AUTOCLAVED AERATED CONCRETE (AAC): AN ALTERNATIVE SUSTAINABLE CONSTRUCTION MATERIAL

BY

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CERTIFICATION

This is to certify that Simeon Dele Roger with the matriculation number 100504043 of the Department of Building, Faculty of Environmental sciences, University of Lagos, carried out this project to the best of its standard.

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DEDICATION

I dedicate this project to God most high, the owner of my soul and the creator of the universe.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to God Almighty for His guidance and mercies throughout the period of this project.

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May God Almighty bless you all (Amen).

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LIST OF ABBREVIATIONS

AAC = Autoclaved Aerated Concrete

AC = Aerated Concrete

ACC = Autoclaved Cellular Concrete

ALC = Autoclaved Lightweight Concrete

ANOVA = Analysis of Variance

AP = Aluminium Powder

AS = Air-cooled Slag

ASTM = American Society for Testing and Materials

BIA = Building Industry Association

BFS = Blast Furnace Slag

BLA = Bamboo Leaf Ash

CBA = Coal Bottom Ash

CG = Coal Gangue

CSB = Concrete Sandwich Block

CT = Copper Tailings

DS = Dune Sand

ES = Efflorescence Sand

FA = Fly Ash

GDP = Gross Domestic Product

HP = Halloysite Powder

IOT = Iron Ore Tailings

ISSA = Incinerated Sewage Sludge Ash

LWC= Light Weight Concrete

NACC = Non-Autoclaved Aerated Concrete

NIS = Nigerian Industrial Standard

NZ = Natural Zeolite

OPC = Ordinary Portland Cement

OQS= Online Questionnaire Survey

PF = Polypropylene Fibre

PFA = Pulverized Fuel Ash

POFA = Palm Oil Fuel Ash

PS = Phosphorous Sand

PW = Perlite Waste

RHA = Rice Husk Ash

SAQ = Self- Administered Questionnaire

SCG = Self-ignition Coal Gangue

SF = Silica Fume

SMEs = Small and Meduim Enterprises

SPSS = Statistical Package for the Social Sciences

WG = Waste Glass

ABSTRACT

The rationale for this study stems from reports that while Autoclaved Aerated Concrete (AAC) has been in existence for over a century and has been adopted in Europe and other parts of the world, its awareness and adoption on building projects in Nigeria and Africa at large is still very low or non-existent. The study aims to explore the awareness and usage of AAC block variants with a view to providing walling materials that are sustainable. The objectives of the study are to compare the level of awareness of AAC block variants in Nigeria and South Africa; to determine the prospect for adoption of AAC blocks in Nigeria; to evaluate the adoption level of AAC block variants on South African building projects; to identify drivers to the adoption of AAC blocks on building project; to evaluate barriers impeding the adoption of AAC blocks on building projects and to propose strategies that would improve the adoption of AAC blocks on building projects. Following a review of existing literature, the study mainly adopted quantitative research where questionnaire surveys were administered to the targeted respondents. The population of the study was made up of two groups comprising Nigerian and South African professionals. Structured Self-administered Questionnaires were designed to elicit information from the Nigerian professionals in the Lagos metropolis while Online Questionnaire Survey (through Google Forms) was designed to collect data from the referred South African professionals. The study utilized a multi-sampling method where both convenience and snowball sampling techniques were deployed to gather the viewpoints of the Nigerian and South African professionals acquainted with the knowledge and have been involved in its use on building projects. The response data obtained from the administration of the questionnaires were coded, processed and analyzed with the aid of Statistical Package for the Social Sciences (SPSS) version 23.0, Data were analyzed using the following descriptive statistical tools such as frequency, percentages, mean score and ranking, while One-way ANOVA, Mann-Whitney U test and Kendall’s coefficient of concordance (W) were used as tools of analysis for the inferential statistics, respectively. Results revealed that the Nigerian professionals are slightly aware of 19 out of the 20 AAC variants while the South African respondents are moderately aware of 13 out of 20 AAC variants. Also, there is a moderate disposition for adoption of AAC block by the Nigerian Respondents. Also, AAC with 52.5 grade ordinary Portland cement is the most used AAC variants in South Africa. It was also revealed that the barriers impeding the adoption of AAC block on construction projects in Nigeria were mired by various issues which included inadequate government policies and supports, market potentials and low level of awareness and knowledge on the concept of sustainability while huge capital to set up AAC plant, lack of readily available accessible information and availability of conventional materials were the barriers to its adoption in the South African building industry. Also, the result revealed strategies to improve the adoption of AAC block in Nigeria, these include government encouragement and focusing research on specific green building materials while in South Africa, growth in the infrastructural sector and growth preferences for low cost houses are the strategies to improve its adoption. The study concludes that the level of awareness of AAC block variants is higher in South Africa than in Nigeria. This implies that AAC block producers would not thrive at present in Nigeria because there would be low patronage. If awareness is increased, patronage will be increased. The study hereby recommends that professionals should update their knowledge of AAC block. This can be achieved via continuous development training, seminars and workshops on AAC block in the building industry. The study also recommends that government should provide more support and develop AAC production technology based on the studies of existing foreign technologies which will not only place the nation into the limelight in the use of the material but also enhance the country’s GDP.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

The global trend towards searching for substitutes to conventional building materials, along with the drive for sustainability in local materials and construction technologies, has spurred studies on the viability and application of locally accessible raw materials for construction purposes. One such materials in view is autoclaved aerated concrete (AAC), which according to Rathi and Khandve (2015) has been identified as a potential substitute for bricks in walls to provide eco-friendly solutions to greener environment.

AAC was invented in the early 1920s by a Swedish Architect named Eriksson whose purpose for designing AAC was to reduce consumption of timber and provide a cheaper and sustainable building material. This innovation focuses on eco friendliness and directs a path to sustainable development as it satisfies the rule of 3R's: Reduce, Recycle and Reuse (Cheran, Shanthi & Krithigaa, 2017).

According to Jerman, Keppert, Vyborny and Cerny (2013) AAC is a structural material which is commonly used in Europe and other parts of the world, particularly as it combines ease of construction with excellent combination of mechanical and thermal properties. In addition, Desani, Soni, Gandhi and Mishra (2016) opine that this light weight concrete (LWC) has no coarse aggregates in its mixture and stated that lightweight concrete is either aerated using mortar injected by gas bubbles or air entraining agents.

Keyvani (2014) noted that aerated concrete is relatively homogenous when compared to normal concrete yet, shows vast variation in its properties. The properties of aerated concrete are dependent on its composition and microstructure (void paste system) which is influenced by the curing method; binder used and method of pore-formation (Narayanan & Ramamurthy, 2000).

Aerating concrete by using air entraining agents is more practical in production of LWC. Air entraining agents are expanding agent that increases the volume of the mixture while reducing the dead weight and is generally lighter than conventional concrete.

AAC is manufactured by a process that involves slurry preparation, foaming/rising, cutting and steam curing (autoclaving) process during which the main ingredients react together chemically (Cheran et al. 2017). Curing is an important factor affecting the mechanical and physical properties of concretes in different categories and considering the methods of curing, aerated concrete can be categorized into two main groups which are AAC and non-autoclaved aerated concrete (NAAC) (Desani et al. 2016).

Advancement in modern technology and new building systems has brought to fore a wide range in choice of walling materials with bricks, sandcrete blocks, timber and glass taking the centre stage (Olawuyi & Babafemi, 2013). Sandcrete blocks are however, the most widely used walling units in Nigeria accounting for 90% of houses according to (Baiden & Tuuli, 2004).

According to Oo and Hlaing (2018), the first bricks were sun-dried mud bricks, fired bricks were later found to be more resistant to harsher weather conditions which made them a much more reliable brick for use in buildings where mud bricks would not have been sufficient. Fired clay bricks absorb heat during the day and then release it at night. In addition, it possesses certain inherent sustainable properties such as durability and high thermal mass; however, the kilning process has raised some sustainable concerns because of energy consumption and greenhouse gas emissions (Chusid, Miller & Rapport, 2009).

Similarly, the kilning process of fired clay brick releases large amount of carbon dioxide and other harmful gasses leading to the menace of global warming and climate change (Gautam & Sexena, 2013). Sustainability is defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs (Building Industry Association [BIA], 2009; American Society for Testing and Materials [ASTM], 2006).

The Nigerian Industrial Standard (NIS 87: 2000) provides the range of minimum compressive strength of sandcrete blocks between 2.5N/mm^2 and 3.45N/mm^2. The objective of the Nigerian Industrial Standard (NIS 87:2000) is that all blocks manufacturer meets the minimum standard (Wilson, Raji & Alomaja, 2016). Relatedly, Aiyewalehinmi and Akande (2015) posit that the present sandcrete blocks available in building and construction material market in Nigeria are below the Nigerian Industrial Standard (NIS 87:2000) of 2.5N/mm^2. There are no known studies on AAC in Nigeria. This study, therefore, investigates the application of AAC blocks on construction projects in Nigeria.

1.2 Statement of Research problem

Tropical climates like Nigeria are attributed with high temperature during the day. The outer high temperature heats up the building walls and heat is absorbed within the hollow sections of the sandcrete block from dawn till twilight. Jannat, Hussein, Abdullah and Cotgrave (2020) revealed that sandcrete block walls have high heat absorption, heat diffusivity and heat emissivity capacity compared to other material such as bricks. Similarly, Kadir and Mohajerani (2011) reported that bricks have better thermal properties compared with other materials in the construction industry but still absorbs and emits a level of heat invariably. The heat stored within the mass of the walling systems, radiate or move inwards into the building space; causing a rise in the inside temperature of the rooms/spaces. This rise in the inside temperature directly increase the cost of cooling for thermal indoor comfort of the occupants (Al-Homoud, 2005). Significantly, walls and roof systems are the major culprits of this thermal action in building. Thus, if the wall composition is made of AAC, the thermal comfort demand in the building indoor spaces will be reduced. Singh, Pandey and Srivastava (2017) studied smart and eco-friendly construction materials and revealed that conventional brick material produces large amount of CO_2 and other greenhouse gases which are hazardous/toxic in nature which cause environmental and health related problems.

Relatedly, Kashim (2014) gave a situation report on cement developments in cement manufacturing and distribution in Nigeria and posits that three grades of cement are available globally which are: 32.5 grades, 42.5 grades and 52.5 grades. Kashim (2014) recommended that stakeholders and the general public should be enlightened about the application of these different grades of cement available in the markets for easy identification and application. Similarly, Hudson (2014) stated that the 32.5 grade Ordinary Portland Cement (OPC) is the best multi-purpose cement for Nigeria based on some number of factors as Nigeria is in a very hot tropical environment, with a low heat of hydration. The 32.5 grade becomes very suitable as it does not cause cracking, well grinded, good for workability and has very good environmental impact because with a little bit of extra limestone or other additives put into it, carbon dioxide (CO_2) emissions are reduced.

However, Saiyed, Makwana, Pitroda, and Vyas (2015) explained what is not green about Portland cement as it contains about 60% limestone, or calcium carbonate and must be burned at high temperatures in kilns using lots of energy and creating carbon dioxide (CO_2), a greenhouse gas linked to global warming. The newer magnesia-based cement can be burned at lower temperatures using less energy and creating less CO_2. Moreover, Umoh and Odesola (2016) discovered that up to 15% replacement of cement with bamboo leaf ash (BLA) in concrete produced satisfactory results. There has been no such study of BLA as partial replacement with cement in AAC. These may as well produce satisfactory results, leading to various options of AAC blocks. Additionally, there could be variants of AAC blocks made with several grades of cement, such as 32.5, 42.5 and 52.5 grades. However, the sustainability of each of these variants is yet to be known. Therefore, the problem that this study seeks to solve is the use of unsustainable construction materials on building projects.

1.3 Research questions

The research questions for the study are as follows:

1. What is the level of awareness of AAC block variants in Nigeria and South Africa?
2. What is the prospect for adoption of AAC block in Nigeria?
3. To what extent is the adoption level of AAC block variants in South Africa?
4. What are the drivers to the adoption of AAC on building projects in Nigeria and South Africa?
5. What are the barriers impeding the adoption of AAC on building projects in Nigeria and South Africa?
6. What are the strategies that can improve the adoption of AAC on building projects in Nigeria and South Africa?

1.4 Aim and objectives of the study

The research is aimed at exploring the awareness and usage of AAC block options with a view to providing walling materials that are sustainable.

The specific objectives to be achieved in this study are:

1. to compare the level of awareness of AAC block variants in Nigeria and South Africa.
2. to determine the prospect for adoption of AAC blocks in Nigeria.
3. to evaluate the adoption level of AAC block variants on building projects in South Africa.
4. to identify drivers to the adoption of AAC blocks on building projects in Nigeria and South Africa.
5. to evaluate barriers impeding the adoption of AAC blocks on building projects.
6. to propose strategies that can improve the adoption of AAC blocks on building projects.

1.5 Research hypotheses

The following hypotheses were postulated in line with the objectives of this study:

H_{01a}: There is no significant difference among the ownership of organizations on the awareness of AAC block variants in the Nigerian building industry.

H_{01b}: There is no significant difference on the level of awareness of AAC block variants among the ownership of the organisations in South African building industry.

H_{01c}: There is no significant difference in the perception of Nigerian and South African professionals on the level of awareness of AAC block variants.

H_{02}: There is no significant difference on the prospect for adoption of AAC among the ownership of organisations in the Nigerian building industry.

H_{03}: There is no significant agreement among South African professionals on the adoption of AAC variants on building projects.

H_{04a}: There is no significant difference among the respondents on the drivers of AAC in the Nigerian Construction industry.

H_{04b}: There is no significant difference in the perception of South African respondents on drivers of AAC blocks among the ownership of the organisations.

H_{04c}: There is no significant difference between Nigerian and South African respondents on drivers of AAC blocks.

H_{05a}: There is no significant difference in the perception of the Nigerian respondents on barriers impeding adoption of AAC blocks on building.

H_{05b}: There is no significant difference in the perception of the South African professionals on barriers impeding adoption of AAC blocks on building.

H_{05c}: There is no significant difference in the perception of Nigerian and African respondents' professionals on barriers impeding the adoption of AAC blocks.

H_{06a}: There is no significant difference in the perception of Nigerian respondents on the strategies that can improve the adoption of AAC blocks on building projects.

H_{06b}: There is no significant difference in the perception of South African respondents on strategies that can improve the adoption of AAC blocks on building projects.

H_{06c}: There is no significant difference in the perception of Nigerian and South African professionals on the strategies to improve AAC block adoption.

1.6 Significance of the study

The study on the level of awareness of AAC block variants would be of great benefit to consultants, developers/clients and contractors as it would add to the body of literature on sustainable construction materials and shed more light on the various AAC block options available which materials specifiers can recommend for building projects.

Also, the prospect for adoption of AAC blocks would benefit the Nigerian professionals as it would reveal the possibilities of adopting the block on building projects in the nearest future.

Also, the adoption level of AAC block variants would be of great benefit to developers/clients and Architects as the study would reveal the percentages of usage of each of the AAC block variants available of which professionals can work with the information available on each variant and choose from the options presented.

Being a sustainable construction material, the identified drivers would be beneficial to building owners, developers and occupants as there would be great savings in cost of construction as a result of the blocks being lightweight, energy costs would be reduced due to the block being energy efficient and optimum indoor comfort level for the occupants as a result of the micro-climate characteristics the block offers.

Furthermore, barriers impeding the adoption of AAC blocks on building projects would be identified and findings from the study would be beneficial to building owners, the government, developers, consultants and contractors to put measures in place to guard against the challenges.

Finally, the strategies to achieve AAC block adoption on building projects if implemented would attract patronage from stakeholders, serves as employment generation and increase the country's Gross Domestic Product (GDP).

1.7 Scope and delimitation of the study

The scope of this study is delimited to building projects in Lagos metropolis and building projects in South Africa where AAC blocks are being used. The research is focused on Lagos state, not only because of easy access to information but also due to its large material usage as a result of the massive construction activities ongoing in the state and its high number construction practitioners, stakeholders and policy makers plying their trades in the state.

1.8 Operational definition of terms

Autoclaved Aerated Concrete (AAC): is a lightweight concrete which offers excellent thermal insulation performance resulting from low volume weight and porous structure with sufficient mechanical strength. It is an ecofriendly and certified green building materials.

Sustainability: Sustainability is defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents the literature review. The literature review will examine the following headings: definition of Autoclaved Aerated Concrete (AAC) and sustainable construction materials, awareness of AAC block variants, prospect for adoption of AAC blocks in the Nigerian construction industry, adoption of AAC block variants in the South African construction industry, drivers to AAC block adoption, barriers impeding the usage of AAC and strategies that can improve the usage of AAC blocks on construction projects.

2.2 Definition of AAC and sustainable construction materials

According to Wikipedia (2021) Autoclaved Aerated Concrete (AAC) is otherwise known as Autoclaved Cellular Concrete (ACC), Autoclaved Lightweight Concrete (ALC), Autoclaved Concrete, Cellular concrete, Porous Concrete, and Aircrete. Narayanan and Ramamurthy (2000) define AAC as a load bearing building material with a low density due to its higher porosity compared to other load bearing building materials. AAC is manufactured by varying production parameters as regards densities in the range of 93–1800 kg/m^3 whereas its constituent particle density is around 2600 kg/m^3. This implies 30–90% of its volume consists of pores (Kadashevich, Schneider & Stoyan, 2005).

Relatedly, Pandey, Kirar, Singh and Rajak (2018) posit that AAC is one of the eco-friendly and certified green building materials that is porous, non-toxic, reusable, renewable and recyclable and added that AAC is a lightweight, load-bearing, high insulating, durable building product, which is produced in a wide range of sizes and strengths. Saiyed, Makwana, Pitroda and Vyas (2015) explain that AAC is quite different from dense concrete (i.e. "normal concrete") in both the way it is produced and in the composition of the final product. AAC does not contain any aggregate as all the main mix components are reactive, even milled sand where it is used. The sand, inert when used in dense concrete, behaves as a pozzolana in the autoclave due to the high temperature and pressure. Different researchers have provided different definitions to AAC. Therefore, different definitions can be found in different references. Basically, AAC is a green building material that offers excellent thermal insulation property and directs a path to sustainability.

On the other hand, Sustainable construction materials can be defined as materials with overall superior performance in terms of specified criteria. For Selection of Sustainable construction materials the following criteria are commonly used: locally produced and sourced materials; transport costs and environmental impact; thermal efficiency; occupant needs and health considerations; financial viability; recyclability of building materials and the demolished building; waste and pollution generated in the manufacturing process; energy required in the manufacturing process; use of renewable resources; toxic emissions generated by the product and maintenance costs (Patil & Patil, 2017).

Sustainability in construction is all about following suitable practices in terms of choosing materials, their sources and construction methodologies as well as design philosophy, so as to be able to improve performance, decrease the environmental burden of the project, minimize waste and be ecologically friendlier, taking into consideration environmental, socio-economic and cultural values. All materials are ultimately derived from the bio-geo-sphere. They are everything between the take and waste and are the key to sustainability. The choice of materials for construction controls whole of life cycle impacts such as emissions, gross take, properties of wastes returned to the bio-geosphere, use of recycled wastes and their own recyclability. Materials also strongly influence lifetime energies, user comfort and durability (Kibert, 1994).

Similarly, Sustainable building materials are those which are produced or sourced locally. These materials are containing recycled & industrial waste materials and byproducts. Sustainable materials have a lower impact on environment & are thermally efficient. The production of these building materials requires considerably less amount of energy in production when compared to the modern or traditional construction materials.

The advantages in selection of sustainable building material lies in the fact that they are not only economically viable but also reduce toxic emissions thereby reduce overall environment impact. Sustainable building material & technology should be utilized appropriately & contextually in each neighborhood development. The use of sustainable material & technology not only reduces transport & production cost, carbon emissions but also provides avenues for employment & skill development for community members (Patil & Patil, 2017).

2.2.1 Classification of Aerated concrete

According to Narayanan and Ramamurthy (2000) Aerated concrete is classified based on three methods. They comprise:

i. Based on the method of pore formation

a. Air-entraining method (also known as gas forming): this method results in a mass of increased volume when injected into lime/cement mortar mixture during the liquid or plastic stage.

A porous structure is formed when the gas escapes. Examples of aerating agents are: Aluminum powder; hydrogen peroxide/bleaching powder; calcium carbide; liberated hydrogen; oxygen and acetylene respectively. However, Aluminium powder is the most commonly used aerating agent.

b. Foaming method (foamed concrete): there are no chemical reactions involved in this method and it is regarded as the most economical and controllable pore-forming process. Pores are introduced through chemical means either by pre-formed foaming (foaming agent mixed with a part of mixing water) or mix foaming (foaming agent mixed with mortar). The various foaming agents used comprise: detergents; resin soap; glue resin; saponin; hydrolyzed proteins such as keratin, etc., (Valore, 1954).

c. Combined pore-forming method: production of cellular concrete by combining foaming and air-entraining methods using Aluminium powder and glue resin.

ii. **Based on the type of binder**

Aerated concrete is classified into cement or lime based depending on the binder used. Attempts have been made to use pozzolanic materials such as pulverized fuel ash (PFA) or slate waste as partial replacement to the binder or sand. Vu and Nguyen (2017) investigated the influence of admixtures on properties of AAC using Dune sand as the fine aggregate. Similarly, Naik et al. (2018) carried out studies and experiments on AAC by using flu Ash. In addition, Rahman, Fazlizan, Asim and Thongtha (2020) conducted a review on the utilization of waste material for AAC production.

iii. **Based on the method of curing**

Based on the method of curing, Aerated concrete can be non-autoclaved (NACC) or Autoclaved (AAC). The compressive strength, absorption properties, dry shrinkage etc., directly depends on the method and duration of curing. The strength development is rather slow for moist-cured products. The variables of significance are the age and condition of the mix at the start of the curing cycle and rates of change of temperature and pressure (Narayanan & Ramamurthy, 2000; Ikponmwosa, Falade & Fapohunda, 2014).

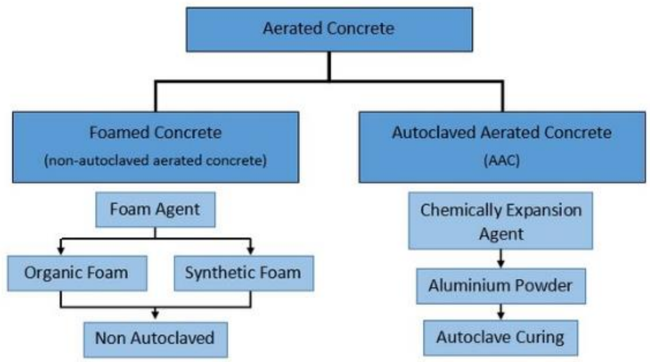

Figure 1. **Process flow of aerated concrete between the foamed concrete (NAAC) and AAC (Hamad, 2014)**

It should be noted however, that properties of aerated concretes are classified in terms of physical (microstructure, density), chemical, mechanical (compressive & tensile strengths, modulus of elasticity, drying shrinkage and functional (thermal insulation, moisture transport, durability, fire resistance & acoustic insulation characteristics (Narayanan & Ramamurthy, 2000).

2.3 Constituent material and manufacture of AAC Block

The AAC production process differs slightly between individual production plants but the principles are similar. The basic raw materials used in the production of AAC blocks include:

Portland cement, fine aggregate (sand), quicklime, gypsum, aluminum powder and water (Rathi & Khandve, 2015; Naik et al. 2018; Manikandan, Gopalakrishnan & Cheran, 2018).

The batching ratio of AAC block before mixing according to Sahu and Singh (2017) comprises; Fly ash 69%, Sand 20%, Lime: Cement 8%, Gypsum 3 %, Aluminum 0.08% of total dry materials and Water ratio 0.60-0.65**.** Subash, Satyannarayana and Srinivas (2016) added that unlike most other concrete applications, AAC is produced using no aggregate larger than sand. Quartz sand, calcined gypsum, lime (mineral) and/or cement and water are used as a binding agent. Aluminum powder is used at a rate of 0.05%–0.08% by volume (depending on the pre-specified density). In some countries, fly ash generated from thermal power plants with silica of 50-65% are used as aggregate. Additionally, Rathi and Khandve, (2015); Naik et al. (2018); Manikandan et al. (2018) explained the materials used for the production of AAC block which include:

a. Fly Ash/Sand: Key ingredient for manufacturing AAC blocks is silica rich material like fly ash or sand. Most of the AAC companies in India use fly ash to manufacture AAC blocks. Fly ash is mixed with water to form fly ash slurry. The slurry thus formed is mixed with other ingredients like lime powder, cement, gypsum and Aluminum powder in quantities consistent with the recipe. Alternately, sand can also be used to manufacture AAC blocks or a combination of both materials. A 'wet' ball mill finely grinds sand with water converting it into sand slurry. Sand slurry is mixed with other ingredients just like fly ash slurry.

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type. The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica, usually in the form of quartz (Satish, Sukumar, Srinath, Tamil & Bharathidason, 2017).

Fly ash is one of the naturally occurring products from the coal combustion process and is a material that is nearly the same as volcanic ash. When coal is burned in today's modern electric generating plants, combustion temperatures reach approximately 2800°F. The noncombustible minerals that naturally occur from burning coal form bottom ash and fly ash. Fly ash is the material that is carried off with the flue gases, where it is collected and can be stored in silos for testing and beneficial use.

Fly ash can be classified into classes. Class F fly ash is normally produced by burning anthracite or bituminous coal. Usually it has less than 5% of CaO. Class C fly ash normally produced by burning lignite or sub-bituminous coal. Usually it has CaO content in excess of 10% (Satish, Sukumar, Srinath, Tamil & Bharathidason, 2017).

Recently, bamboo leaf ash (BLA), which was obtained by the burning of bamboo leaf at a controlled temperature has been found to possess high reactive silica, which makes it suitable for use as a supplementary cementitious material (Villar-Cociña, Santos, Savastano & Frías, 2011; Dwivedi, Singh, Das, & Singh, 2006; Arum, Ikumapayi & Aralepo, 2013). The use of bamboo leaf ash in concrete exposed to a sulfate environment has been reported (Ademola & Buari, 2012; Asha, Salman & Kumar, 2014) to enhance the resistance of concrete to sulfate attack.

Similarly, Adewuyi, Olusola and Oladokun (2013) reported its use as a supplementary cementitious material in the production of sandcrete blocks produced satisfactory results. Therefore, the availability of bamboo leaf and the low technology required to process it into ash necessitates its usage as a material for the production of some building elements for affordable housing provision, especially in developing countries.

b. Lime Powder: Lime powder required for AAC production is obtained either by crushing limestone to fine powder at AAC factory or by directly purchasing it in powder form. Although purchasing lime powder might be little costly, many manufacturers opt for it rather than investing in lime crushing equipment like ball mill, jaw crusher, bucket elevators, etc. Lime powder is stored in silos fabricated from mild steel (MS) or built using brick and mortar depending of individual preferences.

c. Cement:

Ordinary Portland Cement (OPC) is the most common cement used in general concrete construction when there is no exposure to sulphates in the soil or groundwater. Cement can be defined as the bonding material having cohesive & adhesive properties which makes it capable to unite the different construction materials and form the compacted assembly. The OPC was classified into three grades namely, 32.5 grade, 42.5 grade and 52.5 grade depending upon the strength of the cement at 28 days when tested (Satish et al., 2017). Cement is usually stored in silos. However, in Nigeria, cement is stored in 50kg sacs.

d. Gypsum: Gypsum is easily available in the market and is used in powder form. It is stored in silos.

e. Aluminium Powder/Paste: Aluminium powder/paste is easily available from various manufacturers. As very small quantity of Aluminium powder/paste is required to be added to the mixture, it is usually weighed manually and added to the mixing unit. Aluminium powder is usually used to obtain AAC by a chemical reaction generating a gas in fresh mortar; it contains a large number of gas bubbles. When Aluminium is added to the mixing ingredients by 0.2%-0.5% to the dry density of cement. The Aluminium powder can be classified into three types: atomized, flake and granules. In case of an atomized particle, its length, width and thickness are all of approximately the same order where the length or width of a flake particle maybe several hundred times in thickness. Aluminium powder in the AAC industry is often made from foil scrap and exists of microscopic flake-shaped aluminium particles (Satish et al., 2017).

2.3.1 Mixing of raw materials

Raw materials containing silica sand or quartz sand, fly ash, cement and water are placed in a huge container and mixed together. The hydration of cement occur forming bond between the fine aggregates and cement paste.

2.3.2 Addition of expansion agent

After the mixing process, an expansion agent such as aluminum powder is added to the mixture to increase its volume which could be up to 2 or 5 times more than the original volume of the paste. Calcium hydroxide is the product of reaction between cement and water. The reaction between aluminum powder and calcium hydroxide causes forming of microscopic air bubbles which results in increasing of pastes volume. These microscopic air bubbles will increase the insulation capacity of AAC.

$2Al + 3Ca(OH)_2 + 6H_2O = 3CaO.Al_2O_3 + 3H_2$

Aluminum powder + Hydrated lime (Tricalcium hydrate) + Hydrogen

2.3.3 Pre-curing and cutting

Pre curing process starts after concrete mix is poured into metal moulds with dimensions of 6000 mm × 1200 mm × 600 mm. In these moulds, concrete will be pre cured after it is poured into mould to reach its shape and after this pre curing process cutting will take place below. Cutting will be done with wire cutter to avoid deformation of concrete during process. Aerated concrete blocks are available in different dimensions and various thicknesses. Dimensions for these blocks which are commonly used are: 600×250×100 mm, 600×250×150mm, and 600×250×200.

2.3.4 Curing process

Steam curing is a heat treatment which has been used for many years to accelerate the strength development of concrete products. Because the hydration rate of cement increases with the increase in strength can be speeded up by curing concrete in steam. For compressive strength development of concrete, duration of steam curing is also an important parameter as well as temperature (Tu¨rkel & Alabas, 2005).

The curing process is achieved by an autoclave. Autoclave is defined as a strong, pressurized and steam-heated vessel. Concrete mix that is categorized as autoclaved has its ultimate mechanical properties conditions. Curing with autoclaving method requires three main factors which are moisture, temperature and pressure. These three factors should be applied on material all at the same time. The temperature inside the autoclave should be 1900C and essential pressure should be about 10 to 12 atmospheres. Moisture will be controlled by autoclave and this process should be continued up to 12 hours to provide proper condition for hydration.

2.3.5 Packing and transporting

After completion of mentioned processes, AAC is ready for packing and transportation, but the important factor that shall be carefully considered for this process is that; material should be cooled, the cut blocks are then loaded into the autoclave. It takes a couple of hours for the autoclave to reach maximum temperature and pressure, which is held for perhaps 8-10 hours, or longer for high density/high strength aircrete.

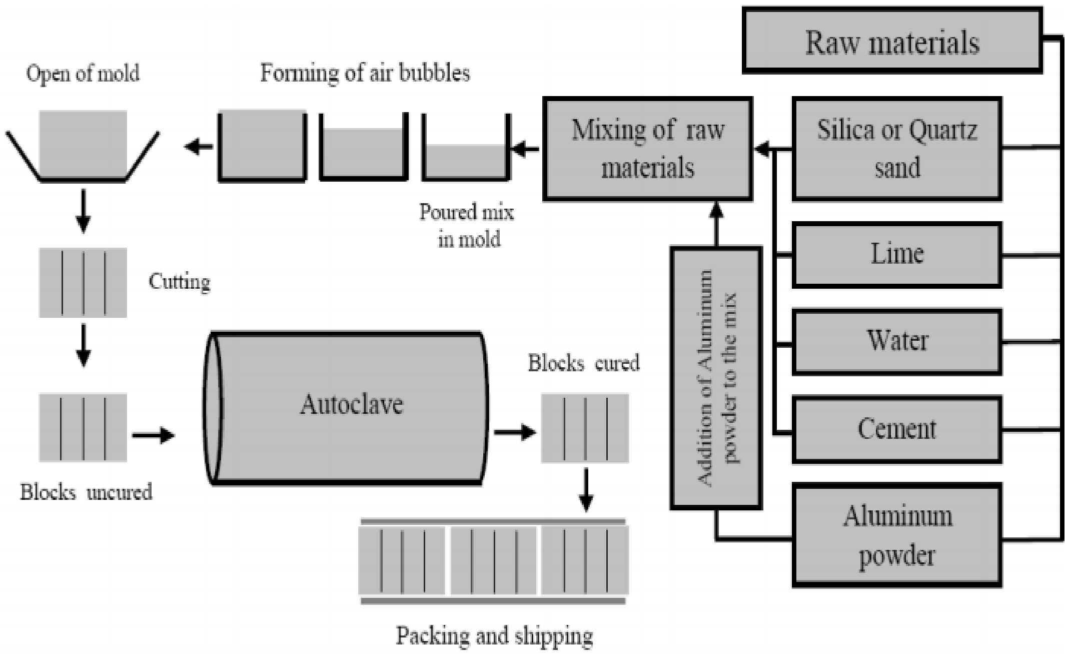

Figure 2. **Manufacturing process of AAC** **(Hamad, 2014)**

2.4 Awareness of Autoclaved Aerated Concrete (AAC) block variants

Table 2.1 shows past and present innovations of 20 variants of AAC available in literature. These innovations have been done by replacing its based materials using waste materials (industrial by-products). These innovations are either to improve AAC characteristics, properties, and performance or the manufacturing cost while maintaining its properties at the acceptable ranges. Besides waste materials, additions or replacement, additives such as fibers, micro-particles, hydrophonic agents and superplasticizers are also being applied in AAC preparation (Deng, Zhang, & Wang, 2020). These additives could also enhance the properties of AAC, such as an addition of amorphous SiO_2 increased the compressive and flexural strength.

Table 2.1: Past and present innovations of 20 variants of AAC

S/N	AAC Variant/Parameter studied	Replacement method/salient feature of the study	Improvement/Enhancement	Sources
1	AAC with 32.5 grade Ordinary Portland Cement (OPC)	Cement is partially being replaced with BLA	Still Under laboratory investigation	Simeon and Oladiran, (2021)
2	AAC with 42.5 grade Ordinary Portland Cement (OPC)	42.5 grade OPC is replaced with ZSM-5 waste. 51% of ZSM-5 waste, 12% cement, 34% quicklime, 3% gypsum, 0.14% Aluminium powder, 0.78 Ca/Si and 0.8 W/C	Compressive strength is enhanced (4.2MPa) which far exceeded the specification of A2.5, B05 grade	Hu, Qian, Wang, Ma, & Wang (2021).
3	AAC with 52.5 grade Ordinary Portland Cement (OPC)	Cement is partially replaced by lime	Lime had no effect on the strength of the mixture.	Khan, (2020)
4	AAC with Coal Bottom Ash (CBA)	CBA was used to replace sand. Optimum replacement of CBA is 50%	Thermal conductivity value is decreased up to 39% and increased strength up to 16% higher than reference AAC.	Kurama, Topcu and Karakurt (2009).
5	AAC with Natural Zeolite Additive (NZ)	Sand was replaced by up to 50% NZ	Decreases the unit weight of aerated concrete specimens hence, decreases density	Karakurt, Karuma and Topcu (2010).
6	AAC with Self-ignition Coal Gangue (SCG)	Optimum mix proportion is SCG to lime to cement to gypsum is 54:23:20:3 with 1.3% aluminum powder	The products consisted of CSH gel and tobermorite phase.	Cong, Lu, Yao & Wang (2016).
7	AAC with Incinerated Sewage Sludge Ash (ISSA)	ISSA for the production of AAC block	Should only be considered for use if alternatives (PFA or Natural Sand) are not available or uneconomic	Dunster (2007).
8	AAC with Bamboo Leaf Ash (BLA)	Up to 15% of BLA is being partially replaced with cement	Still Under laboratory investigation	Simeon and Oladiran, (2021)
9	AAC with Silica Fume (SF) / Fly Ash (FA)	52.5 grade OPC is being replaced with various percentages up to 25% of SF.	Compressive strength increases up to 80% when cement is replaced by 15% of SF.	Rathod and Akbari (2017).
10	AAC with Dune Sand (DS)	Normal sand was being replaced by up to 30% Dune sand	A drastic reduction in strength was observed when higher than 30%	Vu and Nguyen (2017).
11	AAC with Rice Husk Ash (RHA) / Aluminum Powder (AP)	RHA and Aluminium containing waste as a partial aggregate and expansive replacement agent	Delicate particle size has a positive effect on the CSH to tobermorite conversion.	Kunchariyakun, Asavapist and Sombatsompop (2015).

12	AAC with Concrete Sandwich Block (CSB) / Waste Glass (WG)	Sand was being replaced by various types of WG	AAC with cathode ray tube glass has similar characteristics to reference sample.	Walczak, Malolepszy, Reben, Szymanski and Rzepa (2015).
13	AAC with Halloysite Powder (HP)	Clay mineral was used as a cement replacement	Application of halloysite as a cement replacement in the amount of 5.5% increases the strength by 5.8% at the same bulk density of the autoclaved aerated concrete.	Owsiak, Soltys, Sztaboroski and Mazur (2015).
14	AAC with Air-cooled Slag (AS)	AS was used to replace lime and sand (optimum at 50% low-lime mixes and 30% for high-lime mix)	Improvement in compressive strength and shorter curing duration	Mostafa (2005).
15	AAC with Efflorescence Sand (ES)	Normal sand was being replaced by up to 25% ES	Compressive strength is enhanced.	Haung et al. (2012).
16	AAC with Phosphorus Sand (PS)	Normal sand was being replaced by up to 30% PS	Control heat of hydration	Demir, & Güçlüer, (2017).
17	AAC with Coal Gangue (CG) / Iron Ore Tailings (IOT)	Optimum composition at: 20% CGC, 40% IOT, 25% lime, 10% cement, 5% 0.06% Aluminium powder	Completely replaced sand to achieve bulk density and compressive strength of 609kg/m^{3}and 3.68MPa, respectively.	Wang, Ni, Zhang, Wang, and Gai (2016).
18	AAC with Pulverized Fuel Ash (PFA) / Palm Oil Fuel Ash (POFA)	Cement was completely replaced by PFA and POFA	Control heat of hydration	Mehmannavaz et al. (2014).
19	AAC with Copper Tailings (CT) / Blast Furnace Slag (BFS)	Optimum composition SCT to BFS to Sand to Cement to Gypsum is 30:35:20:10:5	The compressive strength was 4.0 MPa, and the dry density was 610.2kg/m^3	Huang, Ni, Cui, Wang and Zhu (2012).
20	AAC with Perlite Waste (PW) / Polypropylene Fiber (PF)	Sand was replaced by PW	PW at 10% reduced the thermal conductivity about 15% without significant reduction of compressive strength.	Rozycka and Pichor (2016).

Simeon (2021).

2.5 Adoption of Autoclaved Aerated Concrete Block Variants

Unlike in Africa, AAC is most used building material in Europe and is rapidly growing in many other countries around the world. According to Pandey, Singh, Kirar and Rajak (2018), AAC has become one of the most adopted building materials in Europe and is rapidly growing in other countries around the world. Due to its excellent properties, AAC is adopted in many building construction projects such as in residential, commercial, schools, hotels, hospitals and many other application. It therefore replaces clay bricks which are environmentally unsustainable. Table 2.2 shows 20 variants that have been adopted on building projects.

Table 2.2: Past and present innovations of 20 variants of AAC adopted on building projects.

S/N	AAC Variant/Parameter studied	Replacement method/salient feature of the study	Improvement/Enhancement	Sources
1	AAC with 32.5 grade Ordinary Portland Cement (OPC)	Cement is partially being replaced with BLA	Still Under laboratory investigation	Simeon and Oladiran, (2021)
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4	AAC with Coal Bottom Ash (CBA)	CBA was used to replace sand. Optimum replacement of CBA is 50%	Thermal conductivity value is decreased up to 39% and increased strength up to 16% higher than reference AAC.	Kurama, Topcu and Karakurt (2009).
5	AAC with Natural Zeolite Additive (NZ)	Sand was replaced by up to 50% NZ	Decreases the unit weight of aerated concrete specimens hence, decreases density	Karakurt, Karuma and Topcu (2010).
6	AAC with Self-ignition Coal Gangue (SCG)	Optimum mix proportion is SCG to lime to cement to gypsum is 54:23:20:3 with 1.3% aluminum powder	The products consisted of CSH gel and tobermorite phase.	Cong, Lu, Yao & Wang (2016).
7	AAC with Incinerated Sewage Sludge Ash (ISSA)	ISSA for the production of AAC block	Should only be considered for use if alternatives (PFA or Natural Sand) are not available or uneconomic	Dunster (2007).
8	AAC with Bamboo Leaf Ash (BLA)	Up to 15% of BLA is being partially replaced with cement	Still Under laboratory investigation	Simeon and Oladiran, (2021)

9	AAC with Silica Fume (SF) / Fly Ash (FA)	52.5 grade OPC is being replaced with various percentages up to 25% of SF.	Compressive strength increases up to 80% when cement is replaced by 15% of SF.	Rathod and Akbari (2017).
10	AAC with Dune Sand (DS)	Normal sand was being replaced by up to 30% Dune sand	A drastic reduction in strength was observed when higher than 30%	Vu and Nguyen (2017).
11	AAC with Rice Husk Ash (RHA) / Aluminum Powder (AP)	RHA and Aluminium containing waste as a partial aggregate and expansive replacement agent	Delicate particle size has a positive effect on the CSH to tobermorite conversion.	Kunchariyakun, Asavapist and Sombatsompop (2015).
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14	AAC with Air-cooled Slag (AS)	AS was used to replace lime and sand (optimum at 50% low-lime mixes and 30% for high-lime mix)	Improvement in compressive strength and shorter curing duration	Mostafa (2005).
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		Cement to Gypsum is 30:35:20:10:5		
20	AAC with Perlite Waste (PW) / Polypropylene Fiber (PF)	Sand was replaced by PW	PW at 10% reduced the thermal conductivity about 15% without significant reduction of compressive strength.	Rozycka and Pichor (2016).

Simeon (2021).

2.6 Drivers to the adoption of AAC block

Rathi and Khandve (2015) replaced red bricks with eco-friendly AAC blocks and it was revealed that as AAC block usage reduces the cost of construction by up to 20%. The reduction of dead load of the wall on the beams makes comparatively lighter members, the use of AAC blocks also reduces the requirements of materials such as cement and sand by up to 50%.

Similarly, in studies conducted by Oo and Hlaing (2018) on the beneficial usage of AAC block, it was revealed that the cost of AAC block for building a wall that has $100ft^2$ is lesser than the cost of conventional brick. In the same vein, the weight of AAC block to build a wall that has $100ft^2$ is lesser than the weight of conventional brick.

Furthermore, the compressive strength of AAC block is higher than that of conventional brick. So also, the quality. Relatedly, Pandey et al. (2018) reported that AAC is one of the eco-friendly and certified green building materials that is porous, non-toxic, reusable, renewable and recyclable. Pandey et al. (2018) asserted that AAC is lightweight, load bearing, high insulating, durable and is produced in a wide range of sizes and strength. Being aerated, it contains 50-60% of air, leading to its lightweight and low thermal conductivity.

AAC is manufactured from common and abundant natural raw materials, it is therefore extremely resource-efficient and eco-friendly. The energy consumed in the production process emits no pollutants and creates no by-products or toxic waste products. The workability of AAC helps to eliminate waste on the job and its compressive strength is comparatively more than traditional clay brick. The density of AAC block is one-third that of traditional clay brick and there is no change in wet condition. It helps in reducing a dead load of the structure thereby reducing cost of construction by up to 20% (Rathi & Khandve, 2015).

Furthermore, Nahhas (2013) reported that AAC block has its obvious advantages of higher strength to weight ratio, better tensile strain capacity, lower coefficient of thermal expansion, and enhanced heat and sound insulation characteristics due to air voids in the concrete.

Research and Market (2020) gives an account of drivers to adoption of AAC on building projects in various regions of the world, these are stated as follows. In China, there is high demand for eco-friendly construction material to drive the AAC market. While in Japan, AAC is widely used due to its lightweight nature in earthquake-prone. In India however, newly-adopted green building AAC material is used to substitute conventional red clay bricks.

Similarly, in South Korea, AAC blocks are widely used to minimize cooling and heating loads in buildings. While in Australia, there is improved investment scenario in commercial construction will drive the demand for AAC. Furthermore, in Europe, Germany aims to have an almost climate-neutral building stock by 2050. While in the UK, changes to building regulations and solutions to improve thermal and acoustic performance drives the market.

AAC which was first developed in Scandinavia is now widely used in buildings. In Russia, demand for AAC is high despite the overall decline in construction activities. In Poland however, growing residential construction increases the demand for AAC construction material. In North America, in the US, demand for AAC is growing and frequently being used in flooded areas owing to its moisture absorbing feature. In Canada, AAC has how been widely accepted in Canada due to its heat resistant property. In Mexico, rapidly growing infrastructure is attracting leading AAC manufacturers in the country.

In the Middle East and Africa, in Turkey, blocks are most widely used AAC materials. In the UAE however, AAC is accepted and approved across UAE for use in many prestigious projects. In Saudi Arabia, several ongoing and upcoming infrastructural projects are in place to boost the demand for AAC materials while in South Africa, surge in private investment in the construction sector is expected to drive the AAC market. In South America, Brazil is witnessing growing demand for AAC materials in infrastructural development. In Argentina, favorable building & construction industry outlook is facilitating Growth of AAC Market.

The major drivers to the use of AAC block for masonry construction comprise: Excellent thermal absorption property; Superior fire insulation; Pest and mold resistant; Lightweight; Better thermal conductivity; Reduced dead weight on structure; Reduction of building costs as a result of decrease structural element; Eco-friendly (lower environmental impact); Adaptability of AAC blocks to tropical climates; Recyclable; Quick and easy installation; Excellent acoustic performance; Breathable wall system; Monetarily and ecologically better than other conventional walling materials; Attractive appearance; Readily adaptable to any style of architecture; Reduced transfer of load on the foundation; Manufactured from common and abundant raw material; Versatile as components can be used for walls, floors and ceiling, Energy efficient; Use of reduced labour in manufacture and its installation; Reduced cost of maintenance; AAC production process does not develop toxic gases; Durability; Used in the construction of dwellings in low-cost housing units on the mass scale and Moisture resistant.

2.7 Barriers impeding AAC block adoption

Research and Market (2020) posit that AAC is one of the world most produced building materials after concrete and is mostly manufactured as blocks and panels. Unlike concrete masonry units, AAC blocks are solid with no moulded core holes. 4 inches of AAC has a 4-hour rating making it ideal in commercial buildings for encasing steel columns, surrounding elevator shafts and for other fire stopping requirements.

Despite the immense benefits of AAC block for construction of sustainable buildings, its level of adoption is still very low when compared to conventional sandcrete blocks and bricks. This according to Falade and Ikponmwosa (2008) is that stakeholders are being addicted to the use of conventional construction materials like sandcrete blocks, concrete and the likes.

Similarly, cost associated with AAC, lack of awareness of AAC blocks, low market penetration and brittle nature of the material are barriers of AAC block adoption (Research & Market, 2020). The use of sustainable building materials in the construction industry still faces a lot of challenges for its implementation.

Based on the studies of Landman (1999), Anderson, Bennett and Collopy (2000), Rao and Brownhill, (2001) factors impeding the use of sustainable building materials as follows: The real or perceived financial cost and risks which include the problem of the upfront cost and the ongoing costs usually coming from separate budgets, if not separate organization, lack of information and training of designers, contractors, and clients, lack of demand from the clients, lack of support from subcontractors and regulation.

In the same vein, Anderson et al. (2000) and Davis (2001) stated that barriers to using sustainable building materials and products are: Construction practitioners that are not aware of how important it is to prevent the environment from being polluted by the waste generated from construction industry, the absence of well-known sustainable building products to be used in construction, the lack of sufficient environmental information about structural materials to make adequate comparison between alternatives and the absence of regulations and codes that encourage the use of green building.

Djokoto, Dadzie and Ohemeng-Ababio (2014) identified 20 barriers to sustainable construction in Ghana which comprises lack of building codes and regulation**,** lack of incentives, higher investment cost, risk of investment**,** higher final cost, lack of public awareness, lack of demand, lack of strategy to promote sustainable construction, lack of design and construction team, lack of expertise, lack of professional knowledge, lack of database and information, lack of technology, lack of government support, lack of a measurement tool, increased documentation, extensive pre-contract planning, change resistance, lack of training, lack of cooperation.

The major barriers impeding AAC block adoption for building projects are simplified and listed below: Unfavorable perception of home buyers to AAC in the short term; Lack of interest in new products by buyers and house owners; Little interest in new products by Architects and Developers; Costs of the "learning curve" while working with a new product; Startup costs associated with promoting and teaching the industry to build with AAC; Market potentials; Inadequate building codes and regulations; Low demand for sustainable housing; Lack of easy rating systems for eco-buildings; Absence of design standards for AAC products; Inadequate government policies and supports; Existing structure of the construction industry; Lack of readily available accessible information; Low level of awareness and knowledge on the concept of sustainability; Low level of demand and knowledge of AAC products; Inadequate exemplar demonstration project to infuse confidence for using AAC; Non-awareness of people towards the advantageous use of AAC, Huge capital to set up AAC plant; Lack of readily available accessible information; Inadequate technical know-how and manpower to manufacture AAC products; Use of unsustainable construction materials; Availability of conventional material and Affordability.

2.8 Strategies that can improve the usage of AAC blocks

Pandey et al. (2018) recommended that in order to improve the application of AAC product in various fields, an approach requires investment in high quality and automated equipment that uses the latest manufacturing technology. Producing a complete AAC solution is a next step towards the market expansion and increasing market share of AAC as a building material. Investment in innovative plant upgrades and new plants with modern AAC technology are essential to staying ahead of the ever-changing construction market.

Furthermore, Research and Markets (2020) posit that strategies that can improve AAC block usage are growth in the infrastructural sector, rising demand for light weight construction materials, growth preferences for low-cost houses and an ever-increasing focus on green and soundproof buildings. Other strategies that can improve AAC block adoption are explained below:

a. Proper awareness of sustainable construction

There is no doubt that sustainable design is an imperative part of design education today. Tertiary Institutions in Nigeria both for Undergraduate and Post graduate level need to optimize sustainable design in their semester curriculum. It could include sustainable development, sustainable design processes, principles, policies and building regulations (Davies & Davies, 2017). Davies and Davies (2017) further stated that the mentality of the younger designers will be built to be more conscious of sustainable development and construction and added that the lack of exposure to sustainable design in Tertiary Institution requires that this education needs to be obtained. To bridge the education gap, practitioners could utilise the services of a consultant or local resource centres. Davies and Davies (2017) revealed that other designers, unlike architects, are not familiar with building regulations that promote energy efficiency and environmental sustainability.

b. Support of government policies

Davies and Davies (2017) recommended that government policies should be made in favour of sustainable construction and energy saving. Regulations should be developed in Nigeria, which should assist the built environment in becoming more sustainable and added that presently, there are no policies, regulations or bodies to sustainable development and promote environmental sustainability and energy savings. And none have been implemented.

Complete overhaul of planning and implementation policies such as building codes, that regulate performance standards for design and construction works based on sustainable principles be facilitated. Ofori (2006) Posit that the National Building Code of the Federal Republic of Nigeria was not developed based on sustainable development but rather on persistence collapse of buildings; the paucity of reference design standards for professionals; and the use of unskilled professionals.

However, total overhaul of the National Building Code that will incorporate sustainable construction is pertinent most especially for residential buildings. The development of bye-laws for major cities in Nigeria should be advocated and encouraged because of their strategic level of development. Governments (federal, state and local), through respective regulatory agencies, should play significant roles in reversing the trend of building failures and collapse.

c. Products suppliers and manufacturers

It is essential that product and material suppliers and manufacturers continue developing environmentally responsible products and broadening their product ranges, as with greater selection, designers and clients are more likely to choose this alternative. In addition to this, and despite its difficulty, designers need to continually ask product suppliers and manufacturers about their raw materials, processes and the origin of products. With persistence, this would yield positive results (Eley, 2011; El-Gohary & El-Diraby, 2010; Du-Plessis, 2007; Thorpe & Ryan, 2007; Haselbach, 2008).

d. Client education

Barriers preventing clients from committing to a sustainable design approach are presently surplus cost, a selective use of materials, as well as education into the pressing need for sustainability. This results in clients not willing to consider the environmental responsibility, and lack of enthusiasm from designers to advocate sustainable design (Eley, 2011; El-Gohary & El-Diraby, 2010; Du Plessis, 2007; Thorpe & Ryan, 2007; Haselbach, 2008; Hakkinen & Belloni, 2011).

The higher educational background will enable clients to becoming better informed on the benefits of sustainable development/ design alternatives. This will consequently boost the client's awareness and thereby enhance level of acceptance. It will be eventually increase in demand for sustainable construction and cause a reduction in price of the sustainable construction materials and techniques (Yudelson, 2007).

e. Introduction of sustainable construction in the educational institutions

It is pertinent to introduce sustainable and green construction education into the curriculum based on the fact that every year, many people graduate from different educational institutions with degrees in construction and construction related fields. These fields of study also include various renewable resources and building sciences, technology, and design degree programmes. This will facilitate real-world practical experience into classrooms by the professionals and academicians to the students (Davies & Davies, 2017).

g. Accessibility of information and intricacy of analysis

Azapagic and Perdan (2000); Singh et al. (2013) and Yudelson (2009) emphasised on the significant of accessibility of information and intricacy of analysis on the sustainable construction. It is a measure of qualitative, quantitative and progress of sustainable activities for the whole system. It provides a framework and a systematic approach to assess sustainability in construction.

Information and intricacy of analysis guide the decision makers to appraise the selection process of construction equipment on the triple bottom line of sustainability.

An extensive review of the literature of the sub-themes of the project title has been carried out. The following have been extensively reviewed: definition of Autoclaved Aerated Concrete (AAC) and sustainable construction materials, awareness of AAC block variants, adoption level of AAC on building projects, barriers impeding AAC block adoption and strategies that can improve the usage of AAC blocks on building projects.

CHAPTER THREE

3.0 RESEARCH METHOD

3.1 Introduction

This chapter presents the general outline or procedure for conducting the study. It discusses the research design, population of the study, area of the study, sampling technique and procedures, method of data collection, instrument of data collection, types of data used, reliability and validity of the research instrument, method of data analysis and constraints to the study.

3.2 Area of the study

The first study area was delimited to Lagos state which is located in the south-western region of Nigeria. It is the largest metropolitan area in Nigeria (Ayeni, 1979). The choice of Lagos state was because it is the economic nerve center of Nigeria. As the economic and commercial nerve-center of the country, Lagos has a high number of construction practitioners as well as a large concentration of construction related organizations of various categories and sizes. There is a high demand of building materials for residential, commercial and institutional buildings, civil and heavy engineering works in Lagos due to the large population of the state.

It is the second most populous state in Nigeria with over 9 million human populations (National Population Commission, 2009). This ranks the state among the fastest growing cities in Nigeria with a significant level of construction activities which enhanced the collection of data for this study. The second study area was delimited to five provinces from South Africa and the respondents were obtained through referral.

3.3 Research design

Research design provides an outline that serves the purpose of guiding a researcher on how to generate data on a particular study (Asika, 2012). A survey research design was adopted in the study to achieve the outlined research questions, hypothesis testing to meet the study's objectives. Specifically, a cross-sectional research design was used where samples were drawn from the population of study at one point in time. The term survey is used for the techniques of investigation by a direct observation of a phenomenon or a systematic gathering of data from population by applying personal contact and interviews when adequate information about certain problem is not available in records, files and other sources (Pandey & Pandey, 2015).

3.4 Population of the study

Umeh (2018) defines the study population as the totality of all elements, subjects, or members that possess one common or a set of common characteristics. The targeted population for this study were made up of two groups comprising Nigerian and South African professionals acquainted with the knowledge and have been involved in the use of AAC on building projects.

3.5 Sample size and sampling techniques

Asika (2012) defines a sample as precisely a part of the population. A sample is a subset of a population drawn specifically to make inference about the population.

The study adopted multi-sampling method, with convenience sampling method being the first. Convenience sampling is a non-probabilistic sampling technique and one in which selection of sampling units by a researcher is based on the members of the frame that: easily volunteered; are available; or are easy to assess (Umeh, 2018). It was adopted due to the researcher's inability to obtain a current and comprehensive list of built environment professionals in the construction industry operating or based in Lagos as at the time of carrying then study.

Secondly, the study also utilized snowball sampling method to obtain responses from the referred South African respondents. Snowball sampling is especially useful when a researcher is trying to identify samples of a population that are difficult to locate (Umeh, 2018). Absence of list comprising registration of AAC contractors/firms (sample frame) afforded the researcher to rely on participant referrals to recruit new participant and this prompted the use of snowball sampling technique as AAC block is not one of the conventional walling materials adopted in the provinces. Few respondents who met the criteria and have been involved in AAC projects were first identified. The identified respondent then made referrals to others that have used the block until the last respondent is attained. Snowball sampling could be used for qualitative and quantitative studies, and the use of a questionnaire for collecting data could be appropriate (Gaal, 2016; Showkat & Parveen, 2017).

3.6 Instrument for data collection

Two field research instruments were developed to collect data namely: "Structured Self-administered Questionnaires was designed for the Nigerian professionals in the Lagos metropolis" and "Online Questionnaire Survey (through Google Forms) was designed to collect data from the referred South African respondents".

The structured questionnaire contained close-ended questions for eliciting information relating to the research objectives from the targeted respondents. The variables were being identified through a comprehensive literature review which were summarized and simplified for the study.

Copies of the structured questionnaires were used in obtaining responses from the Nigerian professionals as regards their demographic profile; level of awareness of AAC block variants; prospect for adoption of AAC block in the Nigerian building industry; drivers of AAC blocks; barriers impeding AAC block adoption and strategies to enhance AAC block adoption. While Online survey questionnaire through Google forms were used to gather responses from the viewpoints of referred South African respondents as regards their demographic profile; level of awareness of AAC block variants; adoption level of AAC block on building projects in South Africa provinces; drivers of AAC blocks; barriers impeding AAC block adoption and strategies to enhance AAC block adoption.

The survey instrument consists of six sections for each categories of respondents. Section 'A' sought to obtain information on the demographic profile of the respondents. The information in section A was required to moderate the core parts of sections B, C, D, E, & F. In section B, the respondents were required to indicate their level of awareness of the 20 different variants of AAC available in literature (Source: Almajeed & Turki (2019); Khan (2020); Naik et al. (2018); Wahane (2017); Abed et al. (2017); Owsiak et al. (2015); Rathod & Akbari (2017); Dunster (2007); Huang (2012); Mostafa (2004); Rathod & Akbari (2017); Demir & Güçlüer (2017); Vu & Nguyen (2017); Kuram et al. (2008); Demir, & Güçlüer, (2017); Haung et al. (2012); Owsiak et al. (2015); Naik et al. (2018); & Hauser et al. (1999)) by ticking the appropriate scale that indicates their level of awareness of AAC block options: 5 represents fully aware, 4 represents highly aware, 3 represents somewhat aware, 2 represents slightly aware and 1 represents not at all aware.

Section C1 of the research instrument sought to evaluate prospect for AAC block adoption in the Nigerian building industry by ticking: 1 represents very poor, 2 represents poor, 3 represents moderate, 4 represents good and 5 represents very good.

Section C2 of the research instrument sought to evaluate the adoption level of AAC by ticking the AAC variants that were used in the last ten (10) projects: Note: 0 represents Nil, 1 represents project 1, 2 represents project 2, 3 represents project 3, 4 represents project 4, 5 represents project 5, 6 represents project 6, 7 represents project 7, 8 represents project 8, 9 represents project 9 while 10 represents project 10.

Section D of the research instrument sought to assess 26 drivers of AAC on building projects (Source: Talati et al. (2018); Walczok et al. (2015); Habib et al. (2015); Aasif & Shrivastava (2018); Nagavenkatasaikumar & Satihish (2017); Domingo (2008); *www.researchandmarkets.com*; Manikandan et al. (2018); Sachin et al. (2018); Rathi & Khandve (2015); Asha et al. (2014); Oo & Hlaing (2018); Pulliattu & John (2017); & Güçlüer et al. (2015)) by ticking the appropriate scale that indicates drivers of AAC by ticking one of the options for each driver: **5** represents most important, **4** represents more important, **3** represent moderately important, **2** represents slightly important and **1** represents not important.

Section E of the research instrument sought to assess significant barriers impeding the adoption of AAC (**Source:** Abidin, (2010); Muazu, & Alibaba, (2017); Tey et al. (2013); *www.researchandmarkets.com*; Djokoto et al. (2014); Williams & Dair (2017); Ametepey et al. (2015); Sutton (1999); Landman (1999); Anderson et al. (2000); Rao & Brownhill, (2001); Kissi et al. (2018); Dahle & Neumayer (2001), Griffin et al. (2010), Shafii et al. (2006); Muazu & Alibaba (2017); & Tey et al. (2013)) by ticking one of the options for each factor: **5** represents most Significant, **4** represents more Significant, **3** represents moderately significant, **2** represents slightly significant and **1** represents not significant.

While section F evaluates important strategies that can improve the adoption of AAC on construction sites in Lagos state (Source: *www.marketsandmarkets.com*; *www.researchandmarkets.com* & Davies & Davies (2017)) by ticking one of the options for each effect: **5** represents most important, **4** represents more important, **3** represent moderately important, **2** represents slightly important and **1** represents not important.

3.7 Data distribution and collection procedure

Primary data was collected via Structured Self-administered Questionnaires to the Nigerian professionals, while Online Questionnaire Survey (through Google Forms) were administered to gather the viewpoints of 17 referred South African Professionals who have been involved in the use AAC blocks in five South African provinces. Personal phone calls and site visits were made to the respondents to retrieve the questionnaires in Lagos metropolis. While, Google form links and reminders were sent to the mails of the referred respondents to obtain their responses.

3.8 Types of data used in the study

Two types of data were used: primary data and secondary data. The primary data was obtained from the field with the aid of structured questionnaire while the secondary data were obtained from the review of relevant literature from published sources such as journals, seminar papers, conference proceedings and textbooks.

3.9 Validity of Research Instrument

According to Ogolo (1996) Validity testing entails content rating by a group of judges. An instrument is said to be valid if it covers the entire subject. The content validity of the instrument was assessed by my project Supervisor, a Lecturer in Civil Engineering department, an AAC block manufacturer and a staff PhD candidate in Cape Town University, South Africa. The corrections identified by these experts were rectified in the questionnaire before it was administered.

3.10 Procedure for data processing and analysis

The response data from the study were coded, processed and analyzed with the aid of Statistical Package for Social Sciences (SPSS) version 23.0, Data were analyzed using the following descriptive statistical tools such as frequency, percentages, mean score and ranking, while One-way ANOVA, Mann Whitney U test and Kendall's coefficient of concordance were used as the tools of analysis for the inferential statistics, respectively.

3.11 Constraints to study

The research faced some constraints which are listed below:

There was reluctance of some respondents to participate in the survey. Whereas, some respondents were most interested in the research project but unwilling to participate because they felt the questionnaire was geared towards eliciting confidential information pertinent toward their own market and technical research which they believe is not relevant to my evaluation of the Nigerian market.

Also, there was time constraint due to the short time this dissertation was conducted however, if there had been more time all the questionnaires would have been retrieved and there would have been a more robust analysis of data. Lastly, the fund required to aid the retrieval of the questionnaire was on the high side which made it impossible for all the questionnaires to be retrieved.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION OF FINDINGS

4.1 Introduction

This chapter deals with the presentation of results of the analysis of data. The discussions of the results are also presented in this chapter.

4.2 The response rates

The response rate is depicted in Table 4.1

Table 4.1: Response rates from respondents

Questionnaires	Number
Total numbers of questionnaire administered	145
Total numbers of questionnaire returned	99
Response rate	68.3%

Table 4.1 shows that 145 copies of questionnaire were distributed to the respondents. At the end of the survey period, a total of 99 questionnaires were duly completed and retrieved. A total of 99 questionnaires were then analyzed for the study representing a 68.3% response rate. This is a good response rate considering the difficulties in getting responses to questionnaires in Lagos state.

Moreover, 17 numbers of questionnaires were obtained from referred South African construction professionals acquainted with the material and have been involved in the use of AAC block for building projects in 5 South African provinces.

4.3 Demographic profile of the respondents

The demographic data of the respondents are presented in Tables 4.21 and 4.22

Table 4.21: Demographic profile of the Nigerian respondents

	Nigerian Professionals	
Profile	**Frequency**	**Percentage**
Professional Background		
Architecture	7	7.1
Building	38	38.4
Civil Engineering	45	45.5
Quantity Surveying	9	9.1
Total	**99**	**100.0**
Professional Body		
NIA	7	7.1
NIOB	38	38.4
NSE	45	45.6
NIQS	9	9.1
Total	**99**	**100.0**
Grade of membership		
Graduate	48	48.5
Corporate	47	47.5
Fellow	4	4
Total	**99**	**100.0**
Highest Academic Qualification		
OND	0	0
HND	10	10.1
BSc/BTech	55	55.6
MSc/MBA	31	31.3
PhD	3	3
Total	**99**	**100.0**
Years of Experience		
1-5 Years	25	25.3
6-10 Years	29	29.3
11-15 Years	26	26.3
16-20 Years	12	12.1
21 Years and above	7	7.1
Total	**99**	**100.0**
Organisation Type		
Consulting	31	31.3
Contracting	45	45.5
Client Organisation	5	5.1
Design & Build	18	18.2
Total	**99**	**100.0**

Organisation Size		
Small sized with 1-50	43	43.4
Medium sized with 51-250	47	47.5
Large size with 250 or more	9	9.1
Total	**99**	**100.0**
Ownership and Management		
Fully Indigenous	60	60.6
Fully Expatriate	5	5.1
Partly Indigenous & partly expatriate	34.3	34.3
Total	**100**	**100.0**
Nature of work undertaken		
New construction	27	27.3
Renovation	5	5.1
General contracting	67	67.7
Total	**99**	**100.0**

Table 4.21 shows the demographic information of the Nigerian respondents as it captured the professional background of respondents that participated in the study. From the first category of respondents; 7.1% were Architects, 38.4% were Builders, 45.5% were Civil Engineers while 9.1% were Quantity Surveyors. This result revealed that most of the respondents had Civil Engineering academic background. Also, for professional affiliation, 7.1% are registered with Nigerian Institute of Architects (NIA), 38.4% are registered with Nigerian Institute of Building (NIOB), 45.5% are registered with Nigerian Society of Engineers (NSE) while 9.1% are registered with Nigerian Institute of Quantity Surveyors (NIQS). This result indicates that most of the respondents are registered with the Nigerian Society of Engineers.

Table 4.21 also indicates the highest academic qualification of the Nigerian respondents. 10.1% of the respondents have higher National Diploma, 55.6% of the respondents have University's Bachelor degree, 31.3% and 3.0% of the respondents possesses Master's and Doctorate Degrees respectively. This inference that can be drawn from this result is that the respondents have acquired a significant level of formal education and were able to understand the questions and were able to provide quality responses to the various research questions.

Experience is key and could depict the level of knowledge of a respondent with reference to a study. 25.3% of the Nigerian respondents had years of experience ranging from 1 to 5 years, 29.3% of the respondents had years of experience ranging from 6 to 10 years, 26.3% of the Nigerian respondents had years of experience ranging from 11 to 15 years, 12.1% of the Nigerian respondents had years of experience from 16-20 years while 7.1% of the Nigerian respondents had years of experience from 21 and above years.

Table 4.21 further shows the participating proportion of each organisation type. 31.3% of the Nigerian respondents were from Consulting organisation, 45.5% were from Contracting organisation, 5.1% were from Client organisation while 18.2% were from Design & Build organisation.

Table 4.21 further reveal that the study sample consisted of mainly medium-sized organisations with 47.5%, followed by small-sized organisation with 43.4% and large-sized organisations with 9.1%. The table further indicates the type of ownership and management of the organisations that participated in the survey and reveals that 60.6% are indigenously owned, 5.1% are fully expatriate while 34.3% are partly indigenous and partly expatriate.

Table 4.21 further showed the nature of construction works undertaken by the organizations. 27.3% respondents undertake new construction works, 5.1% respondents undertake renovation/refurbishment works while 67.7% respondents undertake general contracting works. This result indicates that a larger number of the Nigerian respondents undertakes general contracting works.

Table 4.22: Demographic profile of the South African respondents

Profile	South African Professionals	
	Frequency	**Percentage**
Years of Experience		
1-5 Years	1	5.9
6-10 Years	3	17.6
11-15 Years	8	47.1
16-20 Years	3	17.6
21 Years and above	2	11.8
Total	**17**	**100.0**
Organisation Size		
Small sized with 1-50	6	35.3
Medium sized with 51-250	7	41.2
Large size with 250 or more	4	23.5
Total	**17**	**100.0**
Ownership and Management		
Fully indigenous	8	47.1
Fully expatriate	3	17.6
Partly indigenous & partly expatriate	6	35.3
Total	**17**	**100.0**
Nature of work undertaken		
New construction	4	23.5
Renovation	1	5.9
General contracting	12	70.6
Total	**17**	**100.0**
Province		
Western Cape	9	52.9
Gauteng	2	11.8
Eastern Cape	2	11.8
Free State	2	11.8
KwaZulu-Natal	2	11.8
Total	**17**	**100.0**

Experience is key and could depict the level of knowledge of a respondent with reference to a study. 5.9% of the South African respondents had years of experience ranging from 1 to 5 years, 17.6% of the South African respondents had years of experience ranging from 6 to 10 years, 47.1%

of the South African respondents had years of experience ranging from 11 to 15 years, 17.6% of the South African respondents had years of experience from 16-20 years while 11.8% of the South African respondents had years of experience from 21 and above years.

Table 4.22 further reveals that the study sample consisted of mainly medium-sized organisations with 35.3%, followed by small-sized organisation with 41.2% while large-sized organisations with 23.5%.

Table 4.22 further indicates the type of ownership and management of the organisation and reveals that 47.1% of the organisation in South Africa that participated in the survey are indigenously owned, 17.6% of the organisation are fully expatriate while 5.3% of the organisation are partly indigenous and partly expatriate respectively.

Table 4.22 further showed the nature of construction works undertaken by the participating organizations. 23.5% of the respondents undertake new construction works, 5.9% of the respondents undertake renovation/refurbishment works while 70.6% of the respondents undertake general contracting works. This result indicates that a larger number of the respondents undertake general contracting works.

The latter part of Table 4.22 revealed the provinces of the referred professionals from South Africa. 59% plies their trade in Western Cape, 11.8% plies their trades in Gauteng, Eastern Cape, Free State, KwaZulu-Natal respectively. This shows that majority of the participating professionals are from Western Cape.

4.4 Results of the stated objectives of the study

4.4.1 Awareness of AAC block variants

The awareness of 20 AAC block variants extracted from literature in Nigeria and South Africa are presented in Table 4.3

Table 4.3: Awareness of AAC block variants in Nigeria and South Africa

	Nigerian Professionals			South African Professionals		
AAC Variants	**N**	**MS**	**Rank**	**N**	**MS**	**Rank**
AAC with 52.5 grade Ordinary Portland Cement (OPC)	94	2.11	1	17	4.94	1
AAC with 42.5 grade Ordinary Portland Cement (OPC)	95	2.07	2	17	4.24	2
AAC with Aluminum Powder (AP)/ Rice Husk Ash (RHA)	93	2.01	3	16	4.00	3
AAC with Self-ignition Coal Gangue (SCG)	95	1.98	4	17	2.47	17
AAC with Coal Bottom Ash (CBA)	94	1.95	5	17	2.94	6
AAC with Concrete Sandwich Block (CSB)/ Waste Glass (WG)	95	1.94	6	17	2.88	7
AAC with Natural Zeolite Additive (NZ)	95	1.94	6	17	2.76	9
AAC with Pulverized Fuel Ash (PFA)/ Palm Oil Fuel ash (POFA)	95	1.89	8	17	3.35	4
AAC with Copper Tailings (CT)/ Blast Furnace Slag (BFS)	94	1.85	9	17	2.76	9
AAC with Efflorescence Sand (ES)	95	1.77	10	17	2.65	12
AAC with Silica Fume (SF)/ Fly Ash (FA)	94	1.76	11	17	3.06	5
AAC with Air-cooled Slag (AS)	94	1.76	11	17	2.59	13
AAC with Perlite Waste (PW)/ Polypropylene Fibre (PF)	95	1.71	13	17	2.35	18
AAC with Phosphorus Slag (PS)	92	1.70	14	17	2.59	13
AAC with Dune Sand (DS)	93	1.68	15	17	2.82	8
AAC with Halloysite Powder (HP)	93	1.68	15	17	2.59	13
AAC with Coal Gangue (CG)/ Iron Ore Tailings (IOT)	95	1.67	17	16	2.69	11
AAC with Incinerated Sewage Sludge Ash (ISSA)	93	1.66	18	17	2.59	13
AAC with 32.5 Grade Ordinary Portland Cement (OPC)	97	1.63	19	17	1.94	19
AAC with Bamboo Leaf Ash (BLA)	95	1.36	20	17	1.41	20

Note: 1 represents not at all aware, 2 represents slightly aware, 3 represents moderately aware, 4 represents highly aware, 5 represents fully aware. N represents the number of Respondents; MS represents the Mean Score.

Table 4.3 shows the responses of respondents on the level of awareness of AAC block variants. To quantify the respondents' awareness level of the variants, a graduated scale of 1.00 to 5.00 was adopted and the mean scores were calculated. The mean values were interpreted using the following scale $1.00 \leq MS < 1.49$ ''means not at all aware', $1.50 \leq MS < 2.49$ means 'slightly aware', $2.50 \leq MS < 3.49$ means 'moderately aware', $3.50 \leq MS < 4.49$ means 'highly aware' and $4.50 \leq MS \leq 5.00$ means 'fully aware'.

The study revealed that the Nigerian respondents are slightly aware of 19 out of the 20 listed AAC variants, with mean score ranging from 1.63 to 2.11. The top ranked AAC variants that were slightly aware by the professionals comprises AAC with 52.5 grade OPC (MS=2.11), closely followed by AAC with 42.5 grade OPC (MS= 2.07) and AAC with RHA/AP (MS=2.01). On the other hand, as evidenced, AAC with Bamboo Leaf Ash (MS= 1.36) ranked the least of the AAC variants and the professionals are not at all aware of the variant. On the other hand, from table 4.3, the mean scores of AAC block options as perceived by the South African respondents range from 1.41 to 4.94. The South African professionals are Fully aware of AAC made with 52.5 grade OPC. Relatedly, the professionals are highly aware of AAC made with 42.5 grade OPC and AAC with RHA/AP.

The professionals are moderately aware of 13 of the 20 AAC variants. Also, the professionals are slightly aware of three AAC variants include; AAC made with SCG with a mean score of 2.47, AAC made with PW/PF with a mean score of 2.35 and AAC made with 32.5 grade OPC with a mean score of 1.94. The professionals are not at all aware of AAC made with BLA (MS=3.07).

4.4.2 Prospect for adoption of AAC block in the Nigerian Construction industry

Table 4.4: Prospect for adoption of AAC block in the Nigerian Construction industry

Type	Response rate					MS	SD
	1	2	3	4	5		
Prospect	5 (5.2%)	25(25.8%)	36(37.1%)	26(26.8%)	5(5.2%)	3.01	.794

Note: 1 represents very poor, 2 represents poor, 3 represents moderate, 4 represents good and 5 represents very good. MS represents Mean Score while SD represents Standard Deviation.

Table 4.4 shows the responses of Nigerian professionals on the prospect for adoption of AAC blocks in the Nigerian construction industry. The response rates for the prospect for adoption of AAC block variants are: 5.2% of the respondents are indicated “very poor”, 25.8% of the respondents indicated “poor”, 37.1% of the respondents indicated “moderate”, 26.8% of the respondents indicated “good” while 5.2% of the respondents indicated “very good”. Based on these results, majority of the Nigerian professionals have a moderate disposition about AAC block being adopted in the future.

Also, the mean value for the prospect for adoption of AAC block in the Nigerian construction industry was interpreted using the following scale $1.00 \leq MS < 1.49$ represents ‘Very poor’, $1.50 \leq MS < 2.49$ represents ‘Poor’, $2.50 \leq MS < 3.49$ represents ‘Moderate’, $3.50 \leq MS < 4.49$ represents ‘Good’ and $4.50 \leq MS \leq 5.00$ represents ‘Very good’. The table indicated a moderate prospect for adoption of AAC block by the Nigerian Respondents. This implies that there is a likelihood of the block being adopted in the future.

4.4.3 Adoption level of AAC block variants on building projects in the South African Construction Industry

Table 4.5: Adoption of AAC block variants in South Africa

AAC variant	Freq.	% MU	Rank
AAC with 52.5 grade Ordinary Portland Cement (OPC)	85	31.5	1
AAC with 42.5 grade Ordinary Portland Cement (OPC)	74	27.4	2
AAC with Rice Husk Ash (RHA) / Aluminum Powder (AP)	43	15.9	3
AAC with Pulverized Fuel Ash (PFA) / Palm Oil Fuel Ash (POFA)	43	15.9	3
AAC with Silica Fume (SF) / Fly Ash (FA)	11	4.1	5
AAC with 32.5 grade Ordinary Portland Cement (OPC)	9	3.3	6
AAC with Dune Sand (DS)	3	1.1	7
AAC with Efflorescence Sand (ES)	2	0.7	8
AAC with Coal Bottom Ash (CBA)	0	0	9
AAC with Natural Zeolite Additive (NZ)	0	0	9
AAC with Self-ignition Coal Gangue (SCG)	0	0	9
AAC with Incinerated Sewage Sludge Ash (ISSA)	0	0	9
AAC with Bamboo Leaf Ash (BLA)	0	0	9
AAC with Concrete Sandwich Block (CSB) / Waste Glass (WG)	0	0	9
AAC with Halloysite Powder (HP)	0	0	9
AAC with Air-cooled Slag (AS)	0	0	9
AAC with Phosphorus Sand (PS)	0	0	9
AAC with Coal Gangue (CG) / Iron Ore Tailings (IOT)	0	0	9
AAC with Copper Tailings (CT) / Blast Furnace Slag (BFS)	0	0	9
AAC with Perlite Waste (PW) / Polypropylene Fiber (PF)	0	0	9
Total uses of variants	**270**	**100**	

Note: Freq. represents frequency of usage on the project, % MU represent percentage mean usage

Table 4.5 shows the descriptive analysis result of the adoption level of AAC block variants in the South African building construction industry. Respondents were asked to indicate the AAC block variants that they used in their last 10 recent projects. Results show that the major AAC block variants used on building projects are AAC with 52.5 grade OPC with (% MU=31.5%), AAC with 42.5 grade OPC with (% MU=27.4%), AAC with Aluminum Powder/RHA with (% MU=15.9%) and AAC with

PFA/POFA with (% MU=15.9%) as they are the top most four used AAC variants on building projects. However, AAC with 52.5 grade OPC is mostly adopted AAC block variants in South Africa.

4.4.4 Important drivers for the adoption of AAC on building projects

Table 4.6: Important drivers for the adoption of AAC on building projects

Drivers	Nigerian Professionals			South African Professionals		
	N	MS	Rank	N	MS	Rank
Lightweight	95	4.17	1	17	4.71	2
Energy efficient	96	4.16	2	17	4.71	2
Ecologically better than other conventional walling materials	93	3.98	3	17	4.41	14
Adaptability of AAC to tropical climates	95	3.95	4	17	4.35	16
Superior thermal absorption property	96	3.84	5	17	4.71	2
Excellent fire insulation	96	3.84	5	17	4.76	1
Readily adaptable to any style of architecture	94	3.84	5	17	4.59	5
Use of reduced labor in manufacture and installation	96	3.81	8	17	4.35	16
Made from abundant raw materials	96	3.80	9	17	4.18	21
Reduction in construction cost	96	3.80	9	17	4.35	16
Eco-friendly	97	3.78	11	17	4.59	5

Optimum thermal conductivity	94	3.73	12	17	4.59	5
Low maintenance cost	94	3.72	13	17	4.12	23
Fast and easy installation	96	3.70	14	17	4.53	8
Reduced dead load on structure	95	3.69	15	17	4.41	14
Good acoustic performance	93	3.68	16	17	4.18	21
Highly durable	96	3.68	16	17	4.47	10
Versatile as components can be used for walls, floors and ceilings	96	3.68	16	17	4.24	20
Recyclable	96	3.65	19	17	4.35	16
Reduced transfer of load on the foundation	96	3.64	20	17	4.47	10
Reduced transfer of load on foundation	96	3.64	20	17	4.47	10
Breathable wall system	95	3.62	21	17	4.47	10
Its production process does not emit toxic gasses	96	3.61	22	17	4.53	8
Used for construction of low housing units	96	3.53	23	17	4.47	10
Moisture resistant	95	3.52	24	17	4.12	23
Resistance to pest and mold	96	3.33	25	17	3.94	26
Aesthetically appealing	96	3.07	26	17	4.06	25

Note: 1 represents not important, 2 represents slightly important, 3 represents moderately important, 4 represents more important, 5 represents most important. While, N represents the number of Respondents; MS represents the Mean Score

Table 4.6 shows the responses of Nigerian and referred South African professionals to important drivers to AAC block adoption on building projects. To quantify the drivers of AAC adoption, a graduated scale of 1.00 to 5.00 was adopted and the mean scores were calculated. The mean values were interpreted using the following scale 1.00 ≤ MS < 1.49 ‘'means not important’, 1.50 ≤ MS < 2.49 means ‘slightly important’, 2.50 ≤ MS < 3.49 means ‘moderately important’, 3.50 ≤ MS < 4.49 means ‘more important’ and 4.50 ≤ MS ≤ 5.00 means ‘most important’. The survey instrument used was a 26-item questionnaire. Frequency counts and mean scores of the drivers to the adoption of AAC blocks on building projects ranged from 3.07 to 4.17 and 4.06 to 4.71 for the Nigerian and South African respectively. Results confirmed 24 drivers were more important to the professionals in the Nigerian construction industry while 2 drivers (resistance to pest and mold MS=3.33 and aesthetically appealing MS=3.07) were moderately important to the Nigerian construction professionals. Moreover, results confirmed 9 out of the 26 drivers were most important to the South African Professionals, while the remaining 17 drivers were more important to the respondents.

4.4.5 Barriers impeding the adoption of AAC block for building projects

Table 4.7: Significant barriers impeding AAC block adoption for building projects

Barriers	Nigerian Professionals			South African Professionals		
	N	MS	Rank	N	MS	Rank
Inadequate government policies and supports	94	3.88	1	17	3.35	15
Market potentials	95	3.81	2	17	3.53	5
Low level of awareness and knowledge on the concept of sustainability	96	3.80	3	17	3.18	21

Non-awareness of people towards the advantageous use of AAC products	96	3.79	4	17	3.35	14
Lack of interest in new products by buyers and house owners	96	3.78	5	17	3.47	8
Lack of readily available accessible information	95	3.78	5	17	3.59	2
Huge capital to set up AAC plant	95	3.76	7	17	4.00	1
Existing structure of the construction industry	95	3.76	7	17	3.47	8
Little interest in new products by Architects and Developers	95	3.76	7	17	3.53	5
Absence of design standards for AAC products	96	3.75	10	17	3.41	12
Availability of conventional materials	95	3.75	10	17	3.59	2
Startup costs associated with promoting and teaching the industry to build with AAC products	95	3.75	10	17	3.47	12
Inadequate exemplar demonstration project to infuse confidence for using AAC products	96	3.74	13	17	3.47	12
Low level of demand and knowledge of AAC products	96	3.74	13	17	3.12	23
Little demand for energy efficient buildings	93	3.72	15	17	3.59	2
Use of unstainable construction materials	95	3.72	15	17	3.35	14
Affordability	95	3.71	17	17	3.35	14

Unfavorable perception of home buyers to AAC block in the short term	95	3.71	17	17	3.47	8
Inadequate technical know-how and manpower to manufacture AAC products	93	3.69	19	17	3.53	5
Inadequate building codes and regulations	96	3.69	19	17	3.29	19
Costs of the 'learning curve' while working with a new product	96	3.68	21	17	3.18	21
Low demand for sustainable housing	96	3.66	22	17	3.35	22
Lack of easy rating systems for eco-friendly	97	3.65	23	17	3.29	23

Note: 1 represents not significant, 2 represents slightly significant, 3 represents moderately significant, 4 represents more significant, 5 represents most significant. While, N represents the number of Respondents; MS represents the Mean Score

Table 4.7 shows the responses of Nigerian and referred South African professionals to significant barriers impeding AAC block adoption on building projects. To quantify the barriers impeding AAC adoption, a graduated scale of 1.00 to 5.00 was adopted and the mean scores were calculated. The mean values were interpreted using the following scale 1.00 ≤ MS < 1.49 ‘'means not significant’, 1.50 ≤ MS < 2.49 means ‘slightly significant’, 2.50 ≤ MS < 3.49 means ‘moderately significant’, 3.50 ≤ MS < 4.49 means ‘more significant’ and 4.50 ≤ MS ≤ 5.00 means ‘most significant’. The survey instrument used was a 23-item questionnaire. Frequency counts and mean scores of the barriers to the adoption of AAC blocks on building projects ranged from 3.65 to 3.88 and 3.29 to 4.00 for the Nigerian and South African respectively. Results confirmed all the 23 barriers were more significant to the professionals in the Nigerian construction industry. Moreover, results confirmed 7 out of the 23 barriers were more significant to the referred South African Professionals, while the remaining 16 barriers were moderately significant to the respondents.

4.4.6 Important strategies that can improve the adoption of AAC for building projects

Table 4.8: Important strategies that can improve the adoption of AAC for building projects

Strategies	Nigerian Professionals			South African Professionals		
	N	MS	Rank	N	MS	Rank
Government encouragement	94	3.88	1	17	4.41	11
Focusing research on specific green building materials	95	3.81	2	17	4.59	4
Development of new construction materials and processes	96	3.80	3	17	4.35	13
Public private partnerships on energy efficiency and sustainable materials	96	3.79	4	17	4.18	17
Industrialization	96	3.78	5	17	4.82	2
Growth preferences for low cost houses	95	3.78	5	17	4.59	4
Growth in the infrastructural sector	95	3.76	7	17	4.94	1
Education and training to built environment professionals about AAC products	95	3.76	7	17	4.47	9
The readiness of construction practitioners such as developers and contractors in adopting sustainable materials	95	3.76	7	17	4.29	15
Increasing funding for sustainable building materials	96	3.75	10	17	4.47	9
Government financial supports and subsidy	95	3.75	10	17	4.24	16

Demand for lightweight construction materials	95	3.75	10	17	4.65	3
Marketing strategy development	96	3.74	13	17	4.53	6
Integrating sustainability into formal curricula	96	3.74	13	17	4.35	13
Increasing focus in green and sound proof buildings	93	3.72	15	17	4.53	6
Creating demonstration and training centers	95	3.72	15	17	4.41	11
Government promotion of product	95	3.71	17	17	4.53	6
Use of tool ratings	95	3.71	17	17	4.12	18

Note: 1 represents not important, 2 represents slightly important, 3 represents moderately important, 4 represents more important, 5 represents most important. While, N represents the number of Respondents; MS represents the Mean Score

Table 4.8 shows the responses of Nigerian and referred South African professionals to important strategies to AAC block adoption on building projects. To quantify the strategies of AAC adoption, a graduated scale of 1.00 to 5.00 was adopted and the mean scores were calculated. The mean values were interpreted using the following scale $1.00 \leq MS < 1.49$ ‘'means not important’, $1.50 \leq MS < 2.49$ means ‘slightly important’, $2.50 \leq MS < 3.49$ means ‘moderately important’, $3.50 \leq MS < 4.49$ means ‘more important’ and $4.50 \leq MS \leq 5.00$ means ‘most important’.

The survey instrument used was an 18-item questionnaire. Frequency counts and mean scores of the enhanced strategies of AAC blocks adoption on building projects ranged from 3.71 to 3.88 and 4.12 to 4.94 for the Nigerian and referred South African professionals respectively. Results confirmed 18 strategies were more important to the professionals in the Nigerian construction industry. Besides, the results confirmed 8 out of the 18 important strategies were most important to the referred South African Professionals, while the remaining 10 strategies were more important to the respondents.

4.5 Test of Hypothesis

4.5.1: There is no significant difference among ownership of organisations on the awareness of AAC block variants in the Nigerian construction industry.

One-way Analysis of Variance (F test) was used to test for significant difference in the level of awareness of AAC block variants among organisations. The inferential results are presented in Table 4.9

Table 4.9: ANOVA on the level of awareness of AAC block variants among ownership of organisations

AAC Block Variants	DFb	DFw	DFt	F	P-value	Decision
AAC with 32.5 grade Ordinary Portland Cement (OPC)	2	94	96	.047	.954	NS
AAC with 42.5 grade Ordinary Portland Cement (OPC)	2	92	94	.401	.671	NS
AAC with 52.5 grade Ordinary Portland Cement (OPC)	2	91	93	.424	.656	NS
AAC with Coal Bottom Ash (CBA)	2	91	93	.621	.540	NS
AAC with Natural Zeolite Additive (NZ)	2	92	94	.556	.576	NS
AAC with Self-ignition Coal Gangue (SCG)	2	92	94	.510	.602	NS
AAC with Incinerated Sewage Sludge Ash (ISSA)	2	90	92	.112	.894	NS
AAC with Bamboo Leaf Ash (BLA)	2	92	94	.015	.985	NS

AAC with Silica Fume (SF) / Fly Ash (FA)	2	91	93	.702	.498	NS
AAC with Dune Sand (DS)	2	90	92	.043	.958	NS
AAC with Rice Husk Ash (RHA) / Aluminum Powder (AP)	2	90	92	1.378	.257	NS
AAC with Concrete Sandwich Block (CSB) / Waste Glass (WG)	2	92	94	.522	.595	NS
AAC with Halloysite Powder (HP)	2	90	92	.541	.584	NS
AAC with Air-cooled Slag (AS)	2	91	93	.908	.407	NS
AAC with Efflorescence Sand (ES)	2	92	94	1.062	.350	NS
AAC with Phosphorus Sand (PS)	2	89	91	1.163	.317	NS
AAC with Coal Gangue (CG) / Iron Ore Tailings (IOT)	2	92	94	.769	.466	NS
AAC with Pulverized Fuel Ash (PFA) / Palm Oil Fuel Ash (POFA)	2	92	94	.448	.640	NS
AAC with Copper Tailings (CT) / Blast Furnace Slag (BFS)	2	91	93	.733	.483	NS
AAC with Perlite Waste (PW) / Polypropylene Fiber (PF)	2	92	94	.609	.546	NS

DFb represents degree of Freedom between groups, DFw represents degree of Freedom within groups, DFt represents degree of Freedom total, NS represents no significant difference, S represents Significant difference. Note: P is significant at $P \leq 0.05$.

From the results of the one-way ANOVA presented in table 4.9, there are no significant differences ($P \leq 0.05$) on the level of awareness of AAC block variants among the ownership and management of the organisations on twenty (20) out of the twenty (20) hypothesized AAC block variants. The overall result indicated no significant difference among organisations as regards the level of awareness of AAC variants. The results of the hypotheses imply that the level of awareness of AAC variants is similarly perceived among the ownership of the organisations in the Nigerian construction industry.

4.5.2 There is no significant difference on the awareness of AAC block variants among the ownership of the organisations in South Africa building industry.

The inferential results are presented in Table 4.10

Table 4.10: ANOVA on the awareness of AAC block variants among organisations

AAC Block Variants	DFb	DFw	DFt	F	P-value	Decision
AAC with 32.5 grade Ordinary Portland Cement (OPC)	2	14	16	.905	.910	NS
AAC with 42.5 grade Ordinary Portland Cement (OPC)	2	14	16	1.083	.365	NS
AAC with 52.5 grade Ordinary Portland Cement (OPC)	2	14	16	.529	.600	NS
AAC with Coal Bottom Ash (CBA)	2	14	16	.705	.511	NS
AAC with Natural Zeolite Additive (NZ)	2	14	16	3.157	.074	NS
AAC with Self-ignition Coal Gangue (SCG)	2	14	16	1.390	.281	NS
AAC with Incinerated Sewage Sludge Ash (ISSA)	2	14	16	2.117	1.57	NS
AAC with Bamboo Leaf Ash (BLA)	2	14	16	.786	.475	NS
AAC with Silica Fume (SF) / Fly Ash (FA)	2	14	16	.622	.551	NS
AAC with Dune Sand (DS)	2	14	16	.824	.459	NS
AAC with Rice Husk Ash (RHA) / Aluminum Powder (AP)	2	13	15	1.690	.223	NS
AAC with Concrete Sandwich Block (CSB) / Waste Glass (WG)	2	14	16	.487	.625	NS
AAC with Halloysite Powder (HP)	2	14	16	1.343	.293	NS
AAC with Air-cooled Slag (AS)	2	14	16	.967	.404	NS

Table 4.10 Cont'd

AAC with Efflorescence Sand (ES)	2	14	16	2.242	.143	NS
AAC with Phosphorus Sand (PS)	2	14	16	1.499	.257	NS
AAC with Coal Gangue (CG) / Iron Ore Tailings (IOT)	2	13	15	.129	.880	NS
AAC with Pulverized Fuel Ash (PFA) / Palm Oil Fuel Ash (POFA)	2	14	16	.451	.646	NS
AAC with Copper Tailings (CT) / Blast Furnace Slag (BFS)	2	14	16	1.984	.174	NS
AAC with Perlite Waste (PW) / Polypropylene Fiber (PF)	2	14	16	.487	.625	NS

DFb represents degree of Freedom between groups, DFw represents degree of Freedom within groups, DFt represents degree of Freedom total, NS represents no significant difference, S represents Significant difference. Note: ρ is significant at $\rho \leq 0.05$.

From the results of the one-way ANOVA presented in table 4.10, there are no significant differences ($P \leq 0.05$) on the level of awareness of AAC block variants among the ownership and management of the owners of the South African construction organisations on twenty (20) out of the twenty (20) hypothesized AAC block variants. The overall result indicated no significant difference among organisations as regards the level of awareness of AAC variants.

The AAC variants for which there are no significant differences and for which the null hypothesis was accepted comprise (AAC with 32.5 grade Ordinary Portland Cement (OPC), AAC with 42.5 grade Ordinary Portland Cement (OPC), AAC with 52.5 grade Ordinary Portland Cement (OPC), AAC with Coal Bottom Ash (CBA), AAC with Natural Zeolite Additive (NZ), AAC with Self-ignition Coal Gangue (SCG), AAC with Incinerated Sewage Sludge Ash (ISSA), AAC with Bamboo Leaf Ash (BLA), AAC with Silica Fume (SF) / Fly Ash (FA), AAC with Dune Sand (DS), AAC with Rice Husk Ash (RHA) / Aluminum Powder (AP), AAC with Concrete Sandwich

Block (CSB) / Waste Glass (WG), AAC with Halloysite Powder (HP), AAC with Air-cooled Slag (AS), AAC with Efflorescence Sand (ES), AAC with Phosphorus Sand (PS), AAC with Coal Gangue (CG) / Iron Ore Tailings (IOT), AAC with Pulverized Fuel Ash (PFA) / Palm Oil Fuel Ash (POFA), AAC with Copper Tailings (CT) / Blast Furnace Slag (BFS) and AAC with Perlite Waste (PW) / Polypropylene Fiber (PF)). The results of the hypotheses imply that the level of awareness of AAC variants is similarly perceived among the ownership of the organisations in the South African construction industry.

4.5.3: There is no significant difference in the perception of Nigerian and South African professionals on the level of awareness of AAC block variants.

The inferential results are presented in Table 4.11

Table 4.11: Mann-Whitney U test results for comparing perception of Nigerian professionals and South African Professionals on the level of Awareness of AAC block variants

AAC Variants	Nigerian Professionals		South African Professionals		U	P-value	Decision
	N	MS	N	MS			
AAC with 32.5 grade Ordinary Portland Cement (OPC)	97	54.85	17	72.62	567.500	.024	S
AAC with 42.5 grade Ordinary Portland Cement (OPC)	95	49.78	17	94.03	160.500	.000	S
AAC with 52.5 grade Ordinary Portland Cement (OPC)	94	48.06	17	99.91	52.500	.000	S
AAC with Coal Bottom Ash (CBA)	94	51.68	17	79.88	393.000	.000	S
AAC with Natural Zeolite Additive (NZ)	95	52.54	17	78.65	431.000	.001	S
AAC with Self-ignition Coal Gangue (SCG)	95	53.71	17	72.12	542.000	.023	S

AAC with Incinerated Sewage Sludge Ash (ISSA)	93	51.17	17	79.18	388.000	.000	S
AAC with Bamboo Leaf Ash (BLA)	95	55.75	17	60.68	736.500	.457	NS
AAC with Silica Fume (SF) / Fly Ash (FA)	94	50.03	17	89.03	237.500	.000	S
AAC with Dune Sand (DS)	93	49.42	17	88.76	225.000	.000	S
AAC with Rice Husk Ash (RHA) / Aluminum Powder (AP)	93	48.99	16	89.91	185.500	.000	S
AAC with Concrete Sandwich Block (CSB) / Waste Glass (WG)	95	52.15	17	80.79	394.500	.000	S
AAC with Halloysite Powder (HP)	93	50.88	17	80.79	360.500	.000	S
AAC with Air-cooled Slag (AS)	94	51.36	17	81.68	362.500	.000	S
AAC with Efflorescence Sand (ES)	95	52.14	17	80.85	393.500	.000	S
AAC with Phosphorus Sand (PS)	92	50.36	17	80.12	355.000	.000	S
AAC with Coal Gangue (CG) / Iron Ore Tailings (IOT)	95	51.33	16	83.72	316.500	.000	S
AAC with Pulverized Fuel Ash (PFA) / Palm Oil Fuel Ash (POFA)	95	51.10	17	86.68	294.500	.000	S
AAC with Copper Tailings (CT) / Blast Furnace Slag (BFS)	94	51.41	17	81.35	368.000	.000	S
AAC with Perlite Waste (PW) / Polypropylene Fiber (PF)	95	52.43	17	79.26	420.500	.001	S

Note: P represents significant at $P \leq 0.05$, U is Mann-Whitney, S represents significant difference, NS represents not significant

The hypothesis states that there is no significant difference in the perception of Nigerian professionals and South African professionals on the awareness of AAC block variants as illustrated in Table 4.11. In Table 4.11 indicated that there are significant differences in the perception of respondents on 19 out of the 20 hypothesized AAC block variants. AAC block options for which there are significant differences and for which the null hypothesis were rejected are: (AAC with 32.5 grade Ordinary Portland Cement (OPC), AAC with 42.5 grade Ordinary Portland Cement (OPC), AAC with 52.5 grade Ordinary Portland Cement (OPC), AAC with Coal Bottom Ash (CBA), AAC with Natural Zeolite Additive (NZ), AAC with Self-ignition Coal Gangue (SCG), AAC with Incinerated Sewage Sludge Ash (ISSA), AAC with Silica Fume (SF) / Fly Ash (FA), AAC with Dune Sand (DS), AAC with Rice Husk Ash (RHA) / Aluminum Powder (AP), AAC with Concrete Sandwich Block (CSB) / Waste Glass (WG), AAC with Halloysite Powder (HP), AAC with Air-cooled Slag (AS), AAC with Efflorescence Sand (ES), AAC with Phosphorus Sand (PS), AAC with Coal Gangue (CG) / Iron Ore Tailings (IOT), AAC with Pulverized Fuel Ash (PFA) / Palm Oil Fuel Ash (POFA), AAC with Copper Tailings (CT) / Blast Furnace Slag (BFS) and AAC with Perlite Waste (PW) / Polypropylene Fiber (PF). Whereas, AAC variant which there are no significant difference between the perception of Nigerian and South African professionals and for which the null hypothesis is accepted include AAC made with Bamboo leaf Ash (BLA) as obtained in table 4.11.

4.5.4 There is no significant difference on the prospect for adoption of AAC block among the ownership of the organisations.

The inferential results are presented in Table 4.12

Table 4.12: ANOVA on the prospect for adoption of AAC block among organisations

	Sum of Squares	df	Mean Square	F	P-value
Between Groups	3.103	2	1.552	1.659	.196
Within Groups	87.887	94	.935		
Total	90.990	96			

Note: ρ is significant at $P \leq 0.05$.

The result in table 4.12 indicated there is no significant difference among the groups of ownership of the organisations as regards agreement with prospect for adoption of AAC in the Nigerian construction industry.

4.5.5 There is no significant agreement among South African professionals on the adoption of AAC block variants on building projects.

The inferential results are presented in Table 4.13

Table 4.13: Kendall's Coefficient of Concordance test of agreement on the ranking of AAC variants on 10 building projects

N	Kendall's W	Chi-square	Df	P-Value
17	.743	240.065	19	.000

Note: P represents significant at P ≤ 0.05, W represents Kendall's Coefficient of concordance test, N is the number of Respondents.

Table 4.13 shows Kendall's coefficient of concordance test used to test agreement among respondents in their ranking of 20 variants of AAC. It is used to find out if there is an agreement between respondents or raters. The result indicated a significant agreement at P ≤ 0.05 level; hence the null hypothesis was rejected.

4.5.6 There is no significant difference among the respondents on the drivers of AAC blocks in the Nigerian construction industry.

The inferential results are presented in Table 4.14

Table 4.14: ANOVA on the drivers of AAC block among the ownership organisations

Drivers	DFb	DFw	DFt	F	P-value	Decision
Superior thermal absorption property	2	93	95	.908	.407	NS
Excellent fire insulation	2	93	95	1.339	.267	NS
Resistance to pest and mold	2	93	95	1.218	.301	NS

Lightweight	2	92	94	1.161	.318	NS
Optimum thermal conductivity	2	91	93	1.565	.215	NS
Reduced dead load on structure	2	92	94	3.192	.406	NS
Reduction in construction cost	2	93	95	.398	.673	NS
Eco-friendly	2	94	96	2.241	.112	NS
Adaptability of AAC to tropical climates	2	92	94	.155	.856	NS
Recyclable	2	93	95	1.309	.275	NS
Fast and easy installation	2	93	95	1.646	.198	NS
Good acoustic performance	2	90	92	.836	.437	NS
Breathable wall system	2	92	94	1.503	.228	NS
Ecologically better than other conventional walling materials	2	90	92	1.429	.245	NS
Aesthetically appealing	2	93	95	.585	.559	NS
Readily adaptable to any style of architecture	2	91	93	1.910	.154	NS
Reduced transfer of load on the foundation	2	93	95	.616	.542	NS
Made from abundant raw material	2	93	95	2.258	.110	NS
Versatile as components can be used for walls, floors and ceilings	2	93	95	2.840	.064	NS
Energy efficient	2	93	95	1.898	.156	NS
Use of reduced labour in manufacture and installation	2	93	95	.309	.735	NS
Low maintenance cost	2	91	93	2.078	.131	NS

Its production process does not emit toxic gasses	2	93	95	2.879	.061	NS
Highly durable	2	93	95	2.534	.085	NS
Used for construction of low housing units	2	93	95	1.779	.175	NS
Moisture resistant	2	92	94	1.824	.167	NS

DFb represents degree of Freedom between groups, DFw represents degree of Freedom within groups, DFt represents degree of Freedom total, NS represents no significant difference, S represents Significant difference. Note: ρ is significant at $\rho \leq 0.05$.

The results in table 4.14 shows that each of the drivers to AAC block adoption has ρ-values greater than 0.05 ($p>0.05$), therefore the null hypothesis is accepted for each of the drivers. This implies that there is no statistical difference in the perception of respondents on drivers to adoption of AAC block on building projects in Nigeria.

4.5.7 There is no significant difference in the perception of South African respondents on drivers of AAC blocks among the ownership of the organisations.

The inferential results are presented in Table 4.15

Table 4.15: ANOVA on the drivers of AAC block among the ownership of organisations

Drivers	DFb	DFw	DFt	F	P-value	Decision
Superior thermal absorption property	2	14	16	2.720	.100	NS
Excellent fire insulation	2	14	16	.906	.427	NS
Resistance to pest and mold	2	14	16	.043	.958	NS
Lightweight	2	14	16	1.446	.269	NS
Optimum thermal conductivity	2	14	16	1.540	.249	NS
Reduced dead load on structure	2	14	16	5.235	.020	S
Reduction in construction cost	2	14	16	2.785	.096	NS

Eco-friendly	2	14	16	7.895	.005	S
Adaptability of AAC to tropical climates	2	14	16	2.785	.096	NS
Recyclable	2	14	16	2.502	.118	NS
Fast and easy installation	2	14	16	.115	.892	NS
Good acoustic performance	2	14	16	1.173	.338	NS
Breathable wall system	2	14	16	.335	.721	NS
Ecologically better than other conventional walling materials	2	14	16	1.784	.204	NS
Aesthetically appealing	2	14	16	1.299	.304	NS
Readily adaptable to any style of architecture	2	14	16	1.540	.249	NS
Reduced transfer of load on the foundation	2	14	16	2.241	.143	NS
Made from abundant raw material	2	14	16	1.441	.270	NS
Versatile as components can be used for walls, floors and ceilings	2	14	16	.366	.700	NS
Energy efficient	2	14	16	1.235	.321	NS
Use of reduced labour in manufacture and installation	2	14	16	.661	.532	NS
Low maintenance cost	2	14	16	.041	.960	NS
Its production process does not emit toxic gasses	2	14	16	2.030	.168	NS
Highly durable	2	14	16	.115	.892	NS
Used for construction of low housing units	2	14	16	.936	.415	NS
Moisture resistant	2	14	16	.164	.851	NS

DFb represents degree of Freedom between groups, DFw represents degree of Freedom within groups, DFt represents degree of Freedom total, NS represents no significant difference, S represents Significant difference. Note: P is significant at $P \leq 0.05$.

The results in table 4.15 shows that 24 out of the 26 listed drivers to AAC block adoption has P-values greater than 0.05 (P>0.05), therefore the null hypothesis is accepted for each of the 24 drivers. However, reduced dead load to structure and eco-friendliness have ρ-values lesser than 0.05 ($P \leq 0.05$), therefore the null hypothesis is rejected.

4.5.8 There is no significant difference between Nigerian and South African professionals on drivers of AAC blocks.

The inferential results are presented in Table 4.16

Table 4.16: Mann-Whitney U test results for comparing perception of Nigerian professionals and referred South African Professionals on drivers to AAC block adoption.

Drivers	Nigerian Professionals		South African Professionals		U	P-value	Decision
	N	MS	N	MS			
Superior thermal absorption property	96	53.45	17	77.03	475.500	.004	S
Excellent fire insulation	96	53.02	17	79.57	434.000	.001	S
Resistance to pest and mold	96	54.51	17	71.09	576.500	.047	S
Lightweight	95	56.21	17	58.12	780.000	.803	NS
Optimum thermal conductivity	94	52.70	17	74.26	488.500	.008	S
Reduced dead load on structure	95	53.36	17	74.06	509.000	.012	S
Reduction in construction cost	96	54.78	17	69.56	602.500	.073	NS
Eco-friendly	97	54.14	17	76.68	498.500	.006	S
Adaptability of AAC to tropical climates	95	55.23	17	63.59	687.000	.301	NS
Recyclable	96	54.26	17	72.50	552.500	.028	S
Fast and easy installation	96	53.18	17	78.56	449.500	.002	S
Good acoustic performance	93	53.40	17	67.00	595.000	.093	NS
Breathable wall system	95	52.61	17	78.24	438.000	.002	S
Ecologically better than other conventional walling materials	93	54.56	17	60.65	703.000	.436	NS
Aesthetically appealing	96	52.40	17	83.00	374.000	.000	S

Readily adaptable to any style of architecture	94	52.70	17	74.24	489.000	.008	S
Reduced transfer of load on the foundation	96	53.20	17	78.47	451.000	.002	S
Made from abundant raw material	96	55.55	17	65.21	676.500	.241	NS
Versatile as components can be used for walls, floors and ceilings	96	54.75	17	69.71	600.000	.071	NS
Energy efficient	96	55.21	17	67.12	644.000	.120	NS
Use of reduced labour in manufacture and installation	96	55.10	17	67.74	633.500	.120	NS
Low maintenance cost	94	54.32	17	65.29	641.000	.177	NS
Its production process does not emit toxic gasses	96	52.90	17	80.15	422.500	.001	S
Highly durable	96	53.87	17	74.68	515.500	.012	S
Used for construction of low housing units	96	52.94	17	79.91	426.500	.001	S
Moisture resistant	95	53.94	17	70.79	564.500	.041	S

Note: P represents significant at $P \leq 0.05$, U is Mann-Whitney, S represents significant difference, NS represents not significant

Table 4.16 shows that there is no significant difference in the perception of 10 out of the 26 hypothesized drivers of AAC variants with p-values greater than 0.05 (p>).

Drivers for which there is no significance and for which the null hypothesis is accepted include; superior thermal insulation, excellent fire insulation, resistance to pest & mold, optimum thermal insulation, reduced dead load on structure, eco-friendly, recyclable, fast & easy insulation, breathable wall system, aesthetically appealing, readily adaptable to any style of architecture, reduced transfer of load on the foundation, its production process does not emit toxic gasses, highly durable, used for construction of low housing units and moisture resistant.

Whereas, drivers for which there is significant difference between the two categories of professionals with a p-value less than or equal to 0.05 ($p \leq 0.05$), and for which the null hypothesis is rejected include; lightweight, reduction in construction cost, adaptability of AAC block to tropical climates, good acoustic performance, ecologically better than other conventional walling materials, made from abundant raw material, versatile as components can be used for walls, floors and ceilings, energy efficient, use of reduced labour in manufacture and installation and low cost of maintenance.

4.5.9 There is no significant difference in the perception of the Nigerian professionals on barriers impeding adoption of AAC blocks on building.

The inferential results are presented in Table 4.17

Table 4.17: ANOVA on the drivers of AAC block among the ownership of organisations

Barriers	DFb	DFw	DFt	F	P	Decision
Unfavorable perception of home buyers to AAC block in the short term	2	92	94	.999	.372	NS
Lack of interest in new products by buyers and house owners	2	93	95	.649	.525	NS
Little interest in new products by Architects and Developers	2	92	94	.490	.614	NS
Costs of the 'learning curve' while working with a new product	2	93	95	1.138	.325	NS
Startup costs associated with promoting and teaching the industry to build with AAC products	2	92	94	.573	.566	NS
Market potentials	2	92	94	1.374	.258	NS
Inadequate building codes and regulations	2	93	95	1.517	.225	NS
Low demand for sustainable housing	2	93	95	1.987	.143	NS
Lack of easy rating systems for eco-buildings	2	89	91	1.010	.368	NS
Absence of design standards for AAC products	2	93	95	3.101	.050	S
Inadequate government policies and supports	2	91	93	1.609	.206	NS
Existing structure of the construction industry	2	92	94	.911	.406	NS

Lack of readily available accessible information	2	92	94	.536	.587	NS
Low level of awareness and knowledge on the concept of sustainability	2	93	95	.364	.696	NS
Low level of demand and knowledge of AAC products	2	93	95	.387	.680	NS
Inadequate exemplar demonstration project to infuse confidence for using AAC products	2	93	95	.039	.962	NS
Non-awareness of people towards the advantageous use of AAC products	2	93	95	.186	.830	NS
Huge capital to set up AAC plant	2	92	94	.700	.499	NS
Lack of readily available accessible information	2	90	92	.108	.898	NS
Inadequate technical know-how and manpower to manufacture AAC products	2	90	92	1.003	.371	NS
Use of unstainable construction materials	2	92	94	2.397	.097	NS
Availability of conventional materials	2	92	94	2.709	.072	NS
Affordability	2	92	94	2.228	.113	NS

DFb represents degree of Freedom between groups, DFw represents degree of Freedom within groups, DFt represents degree of Freedom total, NS represents no significant difference, S represents Significant difference. Note: P is significant at $P \leq 0.05$.

The results in table 17 shows the barriers to AAC block adoption. All but absence of design standards for AAC products ($P \leq 0.05$) have P-values greater than 0.05 (P>0.05), therefore the null hypothesis is accepted for all the other. This implies that there is no statistical difference in the perception of respondents on barriers to adoption of AAC block on building projects in Nigeria.

4.5.10: There is no significant difference in the perception of the South African professionals on barriers impeding adoption of AAC blocks on building.

The inferential results are presented in Table 4.18

Table 4.18: ANOVA on the barriers impeding AAC block adoption among the ownership of organisations

Barriers	DFb	DFw	DFt	F	P	Decision
Unfavorable perception of home buyers to AAC block in the short term	2	14	16	1.120	.100	NS
Lack of interest in new products by buyers and house owners	2	14	16	2.030	.167	NS
Little interest in new products by Architects and Developers	2	14	16	.642	.541	NS
Costs of the 'learning curve' while working with a new product	2	14	16	1.076	.368	NS
Startup costs associated with promoting and teaching the industry to build with AAC products	2	14	16	.206	.816	NS
Market potentials	2	14	16	.412	.670	NS
Inadequate building codes and regulations	2	14	16	.201	.820	NS
Low demand for sustainable housing	2	14	16	.661	.532	NS
Lack of easy rating systems for eco-buildings	2	14	16	.037	.963	NS
Absence of design standards for AAC products	2	14	16	.289	.753	NS
Inadequate government policies and supports	2	14	16	1.124	.198	NS
Existing structure of the construction industry	2	14	16	2.098	.160	NS
Lack of readily available accessible information	2	14	16	1.222	.324	NS
Low level of awareness and knowledge on the concept of sustainability	2	14	16	.093	.912	NS

Low level of demand and knowledge of AAC products	2	14	16	1.071	.369	NS
Inadequate exemplar demonstration project to infuse confidence for using AAC products	2	14	16	.137	.873	NS
Non-awareness of people towards the advantageous use of AAC products	2	14	16	.379	.691	NS
Huge capital to set up AAC plant	2	14	16	1.400	.279	NS
Lack of readily available accessible information	2	14	16	.053	.954	NS
Inadequate technical know-how and manpower to manufacture AAC products	2	14	16	.047	.954	NS
Use of unstainable construction materials	2	14	16	.282	.759	NS
Availability of conventional materials	2	14	16	2.429	.124	NS
Affordability	2	14	16	.524	.603	NS

DFb represents degree of Freedom between groups, DFw represents degree of Freedom within groups, DFt represents degree of Freedom total, NS represents no significant difference, S represents Significant difference. Note: P is significant at $P \leq 0.05$

The results in table 4.18 shows that each of the barriers to AAC block adoption has P-values greater than 0.05 ($P>0.05$), therefore the null hypothesis is accepted for each of the barriers. This implies that there is no statistical difference in the perception of referred respondents on barriers to adoption of AAC block on building projects in South Africa.

4.5.11 There is no significant difference in the perception of Nigerian and South African professionals on barriers impeding AAC block adoption.

The inferential results are presented in Table 4.19

Table 4.19: Mann-Whitney U test results for comparing perception of Nigerian and South African professionals on barriers impeding AAC block adoption.

Barriers	Nigerian Professionals		South African Professionals		U	P-value	Remark
	N	MS	N	MS			
Unfavorable perception of home buyers to AAC block in the short term	95	58.26	17	46.65	640.000	.156	NS
Lack of interest in new products by buyers and house owners	96	59.29	17	44.09	596.500	.065	NS
Little interest in new products by Architects and Developers	95	58.18	17	47.12	648.000	.174	NS
Costs of the 'learning curve' while working with a new product	96	60.18	17	39.03	510.500	.010	S
Startup costs associated with promoting and teaching the industry to build with AAC products	95	58.89	17	43.12	580.000	.053	NS
Market potentials	95	58.87	17	43.24	582.000	.052	NS
Inadequate building codes and regulations	96	59.77	17	41.38	550.500	.026	S
Low demand for sustainable housing	96	59.08	17	45.26	616.500	.093	NS
Lack of easy rating systems for eco-buildings	92	57.54	17	41.26	548.500	.041	S
Absence of design standards for AAC products	96	59.43	17	43.29	583.000	.049	S
Inadequate government policies and supports	94	59.17	17	38.47	501.000	.011	S
Existing structure of the construction industry	95	58.40	17	45.88	627.000	.127	NS
Lack of readily available accessible information	95	58.01	17	48.06	664.000	.225	NS

Low level of awareness and knowledge on the concept of sustainability	96	60.17	17	39.12	512.000	.011	S
Low level of demand and knowledge of AAC products	96	60.47	17	37.41	483.000	.006	S
Inadequate exemplar demonstration project to infuse confidence for using AAC products	96	58.72	17	47.26	650.500	.160	NS
Non-awareness of people towards the advantageous use of AAC products	96	59.69	17	41.82	558.000	.028	S
Huge capital to set up AAC plant	95	55.89	17	59.88	750.000	.623	NS
Lack of readily available accessible information	93	56.66	17	49.18	683.000	.350	NS
Inadequate technical know-how and manpower to manufacture AAC products	93	56.63	17	49.29	685.000	.364	NS
Use of unstainable construction materials	95	58.47	17	45.50	620.500	.116	NS
Availability of conventional materials	95	57.86	17	48.88	678.000	.271	NS
Affordability	95	58.71	17	44.18	598.000	.074	NS

Note: P represents significant at P ≤ 0.05, U is Mann-Whitney, S represents significant difference, NS represents not significant

Table 4.19 shows that there is no significant difference in the perception of 15 out of the 23 hypothesized barriers impeding AAC block adoption with p-values greater than 0.05 (p>0.05). Barriers for which there is no significance and for which the null hypothesis is accepted include; unfavorable perception of home buyers to AAC block in the short term, lack of interest in new products by buyers and house owners, little interest in new products by architects and developers, startup costs associated with promoting and teaching the industry to build with AAC products, market potentials, low demand for sustainable housing, existing structure of the construction industry, lack of readily available accessible information, inadequate exemplar demonstration project to infuse confidence for using AAC products, huge capital to set up AAC plant, lack of readily available accessible information, inadequate technical know-how and manpower to manufacture AAC products, use of unstainable construction materials, availability of conventional materials and affordability. Whereas, barriers for which there is significant difference between the two categories of professionals with a p-value less than or equal to 0.05 ($p \leq 0.05$), and for which the null hypothesis is rejected include; costs of the 'learning curve' while working with a new product, inadequate building codes and regulations, lack of easy rating systems for eco-buildings, absence of design standards for AAC products, inadequate government policies and supports, low level of awareness and knowledge on the concept of sustainability, low level of demand and knowledge of AAC products and non-awareness of people towards the advantageous use of AAC products.

4.5.12 There is no significant difference in the perception of Nigerian respondents on strategies that can improve the adoption of AAC blocks on building projects.

The inferential results are presented in Table 4.20

Table 4.20: ANOVA on enhanced strategies to AAC block adoption among the ownership of organizations

Strategies	DFb	DFw	DFt	F	P	Decision
Growth in the infrastructural sector	2	94	96	4.106	.020	S
Industrialization	2	94	96	3.786	.026	S
Demand for lightweight construction materials	2	94	96	3.093	.050	S
Growth preferences for low cost houses	2	93	95	1.598	.208	NS
Increasing focus in green and sound proof buildings	2	94	96	2.871	.062	NS
Creating demonstration and training centers	2	92	94	2.405	.096	NS

Integrating sustainability into formal curricula	2	92	94	.908	.407	NS
Increasing funding for sustainable building materials	2	93	95	.875	.420	NS
Focusing research on specific green building materials	2	92	94	.788	.458	NS
Education and training to built environment professionals about AAC products	2	93	95	.713	.494	NS
Public private partnerships on energy efficiency and sustainable materials	2	92	94	2.191	.118	NS
Government financial supports and subsidy	2	93	95	1.379	.257	NS
Government encouragement	2	91	93	1.288	.281	NS
Development of new construction materials and processes	2	93	95	.557	.575	NS
Government promotion of product	2	93	95	.845	.433	NS
The readiness of construction practitioners such as developers and contractors in adopting sustainable materials.	2	93	95	.708	.495	NS
Use of tool ratings	2	91	93	.789	.457	NS
Marketing strategy development	2	93	95	.836	.437	NS

DFb represents degree of Freedom between groups, DFw represents degree of Freedom within groups, DFt represents degree of Freedom total, NS represents no significant difference, S represents Significant difference. Note: P is significant at $P \leq 0.05$.

The results in table 4.20 shows that 15 out of the 18 listed strategies to AAC block adoption has P-values greater than 0.05 ($P>0.05$), therefore the null hypothesis is accepted for each of the 15 enhanced strategies. However, growth in the infrastructural sector, Industrialization and demand for lightweight construction materials have ρ-values lesser than 0.05 ($P \leq 0.05$), therefore the null hypothesis is rejected.

4.5.13 There is no significant difference in the perception of South African respondents on strategies that can improve the adoption of AAC blocks on building projects

Inferential results are presented in Table 4.21

Table 4.21: ANOVA on enhanced strategies to AAC block adoption among the ownership of organizations

Strategies	DFb	DFw	DFt	F	P	Decision
Growth in the infrastructural sector	2	14	16	.906	.427	NS
Industrialization	2	14	16	.282	.759	NS
Demand for lightweight construction materials	2	14	16	.765	.484	NS
Growth preferences for low cost houses	2	14	16	.206	.816	NS
Increasing focus in green and sound proof buildings	2	14	16	.429	.659	NS
Creating demonstration and training centers	2	14	16	4.310	.035	S
Integrating sustainability into forral curricula	2	14	16	1.745	.210	NS
Increasing funding for sustainable building materials	2	14	16	1.120	.354	NS
Focusing research on specific green building materials	2	14	16	1.860	.192	NS
Education and training to built environment professionals about AAC products	2	14	16	1.184	.335	NS
Public private partnerships on energy efficiency and sustainable materials	2	14	16	1.941	.180	NS
Government financial supports and subsidy	2	14	16	1.853	.193	NS
Government encouragement	2	14	16	1.540	.249	NS
Development of new construction materials and processes	2	14	16	1.052	.375	NS

Government promotion of product	2	14	16	.335	.721	NS
The readiness of construction practitioners such as developers and contractors in adopting sustainable materials	2	14	16	1.235	.321	NS
Use of tool ratings	2	14	16	1.071	.369	NS
Marketing strategy development	2	14	16	.115	.892	NS

DFb represents degree of Freedom between groups, DFw represents degree of Freedom within groups, DFt represents degree of Freedom total, NS represents no significant difference, S represents Significant difference. Note: P is significant at $P \leq 0.05$.

The results in table 4.21 shows that 17 out of the 18 listed strategies to AAC block adoption has P-values greater than 0.05 (P>0.05), therefore the null hypothesis is accepted for each of the 17 enhanced strategies. However, growth in the infrastructural sector, Industrialization and demand for lightweight construction materials have P-values lesser than 0.05 ($P \leq 0.05$), therefore the null hypothesis is rejected.

4.5.14 There is no significant difference in the perception of Nigerian and South African professionals on strategies to improve AAC block adoption.

The inferential results are presented in Table 4.22

Table 4.22: Mann-Whitney U test results for comparing perception of Nigerian South African Professionals on enhanced strategies of AAC block adoption.

Strategies	Nigerian Professionals		South African Professionals		U	P-value	Decision
	N	MS	N	MS			
Growth in the infrastructural sector	97	54.13	17	76.74	497.500	.003	S
Industrialization	97	55.08	17	71.29	590.000	.032	S
Demand for lightweight construction materials	97	55.79	17	67.24	659.000	.146	NS
Growth preferences for low cost houses	96	55.70	17	64.32	691.500	.270	NS
Increasing focus in green and sound proof buildings	97	56.22	17	64.82	700.000	.279	NS

Creating demonstration and training centers	95	55.32	17	63.09	695.500	.324	NS
Integrating sustainability into formal curricula	95	56.33	17	57.47	791.000	.885	NS
Increasing funding for sustainable building materials	96	56.32	17	60.85	750.500	.563	NS
Focusing research on specific green building materials	95	55.53	17	61.91	715.500	.397	NS
Education and training to built environment professionals about AAC products	96	56.32	17	60.82	751.000	.566	NS
Public private partnerships on energy efficiency and sustainable materials	95	57.91	17	48.62	673.500	.237	NS
Government financial supports and subsidy	96	57.80	17	52.50	739.500	.504	NS
Government encouragement	94	56.70	17	52.15	733.500	.546	NS
Development of new construction materials and processes	96	57.75	17	52.76	744.000	.523	NS
Government promotion of product	96	55.66	17	64.59	687.000	.262	NS
The readiness of construction practitioners such as developers and contractors in adopting sustainable materials	96	57.89	17	51.97	730.500	.453	NS
Use of tool ratings	94	56.15	17	55.15	784.500	.900	NS
Marketing strategy development	96	56.01	17	62.59	721.000	.403	NS

Note: P represents significant at $P \leq 0.05$, U is Mann-Whitney, S represents significant difference, NS represents not significant

Table 4.22 shows that there is no significant difference in the perception of 16 out of the 18 hypothesized strategies to AAC block adoption with p-values greater than 0.05 ($p>0.05$). Strategies for which there is no significance and for which the null hypothesis is accepted include; demand for lightweight construction materials, growth preferences for low cost houses**,** increasing focus in green and sound proof buildings**,** creating demonstration and training centers, integrating sustainability into formal curricula, increasing funding for sustainable building materials, focusing research on specific green building materials, education and training to built environment professionals about AAC products, public private partnerships on energy efficiency and sustainable materials, government financial supports and subsidy, government encouragement, development of new construction materials and processes, government promotion of product, the readiness of construction practitioners such as developers and contractors in adopting sustainable materials, use of tool ratings and marketing strategy development. Whereas, strategies for which there is significant difference between the two categories of professionals with a p-value less than or equal to 0.05 ($p \leq 0.05$), and for which the null hypothesis is rejected include; growth in the infrastructural sector and industrialization.

4.6 Discussion of Findings

Findings emerging from this study which is aimed at investigating the sustainability of AAC variants with a view to providing walling materials that are sustainable are summarized below:

Awareness of AAC block variants in Nigeria and South Africa

The study revealed that the Nigerian professionals are ‘'slightly aware’ of 19 out of the 20 AAC block variants available in literature This result implies that AAC block is not being employed on building projects and the professionals are not aware about its existence as it is not one of the conventional walling materials they use for their building construction. These findings of the professionals being ‘slightly aware’ about AAC block variants corroborates previous studies by

Falade and Ikponmwosa (2014) who stated that there is little or no awareness of aerated concrete in Nigeria.

Whereas, findings from referred construction professionals from South Africa, revealed that they are fully aware of AAC block with 52.5 grade OPC. Relatedly, they are highly aware of AAC block with 42.5 grade OPC and AAC block with RHA/AP. This result agrees with studies conducted by (Oo & Hlaing, 2018; Kamsiah, 2004; Manikandan, Gopalakrishnan & Cheran, 2018 and Khandve, 2015) who stated that grade 52.5 OPC, grade 42.5 OPC and Aluminum powder are the major constituent in the production of AAC block.

Both respondents are however not at all aware of AAC made with Bamboo Leaf Ash (BLA). Moreover, there is a no significant difference in the awareness level of both professionals on AAC with BLA as seen in the results.

Prospect for adoption of AAC blocks in Nigeria

This present study confirms a ‘moderate’ disposition of the first category of respondent on prospect for AAC block adoption by the Nigerian respondents, this result implies that there is a likelihood that the block will be adopted in the short term.

Adoption level of AAC block variants in South Africa

Relatedly, results show that the topmost four AAC block variants adopted on building projects by the referred South African respondents include; AAC with 52.5 grade OPC, AAC with 42.5 grade

OPC, AAC with RHA/AP and AAC with PFA/POFA. However, all but bamboo leaf ash is statistically not significant. This finding is supported by Falade and Ikponmwosa (2014) who stated that if the block is adopted in Nigeria there would be enhanced economic benefits.

Important Drivers to the adoption of AAC block on building projects in Nigeria and South Africa

Furthermore, the study confirmed that 24 out of the 26 drivers are 'more important' to the Nigerian respondents while only 2 of the remaining drivers are considered 'moderately important'. Whereas, results confirmed 9 out of the 26 drivers are 'most important' to the referred South African professionals while the remaining 17 drivers are 'more important' to the respondents.

The study also uncovered that although there are diverse benefits of AAC, the topmost important drivers comprise: lightweight; energy efficient; ecologically better than conventional walling materials; adaptability of AAC blocks to tropical climates; superior thermal absorption property; excellent fire insulation and readily adaptable to any style of architecture are its important drivers to the Nigerian professionals. On the other hand, excellent fire insulation property; lightweight; energy efficient; superior thermal absorption property; readily adaptable to any style of architecture, eco-friendliness, optimum thermal conductivity are the important drivers of AAC to the referred professionals.

Moreover, there is a significant difference in the perception of both professionals on AAC drivers as seen in the results presented. Drivers for which there is significant difference between the two categories of professionals with a p-value less than or equal to 0.05 ($p \leq 0.05$), and for which the null hypothesis is rejected include; lightweight, reduction in construction cost, adaptability of AAC block to tropical climates, good acoustic performance, ecologically better than other conventional walling materials, made from abundant raw material, versatile as components can be used for walls, floors and ceilings, energy efficient, use of reduced labour in manufacture and installation and low cost of maintenance. The results of this study align with findings from previous studies conducted by (Oo & Hlaing, 2018; Keyvani, 2014; Pandey et al. 2018; and Narayanan & Ramamurthy 2000).

Significant barriers impeding the adoption of AAC blocks in Nigeria and South Africa

The findings further show that inadequate government policies & supports, low market potentials, low level of awareness & knowledge on the concept of sustainability and non- awareness of people towards the advantageous use of AAC products are barriers that significantly impedes AAC block usage in the Nigerian construction industry.

In the same vein, huge capital to set up AAC plant, lack of readily accessible information, availability of conventional materials and little demand for energy efficient buildings are barriers that significantly impedes AAC block adoption in the South African construction industry. Moreover, there is a significant difference in how these barriers were recognized by the 2 categories of respondents. These findings are corroborated with previous findings of Falade and Ikponmwosa (2008) who posited that government and built environment professionals are addicted to the use conventional material like sandcrete blocks, concretes etc.

Important Strategies that can improve the Adoption of AAC blocks in Nigeria and South Africa

Lastly, findings further showed that government encouragement, focusing research on specific green building material, development of new construction materials & processes and public private partnerships on energy efficiency and sustainable materials were the strategies by the first group of respondents.

In the same vein, growth in the infrastructural sector, industrialization, demand for lightweight construction materials, focusing research on specific green building materials and growth preferences in the for low cost houses were strategies that can improve AAC block adoption on building projects in South Africa. These submissions were expected because in Nigeria, little focus is placed on research to harness natural resources and develop new materials. These findings are further butressed by Falade and Ikponmwosa (2008) who posited that considering the advantages of aerated concrete usage in the construction industry, it is very imperative at this point in the history of Nigeria and the sub-region to develop its version of the product for the industry.

CHAPTER FIVE

5.0 SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter summarises the findings of the study, draws conclusions based on the findings, makes recommendations, describes the contributions to knowledge and make suggestions for further studies.

5.2 SUMMARY OF FINDINGS

The aim of this study was to explore the awareness and use of Autoclaved Aerated Concrete blocks with a view to providing walling materials that are sustainable on building projects as a forerunner of further research on the sustainability property of AAC block variants. The study investigated the application of AAC block variants on construction project. The problem of the study is that majority of the walling materials in use on construction projects are unsustainable. Therefore, the study sought to solve the use of unsustainable construction materials.

In view of this, the study proposed six objectives which comprise: to compare the level of awareness of AAC block variants in Nigeria and South Africa; to determine the prospect for adoption of AAC blocks in Nigeria; to evaluate the adoption level of AAC block variants on South African building projects; to identify drivers to the adoption of AAC blocks on building projects in Nigeria and South Africa; to evaluate barriers impeding the adoption of AAC blocks on building projects in Nigeria and South Africa and to propose strategies that would improve the adoption of AAC blocks on building projects in Nigeria and South Africa.

Fourteen hypotheses were tested in the study to further support the objectives and they include: There is no significant difference among the ownership of organizations on the awareness of AAC block variants in the Nigerian building industry; there is no significant difference on the level of awareness of AAC block variants among the ownership of the organisations in South African building industry; there is no significant difference in the perception of Nigerian and South African professionals on the level of awareness of AAC block variants; there is no significant difference on the prospect for adoption of AAC among the ownership of organisations in the Nigerian building industry; there is no significant agreement among South African professionals on the adoption of AAC variants on building projects; there is no significant difference among the respondents on the drivers of AAC in the Nigerian Construction industry; there is no significant difference in the perception of South African respondents on drivers of AAC blocks among the ownership of the organisations; there is no significant difference between Nigerian and South African respondents on drivers of AAC blocks; there is no significant difference in the perception of the Nigerian respondents on barriers impeding adoption of AAC blocks on building; here is no significant difference in the perception of the South African professionals on barriers impeding adoption of AAC blocks on building; there is no significant difference in the perception of Nigerian and African respondents' professionals on barriers impeding the adoption of AAC blocks; there is no significant difference in the perception of Nigerian respondents on the strategies that can improve the adoption of AAC blocks on building projects; there is no significant difference in the perception of South African respondents on strategies that can improve the adoption of AAC blocks on building projects and there is no significant difference in the perception of Nigerian and South African professionals on the strategies to improve AAC block adoption.

Following a review of existing literatures from the variables of the study and objectives, the variables obtained were simplified and used for the study. The study area was Lagos metropolis and five South Africa provinces. The main instrument used for data collection was self-administered questionnaire (SAQ) for the Nigerian respondents while Online Questionnaire Survey (OQS) through Google forms was espoused to gather the viewpoints of the 17 referred South African respondents acquainted with the knowledge and have been involved in the use of AAC blocks on building projects. The sampling techniques adopted for the Nigerian and South African professionals were convenience and snowball sampling technique respectively.

The findings of the study indicate that the Nigerian professionals are slightly aware of 19 out of the 20 identified AAC block variants. Topmost AAC variants that the Nigerian professionals are slightly aware of include AAC with 52.5 grade OPC, AAC with 52.5 grade OPC, AAC with AP/RHA. While the South African professionals are fully aware of AAC with 52.5 grade OPC, highly aware of AAC with grade 42.5 OPC and AAC with AP/RHA and moderately aware of 13 out of the remaining 17 AAC variants. However, both categories of respondents are not at all aware of AAC made with Bamboo Leaf Ash (BLA).

In addition, the results showed moderate disposition of the Nigerian professionals to AAC being adopted on construction projects in the nearest future. Whereas, findings from the study revealed that the referred respondents indicated an average adoption level of the material on building projects. Topmost four most adopted AAC block variants on construction projects include: AAC with 52.5 grade OPC, AAC with 42.5 grade OPC, AAC with AP/RHA and AAC with PFA/POFA.

The study also uncovered 26 important drivers for the adoption of AAC blocks on building projects. Topmost drivers include: lightweight; energy efficient; ecologically better than conventional walling materials; adaptability of AAC blocks to tropical climates; superior thermal absorption property; excellent fire insulation and readily adaptable to any style of architecture are its important drivers to the Nigerian professionals. On the other hand, excellent fire insulation property; lightweight; energy efficient; superior thermal absorption property; readily adaptable to any style of architecture, eco-friendliness, optimum thermal conductivity are the important drivers of AAC to the referred professionals.

The study equally evaluated 23 significant barriers impeding the adoption of AAC blocks on building projects. The topmost among them include: inadequate government policies and supports; market potentials; low level of awareness and knowledge on the concept of sustainability; non-awareness of people towards the advantageous use of AAC products; lack of interest in new products by buyers and house owners and lack of readily available accessible information are the barriers impeding the adoption of AAC block in the Nigerian construction industry. On the other hand, huge capital to set up AAC plants, availability of conventional materials, little demand for energy efficient buildings; low market potentials; little interests in new products by Architects and Developers and inadequate technical know-how and manpower to manufacture AAC products are the barriers impeding the adoption of AAC block for building projects in South Africa provinces.

Finally, the study proposed 18 important strategies that would encourage the adoption of AAC blocks on building projects these comprise: government encouragement; focusing research on specific green building materials; development of new construction materials and processes; public private partnership on energy efficiency and sustainable materials; industrialization and growth preferences for low cost housing are the important strategies that can improve the adoption of AAC in the Nigerian construction industry. Whereas, growth in the infrastructural sector; industrialisation; demand for lightweight construction materials; focusing research on specific green building materials and growth preferences for low cost housing are the enhanced strategies to improve the usage of AAC on building projects in the South African construction industry.

5.3 CONCLUSIONS

Based on the findings of this study, the study concludes that the level of awareness of AAC block variants are higher in South Africa than in Nigeria. This implies that AAC block producers would not thrive at present in Nigeria because there would be low patronage. If awareness is increased, patronage will be increased.

In addition, there is a moderate disposition for adoption of AAC blocks on building projects in Nigeria. This implies that professionals are likely to adopt the block on their building projects in the nearest future.

Also, the topmost adopted AAC block variants on South African projects are AAC with 52.5 grade OPC, AAC with 42.5 grade OPC, AAC with AP/RHA and AAC with PFA/POFA. This means that AAC block manufacturers who produces other variants of AAC except the itemized four topmost variants would likely not thrive in business as they would experience low patronage from professionals.

The study further concludes that, the importance of drivers for the adoption of AAC block varies for both countries. Although topmost driver is lightweight. This implies that professionals in both countries appreciate the lightweight characteristics of the block as the AAC block would be preferable in the choice of walling material for tall structures due to cost reduction in foundation and other structural members.

Also, the barriers impeding AAC block adoption varies for both countries. While inadequate government policies and support impedes adoption of AAC blocks in Nigerian projects, inadequate capital to set up AAC plant impedes its adoption in South African projects. This implies that these significant barriers would lead to lack of interest by Architects and developers in adopting the block on their projects.

Finally, topmost strategy that can improve the usage of AAC blocks on building projects in Nigeria is government encouragements while growth in the infrastructural sector is key strategy to enhance the adoption of AAC blocks on South African building projects. This implies that government has a role to play in order to achieve its adoption.

5.4 RECOMMENDATIONS

The study recommends that professionals should improve their awareness of AAC block by updating their knowledge of AAC. This can be achieved via continuous development trainings, seminars and workshops on AAC block and sustainable construction materials in the building industry.

Beyond doubt, the AAC block is relatively new and slowly emerging in Nigeria and South Africa respectively. While its current level of adoption is insignificant in adding values to building firms, contractors and concerned stakeholders. The study recommends that concerned stakeholders, the government and research organisations should focus research on the production and optimization of AAC blocks in order to attract patronage from consultants, clients/developers and contractors. This can be achieved sponsoring research to develop our own version of the block and develop its own production plant.

Construction project participants and specifiers should ensure that concerted efforts are made in selecting and specifying construction materials that are sustainable. This can be achieved during the design and construction phase where the identified AAC drivers would serve as a baseline for materials specifiers to choose sustainable walling product.

The study advocates for the extermination of barriers impeding AAC block adoption by providing government supports to harness local materials so that our own version of AAC blocks would be produced. This can be achieved if funds are provided and local infant industries/SMEs are protected by the government by reducing their taxes. Government should also provide enough capital for the AAC production plant to be set up.

Government should embark on infrastructural developments projects for its citizens. This can be achieved by a strong people-oriented government with strong political will to deliver sustainable housing to its citizens. It should be noted that other nations of the world that made developmental advancement in the adoption of AAC block for housing were supported aggressively with government interventions.

5.5 CONTRIBUTIONS TO KNOWLEDGE

The study has contributed to knowledge in the following ways:

(1) The study established that, AAC block variants professionals are aware of are AAC with 52.5 grade OPC (MS=2.11 & MS=4.94) by the Nigerian and South African professionals respectively; AAC with 42.5 grade OPC with (MS= 2.07 & MS=4.24) for both categories of respondents respectively; and AAC with AP/RHA with (MS=2.01 & MS=4.00) for both categories of respondents respectively. The Nigerian professionals are less aware of AAC block variants than the South African professionals.

(2) The study established that there is a moderate prospect (MS= 3.01) for adoption of AAC blocks on building projects in Nigeria.

(3) The study established that AAC with 52.5 grade OPC with (%MU= 31.5) is the most adopted AAC variants on South African building projects. This is closely followed by AAC with grade 42.5 OPC with (%MU= 27.4) while, AAC with AP/RHA & AAC with PFA/POFA with (%MU= 15.9) respectively are the topmost four most adopted AAC variants on building projects.

(4) The study established that important drivers to AAC block adoption on building projects in Nigeria to include lightweight (MS=4.17), energy efficient (MS= 4.16), while topmost drivers in South Africa are excellent fire insulation (MS=4.76), lightweight (MS=4.71), energy efficient (MS= 4.71) and superior thermal absorption property with (MS=4.71).

(5) The study established that significant barriers impeding AAC block adoption in Nigeria include inadequate government policies and supports with (MS=3.88), market potential (MS=3.81) and low level of awareness and knowledge on the concept of sustainability (MS=3.80) while, Huge capital to set up AAC plant (MS= 4.00), lack of readily available accessible information, availability of conventional materials and little demand for energy efficient buildings with (MS= 3.59) respectively are significant barriers impeding AAC block adoption in South Africa.

(6) The study established that important strategies that can improve the adoption of AAC for building projects in Nigeria include government encouragement (MS= 3.88), focusing research on specific green

building materials (MS=3.81), development of new building materials (MS=3.80), and public private partnerships on energy efficiency and sustainable materials (MS= 3.77), while, growth in the infrastructural sector (MS= 4.94), industrialization (MS=4.82) and demand for lightweight construction materials (MS=4.65) are the important strategies to improve AAC block adoption.

5.6 AREAS FOR FURTHER STUDIES

Based on the findings and the scope of this study, the following suggestions are proposed to provide direction for future research endeavours. Further study should be concentrated on:

1. determining the sustainability properties of AAC variants with local substitute materials

2. investigating the performance of Bamboo Leaf Ash on AAC block

3. replicating this study in Abuja, the Federal Capital Territory where there is a very large number of construction work going on and the results compared with the findings of this study.

References

Ademola, S.A., & Buari, T.A. (2012). Behavior of Bamboo Leaf Ash Blended Cement Concrete in Sulphates Environment. *Journal of Engineering*, 4(6), 1-8.

Adewuyi, T.O., Olusola, K. O., & Oladokun, M. G. (2013). Engineering Properties of Sandcrete Blocks Made with Blended Bamboo Leaf Ash and Ordinary Portland Cement. *Innovation*, 1(1), 49-59.

Ahn, Y.H., Pearce, A.R., Wang, Y., & Wang, G. (2013). Drivers and Barriers of Sustainable Design and Construction: The Perception of Green Building Experience, International Journal of Sustainable Building Technology and Urban Development, 4(1), 35-45.

Aiyewalehinmi, E.O. & Akande, S.P. (2015). Comparison Distilled Water and Cassava Waste Water as An Admixture Sandcrete Blocks. *International Journal of Latest Research in Engineering and Technology*, 1(6), 1-7.

Akeju, A. (2007). Challenges to providing affordable housing in Nigeria. Africa internationalconference on urban housing finance in Nigeria, held at shehu yar'adua centre Abuja, 17-19, 2007.

Alli, M. (2014). Sampling and Sampling Size Estimation. Geneva Foundation for Medical Education and Research. Retrieved May 31, from https://www.gfmer.ch

Almudhaf, H., & Al-Ragom, F. (1998). Autoclaved aerated concrete for construction in hot Regions. Kuwait Institute for Scientific Research, Kuwait.

Arum, C. Ikumapayi, C.M. & Aralepo, G.O. (2013). Ashes of biogenic wastes pozzolanicity,
prospects for use, and effects on some engineering properties of concrete. *Materials Sciences and Applications*, 4, 521-527.

Asha, P., Salman, A. & Kumar, R.A. (2014). Experimental study on concrete with bamboo leaf ash. *International Journal of Engineering and Advanced Technology (IJEAT)*, 3(6), 46-51.

Asif, M. & Muneer, T., & Kelly, R. (2007). Life Cycle Assessment: A Case Study of a Dwelling Home in Scotland. *Build. Environ*, 42, 1391–1394.

Asika, N. (2012). Research in Behavioral Sciences. Learn African Plc.

Autoclaved Aerated Concrete, (2021). https://en.wikipedia.org/wiki/Autoclaved_aerated_concrete#:~:text=Other%20names%20for%20the%20product,Airbeton%2C%20Siporex%2C%20and%20Ytong.

Ayeni, B. (1979). Concept and Technique in Urban Analysis, London: Croom Helm.

Azapagic, P., & Perdan, S. (2000). Indicators for Sustainable Development for Industry: A general Framework. *Process Saf. Environ. Prot.*, 81(5), 303–316.

Baiden, B.K., Price, A.D.F., & Dainty, A.R.J. (2006). The Extent of Team Integration Within Construction Projects. *International Journal of Project Management*, 2(24), 13 – 23.

Baiden, B.K. & Tuuli, M.M. (2014). Impact of Quality Control Practices in Sandcrete Blocks Production. *Journal of Architectural Engineering*, 10(2), 53-66.

Boido, S. C., & Caldera, C. (2002). Potential, Limitations, and Sustainability of Autoclaved Aerated Concrete. *Proceedings of Atti International Conference on Sustainable Building*, Oslo Norway.

Bonakdar, A., Babbitt, F., & Mobasher, B. (2013). Physical and Mechanical Characterization of Fiber-Reinforced Aerated Concrete. *Cem Concr Comp*, 38, 82–91.

Cong, X. Y., Lu, S., Yao, Y., & Wang, Z. (2016). Fabrication and Characterization of Self-ignition Coal Gangue Autoclaved Aerated Concrete. *Materials and Design,* 97, 155–162. DOI 10.1016/j.matdes.2016.02.068.

Davies, O.O.A., & Davies, I.O.E. (2017). Barriers to Implementation of Sustainable Construction Techniques. *Journal of Environmental Science,* 2, 1-9.

Davis, A., (2001) Barriers to Building Green". ArchitectureWeek.com. available at *http://www.architectureweek.com/2001/0822/environment_1-1.html*,

Demir, I. & Güçlüer, K. (2017). An Investigation of the Effect of Blast Furnace Slag on Physical and Mechanical Properties of Autoclaved Aerated Concrete. *1st International Turkish World Engineering and Science Congress in Antalya,* December 7-10, 2017, Turkey. 393-401.

Deng, M., Zhang, W., & Yang, S. (2020). In-plane Seismic Behavior of Autoclaved Aerated Concrete Block Masonry Walls Retrofitted with High Ductile Fiber-reinforced Concrete. *Engineering Structures,* 219, 110854. DOI 10.1016/j.engstruct.2020.110854.

Desani, P., Soni, M., Gandhi, N., & Mishra, V. (2016). Autoclaved Aerated Concrete: A Sustainable Alternate of Clay Brick Masonry in Form of Light Weight Concrete. *Global Research and Development Journal for Engineering | Recent Advances in Civil Engineering for Global Sustainability*, 436-441.

Djokoto, S.D., Dadzie, J., & Ohemeng-Ababio, E. (2014). Barriers to Sustainable Construction in the Ghanaian Construction Industry: Consultants Perspectives. *Journal of Sustainable Development*, 1(7), 134-143.

Domingo, E.R. (2008). An Introduction to Autoclaved Aerated Concrete Including Design Requirements Using Strength Design, Technical Report, Kansas State University.

Duan, P., Zhang, Y., Zhou, X., & Miao, Y. (2014). Application of Precast Aerated Concrete Panel Used as External Wallboard in China. *Study Civil Engr Archit.,* 3, 123–124.

Dunster, A. M. (2007). Characterization of Mineral Wastes, Resources and Processing Technologies – Integrated Waste Management for the Production of Construction material. Case study on: Incinerated Sewage Sludge Ash (ISSA) in Autoclaved Aerated Concrete (AAC), 1-6.

Du Plessis, C. (2007). A Strategic Framework for Sustainable Construction in Developing Countries. *Construction Management and Economics*, 25, 67-76.

Dwivedi, V.N., Singh, N.P., Das, S.S. & Singh, (2006). A new pozzolanic material for cement industry: Bamboo leaf ash. *International Journal of Physical Sciences*, 1(3), 106-111.

Eley, J. (2011). Sustainability Building: The Client's Role, London: RIBA Publishing.

El-Gohary, N.M., & El-Diraby, TE. (2010). Dynamic Knowledge-based Process Integration Portal for Collaborative Construction, *Journal of Construction Engineering and Management,* 136(3), 316 –328.

Enshassi, A., & Mayer, P.E. (2005). Barriers to the Application of Sustainable Construction Concepts in Palestine. *World Sustainable Building Conference,* Tokyo, 27-29 September 2005, 4624-4628.

Falade, F., & Ikponmwosa, E. (2008). An Overview of Foamed Aerated Concrete- A Building and Civil Engineering Construction Material. *Journal of Engineering Science and Technology, 3(3), 5-14.*

Garold, O. (2000). Project Management for Engineering and Construction, 2nd Ed. McGraw Hill, Boston.

Gaal, B. V. (2016). Determining Sample Size. Retrieved May 31, from https://europeanacademy-of nursing-science.com

Hakkinen, T., & Belloni, K. (2011). Barriers and Drivers for Sustainable Building. *Building Research and Information,* 3(39), 239–255.

Hamad, A.J. (2014). Materials, Production, Properties and Application of Aerated Lightweight Concrete: Review. *International Journal of Material Science and Engineering*, 2(2), 152-157.

Haselbach, L. (2008). The Engineering Guide to LEED-New Construction. *Sustainable Construction for Engineers,* McGraw Hill: New York.

Hebel, J. (2013). Hebel Australia, [ONLINE], accessed 18 February 2020, <*http://www.hebelaustralia.com.au/Pages/About/What-is-Hebel.aspx*>

Huang, X. Y., Ni, W., Cui, W. H., Wang, Z. J., & Zhu, L. P. (2012). Preparation of Autoclaved Aerated Concrete Using Copper Tailings and Blast Furnace Slag. *Construction and Building Materials,* 27(1), 1–5. DOI 10.1016/j.conbuildmat.2011.08.034.

Hydes, K. & Creech, L. (2000). Reducing Mechanical Equipment Cost: The Economics of Green Design. *Building Research & Information,* 28(5/6), 403-407.

Ikponmwosa, E., Falade, F., & Fapohunda, C. (2014). A Review and Investigations of Some Properties of Foamed Aerated Concrete. *Nigerian Journal of Technology,* 33(1), 1-9.

Israel, G. D. (2013). Determining Sample Size 1. University of Florida, IFAS Extension. Retrieved May 31, from *https://www.tarleton.edu/academicassessment/documents/Samplesize.pdf*

Jannat, N., Hussein, A., Abdullah, B., & Cotgrave, A. (2020). A comparative Simulation Study of the Thermal Performance of the Building Envelope Wall Materials in the Tropic. *Journal of Sustainability,* 1-26.

Jerman, M., Keppert, M., Vyborny, J., Cerny, R. (2013). Hygric, Thermal and Durability Properties of Autoclaved Aerated Concrete. *Construction and Building Materials*, 41(2013), 352-359.

Jiang, J., Ma, B., Cai, Q., Shao, Z., Hi, Y., Qian, B., Wang, J., Ma, F., & Wang, L. (2021). Utilization of ZSM-5 Waste for the Preparation of AAC: Mechanical Properties and Reaction Products. *Construction and Building Materials,* 297(2021), 1-10.

Kadashevich, I., Schneider, H.J., & Stoyan D. (2005). Statistical Modeling of the Geometrical Structure of the System of Artificial Air Pores in Autoclaved Aerated Concrete. *Cem Concr Res*, 5(1), 495–502.

Kamsiah, M.I., Shazli, F.M., & Manaf, N. (2004). Study of Lightweight Concrete Behavior, Technical report.

Karakurt, C., Kurama, H., & Topçu, I. B. (2010). Utilization of Natural Zeolite in Aerated Concrete Production. *Cement and Concrete Composites*, 32(1), 1–8. DOI 10.1016/j.cemconcomp.2009.10.002.

Kats, G., & Capital, E. (2003). The Cost and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force, Developed for Sustainable Building Task Force, California, USA, 2003.

Keiner, M. (2005). History, Definition(s) and Models of Sustainable Development. *International Journal of Engineering Science Technology and Research.*

Keyvani, A. (2014). Thermal Performance and Fire resistance of Autoclaved Aerated Concrete Exposed Humidity Conditions. *International Journal of Research in Engineering and Technology,* 3(3), 267-272.

kibert, C. J. (1994). Sustainable construction. The First International Conference of CIB TG, Tampa, Florida, U.S.A. 1994.

Kreft, O., Hausmann, J., Hubalkova, J., Aneziris, C.G., Sraube, B., & Schoch, T. (2011). Pore Size Distribution Effects on the Thermal Conductivity of Lightweight Autoclaved Aerated Concrete. *In 5th International Conference on Autoclaved Aerated Concrete,* 14–17 September 2011, Bydgoszcz, Poland. 257–264.

Kunchariyakun, K., Asavapisit, S., & Sombatsompop, K. (2015). Properties of Autoclaved Aerated Concrete Incorporating Rice Husk Ash as Partial Replacement for Fine Aggregate. *Cement and Concrete Composites,* 55, 11–16. DOI 10.1016/j.cemconcomp.2014.07.021.

Kurama, H., Topçu, I. B., & Karakurt, C. (2009). Properties of the Autoclaved Aerated Concrete Produced from Coal Bottom Ash. *Journal of Materials Processing Technology,* 209(2), 767–773. DOI 10.1016/j. jmatprotec.2008.02.044.

Larsson, N., & Clark, J. (2000). Incremental Costs Within the Design Process for Energy Efficient Buildings. *Building Research and Information,* 28(5/6), 413-418.

Laerd Statistics. (2018). Kendall's Tau-b Using SPSS. Retrieved May 31, from *https://statistics.laerd.com*

Ma, B. G., Cai, L. X., Li, X. G., & Jian, S. W. (2016). Utilization of Iron Tailings as Substitute in Autoclaved Aerated Concrete: Physico-mechanical and Microstructure of Hydration Products. *Journal of Cleaner Production,* 127, 162–171. DOI 10.1016/j.jclepro.2016.03.172.

Manikandan, D., Gopalakrishnan, S., & Cheran, K. (2018). An Experimental investigation on Autoclaved Aerated Concrete. International Journal of Intellectual Advancements and research in Engineering Computations, 6(2), 2018.

Market & Research (2020). Global Autoclaved Aerated Concrete Market. https://www.globenewswire.com/news-release/2020/07/02/2056831/0/en/Global-Autoclaved-Aerated-Concrete-Market-2020-to-2025-Low-Market-Penetration-Offers-Significant-Market-Opportunity.html

Mehmannavaz, T., Ismail, M., Sumadi, S. R., Bhutta, M. A. R., & Samadi, M. (2014). Binary Effect of Fly Ash and Palm Oil Fuel Ash on Heat of Hydration Aerated Concrete. *Scientific World Journal*, 2014, 1–6. DOI 10.1155/2014/461241.

Mostafa, N. Y. (2005). Influence of Air-cooled Slag on Physicochemical Properties of Autoclaved Aerated Concrete. *Cement and Concrete Research,* 35(7), 1349–1357. DOI 10.1016/j.cemconres.2004.10.011.

Nahhas, T.M. (2013). Flexural Behavior and Ductility of Reinforced Lightweight Concrete Beams with Polypropylene Fibre. *Journal of Construction Engineering and Management,* 1(1), 4-10.

Naik, J.S., Chandana, V., Kumar, K.M., Nagaraju, G., Kishore, P.S.R., & Kumar. A. (2018). Study and Experimentation of Autoclaved Aerated Concrete by using Fly Ash. *International Journal of Innovative Science and Research Technology*, 3(4), 151-155.

Narayanan, N., & Ramamurthy, K. (2000). Structure and Properties of Aerated Concrete: A Review. *Cem Concr Comp,* 22, 321–9.

National Population Commission, (2009). 2006 population and housing census of the Federal Republic of Nigeria. Official Gazette of the Federal Republic of Nigeria, 96(2), 1.

Nelms, C., Russel, A.D. & Lence, B.J. (2005). Assessing the Performance of Sustainable Technologies for Building Projects. *Canadian Journal for Civil Engineering,* 32, 114-128.

NIS 2000, NIS 87: 2000, 2004. Nigerian Industrial Standard for Sandcrete Blocks; Standard Organization of Nigeria, Lagos, (2005).

Olawuyi, B.J. & Babafemi, A.J. (2013). Performance Evaluation of Polystyrene Walling Units. 1-12.

Ofori, G. (2002). Construction: Moving Towards a Knowledge-based Industry". *Building Research and Information*, 30(6), 401-412.

Ofori, G. (2006). Attaining Sustainability Through Construction Procurement in Singapore. *CIB W092–Procurement Systems Conference 2006,* Salford, UK.

Ogolo, M. (1996). Student's Guide to Writing Research and Project Proposals. Lagos: Joytal Commerciall Enterprise.

Ojo, E., Mbowa, C., & Akinlabi, E.T. (2014). Barriers in Implementing Green Supply Chain Management in Construction Industry. *Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management,* Bali, Indonesia, January 7 – 9.

Oluwole, J.O.A. Accelerating Sustainable Construction in Nigeria: The Professionals' Perspective", Civil and Environmental Research, 2(7), 61-67.

Oo, K.W. & Hlaing, S.N. (2018). Beneficial Usage of Autoclaved Aerated Concrete Block. *International Journal of Trend in Scientific Research and Development,* 2(5), 1961-1965.

Owsiak, Z., Sołtys, A., Sztąboroski, P., & Mazur, M. (2015). Properties of Autoclaved Aerated Concrete with Halloysite Under Industrial Conditions. 7th Scientific-Technical Conference Material Problems in Civil Engineering, 214-219.

Pandey, P., & Pandey, M.M. (methodology 2015). Research Methodology: Tools and Techniques. In Bridge Center (Ed). Buzau, Al. Marghiloman, Printed in Romania, Romania. 84-89. ISBN 978-606-93502-7-0

Pandey, S., Singh, K., Kirar, K.G., & Rajak, S. (2018). A Review on Comparison of Strength Parameters Between AAC Blocks and Clay Bricks for Building Construction Using STAAD Pro. *International Journal of Advance Research, Ideas and Innovations in Technology,* 4(5), 71-73. Available online at: www.ijariit.com

Patil, K.M., & Patil, M.S. (2017). Sustainable Construction Materials and Technology in Context with Sustainable Development. *International Journal of Engineering Research and Technology*, 10(1), 112-117.

Pitt, M., Michael, T., Matthew, R., Riley, M., & Longden, J. (2009). Towards Sustainable Construction: Promotion and Best Practices, *Construction Innovation,* 9(2), 201-224.

Pulliattu, P.B., & John, E. (2017). Study on the Properties of Aerated Concrete Incorporating Fly Ash and Quarry Dust. International Journal of Science Technology & Engineering, 3(11), 47-49.

Rafiza, A. R., Chan, H. Y., Thongtha, A., Jettipattaranat, W., & Lim, K. L. (2019). An Innovative Autoclaved Aerated Concrete (AAC) With Recycled AAC Powder for Low Carbon Construction. IOP Conference Series: *Earth and Environmental Science,* 268(1), 012050. DOI 10.1088/1755-1315/268/1/012050.

Rahman, R.A., Fazlizan, A., Asim, N., & Thongtha, A. (2020). A Review on the Utilization of Waste for Autoclaved Aerated Concrete Production. *Journal of Renewable Materials,* 9(1), 61-72.

Rathi, S.O. & Khandve, P.V. (2016). Cost Effectiveness of Using AAC Blocks for Building Construction in Residential Building and Public Buildings. *International Journal of Research in Engineering and Technology*, 05(05), 517-520.

Rathod, S.M., & Akbari, Y.V. (2017). Performance Evaluation of Aerated Autoclaved Concrete Blocks Using Silica Fume. *Journal of Emerging Technologies and Innovative Research,* 4(04), 220-225.

Różycka, A., & Pichór, W. (2016). Effect of Perlite Waste Addition on the Properties of Autoclaved Aerated Concrete. *Construction and Building Materials,* 120, 65–71. DOI 10.1016/j.conbuildmat.2016.05.019.

Rydin, Y., Amjad, U., Moore, S., Nye, M., & Withaker, M. (2006). Sustainable Construction and Planning. The Academic Report", Centre for Environmental Policy and Governance, The LSE SusCon Project, CEPG, London School of Economics, London.

Saiyed, F.M., Makwana, A.H., Pitroda, J. & Vyas, C.M. (2015). Aerated Autoclaved Concrete (AAC) Blocks: Novel Material for Construction Industry. *International Journal of Advanced Research in Engineering, Science & Management,* 1(2), 21-32.

Satish, K.B., Sukumar, R., Srinath. G.S., Tamil, S.K., & Bharathidason, P. (2017). Experimental Analysis of Aerated Concrete Block. International Journal of Engineering Research & Technology, 6(5), 726-730.

Showkat, N. & Parveen, H. (2017). Non-probability and Probability Sampling. Retrieved May 31, from *https://www.researchgate.net/publication/319066480*

Singh, A., Pandey, A. & Srivastava, V. (2017). Smart and Eco-friendly Construction Materials. *National Conference on Environment Friendly Materials & Technologies and Efficient Energy Consumption*, Allahabad, India. 1-3.

Sodagar, B., & Fieldson, R. (2008). Towards a Sustainable Construction Practice. Construction Information Quarterly, 10, 101–108.

Spišáková, M., & Mačková, D. (2015). The Use Potential of Traditional Building Materials for the Realization of Structures by Modern Methods of Construction. *Journal of Civil Engineering,* 10 (2).

Subash, M.C.G., Satyannarayana, V.S.V. & Srinivas, J. (2016). Aerated Autoclaved Concrete (AAC) Blocks: A Revolution Building Material in Construction Industry. *International Journal of Science Technology and Management*, 5(01), 167 – 174.

Tah, J.M.H. (2006). The Role of the African Diaspora in Sustainable Home Building. *In Proceedings of the African Diaspora Conference;* Nwana, H.S., Tah, J.H.M, Eds.; London, UK, 22 July 2006, 18–26.

Tazikova, A. (2014). Sustainability of Existing Buildings Obtained by Reconstruction. *In Innovative Approaches to the Design and Management of Buildings Reconstruction,* Kosice: TUKE

Thorpe, D. & Ryan, N. (2007). Responding to Global Issues: Sustainability and Innovation in the Australian SME Residential Building Construction Sector. *5th International Conference on Construction Project Management / 2nd International Conference on Construction Engineering and Management,* held in Singapore, 1-2 March.

Turkel, S., & Alabas, V. (2005). The Effect of Excessive Steam Curing on Portland Composite Cement Concrete. *Cement and Concrete Research,* 405–11.

Umeh, O.L. (2018). Research Methodology. University of Lagos Press & bookshop Ltd. ISBN: 978-978-964-255-7.

Umoh, A.A. & Odesola, I. (2015). Characteristics of Bamboo Leaf Ash Blended Cement Paste and Mortar. *Civil Engineering Dimension,* 17(1), 22-28.

Valore, R.C. (1954). Cellular Concretes-Composition and Methods of Preparation. *J. Am. Concr. Inst.,* 25, 773-795.
Varela, J.L. (2003). Development of R and Cd Factors for the Seismic Design of AAC Structures. Austin, TX: University of Texas.
Villar-Cociña, E, Morales, E.V., Santos, S.F., Savastano, H. & Frías, M. (2011). Pozzolanic Behavior of Bamboo Leaf Ash: Characterization and Determination of the Kinetic Parameters. *Cement and Concrete Composites*, 33, 68-73.
Vu, H.Q., & Nguyen, T.N. (2017). The Influence of Admixtures on Properties of AAC Using Dune Sand as the Fine Aggregate. *Journal of Civil Engineering Research*, 7(1), 1-8.
Walczak, P., Małolepszy, J., Reben, M., Szymański, P., & Rzepa, K. (2015). Utilization of Waste Glass in Autoclaved Aerated Concrete. *Procedia Engineering*, 122, 302–309. DOI 10.1016/j.proeng.2015.10.040.
Wang, C. L., Ni, W., Zhang, S. Q., Wang, S., & Gai, G. S. (2016). Preparation and Properties of Autoclaved Aerated Concrete Using Coal Gangue and Iron Ore Tailings. *Construction and Building Materials*, 104, 109–115. DOI 10.1016/j.conbuildmat.2015.12.041.
Williams, K., & Dair, C. (2007). What is Stopping Sustainable Building in England? Barriers Experienced by Stakeholders in Delivering Sustainable Developments. *Journal of Sustainable Development,* 3(15), 135-147.
Wilson, U.N., Raji, S.A. & Alomaja, J.A. (2016). Comparative Review on the Use of Sandcrete Blocks and Laterite-cement Bricks in Nigeria. *Ethopian International journal of Multidisciplinary Research,* 3(3), 32-44.
Wittmann, F.H., & Pytlik E.C. (1992). Advances in Autoclaved Aerated Concrete. *Proceedings of the Third Rilem International Symposium on Autoclaved Cellular Concrete: The Building Material for the 21st Century,* Zurich, Switzerland.
Yudelson, J. (2007). Green Building A to Z; Understanding the Language of Green Building. Canada: New Society Publishers, 2007.
Yudelson, J. (2009). Green Building through Integrated Design. New York: McGraw Hill.
Zhang, X.L., Shen, W. Y., & Qi, G.Y., (2011). Barriers to Implement Green Strategy in the Process of Developing Real Estate Projects. The Open Waste Management Journal, 4, 33-37.

APPENDICES

APPENDIX 1 (Nigerian professionals Questionnaire)

DEPARTMENT OF BUILDING
FACULTY OF ENVIRONMENTAL SCIENCES
UNIVERSITY OF LAGOS

Dear sir/ma,

The attached is a survey research instrument designed to facilitate the collection of data which will help investigate the sustainability of Autoclaved Aerated Concrete (AAC) blocks with a view to providing walling materials that are sustainable. The study is purely an academic exercise required for the Award of Master of Science (MSc) in Construction Technology and it is geared towards eliciting information of your awareness on AAC blocks used on building construction sites. It is my hope therefore that you would be willing to contribute to the success of this research by completing the attached questionnaire as your contribution is material to achieving the research goals. Please be assured that all information supplied will be treated with strict confidentiality and used only for research purpose.
Thank you for your co-operation.

Yours Sincerely,
Simeon Dele R.
Phone: 08022513382
Email: dsimeon@unilag.edu.ng

SECTION A: DEMOGRAPHIC PROFILE OF RESPONDENTS

Please tick (√) appropriately

1. Indicate your professional background
   Architecture (   ) Building (   ) Civil Engineering (   ) Quantity Surveying (   )
   Others, please specify …………………………….
2. Indicate your professional body
   NIA (   ) NIOB (   ) NSE (   ) NIQS (   )
   Others, please specify …………………………….
3. Indicate grade of membership
   Student (   ) Graduate (   ) Corporate (   ) Fellow (   )
   Others, please specify …………………………….
4. Indicate your highest academic qualification
   ND (   ) HND (   ) B.Sc./B. Tech (   ) M.Sc/MBA (   ) PhD (   )
   Others, please specify …………………………….
5. Indicate your years of experience in construction
   0-5 years (   ) 6-10 years (   ) 11-15 years (   ) 16-20 years (   ) 21 years and above (   )
6. Indicate the type of your organization

Consulting (   ) Contracting (   ) Client organization (   ) Design & Build (   )

7. Indicate the size of your organization
   Large with more than 250 employees (   ) medium-sized with 51-249 employees (   )
   Small-sized with 1-50 employees (   )
8. Indicate the type of ownership and management of the organization
   Fully indigenous (   ) Fully Expatriate (   ) Partly Indigenous and Partly Expatriate (   )
9. Indicate the nature of construction works undertaken by your organization
   New construction works (   ) Renovation (   ) General Contracting (   )

SECTION B: LEVEL OF AWARENESS OF AAC BLOCK VARIANTS IN LAGOS STATE

Kindly indicate your level of awareness of the following AAC block variants by ticking one of the options for each AAC variant: **5** represents Fully Aware, **4** represents Highly Aware, **3** represents Moderately Aware, **2** represents Slightly Aware and **1** represents Not at all aware.

S/N	**AAC Variants**	**5 Fully Aware**	**4 Highly Aware**	**3 Moderately Aware**	**2 Slightly Aware**	**1 Not at all aware**
1	AAC with 32.5 grade Ordinary Portland Cement (OPC)					
2	AAC with 42.5 grade Ordinary Portland Cement (OPC)					
3	AAC with 52.5 grade Ordinary Portland Cement (OPC)					
4	AAC with Coal Bottom Ash (CBA)					
5	AAC with Natural Zeolite Additive (NZ)					
6	AAC with Self-ignition Coal Gangue (SCG)					
7	AAC with Incinerated Sewage Sludge Ash (ISSA)					
8	AAC with Bamboo Leaf Ash (BLA)					
9	AAC with Silica Fume (SF) / Fly Ash (FA)					
10	AAC with Dune Sand (DS)					
11	AAC with Rice Husk Ash (RHA) / Aluminum Powder (AP)					
12	AAC with Concrete Sandwich Block (CSB) / Waste Glass (WG)					
13	AAC with Halloysite Powder (HP)					
14	AAC with Air-cooled Slag (AS)					
15	AAC with Efflorescence Sand (ES)					
16	AAC with Phosphorus Sand (PS)					

17	AAC with Coal Gangue (CG) / Iron Ore Tailings (IOT)					
18	AAC with Pulverized Fuel Ash (PFA) / Palm Oil Fuel Ash (POFA)					
19	AAC with Copper Tailings (CT) / Blast Furnace Slag (BFS)					
20	AAC with Perlite Waste (PW) / Polypropylene Fiber (PF)					

SECTION C: PROSPECT FOR ADOPTION OF AAC BLOCK IN THE NIGERIAN CONSTRUCTION INDUSTRY

Kindly indicate the prospect for adoption of AAC blocks in the Nigerian construction industry by ticking any of the following options provided:

Very poor (   )   Poor (   )   Moderate (   )   Good (   )   Very good (   )

SECTION D: IMPORTANT DRIVERS FOR THE ADOPTION OF AAC ON BUILDING PROJECTS

Please, assess the following important drivers for the adoption of AAC on building projects by ticking one of the options for each driver: **5** represents Most Important, **4** represents More Important, **3** represents Moderately Important, **2** represents Slightly Important and **1** represents Not Important.

S/N	**Important Drivers**	**5 Most Important**	**4 More Important**	**3 Moderately Important**	**2 Slightly Important**	**1 Not Important**
1	Excellent thermal absorption property					
2	Superior fire insulation					
3	Pest and mold resistant					
4	Lightweight					
5	Better thermal conductivity					
6	Reduced dead weight on structure					
7	Reduction of building costs as a result of decrease structural element					
8	Eco-friendly (lower environmental impact)					
9	Adaptability of AAC blocks to tropical climates					
10	Recyclable					
11	Quick and easy installation					
12	Excellent acoustic performance					
13	Breathable wall system					
14	Monetarily and ecologically better than other conventional walling materials					
15	Attractive appearance					

16	Readily adaptable to any style of architecture					
17	Reduced transfer of load on the foundation					
18	Manufactured from common and abundant raw material					
19	Versatile as components can be used for walls, floors and ceiling					
20	Energy efficient					
21	Use of reduced labour in manufacture and its installation					
22	Reduced cost of maintenance					
23	AAC production process does not develop toxic gases					
24	Durability					
25	Used in the construction of dwellings in low-cost housing units on the mass scale					
26	Moisture resistant					

SECTION E: SIGNIFICANT BARRIERS IMPEDING AAC BLOCK ADOPTION FOR BUILDING PROJECTS

Please, assess the following significant barriers impeding AAC block adoption for building projects by ticking one of the options from the alternatives provided: **5** for most Significant, **4** for more Significant, **3** for Moderately Significant, **2** for slightly Significant and **1** for least Significant.

S/N	**Significant Barriers impeding AAC Block Adoption**	**5 Most Significant**	**4 More Significant**	**3 Moderately Significant**	**2 Slightly Significa nt**	**1 Not Significa nt**
1	Unfavorable perception of home buyers to AAC in the short term					
2	Lack of interest in new products by buyers and house owners					
3	Little interest in new products by Architects and Developers					
4	Costs of the “learning curve” while working with a new product					
5	Startup costs associated with promoting and teaching the industry to build with AAC					
6	Market potentials					
7	Inadequate building codes and regulations					
8	Low demand for sustainable housing					
9	Lack of easy rating systems for eco-buildings					

10	Absence of design standards for AAC products					
11	Inadequate government policies and supports					
12	Existing structure of the construction industry					
13	Lack of readily available accessible information					
14	Low level of awareness and knowledge on the concept of sustainability					
15	Low level of demand and knowledge of AAC products					
16	Inadequate exemplar demonstration project to infuse confidence for using AAC					
17	Non-awareness of people towards the advantageous use of AAC					
18	Huge capital to set up AAC plant					
19	Lack of readily available accessible information					
20	Inadequate technical know-how and manpower to manufacture AAC products					
21	Use of unsustainable construction materials					
22	Availability of conventional material					
23	Affordability					

SECTION F: IMPORTANT STRATEGIES THAT CAN IMPROVE AAC BLOCK ADOPTION ON BUILDING PROJECTS

Please, assess the following important strategies that can improve AAC block adoption on building projects by ticking one of the options from the alternative provided, **5** represents Most Important, **4** represents More Important, **3** represents Moderate Important, **2** represents Slightly Important and **1** represents Not Important.

S/N	Strategies that can improve the usage of AAC	5 Most Important	4 More Important	3 Moderately Important	2 Slightly Important	1 Not Important
1	Growth in the infrastructural sector					
2	Industrialization					
3	Demand for lightweight construction materials					
4	Growth preferences for low cost houses					
5	Increasing focus in green and sound proof buildings					

6	Creating demonstration and training centers					
7	Integrating sustainability into formal curricula					
8	Increasing funding for sustainable building materials					
9	Focusing research on specific green building materials					
10	Education and training to built environment professionals about the product					
11	Public private partnerships on energy efficiency and sustainable materials					
12	Government financial supports and subsidy					
13	Government encouragement					
14	Development of new construction materials and technology					
15	Government promotion of product					
16	The readiness of construction practitioners such as developers and contractors in adopting sustainable materials					
17	Use of tool ratings					
18	Marketing strategy development					

APPENDIX 2 (South African professionals questionnaire)

This is the designed Google link through which they were able to access the questionnaire:

https://forms.gle/wUWBzQ1ETjDS5PJJ7