A PROJECT PROPOSAL ON:
EFFECT OF VARIOUS ALUMINUM ROOF COLOURS ON INDOOR THERMAL COMFORT OF OCCUPANTS IN A NATURALLY VENTILATED BUILDING.

Case study of Lecture Theatres In University Of Benin.

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CERTIFICATION

This is to certify that this work was carried out by MR. OGODO EMMANUEL CHUKWUEMEKA with Matric No: ENV1704556 of the department of Architecture, Faculty of Environmental Sciences, University of Benin, Edo state.

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To my course mates and colleagues who showed solidarity with me during perilous times, gave me moral and intellectual support during my academic voyage, thanks a lot, I will remain grateful of your positive contributions.

DEDICATION

To my family, most especially my loving parents, my loving sister, friends, my lecturers who enabled, supported, gave financial and emotional assistance in the course of my voyage in the University of Benin. I will forever remain appreciative and motivated by your avalanche of love.

ABSTRACT

Coloured aluminium roofing sheets represents the common roofing sheet for the most houses in Benin city. Different colours of aluminium deliver various impacts on the indoor environment. This study focuses on estimating the amount of heat gain and roof surface temperature obtained from different colours of aluminium . The paper hypothesizes that colour techniques could affect the thermal efficiency of aluminium roofs. The research was based on the simulation analysis applied on an actual room size with different colours (dark purple, green and orange} in the University of Benin, Benin-city. As a result, the findings affirm the hypothesis and show the significance of roof colour in the thermal efficiency of aluminium roof. This study contributes efficiently to the knowledge of the roofing design in the tropics. In addition, it will shed light on the economic sector and sustainability for optimum roofing concept particularly for low cost housing components in Nigeria.

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CHAPTER ONE

1.0 INTRODUCTION

. Everyone in the society is concerned about the subject of heat flow, which includes, of course, thermal transfer within a system. When it comes to necessities of life like food, housing, and clothing, both scientists and non-scientists may agree.

Fundamentally, the thermal conductivity of the materials that comprise a system governs thermal conduction and heat transmission. Basically, the heating process entails moving thermal energy from one place to another (Etuk, Akpabio & Akpabio 2005). There are three different mechanisms for this transfer to occur: conduction, radiation, and convection. The three main methods of heat transmission that were discussed before merit a little examination in order to ensure completeness and to jog the mind.

In convection, a physical agent, such as a fluid, transports heat from one location to another (liquid or gas). Conduction involves the movement of molecules through a substance while they are heated up. Convection and conduction both require a material medium, such as a solid, liquid, or gas, for the transmission of heat, but radiation is a wavelike form of heat transfer in which heat is considered as electromagnetic waves and where molecules' average positions do not remain constant.

Therefore, thermal conduction is the transfer of heat energy from the warmer to the colder region of the same body or from the warmer to the colder body in close physical proximity without moving the body's constituent particles.

As the three most significant qualities of materials, thermal conductivity, specific heat capacity, and thermal diffusivity, thermal conductivity is notably a crucial parameter to manufacture devices, expressing the relationship between the parameters as follows;

$$\gamma = d\rho c \qquad (1.1)$$

Where

γ is the thermal conductivity of the material,

$\rho$is the density of the material,

d is the thermal diffusivity and

c is specific heat capacity

Aluminium is the third most common element in the earth's crust, according to Ababio (2003), and is widely distributed as trioxosilicates (IV) in rocks and clays. The mineral bauxite is the principal source of aluminum. The Bayer method can transform bauxite into aluminum oxide (alumina). The Hall-Heroult technique and electrolytic cells are then used to transform the alumina into aluminum metal. It is the most often used metal after steel because of its flexibility.

From ultraviolet to infrared radiation, aluminum is a superb reflector. Since it reflects 80% or more of visible light, it is frequently used in lighting fixtures. The reason aluminum roofing sheets are available in a variety of aesthetically pleasing patterns and colors is due to their great reflection to visible light.

Aluminum is used in an expanding number of applications by combining its physical qualities, such as strength, lightweight, corrosion resistance, recyclability, and formidability. This variety of goods includes everything from building materials, roofing sheets, to thin packing foils. Due to its excellent conductivity and non-toxicity, it is also commonly utilized in the production of cooking equipment.

The goal of this research is to examine how the thermal conductivity (k) of three buildings with dark purple, orange, and green-coated aluminum roofing sheets influences the thermal comfort of the occupants..

Purpose of the Study

The purpose of this work is to determine the thermal conductivity of aluminum roofing sheets of coated dark purple, orange and green colors respectively, and to determine whether or not the thermal conductivity is affected by the color of coating in a naturally ventilated building.

Additionally, based on the findings, appropriate recommendations for the best color for roofing will be made.

Aim and Objectives of Study

The purpose of this work is to measure the thermal conductivity of dark purple, orange, and green-coated aluminum roofing sheets.

The particular goals are:

1. To ascertain the samples' thermal conductivity is one of the specific goals.
2. Based on the thermal conductivity figures, choose the coating color that is best for roofing.
3. To determine if the samples' thermal conductivity is impacted by the coating's color.

Significance of Study

The domestic and industrial environments are both extremely important for this work. According to the color of the coating on the roofing sheets and their thermal conductivity values, it will, among other things, help determine the temperature comfort ability of buildings.

Scope of Study

This work is limited to Buildings constructed with aluminums roofing sheets coated dark purple, orange and green and having a thickness of 0.50mm within the university of Benin premises. Only thermal conductivity of the samples is investigated. Other thermal characteristics are not taken into account.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter goes over any prior information you may have on heat transfer and associated terminologies. This will help in properly comprehending the idea of heat movement..

Introduction

According to research studies, urban areas could have 60% of their surface area covered by pavement and roofs (Akbari, Arthur, & Rosenfeld, 2008). In addition, this estimation is increasing as there is around 50% of the world population currently in urban regions, with expected increases to 70% at the end of 2040. Furthermore, roofing systems represent the main body of urban area that interacts directly with solar rays. Therefore, roof angles and claddings are one of the most elements that may lead to affect considerably the indoor environment. For both traditional and contemporary buildings, the pitched roof system represents the most typical construction design in hot, humid regions. This articular kind of roofing has been used the most because of the ability for it to dispel rain water at a faster rate and how it protects from excessive heat gain in the building

When assessing heat gain, it is necessary to take into account the weather, the location of the sun, the orientation and tilt of the building's external parts, surface reflectance, thermal capacity, and surface area (Mahdavinejad, Ghasempourabadi, Nikhoosh, & Ghaedi, 2012). Vijaykumar, Srinivasan, and Dhandapani's (2007) findings suggest that the roofing system accounts for 70% of all heat gain in a structure. The color of the exterior surfaces, particularly the roof, has a significant impact on the amount of heat gain in buildings and the internal temperature, especially in places without air conditioning..

The first attempt to objectively analyze the thermal behavior of various roof designs in terms of interior temperatures was made by Pearlmutter (1993). Runsheng, Meir, and Etzion (2003) conducted research on how much solar heat is absorbed by flat and domed roofs. The ratio of radiation absorbed by a curved roof to that absorbed by a flat one increases with increasing rim angle, according to the scientists, but it is only marginally influenced by site latitude and climate features. In a different study, Hadavand, Yaghoubi, and Emda (2007) compared the flow field over many roofs with various building shapes. They also calculated the related heat flow and Nusselt number for these roofs..

The temperature difference between two sides of vaulted ceilings rises with rim angle, according to Hadavand and Yaghoubi (2008). Fitzgerald et al. (2011) conducted research on the evaluation of solar gains from roof space in a temperate marine region. In a 2014 review, Al-Obaidi, Ismail, and Abdul Rahman examined the effectiveness of pitched roof angles and pitched roofs with attics in tropical climates.

Jayasinghe, Attalage, and Jayawardena (2003) also looked into how roof orientation, roofing materials, and roof surface color affected indoor thermal comfort in hot, humid regions. The conclusions drawn from this study have;

(i) The orientation of the roof has little bearing on the thermal conditions inside.

(ii) Choose clay tiles over cement fiber sheets for roofing.

(iii) The ceiling can be improved by covering it with aluminum foil, either with or without polystyrene.

(iv) Paint the exterior surface of the roof with a light colour such as off-white, especially if the roof covering is cement fibre sheets

Al-Obaidi, Ismail, and Abdul Rahman (2013) tested the impact of a pitched roof combined with aluminum sheet and reflective roof in Malaysia, but the focus of this research was to gauge the amount of light and heat gain from skylight systems. Rahman, Rahim, Al-Obaidi, Ismail, and Mui (2013) also looked into the effectiveness of affordable housing designs in tropical climates that focused on cement roof tiles for one story, low cost terrace homes. However, neither study evaluated different roof colors or roof pitches on metal..

As a result, most of researchers have not shed light on the investigation of heat gain with roof angles and colours associated with aluminum. Therefore, this paper hypothesizes that colour technique and roof slope could affect the thermal efficiency of aluminum roof. The paper aims to investigate these properties in same room size to shift the paradigm in the understanding of passive roofing design in the tropical architecture.

Brief History of Aluminum roofing Sheet

Aluminum Metal Roofing – /əˈlo͞omənəm/ – our favorite. Like the representatives at the Classic Metal Roofing Systems factory like to say, “Centuries old, forever new …”

First off, the age of this content is astounding. Nevertheless, recycling has led to the continued usage of an estimated 73% of all aluminum that has ever been produced. As early as 2000 B.C., the ancient Babylonians and Egyptians were using the first kinds of aluminum compounds, sometimes known as alums. There is a reason the revered "Dome of the Rock," built in 691, has an aluminum metal roofing system over asphalt roofing, as previously mentioned. Can you see the Dome of the Rock with asphalt shingles? Yikes. Do you not desire that your house resemble The Dome of the Rock? Okay, maybe not... because if it suddenly appeared all over New England, we would ruin the sacredness of the Dome of the Rock. The bottom line is that you should be persuaded by this time that aluminum metal roofing can work with almost any style or form of architecture.

Similar to other materials used for metal roofing, aluminum has been a common roofing material in many European cultures for ages, leading to the development of some stunning designs. There is an aluminum roofing system over 100 years old still standing flawlessly in the land down under, despite the fact that it just achieved its big break in the United States over the previous century. In Sydney, Australia, the Chief Secretary's office building had an aluminum roofing system built on it in 1880. It still exists. And what's this? It is still in excellent shape. In addition to steel and zinc, you can choose an aluminum metal roof. All metal roofs are not created equal. A variable level of performance will result from the usage of different materials, each of which will have unique properties. We shall discuss the drawbacks of aluminum roofing sheets in this essay.

Suppliers of roofing materials would point to the fact that aluminum roofing sheets are corrosion-proof as their key selling point. That's fantastic. But as consumers, we should be aware of additional material considerations. This will assist to clarify it to some extent and, hopefully, aid in guiding your choice.

PRONS OF ALUMINIUM ROOFING SHEETS:

Due to its many advantages, aluminum has become the industry standard in new construction projects. Aluminium roofing sheets are affordable and have a long lifespan. They are simple to handle and install, taking substantially less time. Depending on the application, a variety of alternatives for aluminum roofing sheets are available..

1. Aluminium is lightweight:

Despite its strength, aluminum is a remarkably light material, making it simple to move from one location to another. Additionally, it greatly simplifies handling roofing sheets on the job site. It doesn't add much weight to the overall construction because it isn't that heavy on its own.

2. Aluminium roofing sheets have high strength:

Comparing most other metals, aluminum has the highest strength to weight ratio. They are the preferred material to construct airplanes because of this quality. When combined with its lightweight quality, this special quality of aluminum makes it incredibly sturdy, making it one of the best materials for roofing..

3. As aluminium sheets are lightweight:

They can be installed rapidly on-site and with little difficulty because they are considerably easier to handle. You may do this to cut labor costs, waste time, and eventually save money.

4. Aluminium sheets are corrosion resistant:

Due to its corrosion-resistant qualities, aluminum does not corrode as quickly as other roofing metals do. Aluminium sheets are perfect for usage in industrial regions and all other places since they can tolerate a highly corrosive environment.

5. Aluminium has high malleability:

Aluminum is a flexible substance, making it simple to mould into a variety of forms and sizes. Depending on the nature of your application, this enables your roofing sheet manufacturer to present you with appealing options and designs..

6. Aluminium is environment friendly:

Due to its easy recycling, aluminum is one of the most environmentally friendly metals. When compared to the energy required to produce primary aluminum, recycling aluminum only uses about 5% of that energy. It retains all of its qualities over infinite recycling. Because of this, aluminum is one of the most environmentally friendly materials..

7. Aluminium sheets are safe:

Because aluminum is non-flammable, it does not easily catch fire. Additionally, because of its high strength, it does not dent easily and can sustain falling objects up to a point. Due to their effectiveness against rain, snow, and hail storms, aluminum sheets are also safe against fire..

8. Aesthetically pleasant:

To achieve the required finish, aluminum roofing sheets can be fashioned in a variety of ways and covered with other roofing materials. They can contribute to the modernization of your building and the overall aesthetic appeal of the whole thing..

9. Cost-Effective:

Aluminum roofing sheets have a somewhat greater starting cost than other materials, but they last a lot longer than other materials, making them a more affordable choice in the long run..

CONS OF ALUMINIUM ROOFING SHEETS:

1. Aluminum roofing sheets are much more expensive:

Compared to zinc or steel, aluminum is thought to be a much higher quality material. Due to this, it is priced higher in the market for metal roofs.

It is also much more expensive to install due to its durability when compared to roofing materials like tiles or asphalt shingles. It may be configured differently, necessitating the services of trained roofers.

2. Aluminum roofing sheets can be noisy:

Aluminum roofing sheets and other kinds of metal roofs can be noisy when it rains, which is one of their main drawbacks. Each large raindrop is like a drumstick being struck against the drum's batter.

They create a disorganized symphony of banging during strong storms that some people may find annoying. To lessen the noise, a second layer of soundproof material could be put directly underneath the aluminum roofing sheet..

3. Aluminum is easier to dent:

The malleability of aluminum is one of its qualities. It can be hammered into a shape without breaking or cracking if something is malleable. When it comes to shielding your home from the weather, this aspect of the aluminum sheet may not be as beneficial as it may seem.

Any large objects that fall onto your metal roof during a strong storm, such a limb, may leave their mark. The dent would alter the roof's aesthetically pleasing aspect. Additionally, that may lessen how effectively water flows off the roof.

4. Aluminum roofing sheets expands more under the heat:

This has a slighter stronger scientific connection. Please bear with me.

Let's say that steel and aluminum are the two types of metal roofing materials. Aluminum would expand about twice as much as steel at the same temperature. This is brought on by aluminum's inherent metallic qualities. It is difficult to change these properties.

As a result, there is a chance that the aluminum roof sheet may be harmed or even torn around a nail hole, which could result in roof leaks, as the roof expands. This suggests a terrifying drawback of aluminum roofing sheets. But don't worry! The world has changed!

. A skilled and qualified roofer would be able to properly lay the aluminum roofing sheet and set the roof's foundation. Therefore, the material's expansion while exposed to the light won't be a concern. On the negative side, this would result in higher installation costs for the roof.

5. Roof repair cost for aluminum roofing sheets can be higher :

Aluminum roofing sheets are simply aluminum sheets stacked one atop the other. It is not like tile or asphalt shingles, where a single cracked or damaged shingle may simply be exchanged for a brand-new one. For various kinds of metal roofs, the same holds true. The metal roof can be fixed in a variety of methods depending on the material.

The entire aluminum roofing sheet must be removed and replaced with a new one if it has been damaged and has to be replaced. One of the frequent drawbacks of metal roofs is this. Therefore, the cost of roof repair could not be as low as for those roofs with shingles.

6. Oil canning can happen :

Image from metalconstructionsnews

The oil canning of aluminum roofing sheets is common. That is how the roof appears to have an uneven surface. The roof may appear to be bulking due to apparent waviness that varies throughout the day. For homeowners, this appearance can be a little revolting.

Due to the unevenness of the milling procedure used to create the sheets, oil canning happens. Other contributing causes include inadequate space between the sheets for thermal expansion and incorrect handling of the aluminum roofing sheets during installation.

This can be avoided by choosing a qualified and professional contractor to install your roof, utilizing thicker roofing sheets, using low-gloss paint to lessen the reflecting nature.

7. Poor fasteners installation could cause roof leak:

: The screw holding your roof to the deck or substrate is referred to as a fastener. Unfortunately, improper fastener installation frequently results from human mistake. These could be openings in the roof where rainwater could soak in.

Among the frequent mistakes made by people when installing fasteners are

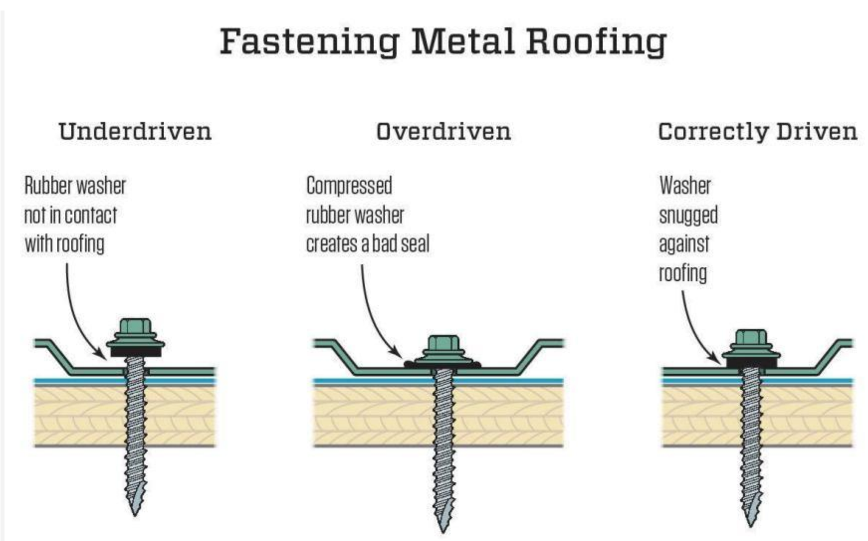

Image from JLConline

- Off-center fastener – An angle is taken when driving the screw into the roofing panel. As a result, the washer is unable to rest flat and successfully plug the hole..

- Under-driven fastener –.This occurs when the screw was not fully driven in to close the gap. The washer fastener is easily bypassed by flowing water, allowing roof leakage. When the roof installer worries about over-driven screws, this frequently occurs.
- Over-driven fastener – Usually, this occurs when a roofer tightens the fastener more than necessary in an effort to make it as waterproof as possible. But this might shatter or harm the washer..

The easiest method to prevent the fastener issue is to hire an experienced and dependable roofer to install your aluminum roofing sheets. This will lessen the likelihood that a roof leak will develop in the future.

Comparing metal roof leak detection to that of other roofing materials will also require a different strategy. But to begin with, you can look at the fasteners.

8. Prone to galvanic corrosion:

When roofs made of various metals interact with one another while being exposed to an electrolyte—in this case, rainwater—galvanic corrosion results. As a result, the material of the roof will deteriorate more quickly.

Due to their unmatched advantages, aluminum roofing sheets are growing in popularity among suppliers and contractors. Due to their high malleability, it is simple for a producer of roofing sheets to tailor them and provide roofing sheets that exactly meet your needs. Aluminum is an excellent material for all types of roofing applications since it is adaptable and simple to work with. Aluminum roofing sheets are now used for commercial and residential purposes as well as in industry.

Temperature Gradient

Yong, Anyakoha, and Okeke (2002) restated that if a metal rod is placed with one end kept at a high constant temperature X (hot end) and the other end kept in contact with another object at lower temperature Y (cold end), the two extreme ends of the rod now behaves as two systems at different temperatures. Initially, the flow of heat through the rod (i.e from end X to end Y) would raise the temperature of the cold end. However, it is not possible for the temperature of the cold end to be equal to the temperature of the hot end. It can therefore be said that a temperature gradient has been set up along the rod.

When the temperature of each part of the rod stops rising, the rod is said to be in its steady state.

Temperature gradient can be defined as the temperature difference per unit length along the bar (Freedman and Young, 2006).

Temperature gradient, is given as

$$\frac{d\theta}{dx} = \frac{(T_H - T_C)}{L} \qquad (2.1)$$

Where;

$\frac{d\theta}{dx}$ is the temperature gradient

T_H is the temperature of the hot end of the rod

T_C is the temperature of the cold end of the rod

L is the length of the rod in meters.

Heat and Internal Energy

When we put a cold spoon into a cup of hot coffee, the spoon warms up and the coffee colds down as they approach thermal equilibrium. The interaction that causes these temperature changes is fundamentally a transfer of energy from one substance to another. The energy transferred in this way is called heat (Freedman and Young, 2006).

Heat is the energy transfer between two bodies, one at a higher temperature than the other. Heat is hence internal energy that is in motion as a result of a temperature difference. Internal energy, not heat, is what a body is made of. The body's internal energy decreases as it gets cold; it increases when it gets hot. When energy is transferred from the environment to a system's thermal energy, represented by the letter Q, it is considered to be heat that is positive (we say that heat is absorbed). When thermal energy from a system is released or lost into the environment, the result is heat, which is a negative quantity (Halliday, Resnick, and Walker, 2001).

Heat Transfer Mechanisms

There are basically three mechanisms for the transfer of heat; conduction, radiation and convection. According to Anyakoha (2007), transfer by conduction involves solid states, convection involves fluids while radiation makes use of electromagnetic waves.

Heat Flow

Let's say we visualize a wall made of a consistent material, like plasterboard, that divides a warm area from a cold room. After some time, the temperature difference across the wall becomes consistent, and heat is continuously transferred from the warmer chamber to the cooler one (Etuket al., 2005).

Experiments show that the rate at which heat flows through the wall is proportional to its area A, proportional to the temperature difference ($T_2 - T_1$) and inversely proportional to the thickness (x) of the wall. This is expressed by the heat flow equation;

$$\frac{dQ}{dt} = kA\,\frac{T_2 - T_1}{x} \quad (2.2)$$

Where

$\frac{dQ}{dt}$ is the rate of heat flow

A is the area of the wall

$T_2 - T_1$ is the temperature difference

x is the thickness of the wall

k is a constant of proportionality known as the thermal conductivity.

The S.I. units for heat flow is J/s or watts.

The constant K (thermal conductivity) will be discussed in section 2.5. The rate of flow of heat through each section of a material depends on the temperature gradient, the cross sectional area A of the material and the nature of the material.

Thermal Conductivity (κ)

The thermal conductivity of a material is the intrinsic property of a material which relates its ability to conduct heat (Alam, Rahman, Halder, Raquib, &Hasan, 2012).

According to Halliday et al., (2001), The attribute of a material's capacity to conduct heat is called thermal conductivity, or k. Most prominently, it can be seen in Fourier's law of heat conduction. Watts per Kelvin meter is the unit of measurement for thermal conductivity (K.m). The rate of energy loss through a piece of material is predicted by thermal conductivity in terms of watts. The U-factor, which measures the rate of heat transmission and indicates how well the window insulates, is one way that thermal conductivity is expressed in the window building industry. The window insulates better the lower the U-factor. Thermal resistance is the inverse of thermal conductivity.

Conduction of heat varies in different types of solids. Metals are in general, good conductors and non – metals poor conductors. Silver is the best conductor followed by copper. Among the common metals, aluminium and iron are the next in the order of conductivity. Wood, paper, cork and polystrene are poor conductors of heat and are good insulators. Table 2.1 gives the thermal conductivities of some common metals, domestic materials, building materials and gases.

A more meaningful definition of thermal conductivity k is that it is the rate at which heat moves through two faces of a cube made of material with a length of 1 m when the difference in temperature between the two faces is 1 K..

Table 2.1 Thermal conductivities of selected materials (Halliday etal., 2001).

Material		Thermal Conductivity $KWm^{-1}k^{-1}$
a)	**Metals**	
	Aluminium	205.00
	Brass	109.00
	Copper	385.00
	Lead	34.70
	Mercury	8.30
	Silver	406.00
	Steel	50.20
b)	**Building Materials**	
	Brick (insulating)	0.15
	Brick (red)	0.60
	Concrete	0.80
	Cork	0.04
	Felt	0.04
	Fibre glass	0.04
	Glass	0.80
	Ice	1.60

	Rock wool	0.04
	Styrofoam	0.01
	Wood	0.12 – 0.04
	Soft wood	0.10
	Asbestos	0.15
c)	**Gases**	
	Air	0.024
	Argon	0.016
	Helium	0.14
	Hydrogen	0.14
	Oxygen	0.02

For a practical model of thermal conductivity k, consider a thin parallel – sided slab of material.

Let the thickness of the material be given as dx, area A, with one face (1) maintained at a temperature 0^0C and the other face (2) at $(\Theta - d\Theta)^0$. In the steady state, heat flows at a steady state from face (1) to face (2) in the direction normal (i.e at right angles) to the faces. The rate of heat transfer under these circumstances has been demonstrated through experiments to be proportional to area A, proportional to temperature decline d, and inversely related to thickness dx.

Hence,

$$\frac{dQ}{dt} \propto A \, \frac{-d\theta}{dx} \qquad (2.3)$$

$$\frac{dQ}{dt} = kA \, \frac{-d\theta}{dx} \qquad (2.4)$$

Therefore;

$$\frac{dQ}{dt} = kA \, \frac{d\theta}{dx} \qquad (2.5)$$

Equation (2.5) the rate of flow of heat is equal to the product of the coefficient of thermal conductivity, area of the slab, and temperature gradient when heat is flowing normally between the faces of a thin parallel slab of a material and a steady state has been attained .

Since,

$$k = \frac{dQ}{dt} \Big/ -A\frac{dQ}{dx} \qquad (2.6)$$

Then, k may be written as;

$$K = \frac{rate\ of\ heat\ flow}{area\ x\ temperature\ gradient} \qquad (2.7)$$

CHAPTER THREE

Research design

The research design is a tool for preparing a research proposal in the form of a complete and thoughtful package (Adeyemi, 2013). It describes the research design and also includes a brief description of the goals achieved. The case study method is the research design used in this study. This method was chosen because of the nature of the research. "The case study method is the preferred strategy for asking how, who, why, and what questions" (Osuala, 2001). This is due to the researchers' lack of control over the events that occurred during the implementation of the project. Therefore, the case study method provides researchers with a very broad subject perspective. Therefore, this method would;

i. Be used as a pilot for further research studies.
ii. Allow the subject to explore objects in the natural environment.
iii. Allow multiple sources of information.
iv. An in-depth study of subject is allowed,

The study includes a study of 3 lecture theatres in the University of Benin, Edo state, Nigeria. Data collected through observations, readings and online journals during the research period were analyzed and processed to help answer research questions.

Purpose of research

The purpose of this research is to educate construction professionals on the use of aluminum roofing sheets in building construction, especially in the area of choice of colors.

Data types and sources

The types of data that was applicable to this study was qualitative, which involves collecting descriptive data on various natural settings in order to understand the subject matter and answer questions such as how and why variables become the way they are, also tehe results of this study were descriptive and narrative in nature.

Data sources

The data sources used in this study include:

Primary data: The data is collected and processed by the researchers. The photos, readings, sketches, etc. were obtained during the research work and through field survey of the selected buildings.

Secondary data: The secondary data collected in this study comes from related literature searches in libraries, the Internet, papers, journals, and newspaper publications.

Techniques of data collection

Methods used by the researcher were; practical test, observations, and document analysis:

Observation:

It involves identifying and recording facts, circumstances and events. The purpose of this method is to provide observations with information that staff may not want to share with researcher for some known reasons.

Actual field work:

Actual field work includes physical inspection selected case studies and carefully carried out test.

Materials and Research Methodology:

This topic deals with materials and methods employed for the research work.

Materials:

The major materials used were long span aluminium roofing sheets of 3 different colours. The colours were orange, dark purple and green. Another tool employed for this research is the Digital Electronic thermometer.

The long span roofing sheet is made from aluminium. Aluminium is a metal belonging to group 3 and period 3 of the periodic table of elements, and is utilized in the manufacturing process. These roofing sheets are resistant to corrosion and are durable in nature.

Sample Preparation

The samples for experiment were gotten from existing lecture theatre buildings at the university of Benin Edo State, with an assumed thickness of 0.50mm ± 0.10mm.

Sample Analysis

The prepared samples were analyzed in during field work to determine their thermal conductivities using readings from a digital thermometer. The readings were tabulated and a graph of temperature against time was plotted and the temperature gradient determined by drawing the tangent to the lower steady state T_1 position.

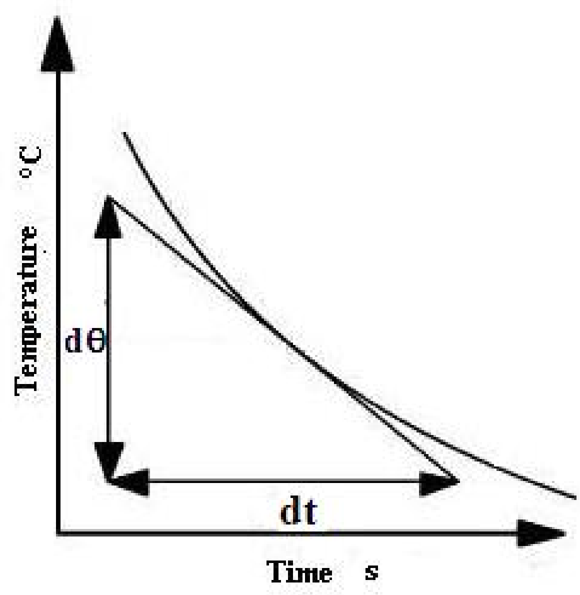

Figure 3.3 A Typical Cooling Curve.

However, in carrying out the experiment, some conditions that could introduce error in the estimates included; uncertainty in measurements of diameter and thickness, uncertainty in measurements of temperatures and heat loss by the sample from its sides.

In view of the errors, the following precautions were taken during the experiment to minimize the errors. The experiment environment attained steady state before commencement of the experiment, the experiment was conducted in drought free environment with all fans put at off positions to prevent instability of atmospheric temperature, the thermometer was placed at the middle of the room and thermometer readings were carefully taken to avoid error due to parallax. The temperature reading was done at appropriate time. Readings were taken morning, afternoon and evening by 7 am, 2pm and 7pm respectively once every week for 2 months.

CHAPTER FOUR

Presentation of Experimental Results

The values/ data of experiments carried out in chapter three are presented, evaluated and analyzed in this chapter. The colours of three (3) different lecture theatre building's roofing sheets were examined within and around the University of Benin, within seven different days chosen at random in the month of November. The days weren't picked twice but rather at random. This was done to ensure that there would be ample time between any two selected days for temperature monitoring. The hues chosen are ones that are frequently utilized in the vicinity of the study area. The colours chosen are ones that are frequently utilized in the vicinity of the study area. All of the roofing sheets had a long span (See pictures at appendix). The long span sheets were all 0.55mm thick, and temperatures were recorded from noon to two o'clock, when it was thought the sun would be at its fiercest. The method involved using an electronic thermometer to measure the internal room temperature, and atmospheric temperature of the immediate environment.

Table 1 Table showing description, dimensions and Color of the samples

SAMPLES	BUILDING DISCRIPTION	ROOF THICKNESS (mm)	ROOF COLOR
1	Education 500 sitting capacity lecture theatre	0.5	Orange
2	Engineering 1000 sitting capacity lecture theatre	0.5	Dark purple

3	Computer science 1000 sitting capacity lecture theatre	0.5	Green

Experimental Results of Thermal reflectivity of samples.

The procedure involves measuring the ambient temperature in the nearby area as well as the mean internal room temperature using an electronic thermometer. The average observation time for all thermometric values was 10 minutes.

Mean Internal room Temp.(X)=$\frac{Morning\ Temp + Afternoon\ Temp, + Evening\ Temp}{3}$

Below is table 1-3 showing the daily recordings of observations on the field.

Table 1: Temperatures readings for sample 1 roof type:3

Roof colour	Temperature	Day 1 3/11/22	Day 2 6/11/22	Day 3 9/11/22	Day 4 12/11/22	Day 5 14/11/22	Day 6 17/11/22	Day 7 18/11/22
Orange	Atmosp.T	31.9	31.0	30.9	29.5	33.2	31.4	32.3
	Room Tem	28.9	29.0	32.0	27.8	27.6	28.7	31.0

Table 2: Temperatures readings for sample 2 roof type:

Roof colour	Temperature	Day 1 3/11/22	Day 2 6/11/22	Day 3 9/11/22	Day 4 12/11/22	Day 5 14/11/22	Day 6 17/11/22	Day 7 18/11/22
Green	Atmosp.T	30.8	31.5	33.2	30.0	31.5	32.0	31.6
	Room Tem	29.6	29.8	31.2	29.8	29.5	30.2	30.0

Table 3: Temperatures readings for sample 3 roof type.

Roof colour	Temperature	Day 1 3/11/22	Day 2 6/11/22	Day 3 9/11/22	Day 4 12/11/22	Day 5 14/11/22	Day 6 17/11/22	Day 7 18/11/22
Dark purple	Atmosp.T	30.0	31.6	31.9	30.5	31.9	32.5	31.7
	Room Tem	29.2	30.0	30.8	29.8	29.9	27.3	29.4

Precautionary measures taken

In order to assure accuracy and minimize errors when obtaining readings during the fieldwork, the following precautions were taken:

a. To minimize parallax error, make sure the thermometer readings were collected at eye level.

b. Ensure that the readings were obtained as soon as possible and that there was no delay between the thermometer being withdrawn from the roofing sheet and the reading being taken..

c. Ensure readings are recorded correctly and written against the correct temperature measured, and the study was carried out in November 2022 in Edo state Nigeria. Table 4 provides a summary of the mean thermometric readings of the room temperatures of the three colored roofs for the seven days that were observed. Table 5 lists the average temperatures of each roof color as well as how well they reflect light.

Table 4: Summary of the mean thermometric readings of room temperature for three roof colours for seven days.

Roof colour	Day 1 3/11/22	Day 2 6/11/22	Day 3 9/11/22	Day 4 12/11/22	Day 5 14/11/22	Day 6 17/11/22	Day 7 18/11/22	Mean Temperature©
Orange	28.9	29.0	32.0	27.8	27.6	28.7	31.0	**29.28**
Green	29.6	29.8	31.2	29.8	29.5	30.2	30.0	**30.01**
Dark purple	29.2	30.0	30.8	29.8	29.9	27.3	29.4	**29.50**

Table 5: shows the overall ranking of each roof colour according to its reflectivity.

S/N	ROOF COLOUR	MEAN ROOM TEMPERATURE	RANK	REMARKS

1	Orange	29.28	1st	High reflectivity
2	Green	30.01	3rd	Medium reflectivity
3	Dark purple	29.50	2nd	Low reflectivity

Table 5 is a summary of all tables from 1 to 3. It shows that orange colour has the highest reflectivity, followed by dark purple. Green have the lowest and least reflectivity from the Experiments carried out. Given its dark appearance, it was unexpected to learn that the second-best roof color was dark purple. It is simple to draw the conclusion that this color should have been the least reflective of all the colors because it looks to be closer to black than the other colors. Due to its very brilliant appearance, it was also unexpected to see the color green near the bottom, ranking least.

Roof Temperature

The findings indicate that different colored roofs reflect sunlight in different ways. Bright colors, such as orange, were shown to reflect light more than dark purple roofing sheets, on average. Table 8 shows that of the three colors, green has the lowest reflectivity, which means it will reflect light poorly and raise the surrounding warmth.

Atmospheric Temperature

During the field investigation, it was noted that the air temperature varied virtually continuously. Because it was also noted that the fluctuation was least on days when the sky was clear and there were few or no clouds in the sky, it was assumed that these variations were caused by the presence of cloud cover. The daily average temperatures utilized in this study were derived from the daily atmospheric data provided by meteorologists. Additionally, it was noted that maintaining a steady temperature for an extended period of time was challenging.

Room Temperature

This study also discovered that, in contrast to the atmospheric temperature outside the buildings, which varied significantly between the different roofs observed, the internal room temperature readings of the buildings that were sampled indicated that the internal room temperature readings were relatively stable. The study found that the temperatures within rooms were consistently roughly 10 C lower than the temperature reading in the atmosphere. None of the buildings under investigation lacked ceilings, despite the fact that all the buildings sampled were sealed (had finished ceilings). If the buildings had not been ceiled, the internal room temperatures would have been significantly different, which could explain their relative stability. However, results show that the hotter a day is or the higher the atmospheric temperature, the higher the room temperature

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

The results of this study clearly demonstrate that brightly colored roofs can reflect light and heat from the sun, which lowers the temperature around structures..

Conclusion

After making reference to three basic colours found in the vicinity of my study, it has been proven that higher heat gain is associated with roofs which possess colours that have low reflective properties which therefore increases the accumulated heat in that specified region or space.

Recommendations

1. Architects should only specify highly reflective colors for roof designs, such as dark purple and silver. However, because to their medium reflecting capabilities, it is advisable that dark brown and blue not be selected until their level of heat reflectance and retention are further confirmed.

2. Green and beige should not be specified by architects for client roof designs because research has shown that they have a poor ability to reflect sunlight, which raises surface temperatures near buildings (s).

3. Manufacturers of roofing sheets ought to do extra research into fresh hues found on the color wheel and create eco-friendly new roof colours.

4. Manufacturers of roofing sheets should stop producing roofing sheets in dark colors, such as dark brown, blue, and green, as well as beige, until further research demonstrates that these colors have different heat reflectance and retention properties.

5. Roof covering sheet surfaces made of aluminum should be as highly reflective as possible. However, eye safety must be taken into account.

6. Since the main problems discussed in this paper are heat generation and emission from roofs, it would be very beneficial if researchers could look into how heat from roofs can be converted to electric power, as most Nigerian and African cities, even rural areas, have significant problems with electric power generation and transmission.

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