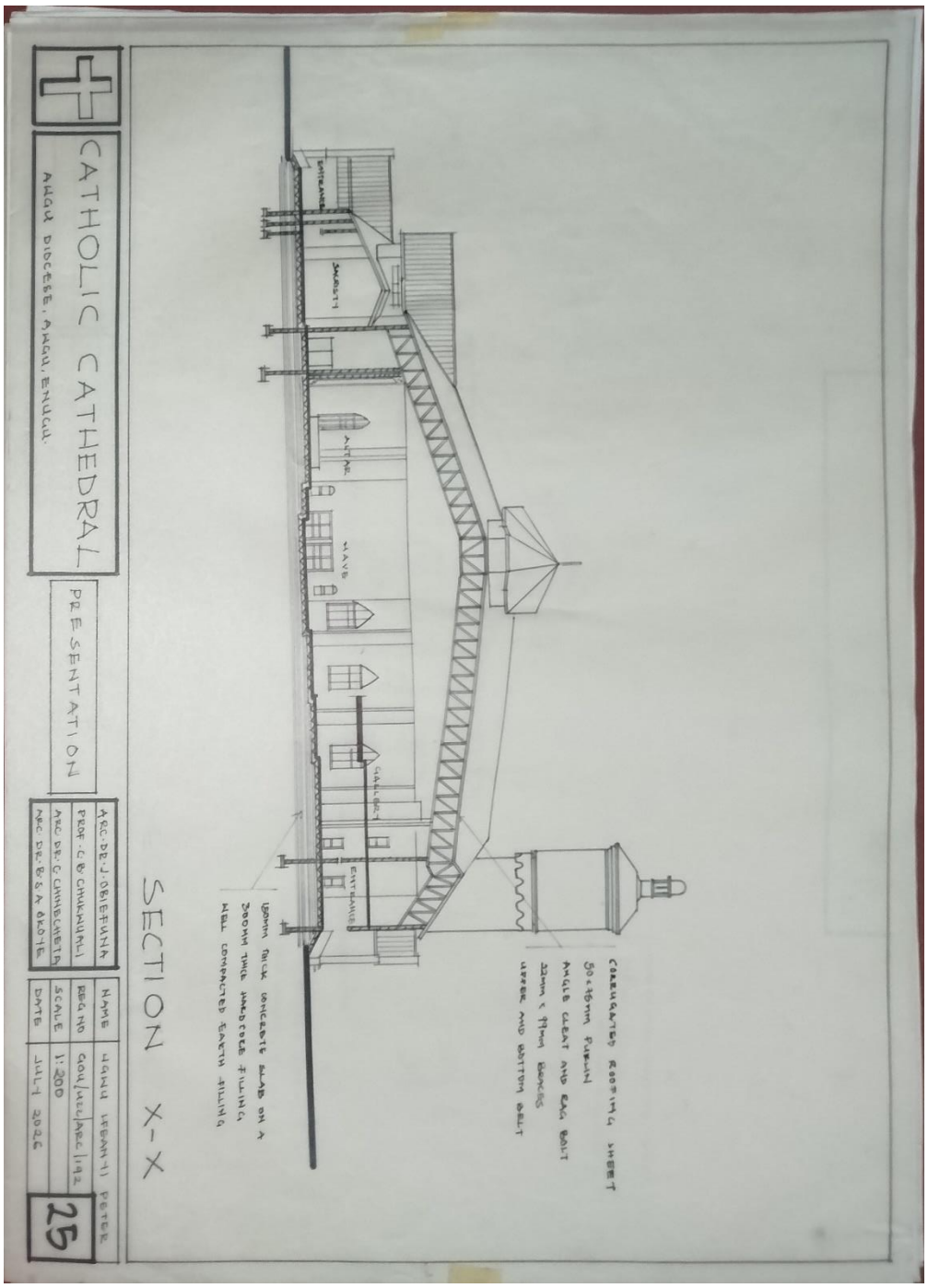

Figure 5.!5: Section x-x

Source: Author

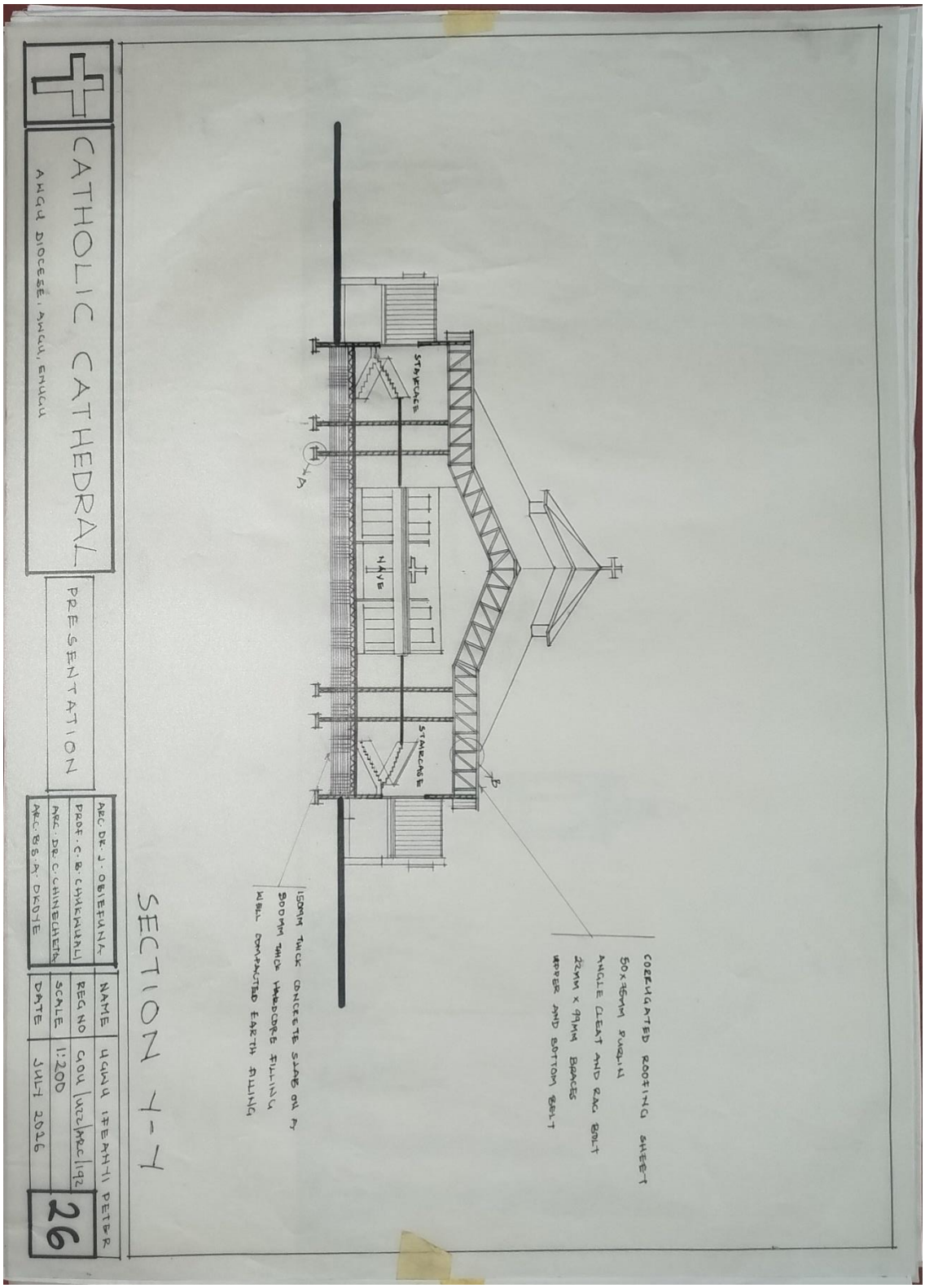

Figure 5.16: Section y-y

Source: Author

VII. Details

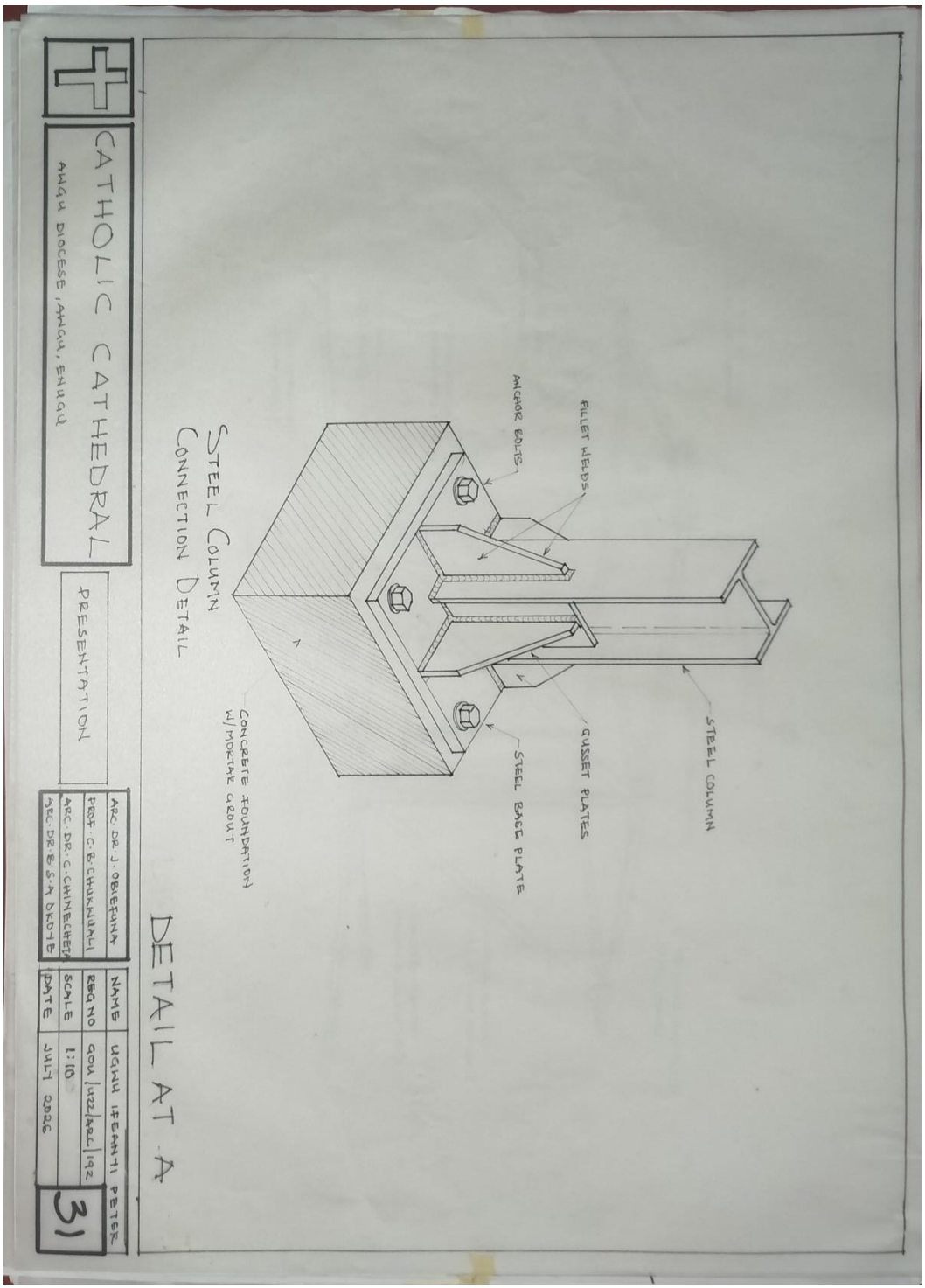

Figure 5.17: Detail at A

Source: Author

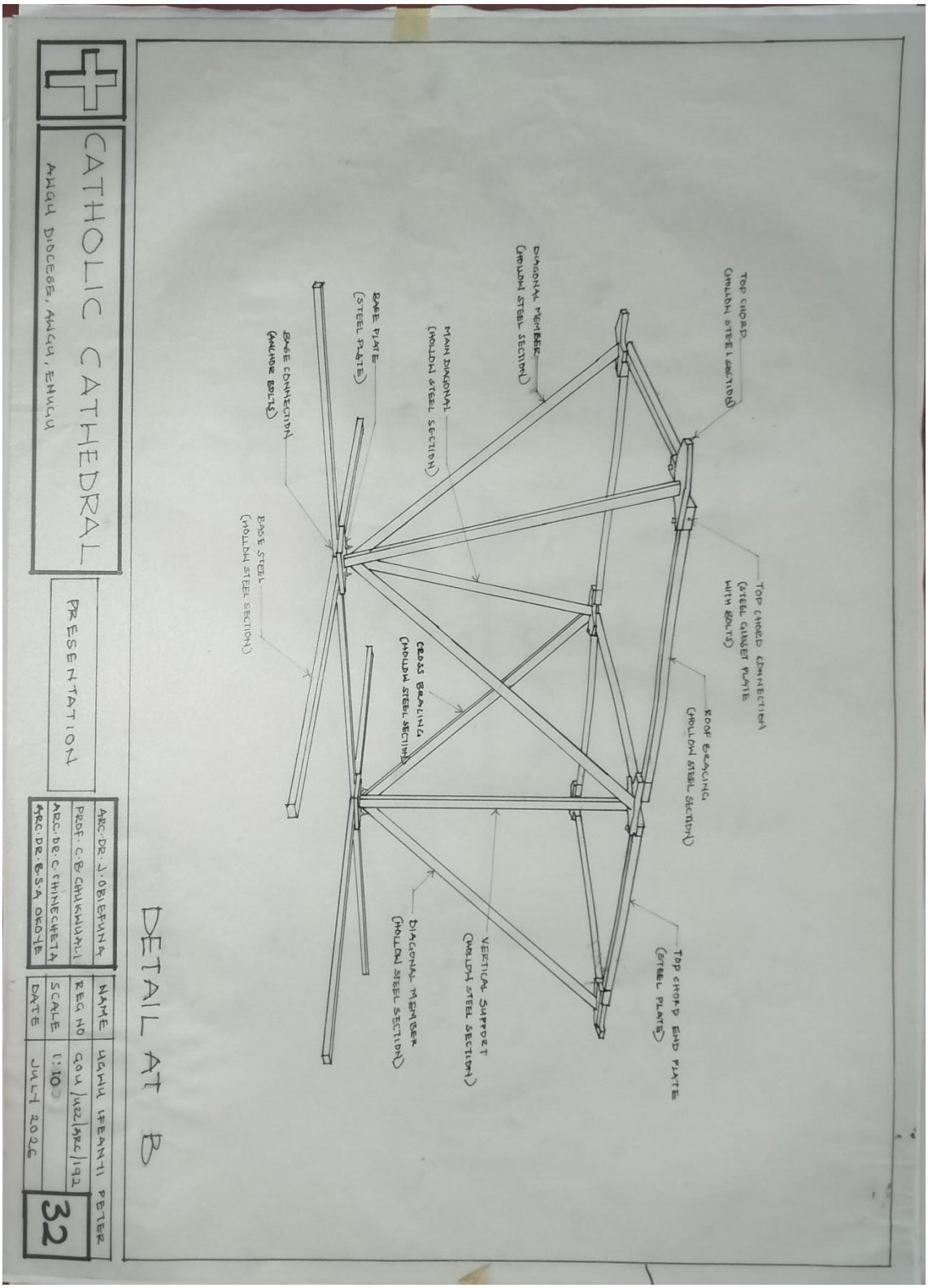

Figure 5.18: Detail at B

Source: Author

VIII. External perspectives

Figure 5.19: External perspective

Source: Author

IX. Internal perspectives

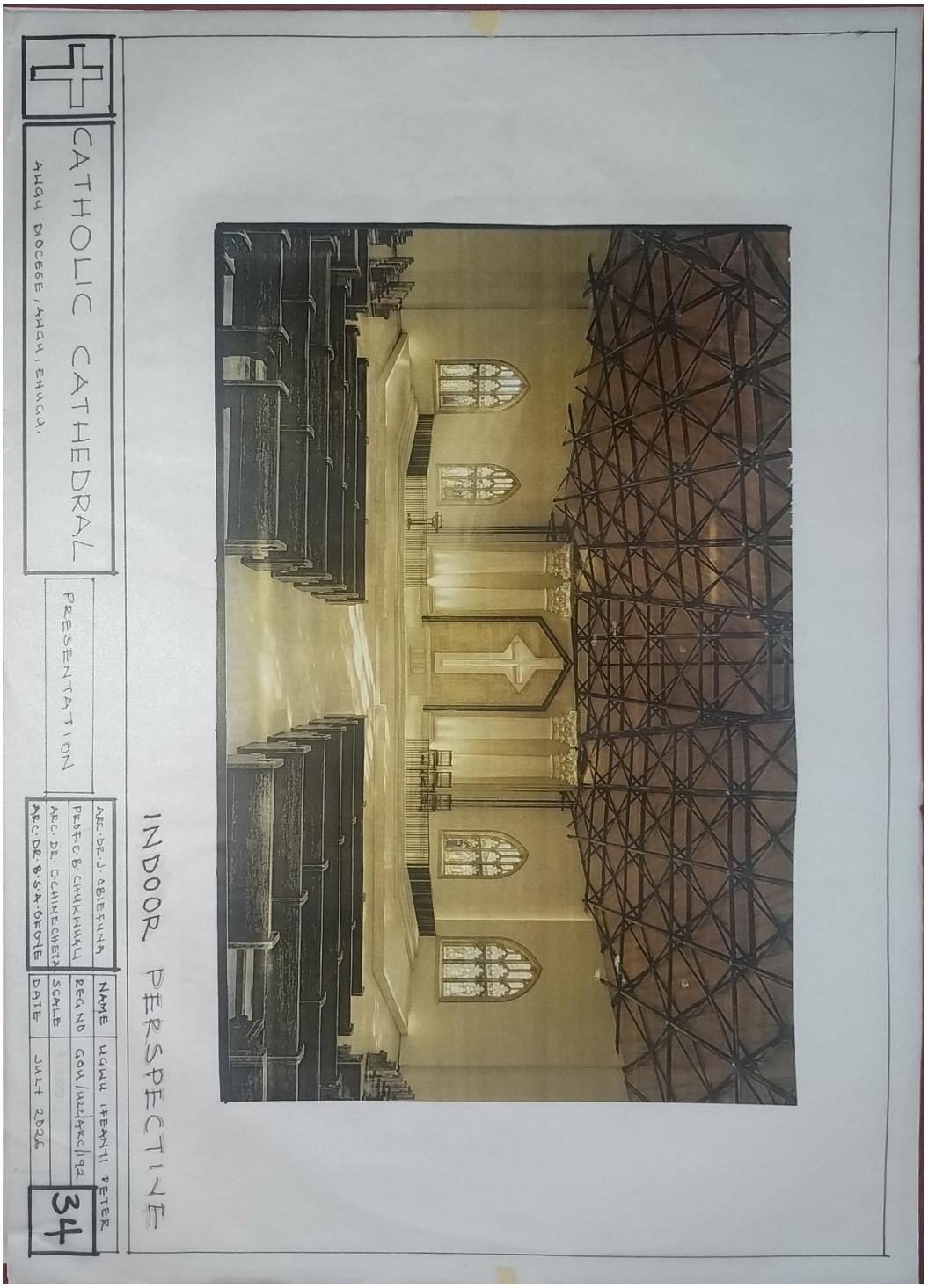

Figure 5.20: Internal perspective

Source: Author

X. Bird's-eye aerial view

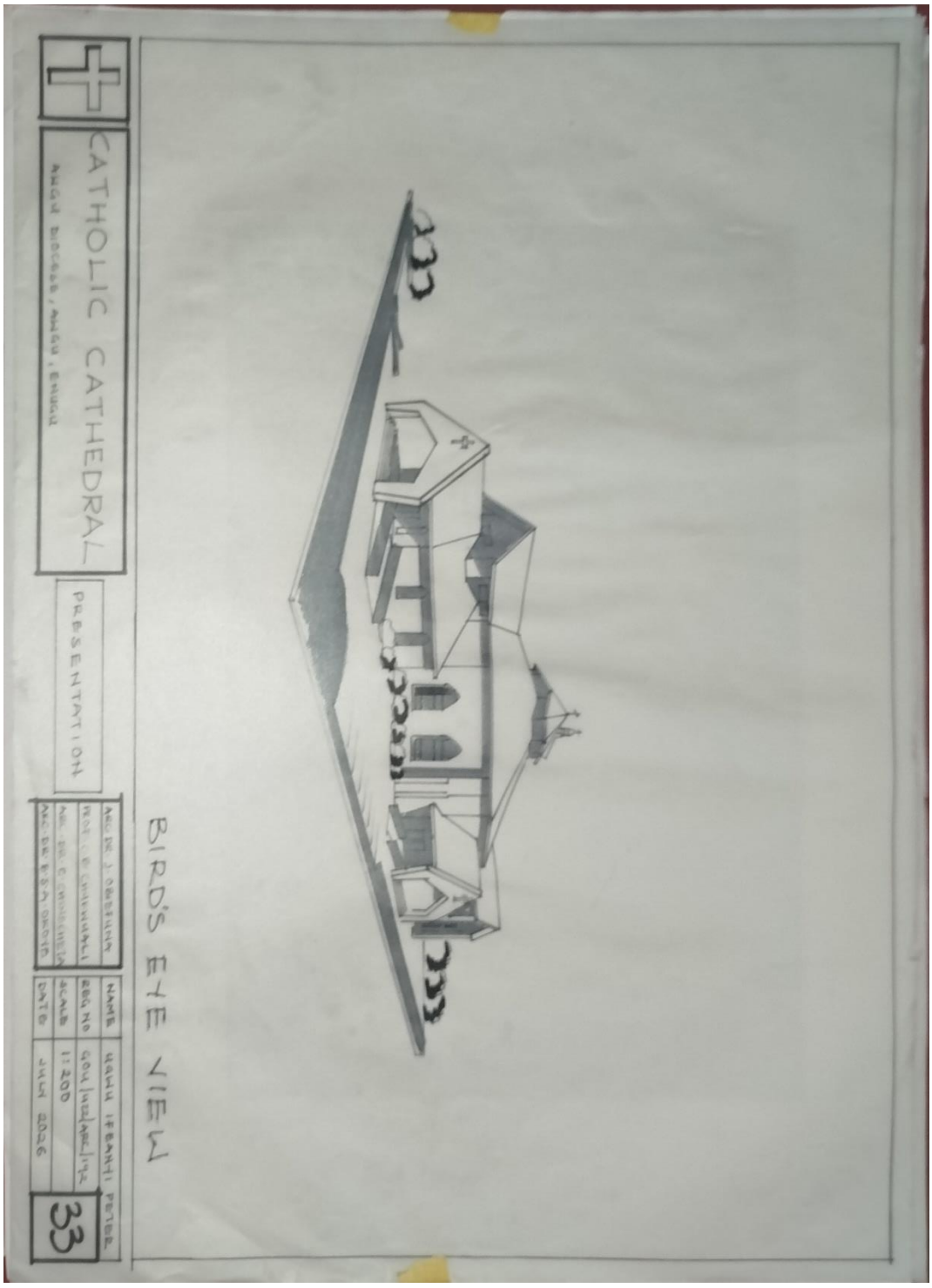

Figure 5.21: Birds eye view

Source: Author

These drawings illustrate the relationship between form, function, structure, environmental response, and acoustic design.

5.9 Detailed Drawings and Physical Model

Key architectural features were also elaborated through detailed drawings including

The floor plans, the elevations, sections, and select details. In addition to the presentation drawings, a physical model of the designed cathedral was produced in order to demonstrate the massing, the hierarchy of spaces, the landscape integration, and the architectural quality of the project.

The physical model also provides a further insight to perceive the relationships of the cathedral with its context, while presenting the circulation and proportions of buildings as well as open spaces. The final design of the cathedral successfully integrates the architectural acoustics with contemporary cathedrals by incorporating appropriate design techniques, material selection, and architectural form.

Plate 5.1: Front view of model

Source: Author

Plate 5.2: Back view of model

Source: Author

Plate 5.3: Side view of model

Source: Author

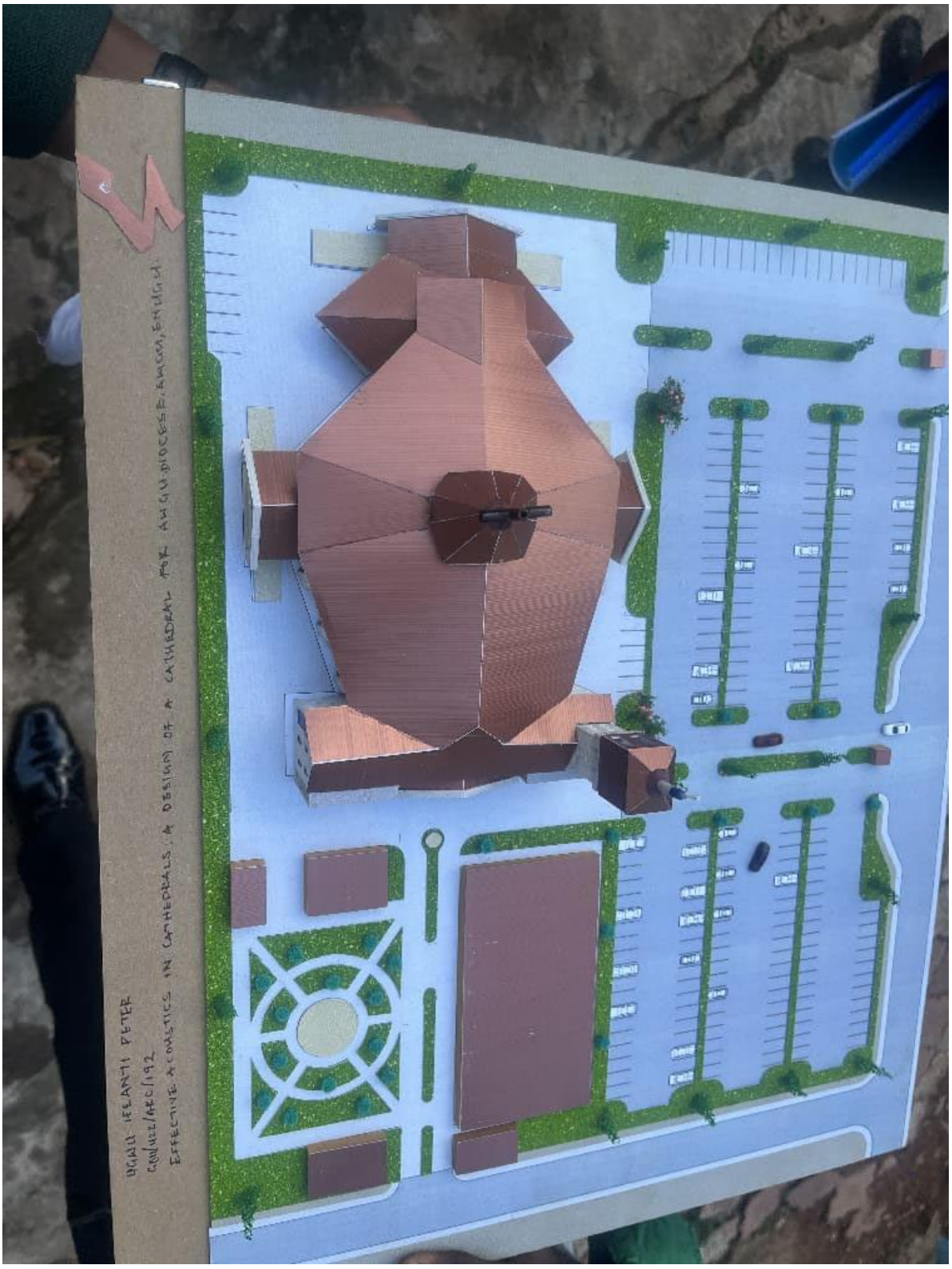

Plate 5.4: Top view of model

Source: Author

Ultimately, this investigation results in the proposal for an Architectural design for a new Cathedral; spiritually uplifting, environmentally conscious, acoustically effective, and future proof to the current and emerging needs of the Catholic Diocese of Awgu.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Summary of Findings

The reason of conducting this study was to examine architectural acoustic properties and how to apply these properties to a Catholic Cathedral for the Awgu Diocese of Enugu State. The study acknowledged that the main function of a cathedral is to create a sacred space for worship, but that the acoustical setting will play an important role in the effectiveness of a cathedral. It is the right of the worshipper to hear the liturgy clearly spoken, to enjoy the luxury of a rich liturgical repertoire, and to participate in the liturgy.

Through the literature search, it was concluded that architectural acoustics is not an add-on to the design, but it is a part of the design. The geometry of the building, the height of the ceiling, room proportions, interior finishes, choice of materials, and the type of seating arrangement all affect sound distribution, speech intelligibility, reverberation time, and acoustic comfort (Long, 2014; Cox &D'Antonio, 2017).

This study also explored the impact of the various architectural shapes on acoustics in a worship space. The layouts found to be most suitable were long forms and modified rectangle forms, which resulted in a greater speech intelligibility and uniformity of sound distribution than circular or centrally planned layouts. Domes and high vaulted ceilings have a positive effect on the musical richness, but must be acoustically treated to avoid excessive reverberation and focusing.

The study of the acoustic materials also showed that the combination of absorptive, reflective, and diffusive materials in an appropriate way is vital to achieve balance in the acoustic condition. When building upon the existing structures, some of the more commonly incorporated sound-

proofing techniques involve adding timber, perforated panels, acoustic plaster, upholstered chairs and textured wall surfaces to name a few.

Both case studies - local and international – demonstrated the critical significance of effectively marrying architecture with acoustics, liturgy and responding to environment in cathedral design. Contemporary cathedrals today are generally fitted with sound systems in a range of sizes, complete with the electronics for amplified sound – however the finest systems begin by addressing acoustical performance by designing architecture, only then installing amplification.

The results of the area investigation indicates that the environment is suitable for the proposed cathedral in Awgu. Low level of ambient noise, generally benign terrain and vegetation, developed road network and tropical wet and dry climate are present which will be addressed in the design to achieve a building that will react to the environment and worship requirements.

The findings from the literature review, case studies, and the site analysis formed the foundation of the design proposal that is put forth in Chapter Five. The design for the proposed cathedral represents a confluence of the principles of acoustical design, Catholic liturgical needs, environmental design and expression in the architectural form. It has aimed to provide an appropriate space that allows for the effective and intelligible use of words and music with a minimal reliance on electronic amplification by carefully considering factors such as: building orientation, geometry of ceiling forms, building material selections, natural airflow and layout of buildings.

However, the general finding of the study demonstrates that architectural acoustics should be regarded as a primary design criterion of cathedral projects. If the acoustic criteria are incorporated during the conceptual phase, it contributes to the functionality, comfortability, user experiences, spirituality, and serviceability of the building throughout its service life.

6.2 Conclusion

Design of a Catholic cathedral is more than the making of a magnificent building; it is the making of a place for liturgical, musical, social and spiritual worship to take place. The acoustic response is just one element that can be integral to achieving this and it is often a criterion that gets neglected when considering the design of church buildings.

This research indicates that it is quite possible that in the many situations where worship spaces have inadequate acoustic facilities the fault is not with the sound system but with architectural aspects, as for example the shape and form of the building, its proportions, its surfaces and finishes and even the spatial organization. Architects can use design solutions to create worship spaces for the wholeheartedly interactive congregation to hear the music and the service and participate joyfully in worship.

The suggested Catholic Cathedral in the Awgu Diocese is an application of research in the architectural world. The architecture is concerned about liturgical, environmental, acoustics concerns, and as well, the spiritual as well as symbolic values inherent to the Catholic Cathedral building. It reveals how proper utilization of technology can yield to the acoustic benefits in passive architectural systems.

Additionally, the study calls for a collaborative and interdisciplinary approach to designing cathedrals. There are complementary roles for architects, acoustic consultants, structural engineers, mechanical engineers, liturgical planners, and church authorities in all aspects of worship space planning that make the space both technically and spiritually successful.

Finally, good acoustics should not be considered a frivolous optional design element but must be considered as a necessary part of good church design. The use of acoustical principles from a very early stage in design is a major factor in the success, usability, and durability of cathedral buildings.

6.3 Recommendations

From the results of this study, it is recommended that:

1. Cathedrals should take into account acoustic issues from the conceptual design phase, not once construction has started.
2. During the design process, architects must work closely with acoustic consultants, structural engineers, mechanical engineers, and liturgical planners to ensure both a balanced architectural and acoustic performance of the building.
3. The acoustical quality should be a major consideration in the design of new cathedrals or in major renovations of existing worship spaces, by church authorities.
4. Aesthetic judgment and selection of building form, ceiling configuration, and interior finishes should be made, not only in terms of the building's appearance, but also its impact on the behavior of sound in the worship environment.
5. Proper room geometry, design of sound reflection, sound diffusion, and selective sound absorption should be used as passive acoustic strategies before using electronic amplification systems.
6. Future developments in the cathedral in Nigeria must be designed in an environmentally responsive way, combining all the design principles of natural ventilation, daylighting, sustainable materials, and acoustic performance to enhance the occupiers' comfort and ensure lower running costs.
7. Teaching of architectural acoustics should be improved in design studios and building science courses in architecture schools to boost the training of future architects in the design of specific building types.

8. There is a need to conduct further studies of the acoustic performance of the already built churches and cathedrals in Nigeria and then come up with local design guidelines that match the climatic conditions, materials available, and the worship practices in Nigeria.

6.4 Contribution to Knowledge

From the results of this study, it is recommended that:

Cathedrals should take into account acoustic issues from the conceptual design phase – not once construction has started.

The architects, therefore, have to be able to collaborate with the acoustic consultant, the structural engineer, the mechanical engineer, and the liturgical planner during the design process to achieve both an architectural and an acoustic balance of the building.

The acoustical quality should be a major consideration for church authorities in the design of new cathedrals or major renovations of existing worship spaces.

The use of aesthetic judgment and selection of building form, ceiling configuration, and interior finishes should not be restricted to the visual appearance of the building, but also its acoustical effect on the acoustics in the worship space.

Electronic amplification systems should be used as a last resort; acoustic design of the room, proper room geometry, design of sound reflection, sound diffusion, and selective sound absorption are passive acoustic strategies that should be tried first.

Future developments in the cathedral in Nigeria must be designed in an environmentally responsive way, combining all the design principles of natural ventilation, daylighting, sustainable materials, and acoustic performance so as to enhance the occupiers' comfort and ensure lower running costs.

Teaching of architectural acoustics should be improved in design studios and building science courses in architecture schools to boost the training of future architects in the design of specific building types.

There is a need to conduct further studies of the acoustic performance of the already built churches and cathedrals in Nigeria and then come up with local design guidelines that match the climatic conditions, materials available, and the worship practices in Nigeria.

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