

Strategies for the acceptance of sandbag building technology for sustainable and affordable housing delivery in South Africa

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Abstract:

Although sandbag building technologies have been proposed as an affordable, sustainable, and recyclable alternative building material capable of accelerating housing provision in South Africa, their level of acceptance is still very low in South Africa. The strategies for the social acceptance of sandbag building technologies need detailed investigation. However, little or no study has been done on strategies for the social acceptance of sandbag building technologies in South Africa. This study investigates the strategies for the social acceptance of Sandbag building technologies in South Africa. To achieve this objective, 18 strategies were identified from a comprehensive literature review, and a questionnaire survey was performed with 220 professionals, government officials, end-users and developers. Using mean score ranking and ANOVA, the study revealed the strategies for the social acceptance of sandbag building technologies. A comparative analysis of the perceptions of the diverse groups of survey participants was conducted and discussed. The findings are relevant to policymakers and practitioners in adopting appropriate strategies for sustainable and affordable housing delivery in South Africa. This study adds significantly to the limited body of knowledge on sandbag technology.

Keywords:

Acceptance, alternative, housing, sandbag, sustainability, technology

1 Introduction

More than 20% of the world's population - 1.6 billion people – lack adequate housing, and an estimated 100 million people are homeless (United Nations 2019). In 2019, 12.7 per cent of South African families lived in informal housing (StatsSA, 2019). Furthermore, Adetooto et al. (2022) noted that the current construction processes and materials are incapable of addressing the issues of insufficient housing, necessitating the development of new building materials. Sandbags Technologies (SBTs) (also known as earthbags or soil bags) are granular material-filled polypropylene bags or polymer polymers. The sandbag has been presented as a cost-effective, environmentally friendly, recyclable, and alternative building material capable of supplying housing (Ecobuilders, 2019) because contemporary materials are expensive and rising.

In South Africa, sandbag technology is an alternative construction method. According to Windapo et al. (2022), SBT is the most extensively available unexplored alternative building technology (ABT) in South Africa. Sandbag technology has been promoted as a

low-cost, environmentally friendly, recyclable, and alternative building material to facilitate home access (Cataldo-Born et al., 2016). It has been viewed as a feasible alternative to traditional construction methods, with economic and environmental benefits in delivering affordable housing in both developed and developing countries (Cataldo-Born et al., 2016).

Despite the benefits of sandbag technology in delivering low-cost and sustainable housing, social acceptance and adoption of the technology in South Africa are still limited. As a result, this research looks at the strategies for societal acceptance of sandbag technology.

2 Research Methodology

This research identified and evaluated the social acceptance of sandbag building construction technologies in South Africa. Table 1 highlights the strategies for the social acceptance of SBTs in housing construction. Researchers employed a qualitative research design approach with empirical questionnaire surveys to acquire the essential data for the study. Purposeful sampling approaches and snowball sampling were utilised to identify the right respondents for the study. According to Wilkins (2011), these techniques are appropriate for selecting respondents based on their willingness to participate in the research. The respondents to the research included consultants, contractors, developers, government authorities (National Home Builders Registration Council), and end-users with an extensive understanding of alternative construction technologies.

Two hundred twenty-eight survey responses were obtained in South Africa's nine provinces. The questionnaire return rate was difficult to calculate since snowball sampling techniques were utilised. Before the questionnaire was disseminated, it was pre-tested and assessed by an international expert (a professor with over 10-year experience in alternative building technologies). Through the questionnaire survey, the respondent gave some background information. Following that, respondents were asked to assess the identified strategies for the social acceptance of sandbag technology in South African Housing Construction (Table 1) on a 5-point scale (1 = not critical, 2 = less critical, 3 = neutral, 4 = critical, 5 = highly critical).

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

Code	Strategies	Related sources of data
S1	A financial incentive for sandbag uptake	Dosumu and Aigbavboa (2020).
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., (2017)
S4	Availability of the competent promotion teams and Grassroots Supporters	Ben-Alon et al., (2020); (Grady et al., 2019) and Belofsky and Zemskova (2018).
S5	Availability of sandbag demonstration projects across all provinces	Grady et al. (2019) and Hadjri et al. (2007)
S6	Availability of standard design methods for earthbag	Rincon et al. (2019)
S7	Availability of sandbag research centre	Ben-Alon et al., (2020); Dosumu and Aigbavboa (2020); and Hadjri et al., (2007)
S8	Support from executive management	Belofsky and Zemskova (2018).
S9	formulation of sandbag policies and regulations	Hadji et al., (2007).
S10	Inclusion of sandbag technology in the	Lyamuya and Alam (2013)

Code	Strategies	Related sources of data
	curriculum of technical training colleges	
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).

2.1 Data analysis statistical tools

The study employed SPSS 28.0 statistical programme to analyse the gathered data. The data was analysed using a four-level data analysis framework adapted from a five-level analysis framework used by Chan et al. (2017). As a result, the study's research framework includes five distinct statistical analysis methodologies: (1) Shapiro-Wilk test, (2) Cronbach's alpha analysis, (3) mean and standard deviation and (4), Analysis of Variance (ANOVA), Pearson correlation (Figure 1).

First, the Shapiro-Wilk test was performed to establish whether the data was normal, parametric or non-parametric (Wuni et al., 2020). Second, the Cronbach alpha coefficient test was performed to determine if the data was suitable for further investigation, as it evaluates the data's intrinsic integrity and reliability (Adetooto et al., 2020). Third, the mean Score Ranking Techniques were utilised to determine relative relevance and to demonstrate overall patterns of ranking and mean values. In construction management, mean score approaches are an excellent tool for quickly identifying significant strategies amid many other strategies (factors) (Olawumi et al., 2020, Chan et al., 2017). Furthermore, the ANOVA test evaluated statistically significant variations in mean across different groups. The ANOVA test was chosen above other tests, such as Kruskal walls and Mann-Whitney U tests, because it is a good approach for comparing the means of more than two groups (Olawumi et al., 2020).

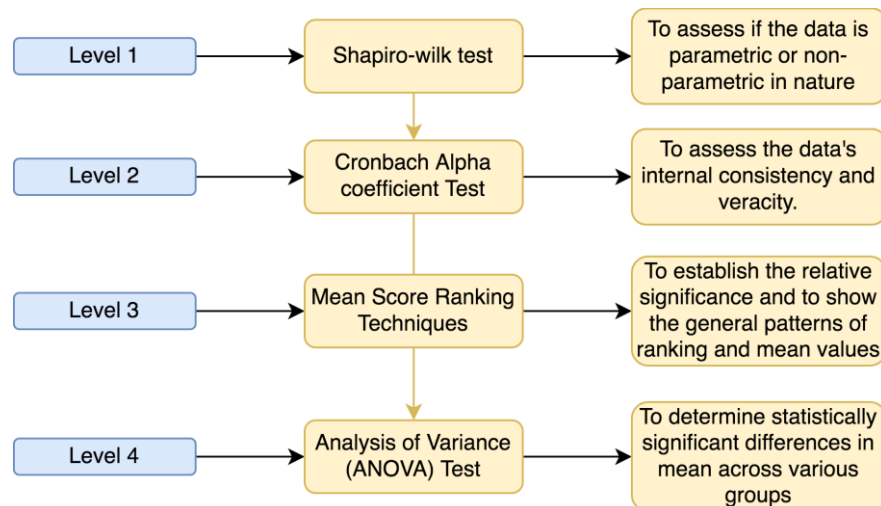


Figure 1: Methodological framework

2.2 Respondents' demographic information

This section demonstrates the significance of the 228 respondents who took part in this survey (see Figure 2). Figure 2 entails the categorisation of the responses based on the respondent provinces, organisational types and their level of awareness of alternative building technology and sandbag building technologies.

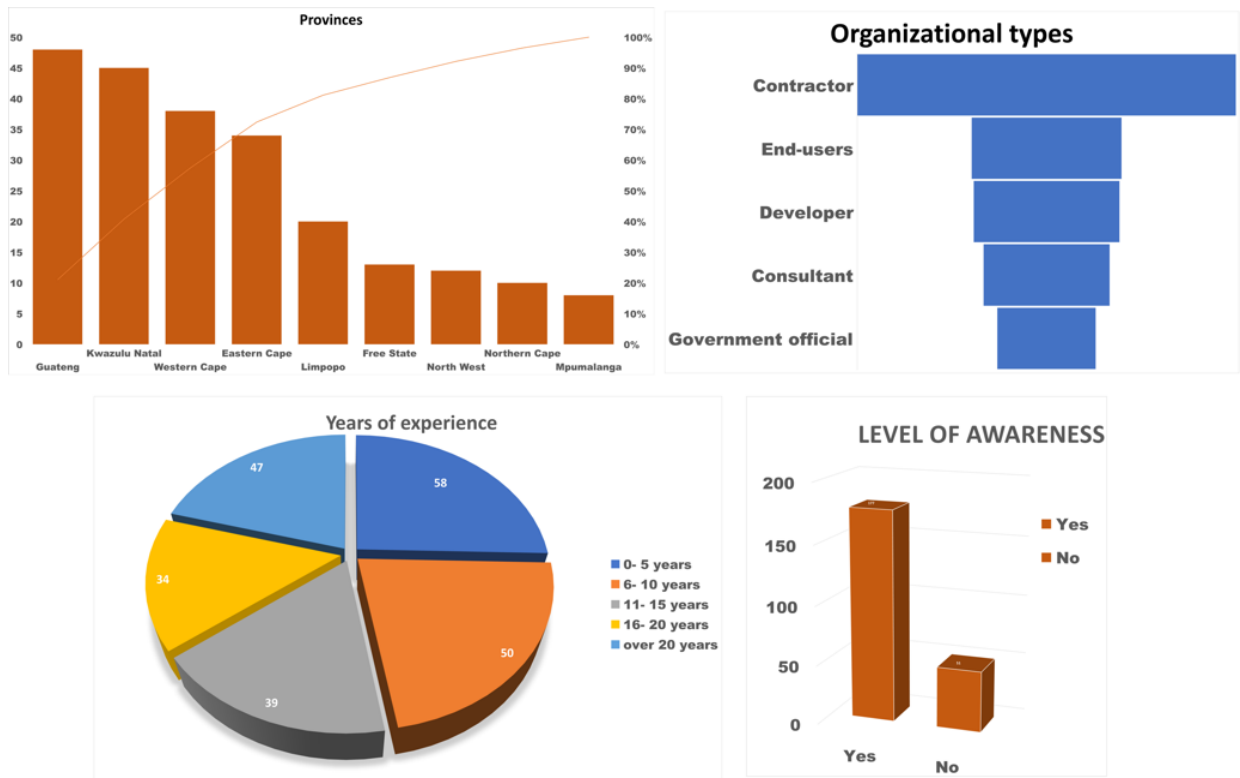


Figure 2: Respondent demographics information

3 Findings and Discussion

3.1 Result of statistical analysis

The section offers a summary of the data gathered through a questionnaire survey and the results of the statistical methods employed 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 2000 sample sizes. This study's Cronbach alpha value is 0.953, which is greater than the 0.7 minimum and indicates internal consistency among survey questionnaire variables (Adetooto et al., 2020).

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 "S11- Reformed tendering procedure" to M= 4.30 (SD= 0.836) for "S5- Availability of sandbag demonstration projects throughout all provinces," with a variance of 0.699.

Furthermore, based on comparable standards used by Olawumi et al. (2020), who used a mean value of 4 on a 5-point Likert scale to consider a factor significant, all 13 strategies (factors) may be considered significant based on the mean score. Meanwhile, "Availability of sandbag demonstration projects across all provinces" was placed first, with the highest mean value, M = 4.30 (SD = 0.836), indicating that constructing sandbag demonstration projects across all provinces is critical to its social acceptance. "S3 - Approved sandbag building code" (M= 4.30, SD= 0.878) was ranked second, "S6 - Availability of standard design methods for earthbag" (M= 4.26, SD=0.849) was ranked third, and "S2 - Public sandbag awareness creation" (M= 4.22, SD=0.854) was ranked fourth. The fifth most significant strategy for increasing the societal acceptability of sandbag building

technologies was "S13 - Educational training for investors, experts, and end-users" (M=4.21, SD=0.977).

According to the research findings, establishing demonstration projects throughout provinces is still a crucial approach to the social acceptability of sandbag technologies in South Africa, along with authorised construction codes, standard design processes, awareness, and training and education.

Furthermore, 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.

3.2 Discussion of findings

Due to space and word limitations from the conference, this research only discusses the top five strategies as assessed by the respondents.

3.2.1. Availability of sandbag demonstration projects across all provinces

According to the research, the availability of sandbag demonstration projects in all provinces is one of the most significant strategies for the widespread acceptance of sandbag technology in housing construction in South Africa. Grady et al. (2019) claim that after seeing a house built using alternative methods, people become more accepting of ABTs. Furthermore, Hajiri 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 of sandbag technology. This result is consistent with the research of Grady et al. (2019) and Adetooto et al. (2022).

3.2.2. Approved sandbag building code

According to this study, the recognised sandbag building code is one of the most important measures for increasing social acceptance of sandbag building technology. According to Ben-Alon et al. (2020), creating worldwide and user-friendly earth building codes, regulations, and standards is critical to its widespread acceptability. However, South Africa's building codes do not mention alternative construction technology. However, the South African government must learn from developed nations like the United States. For example, earthbag technology has been included in California, USA, building regulations when it was determined that these earthbag buildings exceeded the rules' criteria (Cataldo-Born et al., 2016). This discovery demonstrated that integrating sandbag construction technology into building regulations is critical to sandbag technology's societal acceptability. This outcome is consistent with Adetooto et al. (2022)'s recent study.

3.2.3. Availability of standard design methods for earthbag

According to the findings, the availability of standard design methodologies for earthbags is critical to their general acceptability. Rincon et al. (2019) recommended that researchers

focus their study on establishing design methodologies for earthbag and superadobe constructions to increase their widespread use. This study found that the availability of a standardised design approach is critical to the acceptability of sandbag technology. This study revealed that the government and construction stakeholders should collaborate with sandbag professionals and academics to create a standard sandbag construction procedure. This finding is consistent with earlier research on alternative building methods undertaken in South Africa. (Windapo et al., 2022; Adetooto et al., 2022).

3.2.4. Public sandbag awareness creation through workshops, seminars, and conferences
According to the study, raising public understanding of sandbag technology through workshops, seminars, and conferences is a key method for increasing social acceptance of sandbag technology. Ben-Alon et al. (2020) and Grady et al. (2019) showed that repeated and regular outreach activities in low-income regions would enhance communities' views of ABTs. This will also increase people's awareness and knowledge of earthbags. This is reinforced by Adegun and Adedeji (2017), Bobbo et al. (2015), and Sameh (2014), who advocated that using public media to raise knowledge about the benefits of an earthen building is a powerful strategy for its widespread adoption. The study also implies that researchers do further research to illustrate the benefits of sandbag technology or use current studies and information sheets more effectively. According to the study findings, public sandbag awareness development through workshops, seminars, and conferences has been a more significant strategy for sandbag social acceptance. This finding is consistent with previous research on alternative construction methods in South Africa (Adetooto et al., 2022; Grady et al., 2019)

3.2.5. Educational training for investors, professionals and end-user
According to the findings of this study, adequate educational training for investors, experts, and end-users on sandbag technology is a crucial technique for increasing the social acceptance of this technology. According to Belofsky and Zemskova (2018), teaching a rising professional class and rural village builders is critical to sandbag technology acceptability. Succar et al. (2013) agreed, believing that stakeholder training is essential for adopting new technologies and applications effectively. According to the report, the government should set adequate financing to support training and inform actors and the wider public about using sandbag technologies and other alternative technologies.

3.3. Practical implications of research findings

The current study's findings have important implications for ABT and SBT deployment practice and praxis. This study relies on the many viewpoints and hands-on experiences of ABT specialists and stakeholders in the South African housing industry to develop a general framework for successfully deploying sandbag technology in housing projects. Furthermore, the study is the first and only attempt to measure sandbag technology's major social acceptance strategies in housing construction. Furthermore, it is the first effort at a comparative examination of the perspectives of experts and players in the South African housing market on the strategies for social acceptance of sandbag technology. The findings are important for policymakers and practitioners in South Africa as they develop appropriate strategies for delivering sustainable and affordable housing. This research thus considerably contributes to the limited body of knowledge on Sandbag technology.

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		
	MS	Rk	MS	Rk	MS	Rk	MS	Rk	MS	Rk	MS	SD	Rk	Shapiro Wilk P-value	F	P-value
S5	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
S3	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
S6	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
S2	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
S13	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
S10	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
S9	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
S4	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
S7	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
S12	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
S8	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
S1	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
S11	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

Note: MS = Mean score; SD= Standard Deviation, RK= Rank.

^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 Conclusion and Further Research

The major goal of the study was to identify and analyse the strategies for social acceptance of sandbag technology. A desktop literature review yielded a total of 13 strategies. The selected strategies were presented in a questionnaire that 228 respondents ranked from all nine provinces in South Africa who took part in the study and had considerable and extensive knowledge of alternative construction technologies. The survey participants encompass all South African housing market players from varied backgrounds and professional specialities, providing credibility to the data collected. Meanwhile, the study conducted a comparative examination of the study participants' views, which encompassed all stakeholders' perspectives, in order to discover patterns of difference.

A key outcome of this study revealed that all 13 identified social acceptance strategies for sandbag construction technology were essential. The five most important strategies are the availability of sandbag demonstration projects in all provinces, the approval of a sandbag building code, the availability of standard design methods for earthbags, the creation of public sandbag awareness through workshops, seminars, and conferences, and educational training for investors, professionals, and end-users. The study also discovered no statistically significant variations in stakeholder estimations of the importance of these strategies.

This report offers the preliminary findings of a large-scale study on the extent of use and strategies for social acceptance of sandbag building technology. While this study only presents the outcomes of the strategies for social acceptance of sandbag building technology, a future research paper will describe the empirical findings on interrelationships between the important barriers, drivers, and strategies for sandbag technology acceptance.

5 Acknowledgement

The authors would like to thank the Royal Academy of Engineering in the United Kingdom through the Industry-Academia Partnership Programme (Grant No. IAPP 18/19 - 215) and the National Research Foundation (NRF) in South Africa for their financial support in conducting this research. However, the authors' opinions and conclusions should not be attributed to the Royal Academy or the NRF.

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