

Strategies to promote the acceptance of sandbag building technology for sustainable and affordable housing delivery: the South African case

Sustainable
and affordable
housing
delivery

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Johnson Adetooto and Abimbola Windapo
*Department of Construction Economics and Management,
University of Cape Town, Cape Town, South Africa*

Francesco Pomponi
*School of Engineering and the Built Environment,
Edinburgh Napier University, Edinburgh, UK, and*

Fabio Companie, Kehinde Alade and Amanda Mtya
*Department of Construction Economics and Management,
University of Cape Town, Cape Town, South Africa*

Abstract

Purpose – Sandbag building technologies (SBTs) have been offered as a cost-effective and sustainable alternative building technology (ABT) capable of accelerating house construction in South Africa, but its acceptance remains low. However, knowledge about how to effectively improve SBT social acceptance is limited. This study aims to develop and prioritise SBT social acceptability strategies towards providing a comprehensive framework for the successful deployment and widespread adoption of sandbag technology.

Design/methodology/approach – This study used a quantitative research strategy that included a literature review and a structured questionnaire survey of 228 ABT professionals and stakeholders in the South African housing industry. The study statistically analysed 13 strategies for the social acceptance of SBT.

Findings – The analysis showed that the top three strategies include the availability of sandbag demonstration projects in all provinces, the approval of a sandbag building code and the availability of standard design methods for earthbags. A factor analysis clustered the 13 strategies into Stakeholders

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integration and policy formation, Effective education and knowledge sharing and Grassroots advocacy and incentives.

Practical implications – The current study's findings provide a broad framework for the effective implementation and wide acceptance of sandbag technology in housing projects. It offered certain best practices that policymakers and practitioners might use to promote ABT and SBT societal acceptability.

Originality/value – To the best of the authors' knowledge, the study represents the first and only attempt to investigate the viewpoints of experts and housing market stakeholders in South Africa regarding sandbag technology social acceptance strategies and contributes to the social acceptance body of knowledge in ABT and SBT.

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

Paper type Research paper

1. Introduction

More than 20% of the world's population – 1.6 billion people – lacks sufficient housing, and an estimated 100 million people are homeless (Adabre and Chan, 2019). The current housing backlog in South Africa is around 2.2 million units (National Home Builder's Registration Council, 2020; Ncube, 2017), with 12.5 million South African families living in slums without proper homes (Denoon-Stevens, 2018). According to recent estimates, if South Africa continues to use conventional construction technologies and materials, it will take more than 70 years to address its current housing shortfall (City of Cape Town, 2018). As a result, leading researchers and the South African Government advocated the use of alternative building technologies (ABTs), also known as innovative building technologies (IBTs) or alternative construction methods (ACMs), as a viable option for addressing the housing backlog through the construction of affordable and sustainable housing (National Home Builder's Registration Council, 2020; Ncube, 2017; Dosumu and Aigbavboa, 2019). ABTs are non-traditional building technologies with features that differ from standard brick and mortar, and their adoption is thought to improve the construction process significantly (Mbambo *et al.*, 2021).

Sandbag building technology (SBT), also known as earthbag or soil bag, has been proposed as one of the sustainable and affordable low-cost housing options globally and in South Africa (Adetooto *et al.*, 2022b). SBT is a style of earthen architecture that uses locally sourced dirt packed in woven bags and layered to construct a structure (Rincón *et al.*, 2019). Windapo *et al.* (2022b) stated that SBT is the most widely available undiscovered ABT in South Africa. Sandbag technologies emerged from the 17th-century concept of using sand-filled bags for military defence and flood control (Cataldo-Born *et al.*, 2016). SBTs were conceived in the early 1990s in response to the need to provide inexpensive accommodation for millions of refugees and victims of conflict and natural catastrophes (Hunter and Kiffmeyer, 2004). SBTs were a viable option for building dwellings for the underprivileged and on the moon (Sharma, 2015; Khalili and Outram, 2008). The implementation of ABTs, such as SBTs, were seen as a response to the housing crisis that had engulfed the nation after the realisation that the government lacked resources to deal with the large backlog of housing (Ballerino, 2002). With the use of alternative materials, it is possible to build a 43 square meter home in 4–7 days instead of the 30-days required by standard brick-and-mortar construction (Burger *et al.*, 2010).

SBTs have been presented as a low-cost, sustainable, recyclable, alternative building material that gives housing access and more than 15,000 sandbag homes have been constructed worldwide (Cataldo-Born *et al.*, 2016). SBT has been used in countries like the USA, Australia, Brazil, India, Iran, Haiti and Chile to provide low-income, sustainable and

contemporary housing (Rincón *et al.*, 2019). It has been included in the US building code (Geiger and Zemskova, 2015). Despite the advantages and benefits of sandbag technology in providing inexpensive and sustainable homes, the level of social acceptance and uptake of the technology in South Africa remains quite low (Grady *et al.*, 2019; Adetooto *et al.*, 2022a).

Acceptance refers to how willingly individuals embrace and adopt new technology for usage (Louho *et al.*, 2006). According to Dillon (2001), public adoption of new technology is defined as the visible desire of a group to use new technology to achieve a goal that had previously been attained differently. Thus, acceptance is the decisive element in the success or failure of any technology, and it has been characterised as an outcome variable in a psychological process that users undergo while making technology-related choices (Dillon and Morris, 1996).

The social acceptability of ABTs among South African housing players (actors) has been heavily criticised due to their influence on the South African housing market. Before any objective assessment, most South Africans feel that any alternative to traditional brick-and-mortar technology is inferior (Olojede *et al.*, 2019; Mbambo *et al.*, 2021). According to Kulshreshtha *et al.* (2020) and Olojede *et al.* (2019), the social acceptability of sandbag technology is a significant barrier that has prevented the widespread worldwide adoption of sandbag technology. In addition, existing studies (Bosman and Van der Westhuizen, 2014; Adetooto *et al.*, 2022a) have shown that low-income families living in traditional sandbag buildings see sandbags as a non-durable and unpleasant material and wish to live in a brick or concrete home. In addition, Olojede *et al.* (2019) observed that South African financial institutions have not effectively promoted and supported alternative technologies. One example is the lack of financial support for the shipping container alternative technology from two of South Africa's largest banks, Nedbank and First National Bank (Mbambo *et al.*, 2021).

To effectively and efficiently increase the societal acceptability of SBTs, it is necessary to develop measures that overcome housing market obstacles. However, even though a lot of research studies has been done on SBTs in South Africa (Adetooto *et al.*, 2022a, 2022b; Adetooto and Windapo, 2022), there had been few or no empirical studies on the strategies for improving SBT social acceptance in South Africa. Given this context, and to promote SBT widespread acceptance, the study aims to identify the key strategies for the social acceptance of SBT. Moreover, this study's findings will contribute to filling a knowledge gap regarding SBT social acceptance strategies in South Africa. It will also serve as a valuable reference for policymakers and practitioners in defining the essential strategies and providing a generic framework that must be established to ensure the effective implementation of sandbag technology.

The article is structured as follows: Section 1 provides a context for the research on the social acceptance of sandbag technologies in South Africa and the study's aims. Section 2 examines the essential strategies for achieving social acceptance of sandbags in housing construction. Section 3 outlines the research methodology and analytic techniques used in data analysis. The results of the data analysis are presented in Section 4. Furthermore, the discussion and implications of the research are discussed in Section 5. The conclusion and recommendations for promoting social acceptance of sandbags in house delivery are presented in Section 6.

2. Literature review

2.1 Overview of sandbag technologies in South Africa

SBT has been used to create various structures in South Africa, including low-income residential dwellings, a school and a pavilion (Grady *et al.*, 2019; Santos and Beirão, 2016). Empirical investigations have been conducted as part of this study to demonstrate the

current construction methodologies, comparative cost analysis (Windapo *et al.*, 2022b) and material properties of SBT (Windapo *et al.*, 2022a). SBT construction entails pouring soil and a little quantity of binder inside the bag to confine the filling. The bags are piled together to create a wall, and occasionally barbed wire is used to enhance friction and adhesion between the stacked bags (Kennedy, 2002; Rincón *et al.*, 2019). The bags used in SBT come in various sizes; some SBT uses a long continuous bag to retain soil, while others use a short regular degradable bag to contain dirt (Rincón *et al.*, 2019). Figure 1 depicts a typical sandbag dwelling.

2.2 Economic and environmental benefits of sandbag technology

Due to the high cost of building new housing in South Africa, homeowners are usually compelled to take out a lifetime mortgage; consequently, most people prefer low-cost self-sustaining construction options (Freney, 2014). Previous studies by Ben-Alon *et al.* (2020) and Cataldo-Born *et al.* (2016) have shown that sandbag technology is one of the least costly building methods worldwide because it employs naturally existing natural resources (soil) and inexpensive labour. According to Geiger and Zemskova (2015), the average SBT housing in India's developing country costs \$7.25 per square foot, compared to \$20.14 per square foot for concrete block construction.

Houses built using the SBT require less energy during construction and operation (Cataldo-Born *et al.*, 2016) and produce less greenhouse gases throughout their life cycle (Ben-Alon *et al.*, 2020) and have lower embodied energy than other construction technologies. It also consumes less energy during the winter (Hunter and Kiffmeyer, 2004), lowering heating costs (Sharma, 2015). Furthermore, it 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; Santos and Beirão, 2016).

2.3 Strategies for the social acceptance of sandbag technology

This research uses Mintzberg's (1987) definition of strategy: "strategy is a plan, some form of a continuous planned course of action, a guideline (or collection of guidelines) to cope with a problem". SBT is not widely accepted in South Africa (Grady *et al.*, 2019). Adetooto and Windapo (2022)'s research outlines the present state of social acceptance of SBT in South Africa. However, given the degree of acceptability of SBT in South Africa, it is vital to create ways to enhance social acceptance of SBT. Therefore, a study of relevant published material was done to determine the strategies to promote the SBT's social acceptability. Consequently, 13 strategies to the societal acceptance of the sandbag construction technique have been identified as illustrated in Table 1.

Prior research has shown that establishing earthbag construction codes and standards at the national and international levels is crucial for the widespread adoption of earthbag



Figure 1.
Typical sandbag dwelling

Notes: (a) SBT under construction; (b) completed SBT house

Code	Strategies	Related sources of data
S1	A financial incentive for sandbag uptake	Dosumu and Aigbavboa (2019)
S2	Public sandbag awareness creation through workshops, seminars and conferences	Ben-Alon et al. (2020) , Grady et al. (2019)
S3	Approved sandbag building code	Ben-Alon et al. (2020) , Hadjri et al. (2007)
S4	Availability of the competent promotion teams and grassroots supporters	Belofsky and Zemskova (2018) , Ben-Alon et al. (2020) ; Grady et al. (2019)
S5	Availability of sandbag demonstration projects across all provinces	Grady et al. (2019) , Hadjri et al. (2007)
S6	Availability of standard design methods for earthbag	Rincón et al. (2019)
S7	Availability of sandbag research centre	Ben-Alon et al. (2020) , Dosumu and Aigbavboa (2019) ; Hadjri et al. (2007)
S8	Support from executive management	Belofsky and Zemskova (2018)
S9	Formulation of sandbag policies and regulations	Hadjri et al. (2007)
S10	Inclusion of sandbag technology in the curriculum of technical training colleges	Lyamuya and Alam (2013)
S11	Reformed tendering process	Grady et al. (2019)
S12	Standardisation of the material and components	Adegun and Adedeji (2017)
S13	Educational training for investors, professionals and end-user	Belofsky and Zemskova (2018)

Table 1.
Summary of the
identified strategies
for the uptake of
sandbag

building techniques ([Ben-Alon et al., 2020](#); [Hadjri et al., 2007](#)). In addition, [Hadjri et al. \(2007\)](#) suggested the development of national initiatives to encourage and expand the usage of earth building. They advise that advertising, research, development, training and pilot projects should be used to promote the use of earth as a construction material in creating sustainable policies. [Grady et al. \(2019\)](#) suggested that individuals become more receptive to ABTs after physically seeing an ABT-built home; therefore, it is necessary to construct a model earthbag home for community members to examine prior to actual construction to promote acceptance of these alternative building techniques. Moreover, engaging community members in the construction of SBT houses will teach them about the building material and its unique construction process, therefore, fostering its social acceptability ([Hadjri et al., 2007](#)).

Previous research indicated that the community would embrace ABTs such as earthbags more easily if there were more published research findings on the technical performance of ABTs such as earthbags ([Dosumu and Aigbavboa, 2019](#); [Hadjri et al., 2007](#)). Moreover, it may foster collaboration, innovation and integration among stakeholders ([Ben-Alon et al., 2020](#)). In addition, the literature identifies several other strategies for societal acceptance of SBT, including financial incentives for sandbag use ([Dosumu and Aigbavboa, 2019](#)), reformed tendering processes ([Grady et al., 2019](#)), standardisation of materials and components ([Adegun and Adedeji, 2017](#)) and educational training for investors, professionals and end-users ([Belofsky and Zemskova, 2018](#)). In addition, [Belofsky and Zemskova \(2018\)](#) and [Grady et al. \(2019\)](#) stated that the availability of effective promotion teams and grassroots supporters is essential for SBT acceptability.

However, a few efforts have been made by extant researchers to comprehend the strategies for SBTs social acceptance in underdeveloped nations. Specifically, no effort has been made within the ecosystem of South Africa. In addition, most prior research advocates

sandbag's social acceptance strategies but lacks empirical data to support their argument. Given the limits of prior research, it would be worthwhile to do an empirical study on the SBT social acceptance strategies in South Africa. Consequently, this study's results help to address a knowledge gap for SBT societal acceptability strategies in South Africa.

3. Research methodology

3.1 Identification of the strategies for sandbag building technology's acceptance

The strategies for social acceptance of SBT were discovered following a comprehensive literature review and consultation with ABT specialists. The literature review was used to create the preliminary list of strategies for social acceptance of SBT because it allows empirical studies to build on current studies and provides a theoretical framework for future studies (Wuni and Shen, 2020). Based on the review, a tentative list of strategies was established. The tentative list was piloted with three ABT specialists in South Africa to validate the questionnaire; this approach had been used in previous construction management research conducted by Wuni and Shen (2020), Chan *et al.* (2018) and Darko (2019). These specialists were chosen because of their combined academic, research and ABT experience and these three experts were not included in the final questionnaire. The experts were asked to assess the relevance and appropriateness of the strategies for social acceptance of SBT. Certain strategies were reworded, merged, amended or removed based on the expert evaluation. Table 1 shows the final list of strategies that composed the study's questionnaire.

3.2 Sample population, sample size and sampling techniques

The population of this research consisted of all South African housing stakeholders and end-users with knowledge and awareness of ABTs and SBTs. Due to the sample population, this research lacked a sampling frame; hence, the sample was non-probability (Zhao *et al.*, 2015). Therefore, non-probability sampling may be used to get a representative sample (Patton, 2014). It is suitable when only random sampling approach cannot be used to choose respondents from the public, but respondents may also be chosen based on their desire to engage in a research project (Wilkins, 2011). Consequently, snowball sampling approaches were used in this investigation to get a valid and effective overall sample size. Prior construction management research has used snowball methodologies to get a suitable and effective total sample size (Chan *et al.*, 2018; Darko *et al.*, 2017; Darko *et al.*, 2018; Olawumi and Chan, 2020; Olawumi and Chan, 2021).

The survey participants included consultants, contractors, developers, government authorities (National Home Builders Registration Council) and end-users who were well-versed in alternative construction and sandbag technologies.

Two hundred twenty-eight survey responses were obtained from nine South African regions. The questionnaire return rate was difficult to calculate since snowball sampling methods were used (Darko *et al.*, 2018). The researcher copied the uniform resource locators (URL) from the survey monkey platform, which was used to build an online version of the questionnaire. The most practical method of gathering information from respondents was through an online survey (Chan *et al.*, 2018). The selected respondents received personal emails and URLs to the survey questionnaire.

3.3 Questionnaire design and measurement instrument

A prepared questionnaire was used as the survey tool for assessing SBT social acceptance strategies. Despite their subjectivity, questionnaires are commonly used in construction management research to collect quantitative data from practitioners and experts (Wuni and Shen, 2020). As a result, questionnaire survey techniques have been extensively used in the

ABT research area (Darko *et al.*, 2017; Darko *et al.*, 2018). The administered questionnaire included two sections: Part 1 requested background information from the respondent (see Section 3.5) and Part 2 was aimed to assess the criticality of the strategies. A five-point Likert scale was used to assess the techniques for social acceptability of SBT: 1 = not important, 2 = less important, 3 = neutral, 4 = important and 5 = very important. The five-Likert scale was used in this research because it provides precise results that may be analysed without difficulty (Ekanayake and Ofori, 2004).

3.4 Methods of data analysis

The SPSS 28.0 statistical software was used to analyse the data acquired in the research. The data were analysed using a five-level data analysis framework (Figure 2), modified from a six-level analysis framework used by Chan *et al.* (2018). As a result, the study's research framework includes five distinct statistical analysis methodologies:

- (1) Shapiro–Wilk test and Cronbach's alpha analysis;
- (2) mean and standard deviation;
- (3) analysis of variance (ANOVA), Pearson correlation;
- (4) The Kaiser–Meyer–Olkin (KMO) sample adequacy measure and Bartlett's sphericity; and
- (5) factor analysis (Figure 2).

Firstly, Shapiro–Wilk testing was done to evaluate if the data was normal, parametric or non-parametric (Wuni and Shen, 2020). Cronbach alpha also checks internal consistency among survey questionnaire variables and ensures that the questionnaire captures the right notion (Olawumi and Chan, 2020; Adetooto *et al.*, 2020). Secondly, the mean score was used in this research to establish the relative importance and ranking of the proposed strategies for SBT's acceptance. In construction management research, mean score ranking approaches are an excellent way to rapidly find key factors (Anzagira *et al.*, 2022;

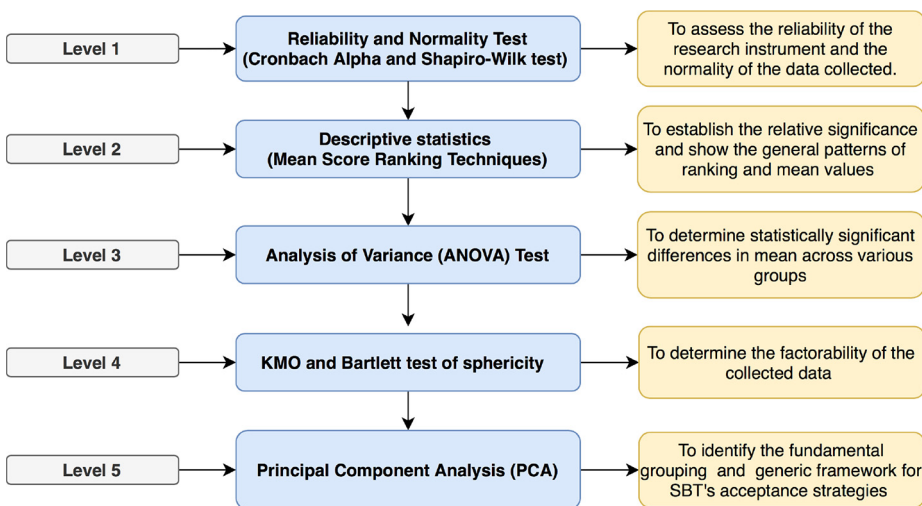


Figure 2.
Methodological
framework

Kukah *et al.*, 2022). In addition, the ANOVA test evaluated statistically significant variations in mean across different groups. ANOVA is an inferential statistical approach used to examine if there is a statistically significant difference between the means of two or more independent data groups (Olawumi and Chan, 2020). In ANOVA, a regularly distributed data point is needed (Olatunji *et al.*, 2017). Olawumi and Chan (2020) and Darko (2019) used ANOVA in prior construction management research.

Finally, the research used factor analysis to find the underlying grouping strategies for the social acceptance of SBTs in house building by investigating the interactions between the components (Hair, 2010; Norusis, 2008). Principal component analysis (PCA) was used to decrease and recombine large components into a limited number of factor scores and sizes (Xu *et al.*, 2010; Li *et al.*, 2011). Before using PCA, it is necessary to confirm the adequacy of the factor analysis for factor extraction. The KMO sample adequacy measure and Bartlett's sphericity test examine the factor analysis's suitability. The KMO ratio, introduced by Field (2013), measures the sampling appropriateness of variables and runs from 0 to 1. Norusis (1993) suggested that if the KMO is over 0.5, the factor analysis (FA) will produce a dependable and unique factor. Before a factor analysis is carried out, the KMO value should not be less than 0.50. Bartlett's test of sphericity is a statistical technique that examines correlations between variables (Chan *et al.*, 2010). When completing Bartlett's test of sphericity, Pett *et al.* (2003) stated that if the original correlation matrix is an identity matrix, there is no relationship between the variables. As a consequence, FA will be useless. FA would be acceptable if the correlation matrices are not identity matrices and the significance level is low with a high sphericity value (Pallant, 2020).

3.5 Respondents' demographic information

This section demonstrates the significance of the 228 respondents who took part in this survey (see Figure 3). Figure 3 entails categorising the responses based on the respondent provinces, organisational types and their level of awareness of ABT and SBTs.

4. Result of statistical analysis

This section summarises survey data and statistical methods used in the research.

4.1 Test of normality

The section offers a summary of the data gathered through a questionnaire survey and the results of the statistical methods used in the study. The Shapiro–Wilk test produced a *p*-value of 0.000, suggesting that the data gathered were not normally distributed. This is expected given that the study's data set has less than 2,000 sample sizes. This study's Cronbach alpha value is 0.953, greater than the 0.7 minimum and indicates internal consistency among survey questionnaire variables (Adetooto *et al.*, 2020).

4.2 Mean score analysis and ranking of the sandbag building technologies social acceptance strategies

Table 2 summarises the conclusions of the ranking research on the strategies for social acceptance of sandbag technology in housing construction. The mean value for the 13 identified strategies varies from $M = 4.06$ ($SD = 0.933$) for "ST11 – Reformed tendering procedure" to $M = 4.30$ ($SD = 0.836$) for "ST5 – Availability of sandbag demonstration projects throughout all provinces", with a variance of 0.699. Based on the mean score and standard deviation, the five most important strategies for SBT's acceptance include; ST5 – Availability of sandbag demonstration projects across all provinces ($M = 4.30$, $SD = 0.836$);

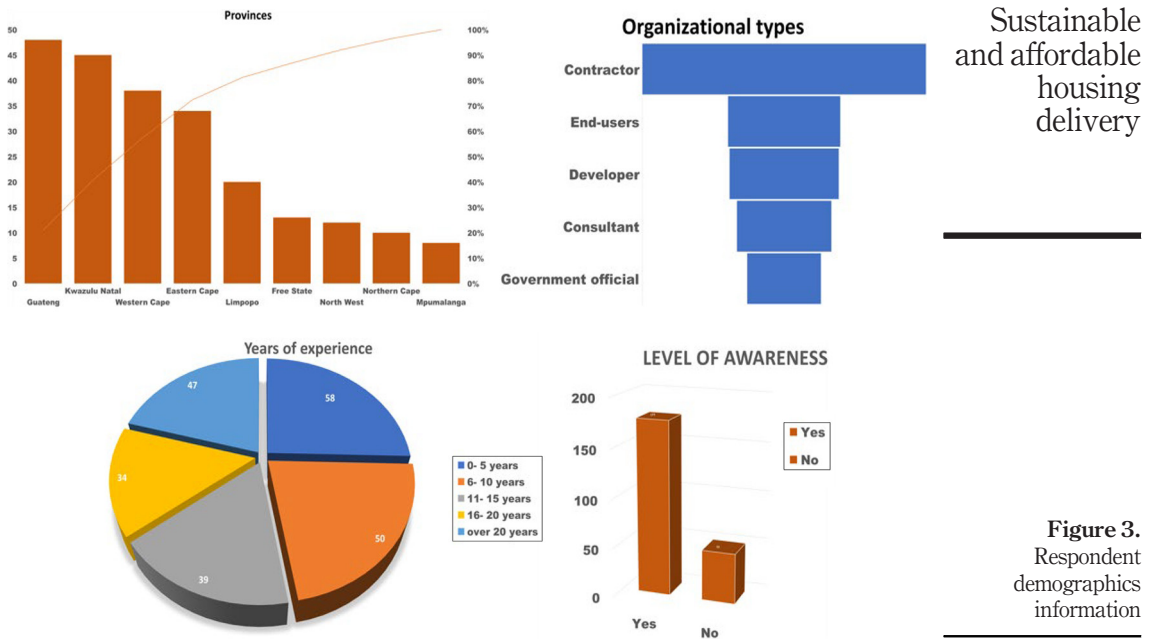


Figure 3.
Respondent demographics information

ST3 – Approved sandbag building code ($M = 4.30$, $SD = 0.878$); ST6 – Availability of standard design methods for earthbag ($M = 4.26$, $SD = 0.849$); S2 – Public sandbag awareness creation ($M = 4.22$, $SD = 0.854$); and S13 – Educational training for investors, experts and end-users ($M = 4.21$, $SD = 0.977$). Furthermore, based on comparable standards used by [Olawumi and Chan \(2020\)](#), who used a mean value of 4 on a five-point Likert scale to consider a factor significant, all 13 strategies (factors) are considered significant based on the mean score.

The data gathered from respondents based on organisational affiliation suggest that contractors, consultants and clients regarded “S5 – availability of sandbag demonstration projects across all provinces” ($M = 4.3$, $SD = 0.836$) as the most significant strategy for social acceptance of SBTs in housing construction. But according to those who work for the government, “S13 – Educational training for investors, experts, and end-users” ($M = 4.21$, $SD = 0.977$) was selected as the most crucial strategy. Meanwhile, the contractor perceived S11 – reformed bidding procedure as the least important obstacle ($M = 4.04$, $SD = 0.933$). The societal acceptability of sandbag construction technologies in South Africa would consequently not be significantly affected by these strategies, which were generally evaluated as the least important strategies.

4.3 Inferential statistical test

The 13 selected strategies were studied using ANOVA to see whether perception differences exist across diverse respondents from various organisational backgrounds (consultants, contractors, developers, government officials and clients). According to the ANOVA results, the significance values of 13 strategies exceeded 0.05 ([Table 2](#)). There are no statistically significant differences in the relevance of these strategies as seen by consultants, contractors, developers, government officials and clients.

Table 2.
Strategies for the social acceptance of sandbag technology uptake in housing construction; intergroup comparisons

Code	Contractors		Consultants		Developers		Client		Government officials		All respondent			ANOVA		
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	SD	Rank	Shapiro-Wilk <i>p</i> -value	F	<i>p</i> -value
ST5	4.38	1	4.32	1	4.54	3	4.25	1	3.89	10	4.30	0.836	1	0.00 ^a	1.410	0.234 ^b
ST3	4.35	2	4.09	5	4.62	2	4.10	3	4.39	2	4.30	0.878	2	0.00 ^a	1.218	0.306 ^b
ST6	4.26	4	4.18	2	4.46	4	4.25	2	4.17	5	4.26	0.849	3	0.00 ^a	0.279	0.891 ^b
ST2	4.26	5	4.14	4	4.46	5	4.00	8	4.22	4	4.22	0.854	4	0.00 ^a	0.684	0.604 ^b
ST13	4.21	9	4.05	9	4.62	1	4.00	11	4.39	1	4.21	0.977	5	0.00 ^a	1.101	0.359 ^b
ST10	4.16	10	4.09	7	4.46	7	4.05	6	4.33	3	4.18	0.930	6	0.00 ^a	0.566	0.687 ^b
ST9	4.31	3	4.09	6	4.46	8	3.90	12	3.89	11	4.18	0.936	7	0.00 ^a	1.575	0.185 ^b
ST4	4.25	6	4.14	3	4.38	9	4.10	4	3.83	13	4.17	0.878	8	0.00 ^a	1.038	0.390 ^b
ST7	4.22	8	3.82	13	4.38	10	4.00	10	4.06	8	4.12	0.960	9	0.00 ^a	1.079	0.370 ^b
ST12	4.12	12	4.05	8	4.38	11	4.00	9	4.11	6	4.11	0.863	10	0.00 ^a	0.435	0.783 ^b
ST8	4.25	7	3.91	10	4.08	13	4.05	7	3.89	12	4.11	0.961	11	0.00 ^a	0.858	0.491 ^b
ST1	4.13	11	3.86	11	4.46	6	3.85	13	4.11	7	4.08	0.903	12	0.00 ^a	1.294	0.276 ^b
ST11	4.06	13	3.82	12	4.38	12	4.05	5	4.00	9	4.04	0.933	13	0.00 ^a	0.765	0.550 ^b

Notes: SD, standard deviation. ^aThe Shapiro-Wilk test result is significant at the significance level of 0.05 (*p*-value < 0.05). ^bThe ANOVA is significant at the significance level of 0.05 (*p*-value < 0.05)

4.4 Grouping of the key strategies

FA was used to investigate the key strategies for social acceptance of SBT in South Africa. Before component analysis, as advised by [Xu et al. \(2010\)](#), a Pearson correlation analysis was done to avoid multiplier effects. Consequently, all 13 strategies were highly correlated.

Using the varimax rotation approach, a PCA was performed on the 13 key strategies from 228 samples of responses (an orthogonal rotation method), as shown in [Table 3](#). Previous research suggested that the sample size is in the 1:5 (number of variables: sample size) before it could be regarded as adequate for component analysis ([Chan, 2019](#); [Chan and Choi, 2015](#); [Lingard and Rowlinson, 2006](#)). As a result, our study met these requirements. The KMO score for this study is 0.939, which is greater than the acceptable threshold of 0.50 ([Norusis, 1993](#)) and also shows an “outstanding degree” of common variance ([Field, 2013](#)). Bartlett’s test of sphericity analysis produces a statistical test result (Chi-square = 1668.554) and a minor significant value ($p = 0.000$, $df = 78$), showing that the correlation matrix is not an identity matrix. Thus, the prerequisite for factor analysis has been met.

Following varimax rotation, PCA discovered three underlying groups (components) with eigenvalues greater than one, accounting for 74.51% of the total variance (see [Table 3](#)). Each strategy is represented by one of the three underlying strategy categories (components). Consequently, the study’s findings and interpretation of the extracted component are consistent and reliable.

5. Discussion of key findings

5.1 Factor 1 – Stakeholders integration and policy formation

Stakeholders integration and policy formation comprise six significant strategies and explain about 45.17% of the total variance in the strategies to SBT’s social acceptance. The six significant strategies are:

- (1) support from executive management;
- (2) approved sandbag building code;
- (3) standardisation of the material and components;
- (4) standard design methods for earthbags;
- (5) availability of sandbag research centre; and
- (6) formulation of sandbag policies and regulations.

It is crucial to get the backing of the executive management to increase the social acceptance of SBT for the development of affordable and sustainable housing in South Africa. These results are congruent with [Belofsky and Zemskova \(2018\)](#) and [Adetooto and Windapo \(2022\)](#). They found that integration among stakeholders (developers, government officials and experts) is necessary to facilitate the adoption of SBTs and ABTs. An institutional framework outlining each stakeholder’s role and responsibility can be developed through the inclusion and support of stakeholders ([Darko et al., 2018](#); [Darko, 2019](#)). This can lay the groundwork for South African communities’ acceptance and implementation of SBTs more widely and sustainably.

Furthermore, according to this research, the recognised sandbag building code is one of the most important measures for enhancing social acceptance of SBT. [Ben-Alon et al. \(2020\)](#) argue that the acceptance of earth construction is dependent on the development of universal and user-friendly standards and codes. This result is consistent with the previous research by ([Adetooto et al., 2022a](#); [Adetooto and Windapo, 2022](#)). More, SBT material and

Code	Key strategies	Factor loading	Eigenvalue	Percentage of variance explained	Cumulative percentage of variance explained
<i>Factor 1-</i>	<i>Stakeholders integration and policy formation</i>		5.873	45.174	45.174
ST8	Support from executive management	0.919			
ST3	Approved sandbag building code	0.801			
ST12	Standardisation of the material and components	0.701			
ST6	Standard design methods for earthbag	0.692			
ST7	Availability of sandbag research centre	0.630			
ST9	Formulation of sandbag policies and regulations	0.513			
<i>Factor 2-</i>	<i>Effective education and knowledge sharing</i>		2.122	16.326	61.500
ST5	Sandbag demonstration projects across all provinces	0.863			
ST10	Inclusion of sandbags in the curriculum of technical training colleges	0.585			
ST13	Educational training for investors, professionals and end-user	0.525			
ST11	Reformed tendering process	0.459			
<i>Factor 3-</i>	<i>Grassroots advocacy and incentives</i>		1.721	13.237	74.736
ST4	Competent promotion teams and grassroots supporters	0.807			
ST1	Financial incentive for sandbag uptake	0.630			
ST2	Public sandbag awareness creation through workshops, seminars and conferences	0.517			

Table 3.
Varimax rotation
factor structure on
the key strategies

components standardisation are critical to its social acceptability. Due to a lack of national regulations, earthen buildings are deemed unapproved and unregulated, according to Burnet (2007). This study's findings are compatible with those of Adegun and Adedeji (2017), who noted that material and component standardisation following global trends, as well as the establishment of national standards and other local institutional regulatory apparatus, are essential.

According to the findings, the availability of standard design methods for earthbags is also vital to their general acceptability. Rincón *et al.* (2019) proposed that researchers focus their study on establishing design methodologies for earthbag and superadobe structures to increase their widespread acceptance. This result is consistent with prior South African investigations on alternative building methods (Windapo *et al.*, 2022a; Adetooto *et al.*, 2022a, 2022b; Adetooto and Windapo, 2022). The study also highlighted that establishing a construction research centre where earthbag materials and methods can be investigated and assessed before being widely deployed is crucial to their social acceptance. According to Hadjri *et al.* (2007), research may enhance the wider acceptance of sandbag building techniques by fostering ground-breaking research, funding, collaboration, innovation and integration among stakeholders. This agrees with Ben-Alon *et al.* (2020)'s earlier research. The findings also emphasised that enacting policies that encourage the use of SBTs is critical to their social acceptance. These results agree with those obtained by Hadjri *et al.* (2007).

5.2 Factor 2 – Effective education and knowledge sharing

Effective education and information sharing comprise four significant strategies and explain about 16.33% of the total variance in the strategies to SBT's social acceptance. The four significant strategies are:

- (1) sandbag demonstration projects across all provinces;
- (2) inclusion of sandbags in the curriculum of technical training colleges;
- (3) educational training for investors, professionals and end-users; and
- (4) reformed tendering process.

The availability of sandbag demonstration projects in all provinces is one of the most important strategies for the social acceptance of sandbag technology in South African housing construction. [Grady et al. \(2019\)](#) claim that after seeing a house built using alternative methods, people become more accepting of ABTs. Furthermore, [Hadjri et al. \(2007\)](#) advocated that community members be included in the construction of such demonstration buildings since it would teach them about the sandbag material and its special construction procedure. As a result, the finding implies that building a sandbag model house for the community to view throughout all provinces will allow community members to observe how the house is made, be involved in the construction process, and, eventually, improve the social acceptance sandbag technology. This result is consistent with the research of [Grady et al. \(2019\)](#) and [Adetooto and Windapo \(2022\)](#). The study also highlighted that the inclusion of sandbags in technical training colleges' curricula is crucial to their social acceptance. This finding is consistent with the research of [Lyamuya and Alam \(2013\)](#). They also advised that earth construction technologies should be included in the curriculum of technical training colleges, polytechnics and universities of technology to enhance its wide adoption.

Another significant strategy for the social acceptance and adoption of sandbag technologies is educational training for investors, professionals and end-users. Providing SBT-related educational and training programmes for developers, professionals and policymakers in fostering SBT social acceptance cannot be overstated. [Succar et al. \(2013\)](#) agreed, believing that stakeholder training is essential for effectively adopting new technologies and applications. This finding is consistent with [Belofsky and Zemskova \(2018\)](#) research, which listed educational training for investors, experts and end-users as one of the primary ways to catalyse SBT social acceptance and implementation in India's underdeveloped nations. Also, according to the study, the reformed tendering process is critical to SBT's social acceptance. [Grady et al. \(2019\)](#) said that the bidding procedure in South Africa should be modified so that innovative construction technologies may be more competitive in the tendering process and used more often.

5.3 Factor 3 – Grassroots advocacy and incentives

Grassroots advocacy and incentives comprise three significant strategies and explain about 13.24% of the total variance in the strategies to SBT's social acceptance. The three significant strategies are:

- (1) competent promotion teams and grassroots supporters;
- (2) financial incentives for sandbag uptake; and
- (3) public sandbag awareness creation through workshops, seminars and conferences.

One of the most important strategies for social acceptance of sandbag technology in South African housing construction is competent promotion teams and grassroots supporters.

According to [Ben-Alon *et al.* \(2020\)](#) and [Grady *et al.* \(2019\)](#), the formation of teams to educate professionals and beneficiaries on the usage and benefits of SBT is critical to its widespread acceptability. Furthermore, establishing grassroots and indigenous demand for earthbag technology in developing nations is critical to its acceptance, according to [Belofsky and Zemskova \(2018\)](#), since most earthbag initiatives in emerging nations have been restricted to foreign-run assistance initiatives. This finding is consistent with [Grady *et al.* \(2019\)](#)'s study. The research also stated that providing financial incentives for sandbag adoption is critical to their social acceptance. This outcome is similar to [Dosumu and Aigbavboa \(2019\)](#) findings, who also recommended a reward system for innovation towards ensuring the adoption of sandbag technology. According to the research, boosting public awareness of sandbag technology via workshops, seminars and conferences is a major technique for increasing the societal acceptability of sandbag technology. [Ben-Alon *et al.* \(2020\)](#) and [Grady *et al.* \(2019\)](#) have shown that recurrent and regular outreach actions in low-income neighbourhoods will improve communities' perceptions of ABTs. This will help raise people's awareness and understanding of earthbags. This is supported by [Adegun and Adedeji \(2017\)](#), [Bobbo *et al.* \(2015\)](#) and [Sameh \(2014\)](#), who argue that using public media to create awareness about the advantages of earthen construction is a potent method for its universal adoption. The report also indicated that researchers do further research to demonstrate the advantages of sandbag technology or improve existing studies and information sheets. This outcome is consistent with earlier studies on alternative building techniques in South Africa ([Grady *et al.*, 2019](#); [Adetooto and Windapo, 2022](#))

5.4 Practical implication of research finding

The present study's results have significant implications for the adoption of ABT and SBT in practice and praxis. This research draws on the different perspectives and hands-on experiences of ABT professionals and stakeholders in the South African housing sector to provide a broad framework for the effective implementation and wide acceptance of sandbag technology in housing projects. Furthermore, the research is the first and only attempt to examine the perspectives of experts and housing market stakeholders in South Africa on sandbag technology social acceptance strategies. It suggested specific best practices that policymakers and practitioners might use to increase ABT and SBT social acceptance. Secondly, the study prioritised the concomitant strategies, defining the important strategies that need to be established to guarantee the effective application of sandbag technology. Finally, the factor analyses yielded a framework of three major areas essential for the successful adoption and acceptance of sandbag technology.

6. Conclusion, limitations and future research

SBT are a cost-effective and sustainable ABT capable of expediting home construction in South Africa, despite its poor adoption.

However, nothing is known about how to promote SBT social acceptance effectively. Based on a survey of ABT experts and housing sector stakeholders in South Africa, the research developed and ranked 13 social acceptability strategies for SBT. Based on the mean scores, all the identified strategies are significant. However, the three most significant SBT social acceptability strategies include the availability of sandbag demonstration projects in all provinces, the approval of a sandbag building code and the availability of standard design methods for earthbags. A structure identification study of the strategies reveals three underlying groups (components) that account for about 74.51% of the overall variation. The three underlying groups include stakeholder integration and policy formation, effective education and knowledge sharing and grassroots advocacy.

Although the study makes theoretical and practical contributions to the ABT and SBT body of knowledge, the suffered a limitation as only sandbag technology was investigated among alternative construction technologies. Section 1 contains the justification behind this, as sandbag is the most readily accessible unknown ACM. Therefore, this research recommends that future studies should consider the strategies for the social acceptance of all the ABT in South Africa. Based on the findings, the study further recommends that interested stakeholders and South Africa housing market should leverage on the research framework and communicate the strategies to the social acceptance of SBT to South African housing stakeholders and the general public.

This study's assessment of significant strategies for the social acceptance of SBTs is intended to provide a framework for government agencies and construction stakeholders to make realistic and well-informed decisions. Furthermore, the findings of this study will fill a knowledge gap regarding strategies for the social acceptance of SBTs in South Africa. Furthermore, the findings can be used as a policy tool and useful guidelines for government agencies, international organisations and advocates interested in promoting ABTs such as sandbags in South Africa, to achieve more sustainable and affordable housing delivery.

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Corresponding author

Johnson Damilola Adetooto can be contacted at: adetootojohnsondamilola@gmail.com

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