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Thematic Approach into Passive Design Optimisation and CSEBS Adoption among Builders in South-Western States of Nigeria

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Abstract

Purpose: This paper examines the extent to which passive design optimization and the adoption of Compressed Stabilized Earth Blocks (CSEBs) have permeated building practice in South-Western Nigeria, and critically interrogates the technical, institutional, and logistical barriers that constrain wider uptake.

Methodology: Employing a qualitative, thematic approach, semi-structured interviews were conducted with eight senior building professionals (architects, civil engineers and builders) purposively sampled across the six states of the geo-political zone; interview data were transcribed, coded and synthesized into themes to reveal patterns of awareness, practice and constraint.

Findings: The study finds near-universal awareness and routine deployment of passive design strategies (orientation, shading, ventilation, daylighting, thermal mass and insulation) among experienced practitioners, yet CSEBs—while recognized for their environmental and cost advantages—face clustered obstacles: unclear production standards, durability and dimensional concerns, curing and transport logistics, limited applicability to high-rise loads, and skills gaps that invite workmanship failures. These barriers act as socio-technical bottlenecks that slow diffusion despite favorable perceptions.

Originality: In juxtaposing passive design optimization with on-the-ground realities of CSEB manufacture and use, this research bridges a gap in region-specific empirical evidence. It also advances a policy-relevant argument that scaling CSEB adoption requires coordinated standardization, targeted capacity building, appropriate site selection, and regulatory advocacy—measures that can unlock low-carbon, resilient housing pathways in tropical contexts.

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Keywords: Passive Design, Optimization, CSEBs, Adoption, Builders, South-Western Nigeria, Thematic Approach

Introduction

Our delicate ecology is being severely impacted by climate change, and it is thought that human activity that releases greenhouse gases into the atmosphere is what has caused these effects to accelerate (Malhi *et al*., 2020; Weiskopf *et al*., 2020) [31, 46]. Incorporating climate variables into building designs has consistently been essential and must be prioritized continually. The development of high-performance buildings that prioritize energy economy while ensuring occupant well-being has made passive design optimization essential. According to Anand *et al*. (2023) [6], passive design is a strategy that uses the climate and natural elements to maintain a comfortable temperature within buildings. Passive design collaborates with the environment to eliminate undesirable heat or cold while harnessing sunlight and breezes (El Gindi, 2024; Faragallah, 2022) [15, 19]. Hence, employing natural energy flows to ensure thermal comfort is the goal of passive design. This entails choosing the right building orientation, building materials, and landscape.

In tropical climates, preventing heat gain through appropriate orientation and building materials are among the primary passive design elements for structures (Malhi *et al*., 2020) [31]. Buildings are composed of various parts, including walls, roofs, and doors, to mention but a few. Out of the afore-stated, walls constitute the majority of building components. Thus, Compressed Stabilized Earth Blocks (CSEBs) are sustainable bricks assembled with beautifully created and durable components that possess little to no cement, dry stacking procedures, and locally produced raw materials like sand and laterite (Olaleye and Ibitoye, 2022) [35]. According to Contreras, Lezcano, and Fernández (2022) [14], sustainable building materials are those that meet the needs of the present generation without compromising the ability of future generations to meet their own needs. These materials do not have a substantial negative impact on the environment.

Moreover, Bibang, Zhu and Francis (2023) [10] express that building with earth is a step in the right direction toward achieving sustainable building in many parts of the world. Meanwhile, Eze *et al*. (2023) [17] submit that environmental concerns have emerged as crucial guidelines for the global realization of sustainable housing, necessitating awareness and education of environmentalists, planners, architects, and engineers on topics like energy consumption, the use of eco-friendly materials, and design strategies that lessen environmental impact. Huang *et al*. (2020) [23] observe that with every year that goes by, the earth gets warmer. Hence, harnessing prefabricated parts, recycling garbage, and locating local resources are some measures that should be employed to mitigate environmental impact. In most South-Western states of Nigeria, building designs do not take into account the demands of the tropical climate. Hence, Nwalusi *et al*. (2022) [33] avow that due consideration is not given to the factors in residential building design that enable thermal comfort with little reliance on mechanical energy sources. As a result, most buildings frequently rely on artificial lighting and ventilation. More of concern, the lives of dwellers in the region have become unbearably difficult due to frequent power outages and load shedding (Nwalusi *et al*., 2022) [33], which can last more than twelve hours on a daily basis in the hot and dry weather. As the problem with load shedding worsens, individuals depend more on mechanical sources of energy generation, in most cases, generating sets in their homes and offices due to the extreme heat. In fact, when the temperature rises sharply during the peak dry season, the situation gets worse. By the way, sandcrete block is the primary walling material used in South-Western Nigeria. Wilson (2024) [47] observes that sandcrete bricks make up over 90% of the physical infrastructure in Nigeria. Majority of the sandcrete blocks are composed of cement, whose production involves the extraction of calcium carbonate and several industrial processes culminating in high embodied energy. The consequence of this is that high embodied energy leads to the emission of greenhouse gases, which in turn causes the ozone layer in the atmosphere to thin, resulting in climate change and global warming (Abey and Anand, 2019) [1]. Given this backdrop (Ochedi and Taki, 2022) [34], the extreme heat and the great need for cooling energy cause the demand forelectricity to rise to an all-time high in recent times. Hence, buildings without active climatization can lead to weariness, health concerns, and inefficiency as a result of the increase in energy consumption characterized by poor supply of natural ventilation.

Therefore, it is imperative to examine building strategies and materials that minimize the environmental impact of human activity. In light of the afore-stated, this study aims to empirically investigate the potential of passive design optimization and CSEB adoption among builders in South-Western states of Nigeria. Besides, there has been a dearth of research conducted in this area of study in relation to the region under investigation. With regard to the latter assertion, this study, therefore, hopes to narrow the research gap to an appreciable extent by contributing to the body of knowledge.

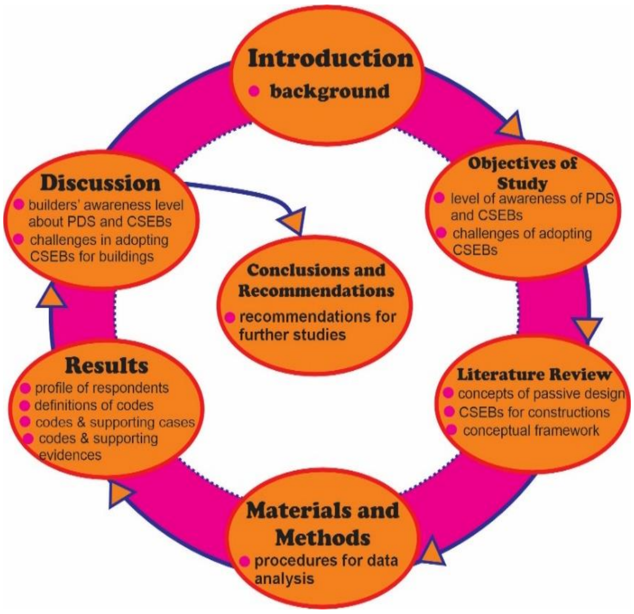
Aim and Objectives of the Study

Based on the practical relevance described in the study background, the aim of this study is to empirically investigate passive design optimization and CSEBs adoption among builders in South-Western states of Nigeria. Thus, the research objectives are to:

1. Ascertain the level of awareness of passive design strategies (PDS) and CSEBs among builders in South-West, Nigeria.
2. Investigate the challenges in adopting CSEBs for building in South-Western Nigeria.

Structure of the Research

The entire organization of this paper is demonstrated in Figure 1.



***Source*:** Authors' design

Fig 1: A Pictorial Representation of the Study Structure

Literature Review

Conceptual Review

The set of ideas, presumptions, expectations and beliefs that guide this paper's investigation are presented in this section.

The Concepts of Passive Design in Building

The creation of high-performance buildings that emphasize energy efficiency and occupant well-being has rendered passive design concepts indispensable. Shum and Zhong (2023) [41] assert that passive design reduces reliance on mechanical systems by employing natural light, ventilation and thermal mass. This reduces energy consumption while maintaining interior comfort. However, finding the ideal balance between energy efficiency and human well-being in building design is difficult because of the intricacy and conflicting objectives involved (Bala *et al*., 2023; Kaur *et al*., 2022) [9, 27]. Building envelope features and passive design elements, such as natural ventilation, shading devices, green outdoor spaces, thermal mass, overhangs, solar protection, double glazing, double-skinned façades, window-to-wall ratios, daylighting, and materials with high thermal inertia in walls and roofs, have drawn more attention because of the enormous potential for energy efficiency in buildings (Amaripadath and Sailor, 2024) [5].

In essence, experts from around the world are beginning to investigate the appropriateness of building optimization methodologies in an attempt to improve the energy performance of buildings. Ali *et al*. (2021) [4] argue that making it simpler to find the best solution that meets benchmarking and designer-architecture requirements is the goal of the methods that have been investigated. Moreover, implementing the finest passive design recommendations for each setting, especially for residential structures, is a crucial technique for helping buildings become more energy efficient (Aldersoni *et al*., 2022) [3]. Moreover, Azar *et al*. (2020) [8] submit that a common method for reducing thermal loads in buildings is the use of energy-efficient building technologies, such as smart automation systems in conjunction with low-energy Heating, Ventilation and Air Conditioning systems (HVAC). Several reviews of the literature indicate that passive cooling in particular has received a lot of attention as a means of reducing the need for mechanical HVAC maintenance (Ochedi and Taki, 2022; Trepci *et al*., 2021; Valavanidis, 2022) [34, 43].

CSEBs for Building Construction

The use of CSEB for building construction follows the principle of dry stacking. In dry stacking construction, the interlocking blocks are laid without mortar, thereby leading to considerable savings in cost associated with mortar. The major material needed for the production of CSEB is earth (see Figure 2), which, according to Nagapan *et al*. (2017) [32], is readily available. The soil is obtained from at least 1m below the topsoil and must be free of dirt in order to achieve a fine finished product. Thus, CSEB buildings are state-of-the-art constructions assembled with beautifully created and durable bricks locally produced from raw materials like sand and laterite (Olaleye and Ibitoye, 2022) [35]. The bricks are compressed using a manual or motorized press, which creates a meshing pattern on the top and bottom of the block. The interlacing pattern allows the bricks to be stacked without the use of mortar, making them a popular alternative to conventional bricks and blocks for construction in many parts of the world. They are especially prevalent in places with limited access to other quality bricks and exorbitant carriage costs for conventional building supplies (Bredenoord, 2017) [12].

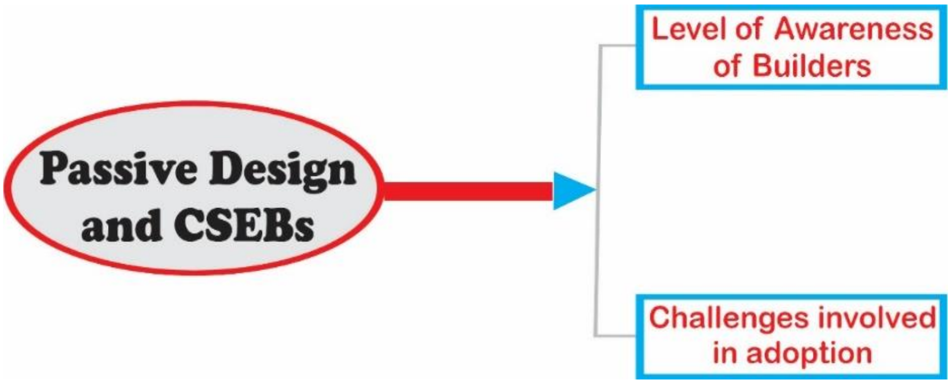
Environmentally friendly and sustainable building materials have received more attention recently. Hence, Hanafi (2021) affirms that CSEBs provide natural, energy-efficient, environmentally beneficial, and agriculturally friendly building materials for sustainable development. During the manufacture of this energy-efficient material, no toxic gases are released; it is a cost-effective and environmentally beneficial replacement for traditional building materials like cement blocks and bricks (Hema *et al*., 2021) [22]. Thus, using CSEBs in building construction is considered an agent of green architecture. Essentially, earth construction is a resource-efficient and cost-effective method of building low-rise dwellings in developing regions.

Certainly, the two most noticeable physical elements of a building envelope are its walls and roof. In the case of passive structures, the buildings' aspect ratio establishes their proportional significance (Kumar *et al*., 2018) [29]. In order to create a habitable and comfortable interior space, passive building design incorporates walls and roofs that insulate the indoor and outside environments. Walls can occasionally be used to provide lighting and allow natural light into the structure. The locals in Nigeria have historically built walls using adobe, mud, and stones—all of which have low absorption capacities and low thermal conductivity (Samuel *et al*., 2017) [39]. But as cities become more populated and taller structures become necessary, masonry or concrete barriers have taken their place.

***Source*:** Author's field work

Fig 2: Earth Soil (left) and A Residential CSEB Building (right)

The Conceptual Framework



***Source*:** Authors' design

Fig 3: Conceptual Framework of the Study

Awareness Level of Builders about PDS and CSEBs

Passive designs are measures implemented by building professionals to attain thermal comfort in buildings by utilizing natural energy flow. It is accomplished by employing suitable building materials and landscaping elements while also taking into account the building's orientation (Anand *et al*., 2023) [6]. Implementing effective PDS demands appropriate knowledge. Golman and Loewenstein (2018) [20] argue that humans have an unquenchable desire for knowledge and will go to great lengths to fulfill this intrinsic pursuit. Knowledge is perceived to consist of justified, factual beliefs. Consequently, Bolisani *et al*. (2018) [11] emphasize that knowledge is made up of three fundamental characteristics, which are commonly referred to as the tripartite account of knowledge. The first and most important scenario is one in which the information contains truth. Second, a believing condition is necessary for a deeper comprehension of knowledge. This implies that one must have belief in the veracity of the information they are getting. Finally, knowledge must be justified in order to demonstrate its veracity. Experience, abilities, and assertions can all be used to gain knowledge.

Furthermore, Bolisani *et al*. (2018) [11] submit that man's direct interactions with his immediate surroundings through his sensory systems are the source of experiential knowledge. Man's mental faculties then use observations to process the knowledge. Only by directly interacting with the sensory systems can one acquire experiential knowledge, which is considered to be individualised. Thus, perception and introspection are its main pillars. Conversely, skills knowledge focuses on completing tasks and activities. As a result, skills knowledge—which is superior to experiencing knowledge—should also be grounded in personal experience. This kind of knowledge is acquired by regularly completing a set of activities and learning from them. The "know-how claim," which is about what is thought to be true, is the final category of knowledge.

In relation to this study, knowledge, as observed by the authors, is mainly attributed to the building industry professionals' level of awareness of the various PDS that are available in building designs and construction. It is assumed that being highly aware of the availability and applicability of the different PDS and CSEB derivatives by experts in the field is essential for the optimization of passive designs and CSEB adoption in the built industry.

Challenges in adopting CSEBs for Building

Every building material has some difficulties, albeit varying degrees of difficulty. These difficulties can include, but are not limited to, a short lifespan, structural issues, improper stability, and inconsistent molding equipment (Islam *et al*., 2020) [25]. It is imperative that CSEBs be preserved and safeguarded, particularly in locations with a medium to high annual precipitation percentage. While exposed walls and parapets are bad for most construction materials, they are far worse when used with CSEBs. Thus, the earth bricks need to be protected and maintained on a regular basis in order to reach their intended economic, functional and structural life span (Pombo *et al*., 2019) [37].

Another shortcoming, according to Aubert *et al*. (2016) [7], is that the tensile strength of CSEBs is low. Additionally, because of the low quantity of cement used as a binding agent, it is unable to effectively accommodate reinforcing. Due to the reason that CSEBs are not subjected to bending moment, their use is therefore practicable mostly in situations where compressive strength is needed, such as walls, vaults, and domes (Turco *et al*., 2021) [44]. Besides, Sitton *et al*. (2018) [42] contend that minimizing the amount of cement used while still producing bricks with ideal strength to carry out the intended purpose is a crucial factor to take into account when using CSEBs. On one hand, as a result of lack of proper knowledge (Islam *et al*., 2020) [25], CSEBs are typically over-stabilized. Thus, the purpose of stabilizing earth bricks tends to be undermined in this case. On the other hand, CSEBs may be under-stabilized, hence resulting in structural failure. Sapna and Anbalagan (2023) [40] point out that CSEBs lack organization, are technically ill-prepared with very little know-how about it and few engineers and scientists who have interest in this industry.

More so, Elahi, Shahriar and Islam (2021) [16] observe that dimensional instability is a disadvantage of CSEBs. The lack of standardization in the molding apparatus is the cause of this. While building with mud or unstable ground is as old as humanity, CSEBs, which emerged as a result of technological improvement via research, are comparatively a new building concept. Although a lot of people are accustomed to using sandcrete blocks for walling, CSEB is a preferable alternative building material to sandcrete blocks and mud, despite it having a negative impact on dimensional appropriateness (Sameer and Bringezu, 2019) [38].

Furthermore, Aubert *et al*. (2016) [7] point out that the compressive strength of CSEBs varies according to their dimension. Hence, in order to encourage developers to use CSEBs more frequently, there is a need for them to be integrated into the construction code. According to a study carried out by Joshua *et al*. (2017) [26] on CSEBs, it was found that earth bricks are denser than some concrete masonry blocks. Moreover, if CSEBs need to be transported over a long distance, the high density is typically seen as a drawback. In addition, CSEBs typically require more units to complete a construction than sandcrete blocks.

Materials and Methods

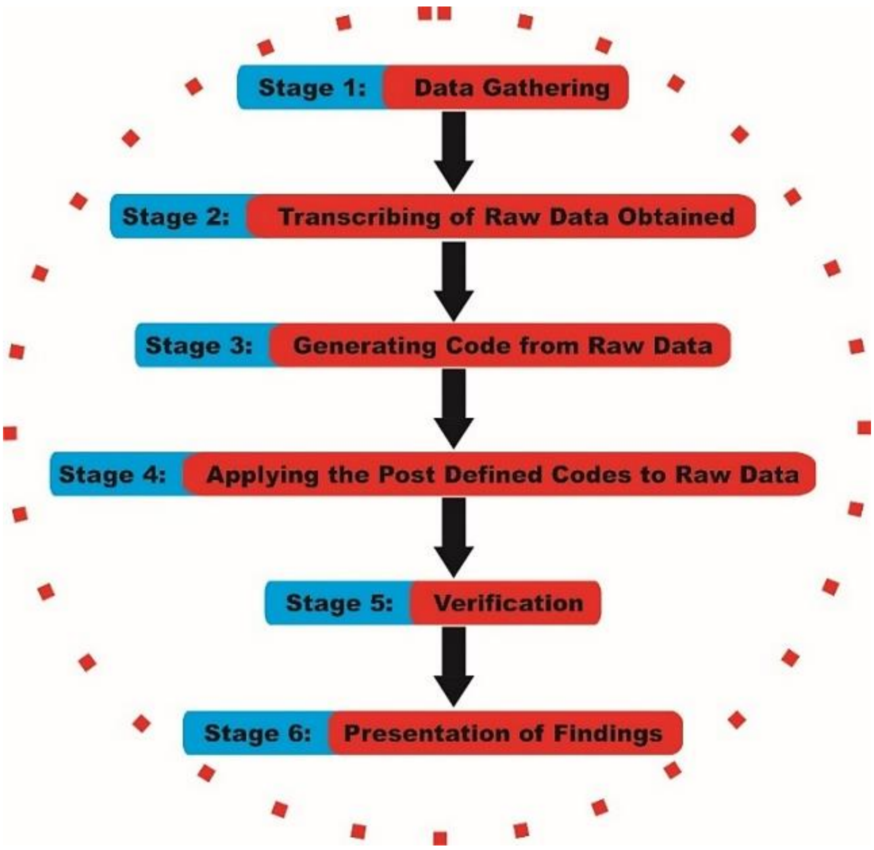
This study employed a qualitative survey research design to assess passive design optimization and CSEBs adoption among builders in South-Western Nigeria. To obtain answers from participants, a researcher-created semi-structured interview was used. This approach was essential as it gives the researcher a complete image from the informants, which may be used to support present methods, uncover elements that hinder or enhance practice, and provide a picture of a scenario as it naturally occurs (Burns and Grove, 2003) [13]. The method's main goal is to collect and use easily auditable semi-structured data. All registered building professionals operating in South-West Nigeria make up the study's target group.

Given the nature, constraints, and goals of the study, the sample size of eight (8) participants was adjudged appropriate for this research. Besides, there are no clear guidelines for researchers to follow or universal numerical recommendations for sample size in qualitative research (Kindsiko and Poltimäe, 2019; Lichtman, 2010; Vasileiou *et al*., 2018) [28, 30]. Purposive non-probability sampling was used as the researchers took into account experts with extensive knowledge of the built environment. In essence, the interview guide was developed in close cooperation with two architectural experts and was also based on knowledge gained from the assessment of secondary literature for validity purposes. In addition, the interview guide was progressively refined during the study's interview phase in order to better understand the phenomena under investigation.

Except for a few brief estimation queries, practically all of the inquiries were open-ended and each transcription provides a description of the question adaptation procedure. Moreover, in order to meet the pre-established goals of the study, the data obtained from eight respondents were appropriately managed, thoroughly examined, and presented. Three main elements comprised the interview guide for the study. The first section of the guide asked questions to gather the interviewee's profile information. The second dealt with questions regarding the level of awareness about PDS and CSEBs. While questions relating to challenges in adopting CSEBs for building were covered in the final section. The interview was scheduled for thirty (30) minutes per interviewee. This was created to help extract sufficient information and reach logical conclusions.

Procedure for Data Analysis

The process of giving the enormous amount of collected data structure, importance and order is known as data analysis (Pallant, 2020) [36]. A thematic approach to data analysis was used to accomplish an effective review of the collected data. Thematic analysis is one of the most widely used forms of analysis in qualitative research (Eze and Bello, 2016) [18]. The steps of the data analysis process, which is consistent with theme analysis, are depicted in Figure 4.



***Source*:** Eze and Bello (2016) [18]

Fig 4: Process of Data Analysis

The researcher must develop codes based on the data gathered from the interviews. Data collection is the first stage of the data analysis process, during which the respondents' answers to interview questions are gathered. The collected data was meticulously listened to and captured on tape. Generating codes from raw data is the third step. Similar statements that provide evidence were grouped together in this instance, and codes were developed based on those characteristics. A comprehensive code-generating guide makes up the fourth stage. Following a thorough description, the codes were used for further analysis and confirmation. In the fifth step, the reliability and authenticity of the data were assessed. The final step includes the presenting of the results.

Results

The results of the interviews conducted are presented with the background information about the building experts (respondents). The section also covers the methodological steps involved in analyzing data and the descriptive coding strategy.

Profile of Study Respondents

Table 1 reveals the profile of the building professionals interviewed in the course of the study. It presents the profession, years of professional practice, location of office, and project type commonly handled by respondents.

Table 1: Profile of Respondents

Respondent	Profession	Years of practice	Location	Project type
A	Civil engineer	32 years	Ogun State	General construction
B	Architect	43 years	Ondo State	Building construction
C	Architect	36 years	Ogun State	Building construction
D	Builder	41 years	Oyo State	Residential building
E	Civil engineer	44 years	Lagos State	General construction
F	Architect	35 years	Lagos State	Building construction
G	Builder	43 years	Osun State	General construction
H	Builder	37 years	Ekiti State	General construction

***Source*:** Field survey

The result in Table 1 as regards the profile of respondents demonstrates that construction experts interviewed for this study were architects (3), civil engineers (2), and builders (3)—all operating within the built environment. Besides, none of the building professionals has less than 32 years of practicing experience behind them, with the longest being 44 years. The result also shows that the entire region was covered, as each of the six states in South-West geo-political zone has at least one representation. Moreover, the interviewed building experts are specialized in handling residential building, general construction, or building construction.

Definitions and Descriptions of Codes

The authors developed codes based on data gathered from interview sessions with the building experts. Accordingly, the codes were created from raw data. The definitions and descriptions of the codes are shown in Table 2.

Table 2: Definitions and Descriptions of Codes

Codes	Definitions	Descriptions
PDS knowledge	This suggests that building experts are familiar with the concepts of PDS.	This is noted when respondents mention that they have awareness about PDS.
PDS implemented	This means that the building expert does implement passive design in building.	This is indicated when respondents state the PDS they have implemented.
PDS industry awareness	This suggests that experts in the built environment have knowledge about PDS in buildings.	This is noted when respondents remark PDS awareness level among colleagues.
Regular implementation	This means that experts often apply PDS to their building projects.	This is stated when respondents comment the level of application of PDS to projects by colleagues.
CSEBs knowledge	This suggests that building experts have knowledge about CSEBs.	This is indicated when respondents state that they are knowledgeable about CSEBs.
CSEBs industry awareness	This means that experts in the built environment have awareness about CSEBs.	This is stated when respondents remark CSEBs awareness level among colleagues.
Low CSEBs adoption	This suggests that CSEBs are not often adopted for building projects.	This is specified when respondents comment low usage of CSEBs for building.
CSEBs challenges	This means that experts encounter challenges in adopting CSEBs for building.	This is noted when respondents state the challenges in using CSEBs for building projects.

Codes and Supporting Cases

Table 3 reveals the codes and supporting cases used for the purpose of data analyses and interpretations, based on the study objectives.

Table 3: Codes and Supporting Cases

Codes	Supporting Cases	Ratings	% Ratings
High level of awareness	A, B, C, D, E, F, G, H	8 / 8	100%
CSEBs adoption has challenges	A, B, C, D, E, F, G, H	8 / 8	100%

***Source*:** Authors' computation

Codes and Supporting Evidences

Table 4 depicts the codes and supporting evidences used for the purpose of data analyses and interpretations.

Table 4: Codes and Supporting Evidences

Codes	Supporting Evidences
High level of awareness	*"I have been familiar with passive designs right from my university days." "... I apply strategic building orientation to all my projects. Also, natural ventilation, roof insulation…" "...all my colleagues implement the concept in their projects…"* – (A). *"... I am an expert in the field, so I know the concept very well." ... there is high awareness and adoption of the concept in the industry"* – (B). *"... I have been actively involved in lots of building projects where passive designs were required. I have great knowledge and so are my colleagues..." "...and of CSEBs too…"* – (C). *"The awareness and knowledge of passive design strategy is high among builders…"* – (D). *"... yes, I have implemented passive designs like use of local materials, building orientation, shading, natural ventilation, daylighting, and overhangs in many of my projects."* – (E). *"... In recent times, I give priorities to passive designs in all my project plans." "...experts in the field very much include it in their construction projects."* – (F). *"...every professional in this field is aware of the concept." "... so, awareness and implementations are at appreciable level…" "... I seldom make use of CSEBs in my work."* – (G). *"I am very familiar and comfortable with implementing them in projects." ... orientation, daylighting, natural ventilation, and insulations are common in my projects." "...earth blocks are popular among builders, but not widely adopted."*– (H).
CSEBs adoption has challenges	*"...most times, it is difficult for CSEBs to be transported across long distances. So, when compared to concrete blocks, its production and transportation can cause delay in completing building projects."* – (A). *"...one thing is that weak blocks and structural failure can result from poor craftsmanship…" "...in contrast to concrete blocks, earth bricks can take up to one month to reach their maximum strength."* – (B). *"To guarantee strength and durability, CSEBs must undergo rigorous testing and stabilisation. The earth bricks are also at disadvantage moving them over lengthy distances."* – (C). *"...another thing is that no clear rules and guidelines for the production of CSEBs in the country. As such, lack of confidence in the blocks' durability has hampered its widespread adoption."* – (D). *"... asides that, they take longer days to cure, which can lead to slow project completion."* – (E). *"It is required that workers must be well trained to properly mix, condense and cure the blocks. The earth blocks if not properly cured may become brittle and weak."* – (F). *"High-rise structures without reinforcing might not be a good fit for CSEBs." "...and when it comes to water absorption, CSEBs are more susceptible than concrete blocks."* – (G). *"...soil resources may be impacted by large-scale production of CSEBs. Also, they are not suited for skyscrapers."* – (H).

Discussion

This section discusses findings putting into consideration the set objectives of the study in South-Western Nigeria.

Builders' Awareness Level about PDS and CSEBs

Thematic analysis was conducted to ascertain the level of awareness about the concepts of passive design and CSEBs among building experts in South-Western Nigeria. The result as presented in Table 4 indicated that professionals in the built environment of the region generally have good knowledge of the concepts investigated in the study. Results demonstrated that building experts in the region are not only familiar with but also adopt passive design concepts such as strategic building orientation, shading, overhangs, local materials usage, roof insulation, wall insulation, natural daylighting, and ventilation. Thus, findings of the investigation carried out reveal that the level of awareness about passive designs and CSEBs among building experts in South-Western states of Nigeria is very high. This is in tandem with the studies by Aghimien and Aghimien (2015) [2] and Ibem *et al*. (2019), whose findings revealed that building experts in the Southwest, Nigeria, have good knowledge about PDS and CSEBs in buildings.

Challenges in adopting CSEBs for Building

From analysis of the interview carried out, findings show that despite the numerous benefits inherent in adopting CSEBs for building, the earth bricks also possess some shortcomings. This is evident in Table 4. Findings demonstrate that lack of clear guidelines for the production; lack of confidence in durability; negative impact on soil resources resulting from large-scale production; difficulty in transporting the bricks across long distances; rigorous stabilization required to guarantee durability; less suitability for use in skyscraper projects; delay in project completion due to the longer days required for curing; and structural failure resulting from poor craftsmanship—all hamper widespread adoption of the earth bricks. This result corroborates those of Aubert *et al*. (2016) [7]; Joshua *et al*. (2017) [26]; and Obianyo *et al*. (2021), who also found CSEBs to have deficiencies ranging from low tensile strength to durability concerns. Besides, Elahi, Shahriar and Islam (2021) [16] found that dimensional instability is a weakness of CSEBs.

Conclusions and Recommendations

Thus far, the study has been able to ascertain the level of awareness of passive designs and challenges encountered in adopting CSEBs for construction among building professionals in South-Western Nigeria. Findings of the study revealed that passive design concepts and CSEBs have gained popularity among construction experts. Essentially, an encouraging level of applying various degrees of passive design concepts is presently being achieved. Outcome of the study further demonstrates that passive design concepts commonly adopted by building experts in the region are strategic building orientation, shading, overhangs, local materials usage, roof insulation, wall insulation, natural daylighting, and ventilation. Hence, there exists a high level of awareness about passive designs and CSEBs among building professionals in South-Western Nigeria.

Moreover, the results show that CSEBs currently suffer from drawbacks, notably, lack of clear guidelines for production, durability concerns, issues emanating from large-scale production, difficulties arising from long-distance transportation, suitability concerns for skyscraper projects, delays in curing, structural failure, and low tensile strength. These could better explain why its adoption in project constructions is slow in the region. Hence, despite the enormous benefits of CSEBs adoption in building constructions, there exist challenges that require hasty solutions.

The study therefore recommends that challenges of CSEBs should be mitigated by employing them in suitable locations, subjecting them solely to the loads for which they are engineered. Proper stabilization and dimensional consistency must also be guaranteed. By doing these, the use of CSEBs will be encouraged among stakeholders as an alternative to conventional materials used in building constructions due to their vast advantages. More so, the Council of Registered Builders of Nigeria (CORBON), which is saddled with the responsibility of registering and regulating builders, setting standards, and promoting ethical practices in the building profession, should embark more on passive design campaigns to serve as a means of increasing awareness of the concepts among stakeholders.

Recommendations for Further Studies

In order to arrive at its findings and conclusions, this study focused only on data generated from construction experts who have demonstrated over thirty years of practical experience. Besides, this was achieved through a qualitative approach. Further research should, therefore, concentrate on adopting qualitative means that would enable it to generate data from more respondents in the field so as to reach a more general conclusion.

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