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The use of alternative building technologies as a sustainable affordable housing solution: perspectives from South Africa

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Abstract

Purpose – This study aims to evaluate the perception of the local experts and end users on the drivers, barriers and strategies to the use of alternative building technologies (ABTs), with a focus on sandbag building technologies (SBTs) in the provision of sustainable housing in South Africa towards improving the public's understanding of SBTs.

Design/methodology/approach – This research adopted a qualitative approach that used focus group meetings as the primary data collection method for this study. This study's focus group participants comprised ABT experts and end users of ABT houses in South Africa who were selected using a convenient sampling technique. The data were recorded, transcribed verbatim and analysed using NVivo 11 software.

Findings – This study found that the perceived drivers to using ABTs such as SBT comprise sustainability, affordability, job creation potentials, fire-resistant and earthquake resistance. This study revealed strategies for the SBTs, including awareness, building sandbag prototypes across cities and training.

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Practical implications – This study's findings have practical implications for the practice and praxis of ABT implementation and uptake in South Africa. This study provides a framework for broadening the worldwide understanding of use and uptake of SBTs to provide sustainable and affordable housing.

Originality/value – This study adds significantly to the limited body of knowledge on ABTs, focusing on sandbag houses. Consequently, the findings provide policymakers with information on the expert and end-user perspectives on the barriers and strategies to using ABTs.

Keywords Word, Alternative building technologies (ABTs), Building materials, Housing, Sandbags, Sustainability

Paper type Research paper

1. Introduction

Adequate and affordable housing is crucial for combating poverty and improving living and health conditions (Adabre *et al.*, 2020). Most of the deteriorating public health problems in the USA are partly attributable to insufficient access to affordable housing (Pollack *et al.*, 2010). In addition, appropriate and affordable housing is crucial for lowering unemployment in a country because most economic sectors (commerce, industry and finance) benefit from the thriving housing sector (Adabre *et al.*, 2020). However, realising some of these housing advantages for low-income earners in developed and developing nations is almost impossible because affordable housing for low- and middle-income families is a huge problem (Adabre and Chan, 2019; Moghayedi *et al.*, 2021). In developed nations, a specific proportion of the population was homeless, such as Australia (0.471%), Canada (0.435%), Chile (0.071%), Denmark (0.095%) and Ireland (0.083%) (Adabre and Chan, 2019; Golubchikov and Badyina, 2012). The lack of affordable housing directly contributes to homelessness and slum growth.

Moreover, Sub-Saharan Africa has the greatest number of urban slum residents (Alaazi and Aganah, 2020). It is estimated that 12.5 million households in South Africa live in slums without access to suitable housing (National Home Builder's Registration Council, 2020). According to a previous study, South Africa's housing shortfall is around 2.2 million units (Ncube, 2017). The Cape Metropolitan MSDF of 2018 has estimated a need for 500,000 dwelling units in the city of Cape Town over the next 20 years (2012–2032) (City of Cape Town, 2018). It is anticipated that it will take more than 70 years to eradicate Cape Town's existing housing backlog with the current resources available (City of Cape Town, 2018). Consequently, developing affordable and sustainable housing solutions remains a pressing goal.

The South African government and scholars view alternative building technologies (ABTs) as a veritable approach to constructing quicker, sustainable and affordable housing (SAH) with better quality (Dosumu and Aigbavboa, 2019; National Home Builder's Registration Council, 2020; Ncube, 2017). ABT is any expertise, skill, knowledge, equipment, machinery or tools other than conventional ones to accelerate housing delivery without compromising the quality and durability of any erected structure (Tshivhasa and Mbanga, 2018). ABTs are also non-conventional building methodologies that use economically valuable and environmentally friendly building materials to deliver affordable houses (South African Housing and Infrastructure Fund, 2020). De-Villiers and Boshoff (2012) established that ABTs are sustainable, affordable and faster construction methods.

Despite the benefits of ABTs and their potential to solve South Africa's housing gap, their use in housing construction is limited. According to Botes (2013) and Salzer *et al.* (2016), traditional brick, concrete and steel houses are most desired and deemed contemporary by the typical citizen. South Africans believed that ABT-built houses were solely for the poor. They expressed their preference to live in a house constructed of traditional materials such

as brick, concrete blocks and mortar (Dosumu and Aigbavboa, 2019; Grady *et al.*, 2019). This is visible because most South African houses are made of conventional materials such as bricks, concrete blocks or mortar (Dlamini, 2020; Schmidt and Msinjili, 2014). As a result, to improve the comprehensive implementation of ABTs in housing delivery in South Africa, it is critical to ascertain the view of local experts and end users on the usage of ABTs as a SAH solution in South Africa.

Various ABTs are available in South Africa, including Moladi (lightweight plastic formwork mould), sandbag/earthbag, jumbo blocks and others (National Home Builder's Registration Council, 2020). This study focuses on sandbag building technology (SBT) because earlier research demonstrated that sandbag is the most readily accessible unknown alternative construction technology in South Africa (Adetooto and Windapo, 2022; Adetooto *et al.*, 2022; Windapo *et al.*, 2022a, 2022b). Sandbag technology has been proposed as a low-cost, sustainable, recyclable and alternative construction material capable of giving home access (Adetooto and Windapo, 2022). Sandbags are polypropylene bags or polymer materials filled with granular substances. They are also known as earthbags or dirtbags. Furthermore, researchers have shown that SBT offers greater economic and environmental benefits than other alternative construction technologies in producing low-income housing in several nations (Cataldo-Born *et al.*, 2016; Hadjri *et al.*, 2007).

In the light of the foregoing, this study aims to determine the level of use and perception of the local experts and end users on using ABTs as a SAH solution in South Africa.

2. The concept of sustainable affordable housing and the use of sandbag building technology

The definition of SAH is "housing that satisfies the requirements and expectations of the current generation without jeopardising future generations' capacity to satisfy their own housing needs and demands" (Pullen *et al.*, 2010). SAH delivers an economic advantage, enhanced occupant health, comfort, energy and water efficiency and cost savings (Golubchikov and Badyina, 2012; Sullivan and Ward, 2012). It is possible to achieve an 80% reduction in energy through a suitable practice (Adabre *et al.*, 2020). Affordable housing is defined as housing that costs less than 30% of a household's income (Friedman and Rosen, 2019). A house is sustainable if it is of excellent quality, in a desirable location for a lower-middle-income family, and the price is modest enough to enable the household to cover other basic living needs on a long-term basis (National Home Builder's Registration Council, 2020).

SBT is an earthen architecture that uses locally accessible dirt in the shape of woven bags filled and piled to make a structure (Rincón *et al.*, 2019). SBT offers economic and environmental benefits in delivering affordable housing in many nations. Sandbag-built houses use less energy during construction and operation than traditional building technologies (Cataldo-Born *et al.*, 2016). It also controls the building's interior temperature by collecting excess heat during the day and releasing it at night, resulting in a relaxed indoor atmosphere in hot and mild weather (Rincón *et al.*, 2019; Shaker *et al.*, 2017; Sharma, 2015). Furthermore, the sandbag technique is less expensive than traditional methods. In India and South Africa, a sandbag home's estimated cost per square meter is US$7.55 and US$24.2, respectively (Cataldo-Born *et al.*, 2016). Despite their benefits, sandbag technologies are not widely used in South Africa.

Cataldo-Born *et al.* (2016) recorded 15,000 sandbag houses worldwide in 2016. SBT has been used in the USA, Australia, Brazil, India, Iran, Haiti and Chile to provide sustainable, inexpensive, low-income and contemporary housing (Rincón *et al.*, 2019). SBT are well-established in the US building code (Geiger and Zemskova, 2015). Even though sandbag

technologies are still in their infancy in Africa, they have been used to deliver some dwellings in various African nations (Figure 1).

Even though researchers and manufacturers believe that implementing ABTs such as SBTs is crucial to addressing South Africa's housing crisis, the complete implementation and acceptance of SBTs in South Africa remain relatively low. As a result, to broaden the public's understanding of SBTs, this study assesses local experts' and end-users perceptions of the drivers, barriers and strategies for using ABTs such as sandbag material technology in the provision of sustainable housing in South Africa.

3. Research methods

This research adopted a qualitative approach that used focus group meetings as the primary data collection method for this study. Qualitative research has been identified as an effective approach in addressing the social perception in housing-related research (Nadal *et al.*, 2018). The two primary methods of data collection used in qualitative research comprise participant observations: typically, through an interview or in focus groups (Gill *et al.*, 2008). The focus group can capture actors' perceptions towards gaining an in-depth understanding of the social issue (Nyumba *et al.*, 2018). This speaks to the objective of this study, which seeks the perception of the stakeholders on the use of ABT in housing delivery. The respondent can share ideas on a particular problem through a focus group discussion and inform future decision-making and strategies (Nyumba *et al.*, 2018). When conducting complex research requiring deep understanding, focus group methods will enable the researcher to generate rich and detailed data (Man *et al.*, 2017).

Notes: (a) SBT house under construction; (b) SBT house post-construction; (c); (d) process of construction of SBT

Source: Adetooto and Windapo 2022

Figure 1.
Houses constructed using sandbag technologies in South Africa

The qualitative descriptive study was guided by Creswell and Clark's (2004) explanation of qualitative descriptive research. In keeping with qualitative descriptive research, this study was conducted without regard for any pre-existing theoretical or philosophical viewpoint. It is based on an inductive content analysis, in which code categories were constructed directly from text data. It is used when there is no existing research to aid data classification (Hsieh and Shannon, 2005). As a result, the study survey was designed to gather detailed information on both expert and end-user perspectives of the use of sandbag technologies in South Africa, as well as the impediments to widespread adoption and strategies for promotion.

3.1 Focus groups

Exploiting pre-existing networks where respondents have an in-depth undertaking and are participating in the same activities may offer rich data and contribute to the success of the focus group (Kamberelis *et al.*, 2018). Given this precedence, the current study's focus group members included ABT professionals and end users of ABT houses in South Africa, who were chosen using a convenient sampling approach. Table 1 indicates the demographics and skills of the focus group members. Table 1 shows that the chosen experts have a common interest in sustainable housing. According to Kamberelis *et al.* (2018), there is

ID	Position	Experience with ABT (years)	Involvement in sandbag technologies
C1	A leading research expert in sustainable, affordable housing	40	A leading researcher on sustainability and ABT
C2	Architect	25	A sandbag technologies expert and the CEO of a sandbag construction company
C3	Member of the sustainable, affordable housing research group	20	United Nation researcher at infrastructural investment, green building and biomimicry
C4	Member of the sustainability research group	15	A doctoral researcher on sustainable and affordable housing in South Africa
C5	Architect	25	A quality assessor inspector at the Centre for Research in housing innovation
C6	End-user 1	3	An occupant of a sandbag technology house in South Africa
D1	A leading researcher on alternative housing	25	A leading researcher on ABT
D2	A leading researcher on alternative housing	30	A leading researcher on ABT
D3	Member of the sustainable, affordable housing research group	5	A researcher on sustainable and affordable housing in South Africa
D4	Engineer	25	A sandbag technologies expert and the CEO of a sandbag construction company
D5	Collaborator on research on the sustainable, affordable housing research group	13	An associate professor and an expert researcher on sustainable construction
D6	Collaborator on research on the sustainable, affordable housing research group	8	A researcher on alternative construction
D7	End-user 2	3	An occupant of a sandbag technologies house in South Africa

Table 1. Profile of the focus group members

always an effective focus group when participants share a similar interest in the research problem and can comfortably talk to other participants.

3.2 Data collection

Cape Town was chosen as the ideal location for the focus group discussions. A wider spectrum of professionals from South Africa's building industry was present in person, while others participated online. In Cape Town, two focus group discussions with six and seven participants were undertaken, falling within Morgan (1996) recommended range of 6–15. Furthermore, the most often referenced prior study requires at least two focus group sessions for studies that depend on focus group data (Guest *et al.*, 2017). However, this research fits the aforementioned condition. The two focus group sessions addressed two broad questions that sought the thoughts and opinions of experts and end users on the study's aims. The general questions were as follows:

Q1. What are your perceptions of using alternative building technologies such as sandbag building technologies as one of the solutions to affordable housing in South Africa?

Q2. What are the drivers, barriers and strategies to adopting ABTs such as sandbags in South Africa?

The primary goal of the focus group discussion is to gather data from the members' discussions, not to force agreement, and the two sessions were handled to accomplish this goal. The talk lasted 4–5 h and was videotaped. In addition, several participants gave formal presentations to explain their views and points. The slides were collected and analysed. The video recording and other output forms generated during the focus group discussion were transcribed.

3.3 Data analysis

The audio data were transcribed verbatim and analysed using NVivo 11 software. NVivo was used to prevent bias while allowing for flexibility in defining codes and categories (Ozkan, 2004). Open coding was used, which involves a line-by-line or verbatim assessment of data in which qualitative data were chosen as the unit of meaning (Draucker *et al.*, 2007). In addition, the different codes derived from the selected data were used to highlight the main point. These were classified into several concepts. The concept was then subdivided further into categories and sub-categories. As a result, this strategy forms the foundation for creating a set of inductive coding frames comprising core categories and sub-categories. The data set revealed 14 themes divided into three primary groups, as well as eight sub-themes (Table 2 and Figure 2).

3.4 Validity and reliability

According to Anderson (2010), qualitative data criticism has been substantial, including prejudice, anecdotal evidence and a lack of rigour. However, this will only be true if the study is poorly conducted. As Fleming and Vanclay (2009) provided, the themes in this study were carefully validated against the data from which they were produced to ensure relevance and validity. Furthermore, an NVivo word frequency analysis (Figure 3) is performed to ensure word consistency. The research adheres to Rosenthal (2016) proposal that actual quotes from respondents be supplied to guarantee the data's reliability and validity. As a result, the themes were complemented by verbatim quotes from the focus group discussion from the respondents.

Categories	Codes (references)	Sub-codes
Perception on the use of SBT (56)	1. Affordability (14)	• Cheaper than brick and block
	2. Sustainability (22)	• Thermally efficient • Reduced CO_2 emission • Improved occupant health
	3. Job creation (8)	• Labour intensive • Easy to learn
	4. Earthquake resistant (6)	
	5. Fire resistance (6)	
The barrier to the use of SBT in South Africa (48)	1. Social acceptance (17)	
	2. Support from Government (11)	• Building codes and regulation • Scarcity of sand in south Africa
	3. Professional expertise (9)	
	4. Preference for brick and block (7)	
	5. Access to finance (4)	
Strategies to enhance the social acceptance of SBT (36)	1. Adequate research on sandbag performance (13)	
	2. Awareness (12)	
	3. Building Sandbag prototype across cities (6)	
	4. Training (5)	

Table 2.
NVivo thematic classification

4. Data analysis and finding

The focus group discussion and analysis of interview transcripts emphasised the major finding of SBT in South Africa's housing delivery, as stated below. Figure 2 and Table 2 provide an overview of perceptions, challenges, and strategies regarding the use of sandbag technology as a SAH option in South Africa. The number of repetitions of each code was used to determine the relative significance of each code. According to Chileshe *et al.* (2016), while analysing qualitative data in construction research, multiple references to codes are processed to show their relative weight and significance. According to Jackson and Bazeley (2019) the above-suggested inferences are true because "people repeat concepts that have meaning to them". Consequently, an explanation of the codes under each category is provided below.

4.1 Perception of the use of sandbag technologies in South Africa

This section primarily investigates the expert's and occupant's perceptions of the sandbag house in South Africa. Four perspectives on using SBT as a SAH solution emerged in the South African context: sustainability, affordability, fire resistance, job creation potential and earthquake resistance. These are described in the following sub-sections.

4.1.1 Sustainability. The respondents perceived sustainability as an essential factor in the use of sandbag technology in South Africa with 22 references (Figure 2). There was an emphasis on sustainable attributes of SBT. One of the experts' presentations of the life cycle assessment of an SBT revealed that SBT is a great alternative to traditional building techniques in terms of sustainability:

Figure 2.
NVivo Sunburst diagram of the perception

> They are a fantastic alternative to traditional building techniques. The concrete used in a sandbag house (columns and lintels) accounts for around 50% of its carbon footprint, and low-carbon concretes or alternative materials may greatly lower the carbon footprint of sandbag construction. (Participant D2)

Given that the vast majority of building in South Africa comprises bricks and concrete with high cement content mortar (Dlamini, 2020; Schmidt and Msinjili, 2014), experts stated that this produces a considerable amount of carbon dioxide to the environment and saw SBT as a better alternative in South Africa:

> Over time, the manufacture of cement has a considerable carbon impact. According to research, every tonne of cement produced emits an equal amount of carbon dioxide into the environment. So, when it comes to sandbag housing, the sandbag is a sustainable building technique that utilises less cement, and I believe that everyone should embrace it. (Participant D1)

The literature supports this finding (Cataldo-Born *et al.*, 2016; Hunter and Kiffmeyer, 2004).

4.1.2 Affordability. Affordability was discussed extensively by the expert forum respondents. This was seen as a significant factor in the use of sandbag technology in South Africa with 14 references. There was a consensus that sandbag technologies are one of the

Figure 3.
NVivo word frequency analysis

alternative solutions to resolving the ever-increasing housing problem in South Africa because of their affordability (cheap and affordable):

> Sandbag technology is the most extensively utilised unknown local building material in South Africa. It is less expensive than traditional materials and is one of the potential solutions to affordable housing. (Participant C1)

This study finding is supported by literature (Barnes *et al.*, 2006; Sharma, 2015). However, several respondents contended that the cost of a sandbag home is determined by many factors, including location, market structure and specifications:

> Sandbag construction should be less expensive than traditional construction, but this relies on how you operate the site, the building specification, the type of sand and availability of sand, the geography of the land, and the market structure. For example, houses developed in Val de Vie will be more costly than those erected in Durbanville or Mossel Bay. (Participant D4)

On the other hand, the argument demonstrated that sandbag technologies are critical to alleviating South Africa's affordable housing crisis, particularly in informal settlements.

> It is typically a good and inexpensive method, especially in remote development, and it might be one of the answers to the question of human settlements. (Participant F4)

These findings are supported by research from the National Home Builder's Registration Council (2020) and Ncube (2017). They established that the employment of alternative

construction technologies, such as sandbag technology, is essential to reducing South Africa's ever-increasing housing shortfall owing to its affordability and capacity to provide houses that are cheaper, quicker and of a higher quality.

4.1.3 Job creation. In light of South Africa's high young unemployment rate, experts emphasised that any suggested housing solution must address South Africa's unemployment problem. As seen in Figure 2, eight references deemed the provision of jobs for unskilled labour an essential factor in the use of sandbag technology in South Africa. "Sandbag is labour-intensive and can generate employment" (Participant C3). This is consistent This is consistent with Ben-Alon *et al.* (2020) and Shaker *et al.* (2017), who confirmed that sandbag construction provides local job possibilities and boosts local economies.

Experts established that SBT is simple to learn because it needs less professional knowledge.

> I've trained many people over the years how to construct a sandbag house since it's simple to understand; they're still doing it and generating money from it. (Participant C2)

This is consistent with Ben-Alon *et al.* (2020) and Shaker *et al.* (2017). They discovered that sandbag technology enables unskilled workers to be taught while building houses. The sandbag technology is easy to build and requires no specialised machinery or knowledge.

4.1.4 Fire-resistant and earthquake resistant. As seen in Figure 2, fire and earthquake resistance were viewed as the least relevant factors for the usage of sandbag technology. According to experts, most structures in South Africa's informal settlements are comprised of shacks, which are easily destroyed by fire. As a result, many people have perished in fire mishaps in South Africa:

> We know that around 2,000 people each year are killed by fire because, in these shacks, when a fire breaks out, it quickly spreads over the whole town, but a sandbag home cannot burn up. (Participant D5)

This result is consistent with existing research (Cataldo-Born *et al.*, 2016).

Furthermore, experts established that SBT is earthquake resistant:

> In 2014, we erected a sandbag school in Nepal. Six days later, a major earthquake struck Nepal, destroying all of the buildings in the town. The only structure that remained intact after the earthquake was the sandbag school we had just completed. And the Nepalese government initiated an inquiry on why this structure is still intact when everything else has crumbled, as broadcast on BBC TV and CNN. Consequently, sandbag construction is now an officially recognised building method in Nepal. (Participant D4)

This finding is consistent with the findings of Shaker *et al.* (2017).

4.2 Experts and end-users perceptions of the barriers to the use of sandbag technologies in South Africa

This section highlights and examines the perspectives of experts and end users on the key challenges to deploying sandbag technology in South Africa. As indicated in Figure 2, they were categorised into six sub-categories, totalling 48 references.

4.2.1 Social acceptance. The expert noted that the lack of social acceptance of sandbags is a key impediment in South Africa, despite their benefits and potential to fix housing issues (17 references as shown in Figure 2). Bricks and concrete are the preferred building materials for most South Africans.

> Social acceptance is a significant difficulty. People associate living in a sandbag house with poverty and prefer to reside in a masonry building. (Participant D6)

This is supported by the findings of Kulshreshtha *et al.* (2020) and Rincón *et al.* (2019), who discovered that the populace connected sandbag homes with poverty and felt embarrassed to live in one.

The experts stated that the informal settlement residents burnt down most houses constructed using alternative construction technologies because the community does not accept or approve of them:

> In Frieda, we erected 600 houses out of polystyrene, and when the contractors finished, people have set fire to buildings because the community does not recognise and approve of alternative building technologies. (Participant C2)

Experts indicated that they were subjected to a life-threatening assault from the community. Because of the lack of acceptance and clearance for this technology, the project team was stoned and forced to leave the townships:

> We attempted to construct SBT houses in townships like Khayelitsha, but we were stoned and forced to leave. If I had remained there for another five minutes, I would have been murdered. (Participant D4)

This conclusion is consistent with previous research that has connected limited adoption of earth technology to stakeholders' lack of social acceptability (Adetooto and Windapo, 2022; Adetooto *et al.*, 2022; Kulshreshtha *et al.*, 2020). Social acceptability surfaced as a significant element that must be addressed in adopting sandbag material technology in South African affordable housing; when people do not accept a notion, adopting it may be challenging.

4.2.2 Preferences of conventional material. From the expert discussion, community members' choice of traditional materials significantly influenced the rejection of ABTs (7 references as shown in Figure 2). South Africans have a natural inclination for brick and concrete structures.

> One of the problems is that South Africans have a natural preference for brick-and-concrete dwellings, and many fear alternative building technology would label them as impoverished. (Participant D3).

According to experts, most people feel that homes built using alternative construction technologies are of inferior quality and have a short lifespan. The expert acknowledged that SBT might never be deployed if the community does not embrace this technology:

> People assume that since a house is made of sand, it is of inferior quality and has a short lifespan. When the community does not accept a notion, it will not be implemented. (Participant C3)

This is consistent with the results of Reddy (2022). They established that the increasing adoption of energy-intensive conventional buildings has dramatically decreased sandbag construction use.

4.2.3 Government support. According to the experts' discussion, South Africa has no government backing in the form of defined building regulation codes and policies for the use of alternative construction technologies such as sandbags. "We've never been able to implement SBT in South Africa, despite our efforts since the impression is negative and the government is unwilling to accept it" (Participant M9). As illustrated in Figure 2, government support was seen as a significant barrier with 11 references, compared with professional expertise (nine references), preference for brick and block (seven references) and access to finance (four references).

The experts ascribed this to the absence of published studies on the performance of alternative building technologies, such as sandbags. "Only until the performance of sandbag housing is made public can the government have faith in its effectiveness" (Participant D1).

This is congruent with the results of Rincón *et al.* (2019), who noted the lack of broad government recommendations and construction codes for sandbag technology.

4.2.4 Professional expertise. As seen in Figure 2, professional expertise was mostly cited as a barrier with nine references. From the expert discussion, it became apparent that the attitude of building professionals towards sandbag technology had a key impact in implementing sandbag technologies in South Africa. According to experts, building professionals lack a comprehensive grasp of the sandbag construction process. Consequently, a practical grasp of the sandbag building requirements is required to use this construction technique effectively. "Construction experts should understand the process of building with sandbags and what must be done to avoid difficulties such as cracking" (Participant C5). This is similar to the findings of Grady *et al.* (2019) and Ugochukwu and Chioma (2015), which found that most experts prefer to employ traditional construction materials and technology since they are better acquainted with them (Grady *et al.*, 2019; Ugochukwu and Chioma, 2015).

4.2.5 Access to finance. Figure 2 shows that access to financing was the least ranked impediment, with four references. According to the experts, banks refused to give bonds/mortgages for sandbag houses, and without this sort of financing, it is not easy to own a sandbag house or receive enough funds to construct one. "The major concern is that banks will not fund it" (Participant C1). According to Grady *et al.* (2019), many investors are unaware of the technology and efficiency of ABTs. As a result, obtaining house finance and insurance from financial organisations is almost difficult (Zami and Lee, 2011).

Some experts, however, contended that the financial institution's backing is contingent on significant government consent. "Banks have no trouble lending money to construct a sandbag home as long as the government has authorised SBT" (Participant C5).

4.3 Expert perception of strategies to improve the social acceptance of sandbag technologies in South Africa

This section investigates experts' perspectives on measures to promote social acceptance of sandbag technology in South Africa. Table 2 shows how the perception was categorised into four sub-categories with 36 references.

4.3.1 Research on sandbag technology performance. A substantial number of specialists believe that the government's and professionals' lack of adoption of sandbag technologies is due to a lack of published findings on the performance of sandbag technologies. There was consensus that there is a need for significant study into the performance of sandbag technologies, as indicated in Figure 2. With 17 references, an extensive study on sandbag technology performance was recognised as a successful strategy to enhance SBT social acceptance, compared to awareness (13 references), building sandbag prototypes throughout cities (six references) and training (five references).

> There is a need to conduct more tests and publish more results to educate people on the performance integrity of sandbag technology to assure its widespread adoption. (Participant D6)

4.3.2 Sandbag technologies prototypes. The expert discussion revealed that developing sandbag technology prototype houses throughout towns and provinces would considerably improve its social acceptance in South Africa. As demonstrated in Figure 2, this was mostly seen as a strategy with six references:

> One approach to get it accepted is to bring that technology into our cities, so people can witness it from start to finish, rather than just building it in rural areas. (Participant D1)

Experts agreed that establishing prototypes is an important technique for promoting this technology, stating, "one essential strategy to sell out this technology is to create prototype buildings in cities" (Participant D4). Existing research indicates that individuals become more receptive to alternate construction technologies after physically seeing a home constructed using an alternative technology (Grady *et al.*, 2019).

4.3.3 Awareness. As indicated in Figure 2, awareness was an effective strategy for increasing social acceptance of ABTs, such as SBT in South Africa. With 12 references, awareness is viewed as the most important approach, followed by training (five references) and establishing sandbag prototypes throughout cities (six references). "I believe raising awareness is one of the most important techniques for promoting the widespread adoption of alternative technology" (Participant C3). There was consensus among the experts that people's awareness of sandbag technologies' environmental and economic benefits profoundly influenced its adoption.

4.3.4 Training. The experts' discussion revealed that training is critical to the social acceptance of sandbag technology. "Training is one strategy to promote the ABT system" (Participant C2). Experts further revealed that professionals and residents of alternative technology housing often claim that they do not comprehend the building process of ABT and hence despise the system. Therefore, training individuals is necessary for SBT acceptance.

5. Practical implication of the finding

The current study's findings have practical implications for the practice and praxis of ABT implementation and uptake in South Africa. To improve the public's awareness of SBTs for SAH delivery, this research draws on the different perspectives and hands-on experience of top experts and local end users in the South. The study benchmarked the drivers, barriers and strategies to the use of SBT to provide SAH. To increase the widespread deployment of SBT in South Africa, drivers uncovered in this research (Figure 4) should be promoted to South

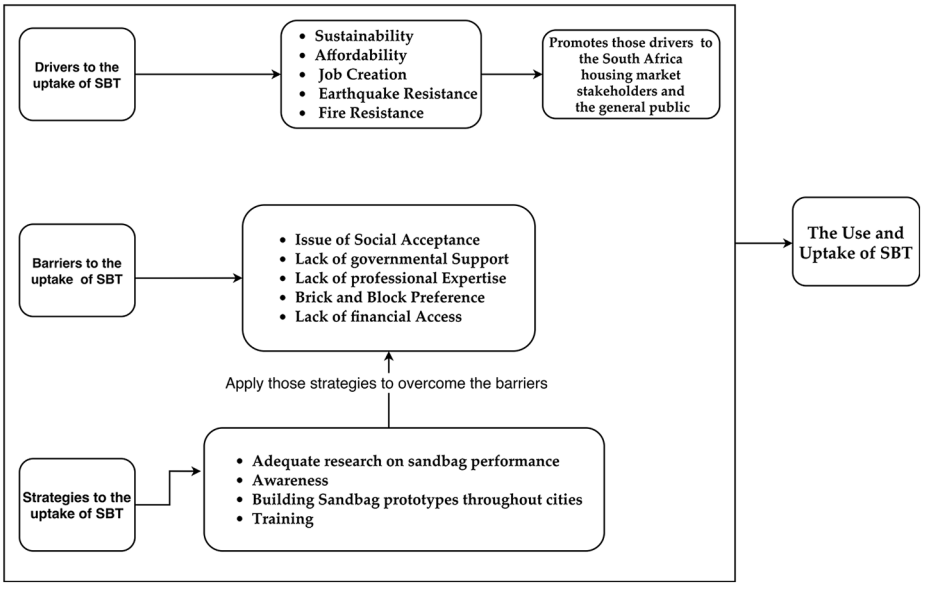

Figure 4.
Framework of the use and uptake of sandbag building technology in South Africa

African housing industry stakeholders and the general public. The knowledge of the drivers of the use of SBT may encourage South African housing stakeholders and the general public to embrace and use SBT (Adetooto and Windapo, 2022; Adetooto *et al.*, 2022), hence, promoting them in the South African housing market and among the general public is vital. Furthermore, understanding the barriers to adopting technology is essential for designing and implementing strategies to overcome the barriers and increase technology's widespread implementation (Darko *et al.*, 2018). This research not only identifies the barriers but also provides considerable strategies for overcoming the barriers (Figure 4). The study provides a framework for broadening the worldwide understanding of the use and uptake of SBTs to produce SAH.

6. Conclusion

Achieving SAH solutions remains a pressing goal in South Africa and most developing countries of Sub-Saharan Africa. This study assessed the perception of experts and end users on the drivers, barriers and strategies to the use of ABTs such as sandbag material technology as a SAH solution in South Africa. This study found that the perceived drivers to the use of ABTs such as sandbag material technology comprise sustainability, affordability, job creation potentials, fire-resistant and earthquake resistance. The study revealed that SBT contributes to a low carbon footprint in the atmosphere and was perceived as a better alternative to delivering SAH in South Africa.

It also emerged that SBT were comparatively cheaper and more affordable than conventional technologies. The study further revealed that with high unskilled youth unemployment statistics in South Africa, SBT would be suitable because it is labour-intensive and can be an employment opportunity for interested youths. Sandbag technologies' fire and earthquake resistance attributes were perceived as significant drivers of its use in South Africa as a sustainable and affordable solution for housing needs. The social acceptance of sandbag houses was perceived as the most significant barrier in South Africa. The study found that South Africans prefer homes built with conventional materials as this emerged as a predominant barrier to the use of alternative technologies in South Africa (seven references). Other barriers include lack of support from the government, limited professional expertise and access to finance. This study further revealed the strategies for the use of ABTs such as sandbag technology as a SAH solution in South Africa. It emerged from the study that the government and industry professionals' lack of acceptance of sandbag technologies is linked to a lack of published results on the performance of sandbag technologies. The need for extensive research on sandbag technology performance was seen as an effective strategy to enhance its use and acceptance as a SAH solution in South Africa. This is followed by other strategies, including awareness, building sandbag prototypes across cities and training.

This research expands beyond philosophical guesses and arguments to capture the more profound and objective perception of the local expert and end users on the use of ABTs such as sandbag material technology as a SAH solution in South Africa. Thus, this study adds significantly to the limited body of knowledge on ABTs, focusing on Sandbag houses. Consequently, the findings provide policymakers with information on the expert and end-user perspectives on the barriers and strategies to the use of ABTs.

Despite the contributions, care must be taken in generalising the finding of this research to other ABTs as it is limited to sandbag material technologies. Another limitation comes with the qualitative nature of the research as it relies on "expert opinion" rather than drawing upon hard evidence. The sample size did not cover the whole of South Africa as some provinces are not represented. Hence, these studies recommend the need for further research on a broader sample size of experts across each province in South Africa, and other ABTs should be considered.

References

Adabre, M.A. and Chan, A.P. (2019), "Critical success factors (CSFs) for sustainable affordable housing", *Building and Environment*, Vol. 156, pp. 203-214.

Adabre, M.A., Chan, A.P.C., Darko, A., Osei-Kyei, R., Abidoye, R. and Adjei-Kumi, T. (2020), "Critical barriers to sustainability attainment in affordable housing: international construction professionals' perspective", *Journal of Cleaner Production*, Vol. 253, p. 119995, doi: 10.1016/j.jclepro.2020.119995.

Adetooto, J. and Windapo, A. (2022), "Concomitant impediments to the social acceptance of sandbag technology for sustainable and affordable housing delivery: the case of South Africa", *Buildings*, Vol. 12 No. 6, p. 859.

Adetooto, J., Windapo, A. and Pomponi, F. (2022), "Barrier to the use of sandbag material technologies as a sustainable affordable housing solution: perspectives from South Africa", *PiC Series in Built Environment*, Vol. 3, pp. 722-730, doi: 10.29007/nqpb.

Alaazi, D.A. and Aganah, G.A. (2020), "Understanding the slum–health conundrum in Sub-Saharan Africa: a proposal for a rights-based approach to health promotion in slums", *Global Health Promotion*, Vol. 27 No. 3, pp. 65-72.

Anderson, C. (2010), "Presenting and evaluating qualitative research", *American Journal of Pharmaceutical Education*, Vol. 74 No. 8, p. 141.

Barnes, B., Kang, M. and Cao, H. (2006), "Sustainable characteristics of Earthbag housing", *Housing and Society*, Vol. 33 No. 2, pp. 21-32.

Ben-Alon, L., Loftness, V., Harries, K.A., Hameen, E.C. and Bridges, M. (2020), "Integrating earthen building materials and methods into mainstream construction", *Journal of Green Building*, Vol. 15 No. 1, pp. 87-106.

Botes, A.W. (2013), *A Feasibility Study of Utilising Shipping Containers to Address the Housing Backlog in South Africa*, Stellenbosch University, Stellenbosch.

Cataldo-Born, M., Araya-Letelier, G. and Pabón, C. (2016), "Obstacles and motivations for Earthbag social housing in Chile: energy, environment, economic and codes implications", *Revista de la Construcción*, Vol. 15 No. 3, pp. 17-26.

Chileshe, N., Rameezdeen, R. and Hosseini, M.R. (2016), "Drivers for adopting reverse logistics in the construction industry: a qualitative study", *Engineering, Construction and Architectural Management*, Vol. 23 No. 2, pp. 134-157.

City of Cape Town (2018), "Municipal spatial development framework", available at: https://resource.capetown.gov.za/documentcentre/Documents/City%20strategies%2C%20plans%20and%20frameworks/CT_Metropolitan_Spatial_Development_Framework.pdf

Creswell, J.W. and Clark, V.L.P. (2004), *Principles of Qualitative Research: Designing a Qualitative Study. Office of Qualitative and Mixed Methods Research*, University of NE, Lincoln.

Darko, A., Chan, A.P.C., Yang, Y., Shan, M., He, B.-J. and Gou, Z. (2018), "Influences of barriers, drivers, and promotion strategies on green building technologies adoption in developing countries: the Ghanaian case", *Journal of Cleaner Production*, Vol. 200, pp. 687-703, doi: 10.1016/j.jclepro.2018.07.318.

De-Villiers, W. and Boshoff, W.P. (2012), "The development of a decision-making model to determine the appropriateness of alternative building technologies for application in the social housing industry".

Dlamini, T.U. (2020), *The Feasibility of Wood Plastic Composites as Building Material for RDP Houses in South Africa*, Stellenbosch University, Stellenbosch.

Dosumu, O. and Aigbavboa, C. (2019), "An investigation of the benefits and challenges of adopting alternative building materials (ABM) in the construction industry", *Innovative Production and Construction: Transforming Construction through Emerging Technologies*, World Scientific, pp. 261-277.

Draucker, C.B., Martsolf, D.S., Ross, R. and Rusk, T.B. (2007), "Theoretical sampling and category development in grounded theory", *Qualitative Health Research*, Vol. 17 No. 8, pp. 1137-1148.

Fleming, A. and Vanclay, F. (2009), "Using discourse analysis to better inform the practice of extension", *Extension Farming Systems Journal*, Vol. 5 No. 1, pp. 1-10.

Friedman, R. and Rosen, G. (2019), "The challenge of conceptualizing affordable housing: definitions and their underlying agendas in Israel", *Housing Studies*, Vol. 34 No. 4, pp. 565-587.

Geiger, O. and Zemskova, K. (2015), "Earthbag technology–simple, safe and sustainable", *Nepal Engineer's Association Technical Journal Special Issue on Gorkha Earthquake*, Vol. 43, pp. 78-90.

Gill, P., Stewart, K., Treasure, E. and Chadwick, B. (2008), "Methods of data collection in qualitative research: interviews and focus groups", *British Dental Journal*, Vol. 204 No. 6, pp. 291-295.

Golubchikov, O. and Badyina, A. (2012), *Sustainable Housing for Sustainable Cities: A Policy Framework for Developing Countries*, UN-HABITAT, Nairobi.

Grady, B., Muzila, D., O'Neill, K., Tanner, A., Belz, M., Tshiguvho, T. and Gumede, D. (2019), "Alternative building technologies for low-income housing in Cape Town, South Africa", Worcester Polytechnic Institute Worcester, MA.

Guest, G., Namey, E., Taylor, J., Eley, N. and McKenna, K. (2017), "Comparing focus groups and individual interviews: findings from a randomized study", *International Journal of Social Research Methodology*, Vol. 20 No. 6, pp. 693-708.

Hadjri, K., Osmani, M., Baiche, B. and Chifunda, C. (2007), "Attitudes towards earth building for Zambian housing provision", Paper presented at the Proceedings of the Institution of Civil Engineers-Engineering Sustainability.

Hsieh, H.-F. and Shannon, S.E. (2005), "Three approaches to qualitative content analysis", *Qualitative Health Research*, Vol. 15 No. 9, pp. 1277-1288.

Hunter, K. and Kiffmeyer, D. (2004), *Earthbag Building: The Tools, Tricks and Techniques*, Vol. 8, New society publishers, Gabriola Island, BC, Canada.

Jackson, K. and Bazeley, P. (2019), *Qualitative Data Analysis with NVivo*, Sage.

Kamberelis, G., Dimitriadis, G. and Welker, A. (2018), "Focus group research and/in figured worlds", *The SAGE Handbook of Qualitative Research*, Sage, pp. 692-716.

Kulshreshtha, Y., Mota, N.J., Jagadish, K.S., Bredenoord, J., Vardon, P.J., van Loosdrecht, M.C. and Jonkers, H.M. (2020), "The potential and current status of earthen material for low-cost housing in rural India", *Construction and Building Materials*, Vol. 247, p. 118615.

Man, S., Chan, A.H. and Wong, H. (2017), "Risk-taking behaviors of Hong Kong construction workers – a thematic study", *Safety Science*, Vol. 98, pp. 25-36.

Moghayedi, A., Awuzie, B., Omotayo, T., Le Jeune, K., Massyn, M., Ekpo, C.O., Braune, M. and Byron, P. (2021), "A critical success factor framework for implementing sustainable innovative and affordable housing: a systematic review and bibliometric analysis", *Buildings*, Vol. 11 No. 8, p. 317.

Morgan, D.L. (1996), *Focus Groups as Qualitative Research*, Vol. 16, Sage publications.

Nadal, A., Cerón-Palma, I., García-Gómez, C., Pérez-Sánchez, M., Rodríguez-Labajos, B., Cuerva, E., Josa, A. and Rieradevall, J. (2018), "Social perception of urban agriculture in Latin-America. A case study in Mexican social housing", *Land Use Policy*, Vol. 76, pp. 719-734.

National Home Builder's Registration Council (2020), "Promoting innovative building technologies", available at: www.nhbrc.org.za/wp-content/uploads/2020/10/Promoting-IBTs-for-the-NHBRC-Website.pdf

Ncube, N.R. (2017), "Investigating the feasibility of the use of Moladi construction technology to assist in-situ upgrading in informal settlements within the eThekwini metropolitan area", Doctoral dissertation.

Nyumba, T., Wilson, K., Derrick, C.J. and Mukherjee, N. (2018), "The use of focus group discussion methodology: insights from two decades of application in conservation", *Methods in Ecology and Evolution*, Vol. 9 No. 1, pp. 20-32.

Ozkan, B.C. (2004), "Using NVivo to analyze qualitative classroom data on constructivist learning environments", *The Qualitative Report*, Vol. 9 No. 4, pp. 589-603.

Pollack, C.E., Griffin, B.A. and Lynch, J. (2010), "Housing affordability and health among homeowners and renters", *American Journal of Preventive Medicine*, Vol. 39 No. 6, pp. 515-521.

Pullen, S., Arman, M., Zillante, G., Zuo, J., Chileshe, N. and Wilson, L. (2010), "Developing an assessment framework for affordable and sustainable housing", *Australasian Journal of Construction Economics and Building*, Vol. 10 Nos 1/2, pp. 60-76.

Reddy, B. (2022), "Characteristics of stabilised compressed earth blocks", *Compressed Earth Block and Rammed Earth Structures*, Springer, pp. 131-209.

Rincón, L., Carrobé, A., Martorell, I. and Medrano, M. (2019), "Improving thermal comfort of earthen dwellings in Sub-Saharan Africa with passive design", *Journal of Building Engineering*, Vol. 24, p. 100732.

Rosenthal, M. (2016), "Qualitative research methods: why, when, and how to conduct interviews and focus groups in pharmacy research", *Currents in Pharmacy Teaching and Learning*, Vol. 8 No. 4, pp. 509-516.

Salzer, C., Wallbaum, H., Lopez, L.F. and Kouyoumji, J.L. (2016), "Sustainability of social housing in Asia: a holistic multi-perspective development process for bamboo-based construction in the Philippines", *Sustainability*, Vol. 8 No. 2, p. 151.

Schmidt, W. and Msinjili, N.S. (2014), "SCC: a solution to the challenges of concrete construction in Africa", *Concrete trends-Journal of the African Cement and Concrete Industry*, pp. 16-20.

Shaker, A., Medhat, H., Abou-Elgheit, M., Nassar, M., Mahmoud, Y., Hamza, A.S. and Abou-Zeid, M. (2017), "A proposed sandbag housing unit for poor and disadvantaged areas", Paper presented at the Conference proceeding: Leadership in Sustainable Infrastructure, Vancouver, May.

Sharma, P. (2015), "A study on feasibility of emergency shelter through super adobe technology", *International Journal Research*, Vol. 2, pp. 512-517.

South African Housing and Infrastructure Fund (2020), "Incremental housing: thought paper", available at: www.sahiffund.co.za/documents/SAHIF-THOUGHT-PAPER_Incremental%20Housing_SEPTEMBER%202020.pdf

Sullivan, E. and Ward, P.M. (2012), "Sustainable housing applications and policies for low-income self-build and housing rehab", *Habitat International*, Vol. 36 No. 2, pp. 312-323.

Tshivhasa, T. and Mbanga, S. (2018), "Pointing innovative building technologies path through learnt experiences for sustainable human settlements development: a case study of Thembelihle Manyano project in the Eastern Cape province", Paper presented at the Out-of-the box 2018 conference proceedings, 24–25 October 2018, CSIR, Pretoria.

Ugochukwu, I.B. and Chioma, M.I.B. (2015), "Local building materials: affordable strategy for housing the urban poor in Nigeria", *Procedia Engineering*, Vol. 118, pp. 42-49.

Windapo, A., Jarratt, N., Johnson, A., Pomponi, F. and Emuze, F. (2022a), "Assessing the structural properties of the sandbag wall for alternative housing construction", *EPiC Series in Built Environment*, Vol. 3, pp. 795-803, available at: https://doi.org/10.29007/w511

Windapo, A., Jarratt, N., Johnson, A., Pomponi, F. and Emuze, F. (2022b), "Sandbag building technologies", South Africa,: Construction Business and Management Research Group; Department of Construction Economics and Management, University of Cape Town: Cape Town, ISBN 978-1-998962-05-1.

Zami, M.S. and Lee, A. (2011), "Inhibitors of adopting stabilised earth construction to address urban low cost housing crisis: an understanding by construction professionals", *Journal of Building Appraisal*, Vol. 6 Nos 3/4, pp. 227-240.

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