Gerhard Bosman & Diaan van der Westhuizen

The effects of climatic conditions on attitudinal changes towards earth construction in South Africa

Peer reviewed and revised

Abstract

Earth construction is an appropriate method for building houses in arid and semi-arid areas in South Africa due to its low environmental impact and responsible use of on-site resources. A *South African Netherlands Research Programme on Alternatives in Development* (SANPAD) project conducted by the University of the Free State's Earth Unit focused on attitudes and perceptions towards building materials used to construct houses in poor communities. For this article, quantitative attitudinal responses from the SANPAD survey and objective rainfall and temperature measurements were analysed for the 2004 dry season before rainstorms (n=784) and for the 2006 wetter season during/after rainstorms (n=609). Using a quasi-experimental research design, the study investigates changes in attitudes after rainstorms in relation to respondents' preferred building materials, preferred qualities of materials, and reasons for disliking earth materials. This article reports on the results of an investigation into the effects of local climatic conditions on changes in the acceptability of building materials with a focus on earth construction. Results indicate that rainfall reinforces and intensifies people's disapproval of earth as a building material and shift perceptions from aesthetic considerations to strength/safety/durability. Severity of rainstorms and extreme temperatures also seem to shape people's perceptions of materials. Perceptions of earth bricks were more negative after the storms and people became more concerned about rain. Findings suggest a link between climatic conditions and perceptions of earth-constructed buildings. An understanding of the present attitudes towards earth construction is necessary in order to support traditional earth construction as an acceptable way forward in contemporary architecture.

Keywords: Acceptability, attitudes, building materials, earth construction, climatic conditions, rainfall, quasi-experimental research

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Abstrak

Grondkonstruksie is 'n gepaste metode vir die bou van huise in dorre en semi-dorre gebiede in Suid-Afrika as gevolg van die lae omgewingsimpak en verantwoordelike gebruik van plaaslike hulpbronne. 'n SANPAD-projek uitgevoer deur die Universiteit van die Vrystaat se Grondeenheid fokus op mense se gesindhede en persepsies van boumateriale wat gebruik word in die konstruksie van huise in lae inkomste gebiede. Hierdie navorsing analiseer kwantitatiewe gesindhede uit die SANPAD-vraelys en objektiewe reënval- en temperatuursyfers tydens die 2004 droë seisoen voor reënstorms (n=784) en tydens die 2006 nat seisoen tydens/na reënstorms (n=609). Die studie ondersoek veranderinge in respondente se gesindhede na reënstorms in terme van hul voorkeure vir boumateriale en vir die kwaliteite van boumateriale, en die redes vir afkeure van boumateriale. Die artikel lewer verslag oor die resultate van 'n ondersoek oor die invloed van plaaslike klimatologiese gebeurtenisse op die aanvaarding van boumateriale deur gebruik te maak van 'n semi-eksperimentele navorsingsontwerp, met spesifieke verwysing na grondkonstruksie. Die bevindinge dui daarop dat reënval mense se afkeure rondom grondkonstruksie as 'n boumateriaal versterk, en dat hul persepsies verander van estetiese oorwegings na sterkte/veiligheid/duursaamheid. Dit wil voorkom of die intensiteit van reënstorms en ekstreme temperatuurverskille ook mense se persepsies van materiale beïnvloed. Respondente se persepsies van songedroogde stene was meer negatief na die reënstorms en hulle was meer bekommerd oor reën. Hierdie bevindinge stel voor dat klimatologiese gebeurtenisse mense se persepsies van grondkonstruksie kan beïnvloed. 'n Meer indiepte begrip van gesindhede teenoor grondkonstruksie is nodig om die ontwikkeling van tradisionele boumetodes as 'n aanvaarbare opsie in kontemporêre argitektuur te ondersteun.

Sleutelwoorde: Aanvaarding, gesindhede, boumateriale, klimatologiese gebeurtenisse, grondkonstruksie, reënval, semi-eksperimentele navorsing

1. Introduction

As with a variety of vernacular built forms, rural earth-construction techniques in southern Africa were developed by indigenous groups settled in a single location for long periods of time. Currently, self-built home construction in southern Africa using traditional materials and seasonal decoration is still strongly linked to rural earth construction (Bosman, 2006). In terms of informal dwellings, the sustainable practices associated with traditional earth construction are being replaced by contemporary urban shacks built from re-used and recycled materials. Even in the formal sector, government-provided RDP (Reconstruction and Development Programme) housing is not constructed from earth and reflects hardly any indigenous references, personality or character (see Figure 1).

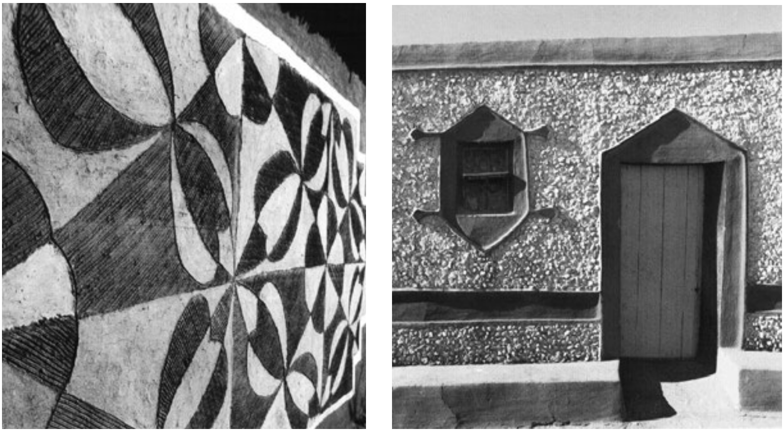

Figure 1: Wall details of traditional southern Sotho earth-constructed houses
Source: Matthews & Changuion, 1989: 6, 130

There is a growing consciousness regarding earth construction in South Africa and across the world (Bosman, 2012; Rael, 2009). A few exceptional examples of modest, yet long-life, low-energy buildings have been constructed over the past few years (Buchanan, 2006). The Earth Unit at the University of the Free State is developing capacity-building and training programmes for various stakeholders such as small-scale builders, community members, students and professionals to further support the growth of this viable construction method (Bosman, 2006).

This article investigates whether the amount of local rainfall in different areas influences people's perceptions of the durability of earth construction, which may further contribute to this shift in building culture. The analysis for this study aims to investigate whether earth construction is viewed differently during rainy and dry seasons in the same areas, suggesting that people's experience of climatic conditions is a contributing factor to whether they perceive earth construction as a viable construction material for shelter. The objective of the research is to suggest the importance of considering local climatic conditions in partially shaping people's attitudes towards what is considered an appropriate construction material, allowing building professionals to anticipate the acceptability of a building material within different contexts.

2. Earth construction

2.1 Climate change

Over the centuries and across cultures, local climatic conditions have shaped traditional building processes (Fathy, 1986; Krishan, Baker, Yannas & Szokolay, 2001; Mumford, 1961). The regional climate not only determines the availability of building materials in an area, but also affects the way in which buildings and houses are constructed to respond to the climate and natural occurrences (e.g., rainfall, wind, sun exposure) (Fathy, 2000; Rudofsky, 1964). More recent studies indicate that natural occurrences also impact on people's perceptions (Marsh, 1996) and behavioural responses (Shanahan, 2000). For example, a study using data from Scotland and England shows that an unusually hot summer and warm weather can affect people's perceptions, and that regional cultural differences can only partly explain behavioural outcomes (Palutikof, Agnew & Hoar, 2004). A large body of research has been conducted on people's perceptions of climate change (Bord, Fisher & Conner, 1998; Dunlap, 1998; Kempton, 1991; Seacrest, Kuzelka & Leonard, 2000), although fewer studies have examined the perceptual and behavioural changes associated with climate change and climatic events. The limited number of studies conducted under the theme of climate change have mostly focused on the psychological impacts of grief experienced as a result of losing one's home due to natural disasters followed by forced relocation (Hinds & Sparks, 2008). In addition, the psychological impacts of environmental degradation over time are rarely acknowledged (Rogan, O'Connor & Horwitz, 2005: 147).

The impact of natural disasters such as cyclones, tornadoes, floods, and earthquakes on heritage buildings is a growing concern, especially with extreme climatic conditions occurring in previously unaffected areas due to climate change. Increasingly, local conferences, proceedings and reports link natural disasters with heritage concerns in South Africa and other southern African countries (Meier, Petzet & Will, 2007; Taboroff, 2001; UNECA, 2002). Despite the mounting concerns, no previous local or international studies have examined the impact of natural disasters (e.g., rainfall) on earth-constructed buildings. The predominantly semi-arid South African climate is ideal for earth buildings, protecting earth structures from persistent rain and moisture. The main concern associated with earth construction in South Africa is protecting earth structures from rapid water infiltration from afternoon showers, thunderstorms, and flash floods.

Some international contributions have promoted heritage and conservation of earth construction. For example, there was a combined effort by the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the World Bank, and other organisations and educational institutions to assist the historic city of Bam in the Islamic Republic of Iran after the devastating 2003 earthquake (ICHO, 2004). Over 26 000 people died and 30 000 were injured, spurring a debate about whether traditional earth construction should be used to rebuild the city. During the debates and decision-making processes, no mention was made of research focusing on the link between perceptions of earth-built structures and cataclysmic weather-related events. It is evident that pressure is mounting, and that adaptation to climate change necessitates more research in this field (Berk & Fovell, 1999; Steemers, 2003).

Structural limitations associated with earth construction and insecurity associated with climate change may be some of the factors responsible for the decline in popularity of traditional earth as a viable building material (Morris & Blier, 2004). Other reasons for the decline in popularity of earth construction may have little to do with the objective properties of the building material, but with growing aspirations to modernise and how people perceive earth construction, for example in terms of aesthetics and durability.

2.2 Perceptions of construction materials

Several studies have investigated people's perceptions of construction materials (Hadjri, Osmani, Baiche & Chifunda, 2007). A recent study in Scotland examined two culturally distinct groups in order to determine what role "place" had in their understanding of materials. One key finding was that the two groups differed significantly in the way in which they perceived construction materials, suggesting that geographic location may influence people's attitudes towards materials. Nine common construction materials were included in the study. There was an overwhelming preference for wood, stone and glass, and a distinct dislike for concrete, plaster, mud and plastic (Stevenson, 2006: 259-262).

To conceptualise the link between locally available materials such as earth construction and people's perceptions, James Gibson's theory of affordances could be considered. The theory offers one way of viewing the relationship between building materials, people's perceptions of these materials, and situational factors such as climatic conditions that may alter people's perceptions of building materials. His theory was developed to describe how people perceive objects in their surroundings as having latent use value and how people experience purposeful relationships with these objects (Gibson, 1979). In this study, such an interactive relationship between people's perceptions and the objects in their surroundings is considered with reference to available building materials and how people perceive these materials to fulfil their purpose as a viable construction material. For example, stone provides strength through its appearance of solidity and strength, whereas wool provides warmth and comfort through the appearance of thickness and softness (Stevenson, 2006: 260). However, people also consider the context in which the object (or building material) is found in order to frame their perceptions of the objects' use value. For example, wool may be perceived to provide little use value in a hot desert climate, whereas a thin cloth may be ideal to cover and protect the human body from the sun. The notion that physical materials are perceived to have inherent qualities and characteristics fit for their intended purposes in specific contexts (e.g., whether materials are considered 'good' enough for permanent shelter in different climatic conditions) may become important in understanding why earth construction as a building method is declining.

3. Research methods

Data from a face-to-face survey conducted in 2004 and 2006 in central South Africa were used to investigate the question as to whether climatic conditions and rainfall, in particular, influence attitudes towards earth-constructed buildings. The data were collected as part of the SANPAD project. No previous study of this kind has been conducted in South Africa, and further analysis of the SANPAD data sets provided an opportunity to explore additional research questions. Usually, data sets from the mid-2000 containing psychosocial and perceptual data would be considered outdated. However, the study presented in this article only investigates the influence of rainfall on differences in perceptions towards building materials in poor communities as an observable phenomenon rather than a time-dependent reporting of social-cultural patterns. This hypothesised link, in particular, is unlikely to change over the course of eight to ten years due to the annual reoccurrence of rainfall and the minimal likelihood of innovation of building techniques in the areas without deliberate intervention, which may be a likely factor that could start to alter people's perceptions.

Study locations were selected within a four-hour drive from Bloemfontein, the most centrally located city in South Africa (see

Figure 2). This enabled the researchers to investigate issues regarding earth-constructed dwellings in arid and semi-arid areas in South Africa where rainfall occurs infrequently, but is more rapid and severe in the form of rainstorms. Due to the nature of rainfall in these areas, it is likely that people experience these occurrences more intensely, affecting their attitudes towards strength, stability, durability, and safety of home-building materials. The sampled areas have some earth-constructed dwellings, are located in both urban and rural settings, and consist of both formally and informally built structures.

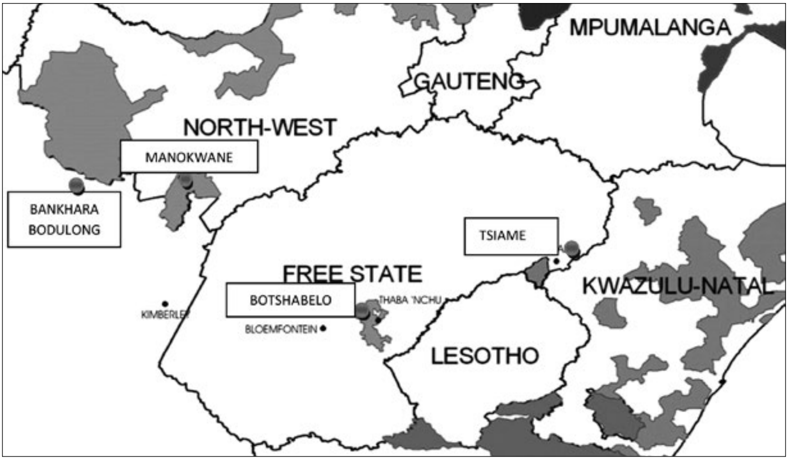

Figure 2: The four research locations selected for the study
Source: Bosman, 2006: 302

The SANPAD survey focused on attitudes of people both living and not living in earth-constructed dwellings. Participants came from poor to below-average poor households where basic services such as running water, a flushing toilet and electricity constituted acceptable living standards. Survey I (n=784) was conducted during the 2004 dry season from 12 June to 1 July, and Survey II (n=609) during the end of the 2006 rainy season from 3 to 7 April. Staff members and Sesotho- and Setswana-speaking students from the University of the Free State conducted the Surveys.

To ensure a representative sample of respondents in households in the areas, Stoker's formula (1981) was used to calculate the number of households to be surveyed from the sampling frame consisting of all households in the areas. According to the formula, the sample size should be a ratio relative to the size of the total population (households) within each area. The formula calculates the sample size as $\sqrt{\frac{N}{20}} \times 20$, with N representing the total number of households in an area. Stoker's formula is applicable to this study, since the areas were fairly homogeneous in terms of socio-economic factors and housing stock (type of house, condition, etc.). In addition, the sample areas had an acceptable mix of houses in terms of urban and rural, formal and informal, and different material applications. For instance, of all the participants interviewed during this study, 23.9% resided in earth dwellings, 33.8% in corrugated iron, 18.6% in cement blocks, 15.8% in burned bricks, and the remainder in a combination of materials (see Figure 3). In other words, there was no need to apply a cluster sampling method to the sample frame which would accommodate location variation.

Accurate household level information for the areas was not available from census or municipal records and counts of housing units were taken from aerial photography to infer the approximate total number of households. Stoker's formula specified the following sample sizes and percentage ratios for the different areas: Bankhara Bodulong, n=245 households (N=3000 at 8%); Botshabelo, n=390 households (N=7600 at 5%); Manokwane, n=154 households (N=1180 at 13%), and Tsiame, n=182 (N=1650 at 11%). Once on site, every 4th housing unit was selected, depending on the sampling ratio from Stoker for each area, and the location was documented. This on-site systematic sampling method was adopted to increase the likelihood of the same households being selected during Survey II. In cases where nobody was home, the previous or next house was interviewed and this modification was recorded.

The respondent was coded as the head of household, spouse, tenant, adult child, or other. Wherever possible, interviewers tried to interview the same person during Survey II; however, another household member was interviewed the second time around in the absence of the Survey I respondent. Completed questionnaires were spot-checked to ensure data quality. The four areas where Survey I (2004) and Survey II (2006) were conducted include Bankhara Bodulong (Survey I – n=231 and Survey II – n=137); Botshabelo (Survey I – n=390 and Survey II – n=155); Manokwane (Survey I – n=91 and Survey II – n=148), and Tsiame (Survey I – n=72 and Survey II – n=169). The response rates during the two Surveys by areas are as follows: Bankhara Bodulong, Survey I = 96.7% and Survey II = 55.9%; Botshabelo, Survey I = 99.5% and Survey II = 39.7%; Manokwane, Survey I = 59.0% and Survey II = 96.1%, and Tsiame, Survey I = 39.6% and Survey II = 92.3%. The differences in response rates between Survey I and Survey II can be attributed to financial constraints. It was decided to have a full sample and a smaller (subset) sample in each of the areas, equally distributing the larger and smaller samples across the two Survey waves.

Figure 3: An adobe house in Tsiame near Harrismith
Source: Bosman, 2006: own picture

Survey I and Survey II contained both qualitative and quantitative response items grouped into 26 questions. Questions 1 and 2 determined the location and questions 3 and 4 recorded respondents' position in the household and language preference. Questions 5 to 9 requested general information (e.g., age, total of people living in the house, permanent jobs, grants and income) on the household from each participant. Questions 10 to 16 dealt with the house as physical building and determined who built the house, total rooms, services, walls and walls construction material. Questions 17 to 18 tested the preferences of building materials, and questions 19 to 23 tested respondents' opinions on earth construction in general. Questions 24 to 26 tested views on RDP houses and who is responsible for building houses for people. The descriptive statistics of this study across nine areas were published in a report (Steÿn, 2009).

For purposes of this article, data for Questions 18, 19, 20, and 22 for four areas are used as the link between attitudes of the acceptability of earth construction; rainfall has not been investigated in the past. In order to conduct this analysis, perceptual data from the face-to-face Surveys (Survey I and Survey II) were supplemented with objectively measured average monthly rainfall for the different areas at the time when the Surveys were conducted. The data were obtained from the South African national weather service. The two waves of Surveys provided data for a quasi-experimental research design, considering the independent influence of the differences in rainfall patterns between Survey I (time 1) and Survey II (time 2).

To rule out possible confounding variables, an analysis of variance (ANOVA) test was employed to examine the associations between respondents' personal characteristics (e.g., location, ethnic background, tenure, socio-economic status and size of household) and measures of acceptability of building materials (e.g., preferred construction materials, preferred qualities of building materials, and disliked characteristics of construction materials). Personal characteristics did not show any relationship with the outcomes used in this analysis.

The new data for this study allowed for changes to be identified in residents' perceptions of building materials and earth construction between Survey I, during the dry season, and Survey II, after/during rainstorms and flooding. The analysis allows for the investigation and presentation of this likely association between differences in perceptions of building materials and natural occurrences such as rainfall and storms. After significant rainfall, differences between Survey I (dry season) and Survey II (wet season) were identified; Question 1 examined whether there are differences between these waves in terms of respondents' preferred materials for walls. Further questions considered the differences in preferred qualities of building materials and the likelihood of associating specific problems with specific building materials. The third set of questions focused on how people rate the quality of adobe blocks/compressed earth bricks (CEB), whether people consider adobe blocks/compressed earth bricks to be problematic building materials, and what are the problematic qualities of adobe blocks and compressed earth bricks.

4. Findings

4.1 General perceptions of construction materials

Previous analysis of the SANPAD data found overall negative perceptions of earth construction as a building material for the 2004 and 2006 samples in nine areas across the country. The acceptability of houses constructed from earth brick was low, with the most important reasons cited for dislike of this construction method being that the houses collapse, are not strong/stable and cannot withstand climatic factors such as rain and storms (Steÿn, 2009). In the ensuing investigation, data from the same and related questions was analysed for four study areas, comparing responses from Survey I with those from Survey II. These four areas were selected from the data set due to the availability of objective rainfall measurements of the areas during the months when the Surveys were conducted.

4.2 Objective rainfall measurements: Seasonal changes

In order to demonstrate the seasonal and climatic differences between the times when the Surveys were conducted, objectively measured rainfall data of 6 months at the time of the two Survey waves are presented next. The four study locations are situated in a summer rainfall area with annual rainfalls ranging between 200mm and 800mm, mostly late afternoon showers or thunderstorms. However, the rainfall data indicate that the 2004 Survey I was conducted during the dry winter months (in June), and the 2006 Survey II during the wet autumn months (in April). Table 1 shows rainfall figures for the four areas prior and during Survey I compared to the months prior and during Survey II. The total rainfall in the different areas for two months, the month before and the month during which the Surveys were conducted, are as follows: Bankhara Bodulong, 2.2mm (Survey I) compared to 189.2mm (Survey II); Botshabelo, 8.8mm compared to 106.7mm; Manokwane, 1.5mm compared to 112.4mm, and Tsiame, 2.7mm compared to 131.3mm. The differences between the average monthly rainfall for the one month prior and during Survey I and Survey II are: Bankhara Bodulong, 93.5mm; Botshabelo, 49.0mm; Manokwane, 60.0mm, and Tsiame, 64.3mm.

Table 1: A comparative table of the rainfall (in mm) between January and June in the four locations at the time of Survey I (2004) and Survey II (2006). The grey fill indicates the months prior and during the Surveys.

Rainfall (mm)	*Bankhara Bodulong*		*Botshabelo*		*Manokwane*		*Tsiame*	
	2004 Survey I	*2006 Survey II*	*2004 Survey I*	*2006 Survey II*	*2004 Survey I*	*2006 Survey II*	*2004 Survey I*	*2006 Survey II*
	conducted during							
	dry months	*wet months*	*dry months*	*wet months*	*dry months*	*wet months*	*dry months*	*wet months*
January	87.9	128.5	130.3	257.2	68.0	44.0	40.1	168.1
February	46.2	242.6	49.6	210.0	41	79.1	109.0	72.6
March	57.2	104.6	n/a	58.0	88.5	92.0	95.2	95.5
April (survey II was conducted)	28.5	84.6	n/a	48.7	21.7	30.4	30.5	35.8
May	2.0	6.85	1.8	20.9	0.5	20.1	0.7	26.92
June (survey I was conducted)	0.2	4.0	7.0	0.2	1.0	20.0	2.0	0.0

It was anticipated that the occurrence of torrential rains and storms would be associated with negative attitudes in all of the target areas, since higher rainfall was observed across the sites during and prior to April 2006. Prior to conducting the analysis presented in this paper, it was anticipated that other considerations such as the appearance, aesthetics, or even ease of construction would be considerations during the dry season, whereas people may be more likely to expect a building material's durability and strength during seasons of higher rainfall.

4.3 Attitudinal responses: Perceptions of construction materials

4.3.1 Preferred construction materials

Table 1 shows the results for Question 18 during Survey I and Survey II concerning respondents' most preferred materials for walls. The question inquiring about respondents' most preferred materials for walls for the two Survey data combined indicated that cement blocks at 27.0% and burnt bricks at 56.6% were the most popular building materials in the four areas. Compressed earth bricks underperformed significantly at 13.8%.

Table 2: Respondents' most preferred materials for walls

Preferred materials for walls	*Survey I (2004) n=784 (1 non-response) N=971*		*Survey II (2006) n=609 N=971*		*Survey I & Survey II combined n=1393 N=1942*	
	n	*%*	*n*	*%*	*n*	*%*
Burned bricks/ Face brick	**556**	**70.9**	**232**	**38.1**	**788**	**56.6**
Cement blocks	**14**	**1.8**	**363**	**59.6**	**377**	**27.0**
Compressed earth bricks	**191**	**24.4**	**1**	**0.2**	**192**	**13.8**
Adobe blocks	10	1.3	10	1.6	20	1.4
Missing	13	1.7	3	0.5	16	1.2
Total	784	100	609	100	1393	100

However, an interesting difference is observed when comparing people's preferred building material between Survey I and Survey II. During Survey I, people preferred compressed earth bricks at 24.4% to cement blocks at only 1.8%, while burned bricks were overwhelmingly selected as the most preferred building material at 70.9%. After the rainstorm during Survey II, people's preference for compressed earth bricks fell to 0.2%. They still preferred burned brick, but to a lesser extent at 38.1%, while showing a higher preference for cement blocks at

59.6%. The preference towards compressed earth blocks and adobe blocks was very low. During Survey I, only 1.3% of participants chose these materials and, during Survey II, even fewer people selected this option at 0.8%.

4.3.2 Perceived qualities of building materials

The participants also responded to the open-ended Question 19, describing the qualities of their preferred building materials used in the construction of walls. Their responses were coded into categories summarised in Table 3.

Table 3: The most preferred qualities of building materials (%) in Survey I and Survey II, in the four locations

Preferred qualities of building material	*Bankhara Bodulong*		*Botshabelo*		*Manokwane*		*Tsiame*	
	% Survey I (n=231)	*% Survey II (n=137)*	*% Survey I (n=390)*	*% Survey II (n=155)*	*% Survey I (n=91)*	*% Survey II (n=148)*	*% Survey I (n=72)*	*% Survey II (n=169)*
Aesthetics	**40.7 (94)**	**10.2 (14)**	**44.6 (174)**	**25.2 (39)**	**45.1 (41)**	**14.2 (21)**	**37.5 (27)**	**20.1 (34)**
Strength/ safety/ durability	**43.7 (101)**	**42.3 (58)**	**39.7 (155)**	**46.5 (72)**	**36.3 (33)**	**52.0 (77)**	**36.1 (26)**	**46.7 (79)**
Less problems/ lower maintenance	2.6 (6)	3.6 (5)	2.3 (9)	5.8 (9)	7.7 (7)	12.2 (18)	2.8 (2)	11.2 (19)
Temperature/ comfort/ climate	3.5 (8)	12.4 (17)	3.8 (15)	3.9 (6)	2.2 (2)	6.8 (10)	13.9 (10)	4.1 (7)
Quick building process/size	0.9 (2)	0.7 (1)	0.5 (2)	0.6 (1)	1.1 (1)	0.7 (1)	2.8 (2)	0.0 (0)
Cost/finance	2.2 (5)	7.3 (10)	2.8 (11)	4.5 (7)	2.2 (2)	3.4 (5)	0.0 (0)	2.4 (4)
Other	**3.9 (9)**	**17.5 (24)**	**2.1 (8)**	**13.5 (21)**	**2.2 (2)**	**10.8 (16)**	**2.8 (2)**	**14.8 (25)**
Missing	2.6 (6)	5.8 (8)	4.1 (16)	0.0 (0)	3.3 (3)	0.0 (0)	4.2 (3)	0.6 (1)
Total	100.0 (231)	100.0 (137)	100.0 (390)	100.0 (155)	100.0 (91)	100.0 (148)	100.0 (72)	100.0 (169)

The two most important preferred qualities of building materials are Aesthetics and Strength/Safety/Durability (see Table 3). During Survey II, participants value aesthetics much less compared to the importance of aesthetics during Survey I: compare the significant drop from Survey I to Survey II in Bankhara Bodulong, 40.7% to 10.2%; in Botshabelo, 44.6% to 25.2%; in Manokwane, 45.1% to 14.2%, and in Tsiame, 37.5% to 20.1%. However, strength/safety/durability remains an important quality of building materials during Survey II. In fact, in three of the four areas (Botshabelo, Manokwane and Tsiame) responses increased significantly. Some differences between Survey I and Survey II are also observed for the 'Other' category, with more people selecting this option during Survey II across the four areas. In order to understand the specific responses under the 'Other' category, the original qualitative responses were considered. It was found that people consistently mention conditions that point to rainfall and that a building material should be able to withstand these conditions.

Table 4: Cross-tabulation of respondents who, in Question 18, selected their preferred material ('Compressed earth bricks/adobe blocks' [var=0] 'Burned bricks/Cement blocks' [var=1]) compared to respondents who, in Question 19, selected preferred qualities of a building material ('Strength/Safety/Durability' [var=0] compared to 'Other reasons' [var=1])

		Question 19: Preferred qualities of a building material							
		Survey I n=784				*Survey II n=609*			
		Strength/ Safety/ Durability [var=0]	*Other reasons [var=1]*	*Missing*	*Total*	*Strength/ Safety/ Durability [var=0]*	*Other reasons [var=1]*	*Missing*	*Total*
Question 18: Preferred materials	*Compressed earth bricks/ adobe blocks [var=0]*	19.1% (150)	6.3% (49)	1.9% (15)	27.3% (214)	0.8% (5)	0.2% (1)	0.5% (3)	1.5% (9)
	Bricks/Face bricks/Cement bricks [var=1]	**37.1%** (291)	**33.9%** (266)	1.7% (13)	72.7% (570)	**44.7%** (272)	**52.7%** (321)	1.1% (7)	98.5% (600)
	Missing	1.8% (14)	1.8% (14)			0.8% (5)	0.8% (5)		
	Total	58.0% (455)	42.0% (329)		100.0% (784)	46.3% (282)	53.7% (327)		100.0% (609)

Cross-tabulating two dichotomous variables, one for the preferred materials and one for the preferred qualities of building materials (Table 4), informs the question as to whether participants who selected 'Burned bricks/Face bricks/Cement bricks' as their preferred material are more likely to choose 'Strength/Safety/Durability' as their preferred quality. (It should be noted that the cross-tabulation implies more missing values than reported on in Table 3, since the tabulation assumes a valid response on both variables for it to be included in the cross-tabulation).

As indicated in Table 4, the data do not support the fact that participants are more likely to value 'Strength/Safety/Durability' if they selected 'Bricks/Face bricks/Cement blocks' as their preferred building material. Furthermore, despite reasons for preferred qualities of a building material, participants are more likely to choose 'Bricks/ Face bricks/Cement blocks' during Survey II during/after rainstorms. In other words, people may hold true to their reasons or report other reasons for describing the ideal qualities of a building material, but tend to associate those qualities more with burned brick and concrete products during/after rainstorms rather than earth materials.

4.3.3 Perceived qualities of adobe blocks

The next analysis focuses specifically on the quality of traditional unstabilised adobe blocks, because this could give more insight into the low preference for adobe blocks reported on in Table 5. Adobe blocks are sun-dried bricks shaped by hand or in a mould and left to dry without applying compression with a press. Table 5 shows the results for Question 20 where respondents were asked to rate how they perceived the quality of adobe blocks on a five-point Likert scale. The response items included were 1 to 5 where 1=Very poor, 2=Poor, 3=Neutral, 4=Good and 5=Very good.

Table 5: Rated quality of adobe blocks

Rated quality of adobe/ CEB buildings	*Bankhara Bodulong*		*Botshabelo*		*Manokwane*		*Tsiame*	
	% Survey I (n=231)	*% Survey II (n=137)*	*% Survey I (n=390)*	*% Survey II (n=155)*	*% Survey I (n=91)*	*% Survey II (n=148)*	*% Survey I (n=72)*	*% Survey II (n=169)*
1 = Very poor	32.5 (75)	**57.7 (79)**	39.0 (152)	**51.0 (79)**	34.1 (31)	**60.8 (90)**	34.7 (25)	**49.1 (83)**
2 = Poor	**44.6 (103)**	35.0 (48)	**41.5 (162)**	41.3 (64)	**58.2 (53)**	31.8 (47)	**45.8 (33)**	41.4 (70)
3 = Neutral	10.0 (23)	0.7 (1)	7.9 (31)	1.3 (2)	3.3 (3)	2.7 (4)	12.5 (9)	1.8 (3)
4 = Good	7.8 (18)	5.1 (7)	6.9 (27)	2.6 (4)	3.3 (3)	3.4 (5)	6.9 (5)	6.5 (11)
5 = Very good	5.2 (12)	1.5 (2)	4.1 (16)	3.9 (6)	1.1 (1)	1.4 (2)	0 (0)	0.6 (1)
Missing	0 (0)	0 (0)	0.5 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0.6 (1)
Total	100 (231)	100 (137)	100 (231)	100 (155)	100 (91)	100 (148)	100 (72)	100 (169)

As Table 5 suggests, people consistently rate the quality of adobe blocks as either 'Poor' or 'Very poor'. More significantly, when responses are viewed for Survey I and Survey II, the majority of people rated the quality of adobe blocks 'Poor' during Survey I (Bankhara Bodulong, 44.6%; Botshabelo, 41.5%; Manokwane, 58.2%; Tsiame, 45.8%) and 'Very poor' during Survey II (Bankhara Bodulong, 57.7%; Botshabelo, 51.0%; Manokwane, 60.8%; Tsiame, 49.1%).

Question 19 asked respondents if they perceive any problems with the use of adobe blocks for walls. See Table 6 for the results. During Survey I, more than five sixths of respondents answered 'Yes' to the question. A higher number of participants considered problems with adobe blocks for walls during Survey II: an increase of 7% in Bankhara Bodulong; 8.6% in Botshabelo; 10.2% in Manokwane, and 2% in Tsiame.

Table 6: Respondents report if they perceive problems with the use of adobe blocks for walls

Problems with adobe blocks/ CEB for walls	*Bankhara Bodulong*		*Botshabelo*		*Manokwane*		*Tsiame*	
	% Survey I (n=231)	*% Survey II (n=137)*	*% Survey I (n=390)*	*% Survey II (n=155)*	*% Survey I (n=91)*	*% Survey II (n=148)*	*% Survey I (n=72)*	*% Survey II (n=169)*
Yes	**85.7 (198)**	**92.7 (127)**	**84.9 (311)**	**93.5 (145)**	**85.7 (78)**	**95.9 (142)**	**90.3 (65)**	**92.3 (156)**
No	13.9 (32)	7.3 (10)	14.6 (57)	5.2 (8)	14.3 (13)	4.1 (6)	9.7 (7)	6.5 (11)
Missing	0.4 (1)	0 (0)	0.5 (2)	1.3 (2)	0 (0)	0 (0)	0 (0)	1.2 (2)
Total	100 (231)	100 (137)	100 (231)	100 (155)	100 (91)	100 (148)	100 (72)	100 (169)

Another survey question was analysed to support the findings presented above and provides a possible link between perceptions of the acceptability of building materials (in general) and earth construction. An open-ended question asked respondents to name the most important problem related to the use of adobe blocks. Their responses were coded into several categories for analysis: 'Collapse'; 'Cracks'; 'Maintenance'; 'Climate/Rain'; 'Not safe/Strong', and 'Other'. Question 22 elaborated on participants' perceived qualities of these building materials and the results for Survey I and Survey II were broken down into areas (see Table 7).

Table 7: Respondents' reports of problems with adobe blocks

Problematic qualities of building material	*Bankhara Bodulong*		*Botshabelo*		*Manokwane*		*Tsiame*	
	% Survey I (n=231)	*% Survey II (n=137)*	*% Survey I (n=390)*	*% Survey II (n=155)*	*% Survey I (n=91)*	*% Survey II (n=148)*	*% Survey I (n=72)*	*% Survey II (n=169)*
Collapse	**31.9 (103)**	**27.0 (37)**	**31.2 (186)**	**18.7 (29)**	**16.9 (38)**	**18.9 (28)**	**22.9 (39)**	**23.1 (39)**
Cracks	14.2 (46)	2.9 (4)	10.2 (61)	1.9 (3)	8.9 (20)	2.7 (4)	5.9 (10)	1.2 (2)
Maintenance	4.3 (14)	3.6 (5)	10.2 (61)	4.5 (7)	4.0 (9)	3.4 (5)	7.1 (12)	3.6 (6)
Climate/Rain	**21.1 (68)**	**41.6 (57)**	**22.3 (133)**	**63.9 (99)**	**19.1 (43)**	**61.5 (91)**	**14.1 (24)**	**59.8 (101)**
Not safe/Not strong	5.3 (17)	9.5 (13)	8.4 (50)	4.5 (7)	3.6 (8)	8.1 (12)	3.5 (6)	2.4 (4)
Other	13.3 (43)	8.0 (11)	7.7 (46)	1.3 (2)	41.8 (94)	1.4 (2)	42.4 (72)	2.4 (4)
Missing	9.9 (32)	7.3 (10)	9.9 (59)	5.2 (8)	5.8 (13)	4.1 (6)	4.1 (7)	7.7 (13)
Total	100 (231)	100 (137)	100 (390)	100 (155)	100 (91)	100 (148)	100 (72)	100 (169)

During Survey I, participants were mostly concerned with structural 'Collapse' due to the qualities of the building material: Bankhara Bodulong, 31.9%; Botshabelo, 31.2%; Manokwane, 16.9%, and Tsiame, 22.9%. However, during Survey II, participants became much more concerned with issues of 'Climate/Rain': Bankhara Bodulong, 41.6%; Botshabelo, 63.9%; Manokwane, 61.5%, and Tsiame, 59.8%.

5. Discussion

This investigation examined differences in people's perceptions for earth construction and other building materials for walls between the dry period in 2004 (Survey I) and the wet period in 2006 (Survey II).

First, participants were asked to select their preferred building material out of all other available building materials: burned bricks/ face bricks, cement blocks, adobe blocks, and compressed earth blocks. Findings suggest that burned brick/face brick are participants' favourite building materials, whereas compressed earth brick (CEB) is also considered during the dry season (see Table 2). Of the Survey I respondents, 24.4% selected compressed earth bricks. After rain, however, people considered materials other than earth construction for their preferred construction materials: cement brick at 59.6% and burned brick at 38.1% were preferred to compressed earth at 0.2% and adobe blocks at 1.6%. Nearly a quarter of the participants selected compressed earth bricks as their preferred building material during Survey I, when between slightly over a third[1] to just over half[2] of the participants experienced problems with adobe and CEB due to 'Collapse' and 'Climate/Rain' (see Table 7). However, when the participants identified problems of 'Collapse' and 'Climate/Rain' after Survey II rainstorms (68.6% for Bankhara Bodulong, 82.6% for Batshabelo, 80.4% for Manokwane, and 82.9% for Tsiame), their preference for adobe blocks and CEB was significantly reduced. The significantly lower responses for earth construction during Survey II support the notion that factors such as higher rainfall and storms may affect people's perceptions of earth construction.

The two most preferred qualities of building materials that respondents mentioned during the two Surveys are 'Aesthetics' and 'Strength/Safety/Durability' (see Table 3). During Survey I (lower rainfall), 'Aesthetics' was the most important consideration of a building material and chosen on average nearly 42.0% of the time. 'Strength/Safety/Durability' was selected on average 39.0% of the time. During Survey II (higher rainfall), the percentage of respondents who considered 'Aesthetics' dropped to an average of 17.4% across the four areas. For most of the areas, a slight increase in the percentage of people reporting 'Strength/Safety/Durability' as an important factor of building materials can be observed between Survey I and Survey II, especially in Manokwane. Respondent reports between the two Surveys in Manokwane show the highest increase in the importance of 'Strength/Safety/Durability'. There is an increase from 36.3% in June 2004 (winter) to 52.0% in April 2006 (summer), suggesting that over half of the respondents considered 'Strength/Safety/Durability' as the most important quality of a building material. This suggests that people in Manokwane became more aware of problems related to 'Strength/Safety/Durability' (often associated with earth construction).

It is interesting to note that the average rainfall before and during the Surveys does not support this observation. In fact, the area had the lowest average rainfall during this season compared to the other study areas. However, the severity of rainfall and storms in the area should also be considered. Several sources describe severe flooding in Manokwane in 2006. The *Mail & Guardian* reports that 1 500 houses and numerous bridges and roads were damaged and

1 Table 7 – Survey I: 'Collapse' and 'Climate/Rain' combined: Manokwane, 36.0%; Tsiame, 37.0%.

2 Table 7 – Survey I: 'Collapse' and 'Climate/Rain' combined: Bankhara Bodulong, 53.0%; Botshabelo, 53.5%.

washed away between February and April 2006 due to flooding in the area (Staff Reporter, *Mail & Guardian*, 2006: online). The impact of flooding was so severe that the National Disaster Management Centre declared the area a disaster zone in their Inaugural Annual Report (South Africa. Provincial and Local Government, 2007). It is likely that this extraordinary climatic occurrence impacted on participants' perceptions in favour of qualities of 'Strength/Safety/Durability'. Where houses are located (e.g., floodplains, wetlands, or close to rivers) may also affect how people experience storms and flooding and their perceptions of how strong, durable and safe their houses are. The increase in the preferred quality of 'Strength/Safety/Durability' in the other three areas may be marginal, but it is evident that this quality of building materials remains an important consideration in the context of seasonal and climatic changes.

It is noteworthy to consider differences in other preferred qualities of building materials between Survey I and Survey II. The data presented in Table 3 suggest that 'Temperature/Comfort/Climate', 'Less problems/Lower maintenance' and 'Other reasons' also play an important role in people's perceptions in some areas. For instance, it is likely that other climatic factors also played a role. In Bankhara Bodulong, people's consideration for 'Aesthetics' decreased by 30.5%, while their preference for 'Strength/Safety/Durability' shows a negligible decrease of 1.4%. With an increase of 8.9% between Survey I and Survey II (from 3.5% to 12.4%) in preferences for materials associated with 'Temperature/Comfort/Climate', it is likely that the summer's high temperatures also affected people's perceptions. In 2004, the summer average daytime temperature in the area was 32.6°C, significantly higher than that in the other areas. Average winter temperatures also seem to affect people's perceptions. In Tsiame, the average maximum daytime temperature during the 2004 winter was 14.7°C, making Tsiame the coldest area compared to the others. Of the Survey I respondents, 13.9% chose 'Temperature/Comfort/Climate' as their most important factor during the winter Survey I, compared to 4.1% of respondents during the summer Survey II. This is a decrease of nearly 10% fewer respondents reporting on 'Temperature/Comfort/Climate' in the summer (Survey II), compared to their initial reporting in the winter (Survey I). These examples provide some suggestions for linking climatic conditions with perceptions; however, the available data collected for this study cannot fully determine these patterns and relationships. This could be a topic for further research.

The analysis in Table 4 attempted to determine whether people are more likely to choose 'Bricks/Face brick/Cement blocks' if they value 'Strength/Safety/Durability' as a preferred quality. The findings suggest that this is not the case. No consistent pattern between the Survey I or Survey II data could be identified. More interestingly, although participants were more likely to select 'Bricks/Face bricks/ Cement blocks' during/after rainstorms in Survey II, their reasons do not seem to favour 'Strength/Safety/Durability' at 44.7%, compared to 'Other reasons' at 52.7%. This may suggest that people articulate their discomfort with earth construction in many ways, possibly indirectly describing issues of strength or climate captured under 'Other'. As suggested earlier, people may describe experiences and situations that point to the impact of rainfall and that building materials should withstand these conditions. Whatever the case, it appears that people shy away from earth construction and revert to their preferred choice of 'Brick/Face brick/Cement blocks' when the quality of building materials is called into question. In other words, as Gibson's theory suggests, people attribute latent qualities to types of materials based on their perceptions of these types, irrespective of whether they understand the true properties of different material options belonging to a certain type (e.g., earth construction, burned bricks, etc.).

When asked to rate the quality of adobe blocks, the majority of the respondents described the material as either 'Poor' or 'Very poor'. Differences can be observed in how people rate the quality of adobe between Survey I and Survey II. During Survey I, the majority of respondents rated the quality as 'Poor', whereas higher percentages of respondents across the four areas rated the quality as 'Very poor' during Survey II (see Table 5). This is not surprising, considering that over five sixths of Survey I respondents said 'Yes' when asked if there are problems with adobe blocks for walls. Over 90% of participants during Survey II agreed on this point.

Table 7 indicates that 'Collapse' and 'Climate/Rain' are the most important perceived problems associated with adobe blocks. During Survey I and Survey II, respondents found 'Collapse' an important factor across all the areas. Significant increases across all areas are observed for 'Climate/Rain'; in some instances, more than double and triple the number of participants became concerned with this problem during Survey II. The data suggest that they perceive adobe blocks generally to be structurally inferior by referring to 'Collapse' in Survey I. However, during the wetter season (Survey II), their favourite explanation for the main problem associated with adobe blocks is 'Climate/Rain'. Again, it is likely that this observable difference between Survey I and Survey II is due to the occurrence of heavy rainfall, because traditional adobe is influenced by the presence of water and/or moisture. Structural failure occurs due to a loss of compressive strength that results from a weakening of the connections between the soil particles. The presence of a stabilizer (natural or chemical), the lack of a structural soil component (gravel, sand, silt or clay), and the mechanical process of stabilisation (compaction), as in the case of compressed earth bricks, all influence the structural integrity of adobe (Houben & Guillaud, 1994). The findings presented in Table 7 suggest that it is likely that people perceive earth-construction materials, in particular, as a less desirable building solution, especially during periods of higher rainfall and storms.

6. Conclusion and recommendations

These findings cannot claim any direct links between preferred building materials, preferred qualities of building materials, and reasons for disliking an earth product such as adobe blocks. However, a pattern does seem to emerge. It appears that, although earth as a building material has some wide application in home building, likely due to need or limited resources, it is not a preferred material if poorer people are presented with alternatives.

This research reflects on the effects of some climatic conditions on perceptions of earth construction as a building material. Specifically, the focus is on how changes in rainfall patterns and other climatic factors are associated with the acceptability of indigenous earth construction. The study presents evidence that higher rainfall seems to negatively affect people's choice of earth construction as an appropriate building method. People also indicated that their preferred qualities of building materials are 'Aesthetics' and 'Strength/Safety/Durability'. However, after significant rainfall 22 months later, aesthetic considerations seem to dwindle and climate-related considerations ('Strength/Safety/Surability', 'Temperature/Comfort/Climate', 'Less problems/Lower maintenance', and 'Other') became more important.

Another observation suggests that it is not necessarily the amount of rainfall that shapes perceptions, but the unexpectedness of rainfall in the form of flash floods, cloud bursts, or sudden climatic events. Unusually high or low temperatures in an area also seem to alter perceptions, where the climatic conditions are more likely to create discomfort (either hot or cold), make people more aware of the much-needed insulative properties of building materials. These finer nuances of the effects of specific climatic variability on perceptions require further research. When asked about adobe blocks, in particular, people generally rated the quality of these blocks as

'Poor' and 'Very poor', but more so after rain. People considered the collapse of adobe blocks a significant problem, followed by climate and rain. However, concerns about climate and rain exceeded concerns about collapse when considering earth building materials after rainstorms.

At the time when the two Surveys were conducted, natural occurrences such as rainfall were not considered to be important factors in affecting people's perceptions of building materials. However, these findings suggest that environmental factors such as rainfall and other climatic conditions should be considered in how earth construction is understood. Apart from the role that rainfall seems to play in people's perceptions of the suitability of earth construction, we may also need to pay more attention to how perceptions differ by geographic location as a result of climatic conditions. In order to improve people's perceptions of earth building techniques and materials, areas with high year-round rainfall may need more training programmes about the benefits of earth construction than arid regions, if we were to ever change prevailing perceptions of earth building materials. On the other hand, people living in areas with consistent levels of rainfall may be less concerned about the structural soundness of earth buildings than those living in drier areas that experience unexpected storms and flash floods. Whatever the case may be, interventions targeted at both the needs of specific communities and the regional climatic conditions are needed for the successful preservation and promotion of earth buildings.

Acknowledgement

SANPAD consisted of staff from the Earth Unit at the Department of Architecture and staff from the Department of Urban and Regional Planning at the University of the Free State, South Africa, in collaboration with staff from the Faculty of Architecture, Building and Planning at the Technical University of Eindhoven in The Netherlands.

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