Considering Alternative Construction Methods for Affordable Houses in the City of Cape Town and Cape Winelands Districts

by

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Declaration

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Abstract

Various challenges exist in the subsidy housing sector in South Africa, such as a housing backlog, unemployment and poor housing quality. However, several of these challenges can be addressed by choosing an appropriate construction method. Therefore, the aim of this study is to investigate prefabricated concrete as an alternative to brick and mortar for the construction of subsidy houses in the City of Cape Town and the Cape Winelands District. A technical and non-technical comparison is performed between these two construction methods.

To contextualise the research problem, challenges that are faced by the subsidy housing sector in South Africa, are first identified. This is followed by identifying the benefits of living in a house. To perform an accurate comparison between the construction methods, the scope of each method is defined. Lastly, housing standards that govern the construction of subsidy housing are identified.

A multimethod qualitative research strategy is used in this study. The methods of data collection include observations, a desktop study and semi-structured interviews. Interviews are performed with three participant groups: architects and urban planners, government officials involved in housing developments and housing activists. The interview data is analysed using content analysis. Due to physical restrictions by the Coronavirus Disease of 2019, beneficiaries of subsidy houses could not form part of the participants.

The goal of the observations is to obtain information regarding challenges within low-income communities. Furthermore, the goal of the desktop study is to obtain technical and non-technical criteria for the comparison of the construction methods. Lastly, the goal of the semi-structured interviews is to identify and/or validate the criteria from the literature sources.

The technical comparison is performed on the consolidated criteria from the desktop study and the interviews. For the non-technical comparison challenges are identified that can be addressed by the construction method only. The effects of these challenges on their contribution towards a progressive community, is determined.

For the technical and non-technical comparison, brick-and-mortar construction was found to be the better option. Therefore, it was concluded that brick-and-mortar construction is the more appropriate construction method for the construction of subsidy houses. This decision was based on its lower cost, resource availability, ease of alteration and extending of the house and for addressing more of the identified challenges.

Opsomming

Verskeie uitdagings bestaan in die subsidie-behuisingsektor in Suid-Afrika, onder andere ‘n behuisingstekort, werkloosheid en behuising van swak gehalte. Sommige van hierdie uitdagings kan egter aangespreek word deur 'n gepaste konstruksiemetode te kies. Daarom is die doel van hierdie studie om voorafvervaardigde beton as 'n alternatiewe konstruksiemetode vir die bou van subsidiehuise, in Kaapstad en die Kaapse Wynlanddistrik, te ondersoek. Dus word voorafvervaardigde beton en beton-steenwerk ondersoek as konstruksiemetodes. 'n Tegniese en nie-tegniese vergelyking word tussen hierdie twee konstruksiemetodes uitgevoer.

Om die navorsingsprobleem te kontekstualiseer, word uitdagings wat deur die subsidie-behuisingsektor in Suid-Afrika in die gesig gestaar word, eers geïdentifiseer. Dit word gevolg deur die voordele van 'n huis te identifiseer. Om 'n akkurate vergelyking tussen die konstruksiemetodes uit te voer, word die omvang van elke metode gedefinieer. Laastens word behuisingstandaarde wat die bou van subsidiebehuising beheer, geïdentifiseer.

'n Multimetode kwalitatiewe navorsingstrategie word in hierdie studie gebruik. Die metodes van data-insameling sluit waarnemings, 'n literatuurstudie en semi-gestruktureerde onderhoude in. Onderhoude word met drie deelnemergroepe gevoer: argitekte en stedelike beplanners, staatsamptenare betrokke by behuisingsontwikkelings en behuisingsaktiviste. Die onderhouddata word met behulp van inhoudsanalise ontleed. Weens die fisiese beperkinge wat met die Koronavirus van 2019 gepaard gegaan het, kon die eindverbruikers van subsidiehuise nie deel vorm van die deelnemergroepe nie.

Die doel van die waarnemings is om inligting rakende uitdagings binne lae-inkomste gemeenskappe te bekom. Verder is die doel van die literatuurstudie om tegniese en nie-tegniese kriteria vir die vergelyking van die konstruksiemetodes te verkry. Laastens is die doel van die semi-gestruktureerde onderhoude om die kriteria uit die literatuurbronne te identifiseer en/of te valideer.

Die tegniese vergelyking word uitgevoer op die gekonsolideerde kriteria van die literatuurstudie en die onderhoude. Vir die nie-tegniese vergelyking word uitdagings geïdentifiseer wat slegs deur die konstruksiemetode aangespreek kan word. Die uitwerking van hierdie uitdagings op hul bydrae tot 'n progressiewe gemeenskap, word bepaal.

Van die tegniese en nie-tegniese vergelyking is gevind dat steenwerkkonstruksie die beter opsie is. vir die bou van subsidiehuise. Hierdie besluit is gegrond op die laer koste, beskikbaarheid

van hulpbronne, die gemak van verandering en uitbreiding van die huis en op vermoë om meer van die geïdentifiseerde uitdagings aan te spreek.

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LIST OF ABBREVIATIONS

ABT	Alternative Building Technology
BNG	Breaking New Ground
COVID-19	Coronavirus Disease of 2019
CSIR	Council for Scientific and Industrial Research
EPWP	Expanded Public Works Programme
FIDIC	International Federation of Consulting Engineers
GCC	General Conditions of Contract
Hz	Hertz
IFRS	International Financial Reporting Standards
JBCC	Joint Building Contracts Committee
NBR	National Building Regulations
NEC	New Engineering Contract
NHBRC	National Home Builders Registration Council
NRC	Noise Reduction Coefficient
RDP	Reconstruction and Development Programme
REC	Research Ethics Committee
SABS	South African Bureau of Standards
SAICE	South African Institution of Civil Engineering
SANS	South African National Standards
SFE	Structural-functional-experiential
SIP	Structurally Insulated Panel
SMI	Serious Mental Illness
SMME	Small, Medium and Micro Enterprises
STL	Sound Transmission Loss
UK	United Kingdom
USA	United States of America

AUTHOR POSITIONALITY

Gerdus van der Watt is a white Afrikaans male who grew up in a middle-class family in a middle-class suburb in Komani in the Eastern Cape Province of South Africa. He attended an Afrikaans school where majority of the pupils resided on farms outside of Komani, or in the suburbs of Komani. Gerdus is currently a student and has no practical experience in the field of subsidy housing in South Africa. Therefore, it is acknowledged that his upbringing and education caused him to have limited contact with people residing in subsidy houses and may influence the research. It is thus imperative to utilise research methods as applied to obtain representative views of the majority of the stakeholders.

1 INTRODUCTION

The aim of this chapter is to develop a research question, and inform the reader of the process followed to answer the research question. In developing the primary and secondary research questions, a brief background study is conducted. To develop the process of answering the research questions, the scope of the study is defined and a research strategy is proposed. This chapter concludes with a brief summary of the subsequent chapters.

1.1 Background

This subsection aims to provide a background to the research question. Thus, this subsection identifies a problem that the study aims to solve.

1.1.1 Regulatory Obligations

In section 26 of the South African Constitution, it is specified that it is the responsibility of the state to ensure that the basic right to adequate housing is progressively realised (South African Human Rights Commission, n.d.). As a measure to ensure that the state fulfils its obligation, the Housing Act 107 of 1997 (hereon referred to as the Housing Act) was passed in 1998 (South African Human Rights Commission, n.d.). Ultimately, the goal of the Housing Act is to provide all South African citizens with permanent residential structures with access to potable water, sanitary facilities and domestic energy supply (South Africa, 1997). Furthermore, it seeks to facilitate the process of housing developments and to provide general principles for housing developments (South Africa, 1997).

General principles highlighted in the Housing Act include participation of and consultation with stakeholders, the feasibility of a housing development and integration (South Africa, 1997). Participation of stakeholders during the development process is also highlighted in the Development Facilitation Act 67 of 1995. This act aims to accelerate the enactment of land-related projects (South Africa, 1995). Participation and consultation with beneficiaries are of value in determining what the beneficiaries prefer in terms of housing developments and how they will benefit from this. Public participation can be beneficial; however, due to the complex dynamics in a community, the right approach towards public participation is important. Mafukidze and Hoosen (2009) emphasised that public participation can result in negative effects if the drivers of housing developments do not have adequate socio-cultural and historical knowledge of a community.

When a new housing development is planned, the feasibility of the development must be determined. The Housing Act considers a housing development feasible when it is economically, fiscally, environmentally and socially justifiable (South Africa, 1997). To increase the economic feasibility of a development, the Housing Act states that housing developments should be densified to ensure the optimal usage of land and services (South Africa, 1997). Furthermore, the social feasibility of a development is dependent on its ability to promote integration and safe and healthy living conditions which meet social standards.

Due to Apartheid, segregation occurred on racial, spatial and social levels. The Housing Act (1998) seeks to address this through integration. The location of a housing development is the main contributing factor to integration. The location of a housing development will not only attend to racial and spatial integration but will also address social segregation. Social class is based on education, wealth and profession; therefore, the Housing Act and Development Facilitation Act seeks to address this by stating that developments should promote education and employment opportunities (South Africa, 1997; South Africa, 1995).

Based on the general principles mentioned in the Housing Act, it is observed that a holistic approach is required when planning a new housing development (Juta & Matsiliza, 2014). Therefore, technical and non-technical (human) aspects should be considered. In the Housing Act, the feasibility of a new housing development addresses the technical aspects and the participation of and consultation with stakeholders and integration of communities, addresses the human aspects.

The Housing Act enables the Minister of Human Settlements to establish and fund (from the national budget) national housing programmes (South Africa, 1997). The state provides housing opportunities through numerous programmes, such as state-subsidised houses, rental units, serviced sites and housing subsidies (GroundUp Staff, 2017). The Housing Act operates in conjunction with the Reconstruction and Development Programme (RDP) and the Breaking New Ground (BNG) policy (South African Human Rights Commission, n.d.).

The RDP is a plan created in 1994, which aims to address the social and economic challenges created by Apartheid (South Africa, 1994). The RDP has identified five key programmes it aims to implement to improve the living quality of all South Africans (Rabbani, 1994). ‘Meeting basic needs’ is one of these programmes and aspires to ensure that the right to adequate housing, among other rights, is realised (Rabbani, 1994). The RDP’s vision of

prioritising housing manifested in the Housing White Paper of 1994 (Department of Housing, 1994).

In 2004, the RDP was replaced by a new policy, called Breaking New Ground (BNG) (South African Human Rights Commission, n.d.). In contrast to the RDP housing policy, the BNG housing policy shifted the focus from quantity to quality. The BNG policy still aims to address the inequalities of the past and the housing backlog but is rather focussed on the creation of sustainable housing developments instead of building a vast number of houses (South African Human Rights Commission, n.d.; Department of Human Settlements, 2004). Furthermore, in the process of delivering houses, the BNG policy aims to create jobs and produce an asset for beneficiaries to assist in wealth creation (Department of Human Settlements, 2004).

There are certain criteria that a person should comply with to receive a government house. As obtained from the Department of Human Settlements' (n.d.) website, to qualify to receive a government house, an individual must:

a. Be a citizen of South Africa.
b. Have contractual capacity.
c. Be married or permanently cohabit with a partner.
d. Be unmarried or unattached and have financial dependents.
e. Have a combined monthly income of less than R3 500.
f. Be a first-time beneficiary of a government subsidy.
g. Be a first-time proprietor of a home.
h. Be an unmarried or unattached military veteran without financial dependents.

If an individual complies with these conditions, the person can apply at the provincial Department of Human Settlements or at the local municipality (Department of Human Settlements, n.d.). This application is also free of charge (Department of Human Settlements, n.d.).

1.1.2 Housing Backlog

From 1994 to 2018, it was reported that approximately 3.3 million housing units, excluding serviced sites, have been delivered (Pretorius, 2019). Despite this effort, it was reported in 2019 that South Africa still has a housing backlog of approximately 2.1 million (Pretorius, 2019). In the Western Cape Province, it is reported that the housing backlog exceeds 550 000 and 300 000 of that is in the City of Cape Town (Gontsana, 2020). According to a general

household survey, approximately 18 percent of all households reside in dwellings not classified as formal (Statistics South Africa, 2019). In addition to this, as of December 2020, the Department of Human Settlements announced that it will no longer provide free housing; instead, serviced sites will be transferred to beneficiaries (Thukwana, 2020).

Rapid urbanisation, corruption, fiscal restrictions, mismanagement, and construction inadequacies are of the factors that contribute to the housing backlog (Turok & Borel-Saladin, 2016; Mashwama, et al., 2018; Greyling, 2009). For this study, the construction inadequacies are of interest. Various construction inadequacies exist in the construction of state-subsidised houses, which included construction defects, material defects and inadequate artisan skills (Buys & Le Roux, 2013; Mashwama, et al., 2018). These inadequacies cause delays on housing projects, which affect the costs and results in less houses being built.

Construction inadequacies are often related to the construction method. State-subsidised houses are generally built with either concrete blocks or clay bricks, depending on availability of materials in the area (Greyling, 2009). This building method is time-consuming and labour intensive, which generally results in higher costs (Thamboo & Dhanasekar, 2011). Poor quality of workmanship is also a prevalent feature in state-subsidised houses (Buys & Le Roux, 2013). These inadequacies often result in rework on poorly built houses and temporary work opportunities (Department of National Treasury, 2015; McCutcheon, 1995).

With only serviced sites being provided by the government, the responsibility of erecting houses shifts from the government to beneficiaries of serviced sites and private developers. This results in the emphasis being changed from providing houses in bulk to erecting affordable, owner specific and good quality houses. Taking the construction inadequacies and the focus-shift into account, the need exists to address the shortcomings of the current building methods used in housing developments.

1.2 Research Question

In this subsection, the primary and secondary research questions are specified. The primary research question is the underlying question the research pursues to answer (Thabane, et al., 2009). To help answer the primary research question, secondary research questions are incorporated. Secondary research questions are complementary questions to help answer the overarching primary research question.

1.2.1 Primary Research Question

With South Africa challenged by the major housing backlog and deterioration of low-income communities, a solution is sought to build more houses, at a faster rate and that will help with the progression of communities. It is stated in the BNG framework that it aims to promote the creation of sustainable human settlements (Department of Human Settlements, 2004); however, the implementation of this policy remains a challenge. As stated in paragraph three of sub-subsection 1.1.2 and elaborated in subsection 2.1, various construction inadequacies exist in the current construction method (brick-and-mortar); therefore, the use of an alternative construction method is required. The use of prefabricated concrete may be a viable alternative for replacing brick-and-mortar. Both construction methods have technical and non-technical advantages and disadvantages; however, a certain method might be more suitable for the advancement of communities than the other. This leads to the primary research question:

> 'Is prefabricated concrete a suitable and more beneficial alternative construction method (compared to brick-and-mortar) for the construction of subsidy houses for the creation of progressive communities in the City of Cape Town and the Cape Winelands district?'

1.2.2 Secondary Research Questions

In this sub-subsection, the primary research question is broken into easier answerable secondary research questions. Fragmenting the primary research question, the following key phrases are acquired: 'suitable', 'compared to brick-and-mortar', 'subsidy houses' and 'progressive communities'. From this, the subsequent secondary research questions are obtained:

a. 'What are the challenges faced by the subsidy housing sector in South Africa that can be addressed by choosing an appropriate and more beneficial construction method?'
b. 'What is meant by brick-and-mortar and prefabricated concrete construction?'
c. 'What are the non-technical criteria for comparing the construction methods?
d. 'What are the technical criteria for comparing the construction methods?'

The subsidy housing sector is applicable to this study; therefore, it is important to determine which challenges are faced by this sector. Additionally, to compare the construction methods, it is important to know what each construction method entails. In terms of a suitable

construction method, technical and non-technical criteria need to be identified to compare these construction methods.

1.3 Hypotheses

A research hypothesis is an expected outcome of a research study and is proven or disproven in the study (Oakland University, n.d.). There are two types of hypotheses: the null hypothesis and the alternative hypothesis. In terms of this study, the hypotheses are formulated as follows:

a. Null hypothesis (H_0): Regarding community progression, prefabricated concrete is not a suitable alternative (compared to brick-and-mortar) for building subsidy houses.
b. Alternative hypothesis (H_a): Regarding community progression, prefabricated concrete is a suitable alternative (compared to brick-and-mortar) for building subsidy houses.

The essence of the study is to determine whether concrete prefabrication is a suitable alternative for the construction of subsidy houses to assist with the progression of communities. Both abovementioned hypotheses are possible outcomes of the study, but the study should prove which hypothesis is correct.

1.4 Significance of the Research

The results of this study aim to address the identified challenges faced by the subsidy housing sector in South Africa and, ultimately, advance the lives of the poor and homeless. Furthermore, the study shows that the process of providing houses is complex and that it goes further than just satisfying physical needs. Therefore, technical and non-technical aspects are considered. Additionally, the study makes the reader aware of needs and preferences of beneficiaries regarding housing. Moreover, it aims to highlight the advantages and disadvantages of each considered building method. Lastly, technical and non-technical criteria for future comparison of construction methods for subsidy houses, are developed.

1.5 Scope

For this research there are limitations, which narrow the scope of the study. Geographically, this study is limited to the City of Cape Town and Cape Winelands districts. The reason for

limiting the study geographically is because cultures differ around South Africa and each different culture might have different preferences.

Additionally, only state-subsidised houses are considered. Therefore, houses where the state built the houses with the subsidy amount and beneficiaries are given a title deed. The subsidy houses are thus owned by the beneficiaries. Any other form of tenure is excluded because these housing typologies tend to differ from subsidised houses, such as social housing that are apartment-type units. For this study, detached and semi-detached houses are considered. It is necessary to limit the housing typology for an accurate cost comparison.

Furthermore, the study investigates the walling systems. Therefore, prefabricated concrete foundations and suspended floor slabs are not included in the comparison.

1.6 Proposed Research Design and Methodology

For this study, a multimethod qualitative approach was used. This means that different qualitative data collection methods were used. A multimethod approach improves the trustworthiness of the data (Mik-Meyer, 2020). The qualitative methods proposed for data collection, in order, were observations, a desktop study and semi-structured interviews. The goal of these methods was to assist in the identification of technical and non-technical criteria to compare the construction methods.

The aim of the observations was to identify challenges within low-income communities that contain subsidy housing developments. Due to COVID-19 limitations, in-person interviews with residents in these communities were not allowed. Therefore, observations were made by driving or walking through these communities. The identified challenges were then used to identify technical criteria for comparing the construction methods. The views of residents were obtained through community representatives as described in Chapter 3.

A desktop study is suitable for obtaining secondary data from literature. Therefore, to validate the information obtained from the observations, a desktop study was performed. The desktop study was also used to find technical and non-technical criteria for the comparison of the construction methods.

Lastly, semi-structured interviews were used. The theme of the interviews was to obtain the needs and preference of beneficiaries in terms of house design. This theme was chosen due to

the lack of information on this topic. From this, the technical criteria obtained from literature had to be validated.

Semi-structured interviews were chosen because they have the benefits of both structured and unstructured interviews (McIntosh & Morse, 2015). Therefore, it gives the ability to ask follow-up questions during the interview process (McIntosh & Morse, 2015).

Once all the qualitative data had been collected, it was analysed using content analysis. This is described in Chapter 3.

1.7 Brief Chapter Overview

As this study has to do with subsidy housing, a central visual theme related to it is chosen for the research study. As subsidy houses are always painted in a variety of colours, it was thought suitable to give table headings similar colours to these subsidy houses. Also, the chapter overview in Figure 1 is related to the housing theme.

Referring to Figure 1, the study begins by identifying a research question in Chapter 1. All other chapters should link to answering this question. In this subsection, it is discussed how each chapter link to the research question to form the 'golden thread'.

Chapter 2 begins by firstly, identifying challenges that the subsidy housing industry in South Africa face. These challenges, in conjunction with the challenges identified in Chapter 4, are used in the non-technical comparison of the construction methods. Secondly, the benefits that living in a house provide to an individual are discussed. This subsection is of importance for determining the effect of the housing backlog on the non-technical criteria.

Chapter 2 continues by discussing the construction methods under consideration and defining the scope of each construction method. This to ensure an accurate comparison between the construction methods. Lastly, the housing standards that govern the construction of subsidy houses are investigated. By consulting these standards, technical criteria are identified for the construction method comparison.

Chapter 3 is the research design and methodology. This chapter begins by elaborating on the research strategy used in the study. Furthermore, the data collection methods are discussed in a step-by-step fashion. Additionally, the trustworthiness of the data is discussed. This is to ensure that the collected data is an accurate representation of reality. Lastly, the ethical considerations are mentioned to ensure that ethical clearance is obtained for the study.

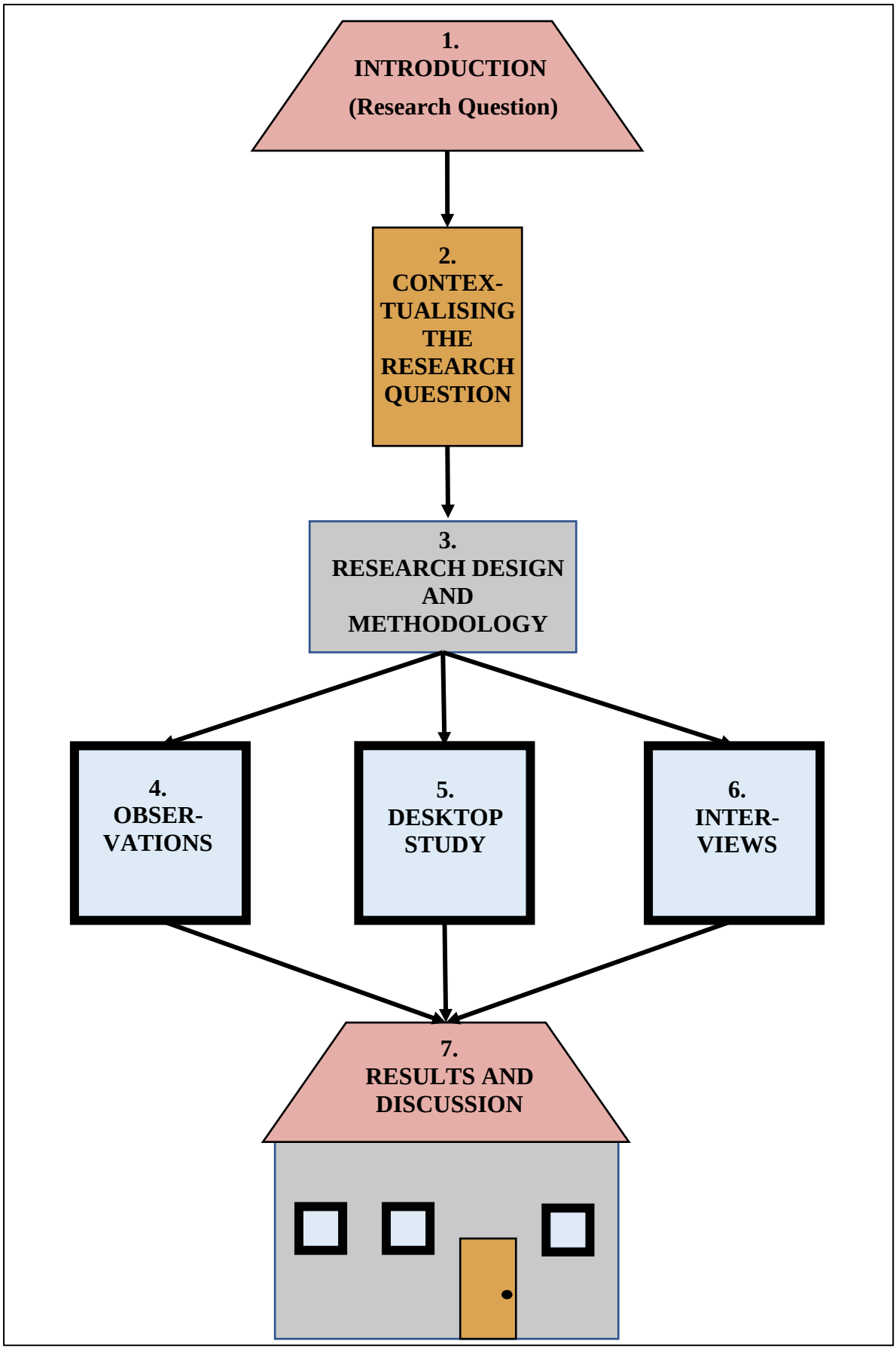

Figure 1: *Visual illustration of the chapter overview for the research study.*

The results from the first data collection method are discussed in Chapter 4. This chapter discusses the observations of the researcher at four low-income communities: Kayamandi, Vrygrond, Hawston and Delft. From these observations, challenges within these communities are identified. These challenges are used in the non-technical comparison of the construction methods.

Chapter 5 discusses the second data collection method. In this chapter, a desktop study is performed to identify technical and non-technical criteria for the comparison of the construction methods. These criteria form an integral part of the study since it is used for comparing the construction methods.

The results of the last data collection method are discussed in Chapter 6. This chapter analyses the data obtained from the interviews. From this data, criteria that are used in the comparison of the construction methods, are identified and discussed. These criteria, in conjunction with the criteria identified in Chapter 5, are used for comparing the construction methods.

Chapter 7 contains the results of the technical and non-technical comparison of the construction methods. This chapter begins by consolidating the challenges identified in Chapters 2 and 4 and identifying which challenges can be addressed by choosing the appropriate construction method. The technical comparison is performed on the consolidated criteria from Chapters 5 and 6. The non-technical comparison is performed on the basis of which construction method best addresses the identified challenges, and the effect of the challenges on the non-technical criteria.

Chapter 8 is the conclusion and recommendations chapter. In Chapter 8 the study is concluded by providing an answer to the research question. Furthermore, it makes recommendations for implementing prefabricated concrete into construction to benefit from its advantages whilst addressing its shortcomings, and it also makes recommendations for future research.

2 CONTEXTUALISING THE RESEARCH QUESTION

The aim of this chapter is to give context to the research question. This is given by firstly, identifying challenges that exist in the subsidy housing sector in South Africa and secondly, by explicating and conveying the benefits of a residential house. Thirdly, the construction methods to be compared, are discussed. Lastly, the reader is informed of the housing standards that govern the construction of subsidy housing, as these standards may contribute to the identification of technical criteria for comparison.

2.1 Subsidy Housing Challenges in South Africa

As discussed in 1.1.2, the housing shortage in South Africa is a major problem. However, the subsidy housing sector in South Africa faces additional challenges and these are discussed in this chapter. These challenges are related to those faced within low-income communities, challenges with the physical house and those with the housing provision process. The aim of the study is to address some of these challenges by choosing a suitable construction method.

2.1.1 Unemployment and Urbanisation

Statistics South Africa makes use of two definitions of 'unemployment rate', the official definition and the expanded definition (Lestrade-Jefferis, 2002). To obtain information regarding unemployment rates, Statistics South Africa performs a Quarterly Labour Force Survey (Statistics South Africa, 2021). The official definition of 'unemployment rate' includes [1] people without work seven days before the survey, [2] people who want to work and can start working within a week of the survey and [3] people who have taken active steps, four weeks prior to the survey, to seek employment or create their own employment (Lestrade-Jefferis, 2002). Before giving the definition of the expanded unemployment rate, it is worthy to define 'discouraged job seekers'. Discouraged job seekers are unemployed individuals who seek to work but have not taken any active steps in seeking employment. A more accurate definition of 'unemployment rate', is the expanded definition of 'unemployment rate'. The expanded unemployment rate includes all unemployed individuals and not just the individuals seeking employment (Lestrade-Jefferis, 2002). Therefore, the expanded definition of 'unemployment rate' includes the individuals in the official definition plus the discouraged job seekers (South African Market Insights, 2020). South Africa had an official unemployment rate of 30.1 percent in the first quarter of 2020 and 23.3 percent in the second quarter (South African Market Insights, 2020). The decrease in unemployment rate during the COVID-19 pandemic

is probably indicative of the increase in discouraged job seekers due to, amongst others, the economic effects of COVID-19. However, South Africa's expanded unemployment rate was 42 percent in 2020 (South African Market Insights, 2020).

Urbanisation is defined as the increase of the population in urban areas, due to a natural increase, migration and the categorisation of rural areas as urban areas (Kok & Collinson, 2006). The natural increase refers to births and deaths in the area, and migration refers to the net movement of people in and out of the area (Kok & Collinson, 2006). Individuals migrate to cities for work opportunities and education (Kok & Collinson, 2006; Mashwama, et al., 2018). Rural areas are sometimes reclassified as urban areas due to the sprawl of urban areas into surrounding rural areas (Kok & Collinson, 2006).

Cities are well known as a place of employment opportunities. Due to individuals' migration to cities to find employment, a link exists between unemployment and urbanisation (Mashwama, et al., 2018). These unemployed individuals are inclined to stay in shacks (Mashwama, et al., 2018). This puts even more pressure on the government to solve the housing shortage (Ratshitanga, 2017).

2.1.2 Insufficient House Size and Spacing

With the two housing subsidy programmes in South Africa (RDP and BNG), different house designs exist. It is important to note that RDP houses are smaller than houses built under the BNG program. RDP houses have a surface area of 30 square metres (Adebayo, 2010; Aigbavboa & Thwala, 2014), while the minimum surface area of a BNG house is 40 square metres (Western Cape Government: Professional and Project Management Services, 2018; Gauteng Department of Human Settlements, 2018). However, the minimum size of RDP houses was only changed to 30 square metres in 1998 (Aigbavboa & Thwala, 2013). Therefore, units exist that have a surface area below 30 square metres, and are referred to as matchbox-type houses.

In a study by Manomano (2013) in the Eastern Cape Province of South Africa, it was found that 80 percent of the 50 participants of the study stated that the spacing in the RDP houses was inadequate. Furthermore, a majority of the participants (64 percent) also stated that the houses are 'small' (Manomano, 2013). In another study by Manomano and Tanga (2018) in the Eastern Cape, 250 participants completed a survey. From this, 91.6 percent of the participants stated that the spacing of their homes is 'very inadequate', while 89.2 percent stated that their homes

are 'very small' (Manomano & Tanga, 2018). This is confirmed in another study of RDP houses in Gauteng by Mashwama et al. (2018), where the size of the house was ranked the biggest challenge faced by occupants.

From these studies, it is evident that the size of and spacing in RDP houses are insufficient. Privacy, confidentiality and hygiene are affected by inadequate sizing and spacing of houses (Manomano, et al., 2016). On the contrary, no sources were found that stated inadequate size and spacing of BNG houses.

2.1.3 Poor House Quality

The sources referring to poor quality of affordable houses, are rife. Sources consulted (and numbered here for reference in Table 1) are [1] Buys and Le Roux (2013), [2] Manomano (2013). [3] Aigbavboa and Thwala (2013), [4] Aigbavboa and Thwala (2014), [5] Juta and Matsiliza (2014), [6] Manomano et al. (2016), [7] Ratshitanga (2017), [8] Mashwama et al. (2018) and [9] Manomano and Tanga (2018). This is not only a feature of RDP houses, but it also occurs in BNG houses. Poor quality and the lack of quality management systems are associated with an increase in rework, which affects the final and maintenance costs of a project (Buys & Le Roux, 2013). From 2012 to 2014, the Department of Human Settlements spent R2.129 billion on the repair of poorly built houses (Department of National Treasury, 2015).

The poor quality of houses is due to four types of defects: design, material, construction and subsurface deficiencies (Buys & Le Roux, 2013). During the design and construction phases, the human causes of house defects are design faults, poor workmanship (Manomano, 2013; Ratshitanga, 2017; Manomano & Tanga, 2018), substandard materials (Manomano, et al., 2016; Mashwama, et al., 2018) and errors in procedure (Stephenson, et al., 2002). Defects commonly occurring in RDP and BNG houses and their sources are listed in Table 1. The number in the column headings refer to the numbered source listed in the first sentence in the first paragraph of this sub-subsection. For example, [3] refers to Aigbavboa and Thwala (2013).

A common quality issue reported in all six sources, is problems with the roof. Some of the problems identified in Manomano and Tanga's (2018) study, was collapsing and leaking roofs. Leaking roofs are also responsible for water damage, which lead to problems such as mould, peeling paint and swelling (Buys & Le Roux, 2013). Other problems include roofing sheets not firmly fixed to the trusses and the trusses not safely secured to the walls (Aigbavboa & Thwala, 2013). Occupants fix this by placing rocks and tyres on the roofs, which hold a safety risk

(Aigbavboa & Thwala, 2013; Manomano & Tanga, 2018). These defects are due to poor workmanship and substandard materials (Aigbavboa & Thwala, 2013).

Table 1: *Commonly occurring quality issues in subsidy houses from literature sources.*

Quality Issues	**[1]**	**[2]**	**[3]**	**[4]**	**[6]**	**[9]**
Roof	X	X	X	X	X	X
Walls	X	X	X	X	X	X
Floors	X	X	X	X	X	X
Doors		X	X	X	X	X
Windows		X	X		X	X
Plumbing	X	X	X	X		
Ceilings			X	X		

Another common quality issue reported in all six sources, is problems with the walls. Wall defects include cracks, detachment of the wall-plaster (Buys & Le Roux, 2013) crumbling (Manomano, 2013) and collapsing of walls (Manomano & Tanga, 2018). Cracks can be cosmetic due to ageing, but it could also be an indication of a more serious problem, such as foundation movement (Buys & Le Roux, 2013). It was also reported in Manomano et al. (2018) that the walls permit wind through it, which indicates that water penetration can also become an issue. These wall defects can be caused by poor workmanship, substandard materials and/or subsurface conditions (Buys & Le Roux, 2013).

The last issue that was raised in all six sources, is floor defects. Problems with floors include cracking (Manomano & Tanga, 2018), unfinished (Aigbavboa & Thwala, 2013) and ground water penetration (Manomano, 2013). Manomano and Tanga (2018) stated that the cracks in some floors are to such an extent where occupants have to wear shoes to prevent injuries. These defects are caused by poor workmanship, poor materials and subsurface deficiencies.

Faulty doors are another prominent quality issue in RDP and BNG houses. Some issues are the direction in which the doors are facing (Manomano, 2013), the doors do not fit the frames (too small), no varnish on the doors (Aigbavboa & Thwala, 2013), improper opening and closing of the doors (Aigbavboa & Thwala, 2014) and improper function (Manomano & Tanga, 2018). Water penetration is an issue due to doors being smaller than the door frames and the absence of varnish on the door. This is illustrated in Figure 2, which was taken during a community visit on a rainy day in Hawston (refer to 4.1.3). Water penetration can also cause the door to

swell, which can contribute to the difficulty of opening and closing of doors. In Manomano and Tanga's (2018) study it was found that the doors in subsidy houses are too weak to perform their function of keeping criminals out. These defects are the result of poor workmanship, substandard materials and poor planning.

Figure 2: *Water penetration in a newly built BNG unit in Hawston.*

The quality of windows is mentioned in four sources. Problems include difficulty of closing (Manomano, 2013), gaps between the window frame and wall, rust of window frames (Aigbavboa & Thwala, 2013) and weakness of the windows (Manomano & Tanga, 2018). It has been stated in Manomano (2013) and Manomano and Tanga (2018), from different participants, that occupants use wire and paper to help close windows. This exposes occupants to the risk of burglary (Manomano & Tanga, 2018). These defects are as a result of poor workmanship, substandard materials and poor planning (Manomano & Tanga, 2018).

Plumbing problems are also common among RDP and BNG houses. Water leaks (Buys & Le Roux, 2013), low water pressure (Aigbavboa & Thwala, 2013), leaking and substandard toilets (Manomano, 2013) are included in plumbing issues. These issues are caused by substandard construction, inferior materials and poor design.

The last quality issue is the lack of ceilings. The absence of ceilings results in extreme temperatures in the house during seasonal changes (Aigbavboa & Thwala, 2014). This means that during the winter, the house is very cold and during the summer, the house is very hot (Aigbavboa & Thwala, 2013). This results in dissatisfaction by the occupants and is caused by poor planning (Aigbavboa & Thwala, 2014).

2.1.4 Poor Locations of Housing Projects

Due to the Group Areas Act of the Apartheid regime, the Black, Indian and Coloured population groups were forced out of the central city areas to semi-urban townships on the peripheries of towns and cities (South African History Online, 2019). However, when the RDP was introduced in 1994, it aimed to rectify the inequalities of Apartheid (South Africa, 1994). Manomano et al. (2016) stated that the location of a house contributes to the growth and socioeconomic empowerment of the recipients.

Nevertheless, RDP houses were still built on the outskirts of towns and cities, which does not promote integration (Aigbavboa & Thwala, 2013; Mashwama, et al., 2018). These neighbourhoods are far from employment opportunities, schools, medical facilities, police offices and other amenities (Manomano, 2013). This is due to poor planning (Manomano, 2013) and the availability of large portions of land at a lower cost (Mashwama, et al., 2018). Juta and Matsiliza (2014) also stated that the availability of land in the Western Cape Province, specifically Cape Town, is a challenge. Poor housing locations result in social issues such as unemployment, crime and prostitution (Manomano, et al., 2016).

2.1.5 Lack of Beneficiary Involvement

A general principle of the Housing Act includes the participation of and consultation with stakeholders in housing projects (South Africa, 1997). Furthermore, it is stated in the White Paper on Reconstruction and Development (1994) that housing projects should attend to the expectations of the targeted recipients. Therefore, a bottom-up approach is required (Manomano, et al., 2016). However, it has been reported in many sources that a challenge with subsidy housing is the lack of beneficiary involvement (Manomano, 2013; Juta & Matsiliza, 2014; Manomano, et al., 2016; Mashwama, et al., 2018). Housing projects are centralised, which means that the project team decide what the needs and preferences of the beneficiaries are (Juta & Matsiliza, 2014).

In the study by Manomano (2013), it was found that consultative meetings were occurring less and that when these meetings took place, they were unproductive and left participants dissatisfied. To contribute to the satisfaction of beneficiaries, the housing process should be decentralised (Juta & Matsiliza, 2014).This will also prevent conflict between government and low-income communities (Juta & Matsiliza, 2014) and the prevention of social issues (Mashwama, et al., 2018).

2.1.6 Inefficiencies

There are various inefficiencies present in subsidy housing projects and they affect the outcome of the project in terms of time, cost and quality. These inefficiencies are caused by slow processes such as procurement and land identification, acquisition and assembling (Ratshitanga, 2017). Furthermore, a lack of communication and accountability, poor management, improper planning (Juta & Matsiliza, 2014) and maladministration (Manomano, 2013) are also causes of inefficient use of resources.

2.1.7 Social Issues

In the study by Manomano (2013) various social issues have been reported, including xenophobia, substance misuse and sexual abuse, specifically against women. Furthermore, Mosavel et al. (2012) state that gangsterism, prostitution, domestic and gender-based violence are also prevalent in communities of low-income. Poor education is another issue in these communities due to factors such as overcrowded classrooms, teacher scarcities and unsafe learning environments (Amnesty International, 2020). The main causes of these issues are poverty and unemployment (Mosavel, et al., 2012).

2.1.8 Poor Infrastructure and Services

According to the literature reviewed by Manomano (2013), it was found that a problem exists with regards to access to clean water. This was confirmed by their study among beneficiaries of RDP houses in Alice, where 92 percent of the participants stated that they did not have access to clean water services (Manomano, 2013). Other infrastructural issues include the absence of streetlights and poor road conditions (Manomano, 2013). The absence of streetlights creates a feeling of insecurity among residents (Manomano, 2013). Also, poor road conditions create a transport challenge, since taxis do not want to drive on poor roads to transport people.

2.1.9 Corruption

The last major challenge that subsidy housing projects face, is corruption. Issues that persist are irregularities in the awarding of tenders to contractors (Mashwama, et al., 2018; Maluleke, et al., 2019) and irregularities in the allocation of houses (Manomano, 2013). This includes the awarding of subsidies to non-qualifying recipients (Maluleke, et al., 2019). Corruption is caused by the misuse of power, a conflict of interest, bribery, favouritism and fraud (Tomlinson, 2011).

This subsection discussed the challenges that are observed in the subsidy housing sector. These challenges were identified for the purpose of determining which challenges can be rectified by choosing a suitable construction method.

2.2 Benefits of Living in a House

Houses are constructed for people and it is therefore valuable to consider the importance of a house to people. There are various benefits that a house can offer, independent of the tenure. These benefits are discussed in this chapter; however, some benefits are limited to certain tenure conditions, but this is clearly stated. It is important to distinguish between tenure options because this study focusses on subsidy housing where the beneficiary owns the house. Living in a house include physical, financial, psychosocial and social benefits and these are discussed in more detail below.

2.2.1 Physical

The physical benefits refer to the benefits that the top structure provides to the physical dimension of an individual. In essence, a house provides shelter, safety, security and health benefits to an individual.

The most significant benefit of a house is the protection against the natural elements. A house not only protects an individual against the elements, but it also protects the individual's valuable assets. Furthermore, a house provides safety and physical security from external dangers and crime (Després, 1991; Somerville, 1997; Parsell, 2012; Dugard, 2020). Therefore, a house is referred to as a shelter (Oswald & Wahl, 2005), a refuge (Després, 1991) and a haven (Kearns, et al., 2000; Ilesanmi, 2011).

2.2.2 Financial

There are various authors that refer to the financial benefit of home-ownership, which include Després (1991), Somerville (1997), Hulse et al. (2010) and Ilesanmi (2011), to name a few. Here it is important to distinguish between the housing tenure. Some advantages are only applicable to homeownership and no other tenure options.

The first financial benefit of a house, only applicable to homeownership, is the house as an asset. According to the 'International Financial Reporting Standards (IFRS) Conceptual Framework' (2018), a house is an asset because it has the potential to generate economic benefits, such as receiving cash when selling it or terminating liabilities when it is transferred. A house as a financial asset can be seen in two dimensions. The first is seeing it as an investment and the second as collateral security for bank loans (Lemanski, 2011). An investment is the procurement of an asset with the aim of increasing the asset's value over time (Merriam-Webster, n.d.). Collateral security refers to an asset that a lender uses to ensure that the borrower does not default on loan repayments (Ali & Haron, 2018).

Internationally, a house is classified as an investment (Després, 1991; Hulse, et al., 2010). Després (1991) made her statement with regards to the United States of America, while Hulse et al. (2010) proved that houses, bought by low-moderate income individuals in Melbourne, did increase in value; thus, making it an investment. However, it is important to investigate whether this is accurate in the South African context. An article by Lemanski (2011) used a case study of an RDP housing project in Cape Town (Westlake Village) to show that the value of RDP houses in this neighbourhood have increased; however, the prices have not increased sufficiently to purchase a better house in a better neighbourhood. Furthermore, Marais et al. (2020) showed, from their study in the area of Mangaung, that the value of houses situated in former (pre-1994) black areas, increased by 7.3 percent from 1991 to 2016. This approximates to South Africa's inflation rate over the same period; therefore, these houses have not increased in value (Statista, 2021).

The proximity of the house to employment prospects, transport networks and amenities is important for determining whether the house is an investment (Lemanski, 2011). The housing market at the stage of selling is also an important factor to consider (Marais, et al., 2020). In summary, based on international evidence and a case study in Cape Town, a house is categorised as an investment for this study.

Owning a property enables the owner to use the house as collateral security when applying for a loan. In the study by Lemanski (2011), it was stated that low-income houses are also eligible as collateral security, with residents in this study-area receiving a mean loan of R108 000. However, there is also evidence that banks are hesitant to finance low-income groups (Pillay & Naudé, 2006; Lemanski, 2011). Furthermore, low-income borrowers are also cautious of using property as security against loans (Pillay & Naudé, 2006; Lemanski, 2011; Dugard, 2020). Nonetheless, properties in low-income neighbourhoods have the potential to serve as collateral security but it is the intentional decision of owners to not use it.

The last financial benefit with regard to homeownership, is using the property as an income-generating mechanism. Landlordism (Lemanski, 2011) and using the property as a business premise (Allan, 2018) are two of these mechanisms (Dugard, 2020). The tenants of additional housing units on the plot, are called backyard dwellers (Brueckner, et al., 2019). Backyard dwellers and spaza shops are a prominent feature in low-income communities.

A financial benefit of living in a home, irrespective of tenure, is the ability to accrue personal belongings (Parsell, 2012). In the study by Parsell (2012) among homeless people, the inability to secure personal belongings, is a problem. Personal belongings are assets and can be sold in times of financial difficulty. Therefore, having a place to store these assets, can be of financial advantage.

2.2.3 Psychosocial

Before investigating the psychosocial advantages of a house, it is important to know what is meant by ‘psychosocial’. How an individual’s psychological aspects affect, or are affected by the social setting, is referred to as the psychosocial notion (Edelmann, 2000; Marmot, 2004). It also includes the interactions in a social situation and how these interactions influence an individual’s thoughts, feelings and behaviour (Clark & Kearns, 2012). Thus, a positive view of oneself in relation to others is supported by a beneficial psychological environment (Clark & Kearns, 2012).

The first psychosocial benefit that a house provides is the sense of emotional security (Kearns, et al., 2000; Hiscock, et al., 2001; Hulse, et al., 2010; Ilesanmi, 2011). This is related to ontological security, which is associated with the confidence of an individual to be himself/herself in society and the reliability of an individual’s social and material environments (Hiscock, et al., 2001; Giddens, 1991). There is evidence to support that ontological security is

related to home ownership (Saunders, 1990; Dupuis & Thorns, 1998); however, it was proven that tenure is not a significant factor in obtaining psychosocial benefit from a house (Kearns, et al., 2000; Ilesanmi, 2011). The sense of security is also related to long-term assurance (Hulse, et al., 2010).

Another benefit of a house is the feeling of safety it instils in occupants (Kearns, et al., 2000; Ilesanmi, 2011). The safety referred to here, is associated with the psychology of an individual and not physical safety. A house is a place of familiarity and comfort (Ilesanmi, 2011). A house, independent of its tenure, is referred to as a metaphoric haven (Kearns, et al., 2000; Ilesanmi, 2011).

Another possible benefit of a house, as a metaphoric haven, is privacy (Clark & Kearns, 2012; Ilesanmi, 2011; Dugard, 2020). Privacy is also linked to dignity. Kearns et al. (2000) specified that the sense of privacy is independent of tenure. However, it was later stated by Hulse and Saugeres (2008) and Hulse et al. (2010) that the benefits of privacy and freedom from surveillance are less in households that rent than at home-owners. It was however stated by Hiscock et al. (2001) and Hulse and Saugeres (2008) that lack of privacy was not solely dependent on tenure but also on the neighbourhoods and housing types and conditions. For instance, less privacy exists in a semi-detached dwelling than in a detached house. However, compared to being homeless or staying in an informal dwelling, residents of a house (independent of tenure) experience privacy to a greater extent. Therefore, based on this, privacy is classified as a benefit of a house in this study.

As stated in the first paragraph of this subsection, ‘psychosocial’ relates to an individual’s view of himself/herself in relation to others. Therefore, another benefit of a house is status (Després, 1991; Somerville, 1997; Kearns, et al., 2000; Hulse, et al., 2010). In the study by Kearns et al. (2000), a majority of the survey participants agreed that the desirability of their house and the feeling of doing well in life, gave them a sense of status. In the context of affordable housing within South Africa, status is obtained in two phases. The first is when a beneficiary is given a subsidy house and the second is when the beneficiary starts to make alterations to the house to improve it.

According to Kearns et al. (2000), Ilesanmi (2011) and Dugard (2020), a house is a location where autonomy can be practised. Autonomy is associated with freedom, control and the embellishment of an individual’s identity (Giddens, 1991; Ilesanmi, 2011; Parsell, 2012). Freedom refers to the ability to act or communicate as one wants to (Merriam-Webster, n.d.).

Furthermore, freedom also refers to the freedom from one's actions and identity to conform to the expectations of others (Kearns, et al., 2000; Dugard, 2020). The freedom to express oneself aids in the formation of one's identity. Furthermore, autonomy is associated with control (Després, 1991; Somerville, 1997; Parsell, 2012). A house offers a space where control can be exercised (Parsell, 2012).

2.2.4 Social benefits

The social benefits of a house refer to the advantages that a house provide to the individual's social interactions within the house and within the community where the house is situated. Research by Watson and Austerberry (1986) articulated the importance of home for social relationships, and Lemanski (2011) classified a home as a social asset. Engelhardt et al. (2010) proved that the social benefits are independent of tenure.

Within an individual's personal social interactions, a house offers a space to host. In research done under homeless individuals in Brisbane by Parsell (2012), these individuals stated that home was a place where one can entertain friends and family. A house presents a space where human relationships can be built. Hulse et al. (2010) confirms that social relationships improve with home ownership. This is related to the psychosocial benefits of privacy and autonomy.

Furthermore, a house provides the ability to be a part of and get involved in a community and take part in community activities. In many of these neighbourhoods there are community centres and sports centres where socialising is made possible. Since these areas are rife with social issues, many committees exist in the community to address these issues, for example housing committees.

In this subsection, the benefits of living in a house were identified. Establishing the benefits of residing in a house, highlights the importance of addressing the challenges experienced in the provision of subsidy house. Therefore, by addressing the backlog, these benefits can be experienced by beneficiaries.

2.3 Construction Methods for Comparison

The first goal of this subsection is to inform the reader of the meaning of each construction method. It is important to distinguish between the construction methods under consideration and other construction methods that could fall under the descriptions of the construction

methods under consideration. Furthermore, this subsection also explains why brick-and-mortar construction and prefabricated concrete construction are chosen for comparison.

2.3.1 Brick-and-Mortar

Brick-and-mortar construction is chosen for comparing to the prefabricated concrete construction, because it is the dominant method of construction for subsidy houses in South Africa (Windapo, et al., 2021). Conventionally, the affordable housing sector in South Africa uses concrete blocks for the external walls (Windapo, et al., 2021). According to the norms and standards document of the Western Cape Government (2018), exterior walls are to be constructed from 140 mm hollow core concrete blocks with a minimum strength of 3.5 MPa for single storey houses and 7 MPa for double storey houses. Furthermore, both the external and internal surfaces are to be plastered and the external surface is painted (Western Cape Government: Professional and Project Management Services, 2018).

2.3.2 Prefabricated Concrete

Prefabricated concrete construction is chosen as an alternative construction method to brick-and-mortar for subsidy housing, based on its advantages. Advantages of prefabricated concrete include its high-quality finishes, faster construction time and its ease of installation (Karthigai Priya & Neamitha, 2018). These advantages may assist in addressing some of the challenges experienced in the subsidy housing sector.

The concept of prefabrication is wide; however, this study focusses on prefabricated concrete. Prefabricated concrete refers to elements that are manufactured in a controlled environment at a different place (on-site or off-site) to its final position. Furthermore, it should be manufactured from a material that contains cementitious material, such as a solid concrete panel. Extending this definition further, if it is a composite, such as a sandwich panel, at least one of the constituents must contain cementitious material. Concrete is a widely researched topic and numerous new types of concrete mix designs are developed and these new types of concretes are also included in this definition if it contains cementitious material. An example of this is fibre reinforced concrete.

Lastly, various systems of prefabricated concrete construction methods exist. Figure 3 shows various prefabricated concrete systems, from left to right, a complete housing unit, complete wall panels and slit panels.

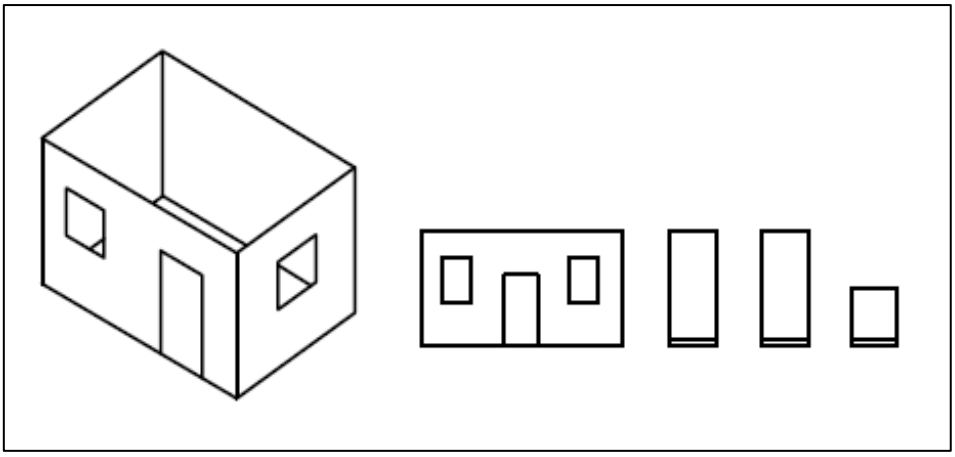

Figure 3: *Various prefabricated concrete systems.*

The prefabricated concrete system can be adapted in any feasible way, considering it is modular and manufactured in a different place to its final position. There are also numerous methods of joining the modular elements.

2.4 Housing Standards

This subsection explains the function of five role players of housing standards. This aims to inform the reader of housing standards that govern the construction of subsidy houses in South Africa. All subsidy houses should comply to the said standards.

The National Building Regulations and Building Standards Act of 1977 governs all construction in South Africa and is incorporated in various role players (Council for Scientific And Industrial Research, 2019). In terms of housing standards, there are five role players to be cognisant of: National Building Regulations (NBR), South African National Standards (SANS) 10 400, National Home Builders Registration Council (NHBRC), provincial minimum standards for subsidised houses and Agrèment South Africa. SANS 10400 and the NHBRC's Home Builders Manual are both dependent on normative reference standards for designs relating to specific materials (De Villiers, et al., 2021). Each of these role players are briefly discussed in this subsection.

The National Building Regulations are a group of functional requirements as enabled by the National Building Regulations and Building Standards Act (SABS, 2010). Functional requirements are high-level requirements and do not give specific detail on how the requirement can be achieved, which is performance requirements. For instance, it would state that a house should not leak water, but it would not give detailed specifications on how leak-

prevention can be achieved. Therefore, the other four role players are responsible for setting performance requirements.

The SANS 10 400 document is issued by the South African Bureau of Standards (SABS) and serves as a code of practice for the application of the NBR. This document presents the regulations (as from the NBR) and explains how it should be interpreted and how it can be satisfied, the so-called 'deemed-to-satisfy rules' (SABS, 1990, p. 11). Following the rules in this document ensures the construction works satisfy the NBR. This document contains standards for walls, roofs, foundations, floors, ventilation and other standards regarding construction.

The NHBRC was established in 1998 under the Housing Consumers Protection Measures Act as a regulatory body (NHBRC, n.d.). The NHBRC's mandate is to provide warranty protection against faults; thus, ensuring the construction of quality homes. Furthermore, under the Act, it should establish standards for the home building industry, which it did through the creation of its Home Builders Manual (NHBRC, n.d.). As a regulatory body, any home-constructor is required by law to register with and be certified by the NHBRC (NHBRC, n.d.). The Housing Consumers Protection Measures Act of 1998 also states that all new houses should be registered with the NHBRC.

The provincial governments also establish minimum norms and standards for subsidised houses. These minimum standards comply with the NBR and incorporate the SANS 10 400 and the NHBRC's Home Builders Manual. In the case of the Western Cape's Minimum Standards for Subsidised (BNG) Houses (2018), it includes standards for the house design, foundations, walls, floor slabs, plumbing, windows, doors, roofs and ceilings. In both the Western Cape and Gauteng Province's minimum norms and standards documents, only brick-and-mortar is accounted for as a walling system.

SANS 10 400, NHBRC's Home Building Manual and provincial government's minimum norms and standards all contain detailed specifications. However, when a building system defers from these standards, it needs to be certified by Agrèment South Africa or a competent person (SABS, 2010). This assessment of a new construction system is based on performance criteria, such as structural integrity, thermal and acoustic performance (Agrément South Africa, 2010). Once approved by Agrèment South Africa, the system may be used for future construction.

In terms of urban planning, the CSIR's Neighbourhood Planning and Design Guide is helpful. It contains information regarding the layout of residential developments and factors to consider regarding placement of houses, housing typologies and the placement of social amenities.

This subsection aimed at informing the reader of the role players in terms of housing standards. Furthermore, it highlights the sources and bodies to consult when constructing a subsidy house or developing a new method of construction. The standards in these documents were also used to help determine technical criteria for the comparison of construction methods later on in this thesis.

2.5 Chapter Summary

This chapter began by identifying challenges that are experienced by the subsidy housing sector in South Africa. It is important to identify these challenges since some of these challenges can be addressed by choosing a suitable construction method. Furthermore, it was found from this chapter that living in a house has physical, financial, psychosocial and social benefits to the occupants. This is of importance for the comparison of the construction methods on non-technical criteria. The construction method that can best address the housing backlog, that is provide these benefits to beneficiaries, has the advantage.

Furthermore, this chapter made the distinction between brick-and-mortar and prefabricated concrete construction by explaining what is meant under each construction method. For brick-and-mortar construction, the use of hollow-core concrete blocks is included under this description. For prefabricated concrete, it is stated that solid concrete units and composite units are included under this description, given that they contain cementitious material, and the units are manufactured in a different location to their final position.

Lastly, the housing standards that govern the construction of subsidy houses, were also discussed. From these standards, technical criteria can be identified for the comparison of the two construction methods.

3 RESEARCH DESIGN AND METHODOLOGY

The goal of this chapter is to discuss the research design and to provide the steps that were followed in the data collection process. Furthermore, the trustworthiness of the data and ethical considerations are discussed.

3.1 Research Design

The aim of this subsection is to inform the reader of the research strategy used for collecting data. The rationale for using a qualitative approach is explained, based on the advantages of the approach. Furthermore, it is briefly discussed how the disadvantages of a qualitative approach are counteracted.

3.1.1 Choice of Research Design

For this research, a multimethod qualitative approach was adopted for data collection from participants. A multimethod approach is research that uses multiple qualitative or quantitative methods of data collection (Mik-Meyer, 2020). This research comprised observations, a desktop study and semi-structured one-on-one interviews. The aim of these methods was to obtain technical and non-technical criteria against which brick-and-mortar and prefabricated construction can be compared.

The data collections methods used, are mentioned in order of performance. Firstly, observations, by means of driving and walking through low-income neighbourhoods, were chosen as research method to visually experience the dynamics of the communities and to identify challenges faced within these communities. These identified challenges (from the literature review and observations) contributed to the identification of criteria. Secondly, a desktop study was done to identify technical and non-technical criteria for the comparison of the construction methods. Lastly, semi-structured interviews were conducted with three participant groups: architects and urban planners, government officials involved in housing and activists fighting for the right to adequate housing, hereon called housing activists. The theme of the interviews was to obtain information regarding the needs and preferences related to the house design of potential and existing beneficiaries of subsidy houses. This would assist in finding and/or validating criteria for the comparison of the construction methods.

3.1.2 Rationale for Qualitative Approach

Qualitative research is a subjective research strategy aimed at gaining insight into the understanding of an experience or interaction from the viewpoint of the participant (Bell, et al., 2019). Rahman (2017) identified numerous advantages of the qualitative research strategy. Firstly, a qualitative approach gives a detailed explanation to the emotions, sentiments and experiences of the participants (Rahman, 2017). Secondly, since the researcher is directly involved (Graue, 2015), the context in which data is collected, is understood (Rahman, 2017). Thirdly, also due to the closeness of the researcher, the data collection is subjective (Rahman, 2017). Lastly, the qualitative approach is flexible in structure and can be steered in the direction the researcher intends (Rahman, 2017).

However, the qualitative approach also has disadvantages. Firstly, the credibility of qualitative results is questioned (Rahman, 2017). Secondly, due to a smaller sample size, the issue is raised whether the results are representative of the whole population (Rahman, 2017). Lastly, the qualitative research procedure is time-consuming (Rahman, 2017).

A qualitative research method was chosen due to COVID-19. COVID-19 brought about restrictions in movement and physical contact and thus prohibited any in-person research methods. A quantitative research strategy (questionnaires) was initially considered. The targeted participant groups were beneficiaries of subsidy houses (i.e. families already staying in subsidy houses) and potential beneficiaries of subsidy houses (i.e. families staying in informal houses). Due to restrictions on performing in-person research, all research had to be done online. However, due to economic circumstances of the participant groups, they would not necessarily have access to smartphones, laptops and/or mobile data to take part in online research methods.

This led to the change of the participant group to people that are involved in subsidy housing but do not necessarily stay in a subsidised house. More on this in Table 2 in 3.2.2(iii). However, these participants are not able to give an accurate quantitative representation of the needs and preferences of the beneficiaries in terms of house design. This would lead to inaccurate results in the data analysis. Therefore, it was chosen to use a qualitative research design.

Based on the actual participant groups, a qualitative research design is deemed a better approach than a quantitative approach. A questionnaire requires concise answers and due to the participants' lack of experience of living in a subsidy house, the context in which he/she

answers it is of importance. The participant has the ability to add additional detail to the answer by sharing past experiences or retelling someone else's experience. As stated by Rahman (2017), a quantitative strategy is a snapshot; therefore, without the right context, the analyser may interpret the data incorrectly. Furthermore, a qualitative approach is also more suitable because the knowledge of the participant groups is experience, and it is therefore important to create the environment for them to share their knowledge and experience.

However, this approach does have disadvantages and the effects thereof should be limited. To address the credibility factor, it should be stated that various literature sources related to affordable housing made use of a qualitative approach (Botes, 2013; Theart, 2014; Manomano & Tanga, 2018; Mashwama, et al., 2018; Grady, et al., 2019). These sources are used throughout this document and their relevance is thus demonstrated. In terms of the sample size issue, Darlington and Scott (2003, p. 18) stated that, 'If one considers the unit of attention as the phenomenon under investigation *(in this study the method of construction)*, rather than the number of individuals, then the sample is often much larger than first appears'. Therefore, including all data collected via the multimethod approach, increases the sample size. Lastly, by using a multimethod approach, the trustworthiness of the results is improved (Mik-Meyer, 2020).

This subsection addressed the research strategy and provided the motivation for the chosen strategy. The steps that were followed to perform these data collection methods are discussed in the next subsection.

3.2 Research Methodology

To assist with the identification of technical and non-technical criteria against which the construction methods can be compared, observations, a desktop study and semi-structured interviews were used. The observations were used to find challenges within low-income communities. A desktop study was done to find technical and non-technical criteria to compare the construction methods, which aims to assist in addressing the identified challenges. To further enhance and/or validate the identified criteria, semi-structured interviews were conducted.

In this subsection, the different research methods and the procedures followed in developing these methods, are discussed. However, the desktop study is not discussed in more detail since it entails the search for literature; thus, explaining the steps is redundant to any researcher.

Although the identification of criteria is limited to the South African context, the literature with regards to the relevant criteria were researched in-depth internationally.

3.2.1 Observations

The aim of using direct observations in this study was to gain an understanding of the dynamics in the communities and to identify challenges faced within these communities. The observations made were also mentioned in interviews to enhance the results of the interviews. The steps that were followed for making the observations, are discussed below.

(i) Step 1: Selection of Communities

No communities were identified by the researcher for observations. In the process of contacting potential participants for interviews, some recipients offered to show the researcher around in their community of interest. The only criterion for attending the community visit was that the community had to contain subsidy houses, whether it was newly built or existing. This was imperative since the aim was to identify challenges within such communities; whether it was challenges with the actual building or social issues. Therefore, the selection process was not rigorous since the observation process was unstructured.

(ii) Step 2: Performing the Observations

Observations were made by walking and/or driving through the communities. As stated by Kawulich (2005), observations help researchers understand the context of the study better. During the observations, the researcher was accompanied by the volunteer who offered to take him on the visit. While driving and/or walking through the communities, the researcher made handwritten notes about his observations. Photos were also taken as reminders of certain phenomena.

(iii) Step 3: Reflection

After the observations, the cryptic field notes were formalised into a more structured document, that is sensible for future use. Photos were also reviewed to ensure that details that were not noted in the field notes, were also added to the structured documents.

3.2.2 Semi-structured Interviews

Semi-structured interviews were used to assist in finding and/or validating criteria for the comparison of the construction methods. It was decided on a semi-structured format because this format contains the benefits of both a structured and unstructured format (McIntosh & Morse, 2015). With a semi-structured format, there are a set number of questions to be answered but the researcher has the flexibility of asking follow-up questions as the interview progresses (McIntosh & Morse, 2015). The steps that were followed, are discussed below.

(i) Step 1: Design of Interview Questions

The interview questions were developed by the researcher. The aim of the interviews was to obtain information regarding the needs and preferences of beneficiaries, specifically in terms of the design of subsidy houses. The questions were thus formulated in a manner to ultimately determine what do beneficiaries prefer and need in the design of a house. Refer to the interview questions in APPENDIX B: Interview Questions.

Although a standard set of questions was asked to all participant groups, some wording in the questions was changed to make the questions applicable to the occupation of the participant. The core of the questions remained the same, just the manner in which it was asked, changed. Refer to Appendix B.1: Government Officials to Appendix B.3: Housing Activists (see definition under Section 3.1.1) to see how the questions were differently formulated. Each question will now be discussed separately to understand the goal of each question.

Referring to APPENDIX B: Interview Questions, the goal of the first question was to determine how architects and government officials decide on the physical properties of a subsidy house. This refers to physical properties such as erf size, number of bedrooms, the size of the units, the walling system used, and similar other properties. However, since this decision is not bestowed upon housing activists, the question was changed to ask what they think the preferences are of beneficiaries in terms of the similar physical properties of a subsidy house. In this way, the rationale of the architects and government officials can be compared to the perceived preferences of the beneficiaries.

The aim of the second question was to determine whether the needs and preferences of the beneficiaries are considered when designing a subsidy house. Factors included in this question were family size, the number of adults, accessibility requirements, building materials and living

conditions such as temperature of the house. The question was asked from a design perspective for architects and government officials and from the experience of housing activists.

The third question was asked to determine whether provision is made for future extension to the subsidy house. This is important for the income-generating benefit of residing in a house, which contributes to poverty alleviation. Furthermore, this is also important for the alteration capability as the beneficiaries' needs change.

The aim of the fourth question was to compare the viewpoints of the various participants on what is considered a successful design. The idea was to find common characteristics among the participant groups.

The last question, gave the interviewee the opportunity to add any additional information he/she deemed helpful to the research. A semi-structured interview format gives this freedom and is helpful in obtaining any additional information that was not treated in the interview.

Referring to Appendix B.1: Government Officials, the interviews with government officials contain an extra question, question 5. The aim of this question was to determine whether the government takes social and economic factors into consideration when developing a new housing initiative. These factors are covered in the BNG Housing Policy (2004); however, it has been stated by Ratshitanga (2017) that the policy is not implemented. Therefore, this question was asked to determine whether the lack of implementation of the BNG Policy sources from the lack of consideration for social and economic factors in housing developments.

(ii) Step 2: Sample Size Determination

After the design of the interview questions, it was important to determine the sample size, in other words how many individuals to interview. However, contrary to a quantitative inquiry, there are no specific rules to sample size (Strydom, 2021). It was stated by Strydom (2021) that the collection of qualitative data is focussed on quality and data saturation, rather than quantity. 'Data saturation' is achieved once no new information is obtained from the interviews and that the newly collected data is just a confirmation of previously collected data (Anderson, 2017; Geyer, 2021). Furthermore, Strydom (2021) stated that data saturation is the most important factor in qualitative research.

Initially, the aim was to conduct 15 interviews in total; five of each participant group. It is stated by Strydom (2021) that data saturation could occur after 13 to 15 interviews. It was decided on a small sample size since the interviews were only used to validate and enhance the

information from the desktop study and observations. Therefore, the outcome of the study is not fully reliant on the results of the data but data-collection was rather done to enhance the study. Due to a low response rate and the prohibition of doing in-person interviews, only 12 interviews were conducted. However, data saturation was still achieved.

(iii) Step 3: Participant Selection

Participant selection is an important part of the research process. Anderson (2017) emphasised the importance of participant selection to rigor. Rigor is the characteristic of research being in-depth and accurate (Cypress, 2017). Furthermore, Cypress (2017) states that trustworthiness is the core of rigour in a qualitative study. Therefore, selecting suitable participants is imperative to the trustworthiness of the data.

As mentioned before, three groups of participants were identified for data collection. Firstly, architects and urban planners were identified as participants since the goal of the data collection process was to obtain information regarding subsidy housing design. Architects and urban planners are responsible for the design of the houses and have experience with providing designs to the needs and preferences of people. Secondly, housing activists were identified due to their contact with beneficiaries and potential beneficiaries in low-income communities. Lastly, government officials involved in subsidy housing developments have been identified because they are the providers of subsidy housing. These participants are representative to both sides of the spectrum; it contains the providers of subsidy houses (government officials), beneficiaries of subsidy houses (housing activists) and the group that combines these ends of the spectrum (architects and urban planners). The list of participants is presented in Table 2.

Two sampling methods were used to find participants for the research. Both of these methods are non-probability methods, since the size of the population is unknown, which means that a probability of selecting a particular individual cannot be calculated (Strydom, 2021). The first method used was the purposive sampling method. This method was used for recruiting government officials and architects.

The purposive sampling method involves the identification and selection of participants that are deemed knowledgeable on the topic of research (Palinkas, et al., 2015). To ensure that participants with knowledge of housing developments were recruited, the human settlements departments of local, district and provincial municipalities were contacted. In some cases, the engineering department was also contacted. Furthermore, specific reference was made to an

individual with experience of subsidy housing developments. Contact was made via emails and phone calls with the following municipalities:

a. Stellenbosch Municipality
b. Drakenstein Municipality
c. Witzenberg Municipality
d. Breede Valley Municipality
e. Langeberg Municipality
f. Cape Winelands District Municpality
g. City of Cape Town Municipality
h. Western Cape Government Human Settlements Department

However, as seen in Table 2, only three government officials were willing to participate in the interviews. All three participants have experience in subsidy housing developments. Of the three participants, two are architects and one is a building control officer.

The purposive sampling method was also used for the recruitment of architects. The process started by identifying architectural firms in the area of study, City of Cape Town and Cape Winelands District. The results were then refined by identifying firms that have done work on subsidy housing projects. Six firms were contacted by means of emails and/or phone calls. As seen in Table 2, all six firms agreed to having interviews. All participants have qualifications in architecture and some with additional urban planning qualifications. Furthermore, all participants have experience with designing subsidy houses.

Table 2: *List of all interviewees, their occupation and their area of influence.*

Participant Number	Occupation	Area of Influence
1	Architect and Urban Designer	Cape Town
2	Architect	Johannesburg
3	Architect	Stellenbosch
4	Architect	Paarl
5	Architect	Stellenbosch
6	Architect and Urban Designer	Cape Town
Total	**6**	

Participant Number	Occupation	Area of Influence
7	Government Official	Western Cape Province
8	Government Official	Western Cape Province
9	Government Official	Ceres
Total	**3**	
10	Housing Activist	Kayamandi, Stellenbosch
11	Housing Activist	Kayamandi, Stellenbosch
12	Housing Activist	Jamestown, Stellenbosch
Total	**3**	
Total Number of Participants	**12**	

Finally, the snowball sampling method was used for the recruitment of housing activists. Snowball sampling is used when there is limited access to suitable participants (Strydom, 2021). Snowball sampling involves identifying one respondent that has knowledge on the research topic and then asking that participant to refer you to other possible respondents, thus growing the database of potential respondents (Strydom, 2021). The process of recruiting housing activists began when the contact details of a housing activist was obtained. From there, the contact details of other housing activists were attained to increase the database of potential respondents. Contact was mainly made through phone calls, although some were emailed too. The response from housing activists was poor. Only 25 percent of those contacted agreed to being interviewed. All participants lived in low-income communities and are activists within that community. Participant 10 works fulltime for a community-based organisation, whereas Participants 11 and 12 are volunteers for community-based organisations. Refer to Table 2 for information pertaining to their area of influence. The participants are either part of housing forums, civic or community-based organisations.

(iv) Step 4: The Interview Procedure

Once respondents confirmed their participation in the study, a date and time for the interview was arranged. This was either done telephonically or over email. Due to COVID-19, all interviews were conducted online. Prior to the interview all relevant information in the form of an interview guideline, was sent to the participant via email. The interview guideline included the ethical documents and the interview questions. Either Zoom or Microsoft Teams was used.

The interviews with two of the housing activists were conducted telephonically, as per their preference. Lastly, interviews were conducted in either English or Afrikaans, as per the preference of the participant.

The interview started by providing a brief introduction to the research and to the goal of the interview. Due to the semi-structured nature of the interview, additional questions were asked as the researcher deemed necessary. Interviews lasted between 45 and 60 minutes.

Advantages of performing virtual interviews are that it is convenient. It saves money and travelling time (Geyer, 2021). However, the exclusion of individuals without the necessary technology or internet access is a major disadvantage, especially when conducting research with less privileged individuals (Geyer, 2021).

Furthermore, the advantages of telephonic interviews are that a smart phone is not required and it saves travelling time (Geyer, 2021). However, disadvantages include the high costs of calls and the absence of facial expressions (Geyer, 2021), which affects the semi-structured interviews since many follow-up questions are based on behaviour and facial expressions.

(v) Step 5: Transcriptions

Every interview was recorded, with consent, for reviewing purposes. This was done by either using the online platform's recording function or the recording function of a cell phone. It is agreed among qualitative researchers that interviews should be transcribed (Geyer, 2021). From these recordings, the interviews were either manually transcribed or by means of software. Otter.ai (2021) is the online-based software used for the transcriptions.

The process of manually transcribing involved listening to the recording, pausing it and typing it verbatim in a Microsoft Word document. A naturalistic approach was taken in the transcription process. This means that idiosyncratic elements such as pauses and stutters were included in the transcription (Geyer, 2021). The automatic transcription process, by using Otter.ai (2021), was faster but the transcription still had to be moderated for mistakes. Afrikaans interviews were manually transcribed by the researcher.

(vi) Step 6: Data Analysis

For the analysis of the qualitative data, content analysis was used. Content analysis entails the coding and categorising of qualitative data to determine trends and relationships in data (Vaismoradi, et al., 2013). Content analysis only involves the coding of the data (Cohen, et al.,

2017). Various methods of code identification exist; deductive means that codes are determined prior to analysis and then searched for in the data, inductive means that codes are identified during the data analysis and abductive means that codes arise iteratively (Leech & Onwuegbuzie, 2007).

Once the codes are identified, different methods exist of analysing the codes to identify trends in the data. A thematic analysis, also known as a constant comparison analysis (Leech & Onwuegbuzie, 2007), analyses the codes qualitatively by grouping similar codes into themes (Vaismoradi, et al., 2013). In contrast, classical content analysis analyses the codes in a quantitative manner by, instead of creating themes, counting the occurrence of the codes (Leech & Onwuegbuzie, 2007).

To explain the coding process, it is imperative to know what a code is. Schurink et al. (2021) describes a code as a placeholder for a certain meaning which is ascribed to a unit of qualitative data. Colours or numbers can be used to distinguish between different codes, when coding is done manually (Schurink, et al., 2021).

The process of data analysis is explained in the following wording: From the observations and the literature review, initial codes had already been identified before the data analysis process. This is called deductive code identification. After transcribing all the interviews, the researcher reread all the transcriptions to familiarise himself with the data. The goal of this is to make observations and to generate provisional ideas about the data in relation to the aim of the interviews (Schurink, et al., 2021). During this process, codes were identified from the text and written down, but they were not yet assigned to quotations. This is inductive code identification.

Once codes had been identified both deductively and inductively, the process of coding began. The process of assigning codes to units of texts in the transcriptions, is called coding (Schurink, et al., 2021). The interviews that were transcribed in Afrikaans were not translated to English for the coding process. With the researcher being fluent and skilled in both Afrikaans (home language) and English (first additional language), it was not deemed necessary to translate any transcriptions. Furthermore, the coding process was done manually by the researcher; therefore, the integrity of the data is not affected by the language difference.

ATLAS.ti version 9 for Windows was used for the coding process and analysing the qualitative data. With ATLAS.ti, codes can be assigned for quotations and the software counts the occurrences of each code. Similar codes can also be categorised into broader code groups.

Once all codes were assigned, data analysis began. Firstly, the data was analysed quantitatively to determine which codes or code groups occurred more frequently. This is called classical content analysis. Codes that occurred less frequent and did not contribute to the aim of the study, were omitted for further analysis.

From the remaining codes and code groups, a theme, in line with the expected outcome of the interviews, was identified. This is called thematic analysis. A theme is a grouping of codes or code groups that have similar features (Schurink, et al., 2021). In this case, codes and code groups that influenced the comparison of the construction methods, were grouped as a theme. This was the only theme of importance to the research; however, other themes can also be identified for another goal.

Once these codes and code groups, related to the theme, were identified, they were qualitatively analysed. Analysing the data entailed reading and analysing the quotations from the transcriptions that are associated with a specific code. In this manner, the context of the code is understood and an accurate conclusion can be made of what was meant by the interviewee. Once this was done, the conclusion was written, referring to quotations in the transcriptions, to inform the reader.

3.3 Trustworthiness

To ensure the trustworthiness of the research and the information gathered through the various techniques, a multimethod approach was taken. It was stated by Mik-Meyer (2020) that a multimethod not only enhances the quality of information gathered, but it also improves the trustworthiness of the results.

The challenges that were identified in the literature review (refer to subsection 2.1) validated the identified challenges gathered from the observations. Therefore, other authors agreed with the observations performed by the researcher. These challenges, in conjunction with a desktop study, assisted in identifying technical and non-technical criteria that could be used to compare the construction methods. However, interviews were conducted to add new criteria or to validate the criteria found from literature. Based on this, the trustworthiness is improved since each data collection technique is validated by another data collection technique.

Lastly, sample size is typically to be considered in determining the trustworthiness of a study (Anderson, 2017). Various authors suggest various numbers of individuals for interviews; however, it is stated by Geyer (2021) that the data determines the sample size and not the

researcher. Geyer (2021) further states that data saturation is of importance in qualitative research. In terms of this study, data saturation was obtained among the interviewees, but information was also confirmed from the other data sources.

In conclusion, the data gathered in this study can be regarded as trustworthy because all information gathered through one method, was validated by another method. It was also ensured that the processes followed in each data collection method ensured accurate results.

3.4 Ethical Considerations

Ethical clearance had to be obtained from Stellenbosch University's Research Ethics Committee (REC) for the semi-structured interviews because it involved the interaction with human participants (Senate Research Ethics Committee, 2016). The letter of confirmation from the Stellenbosch University's REC is added in APPENDIX C: Ethical Clearance.

3.5 Chapter Summary

The aim of this chapter was to inform the reader of the research strategy and data collection methods that was used in the study. Additionally, the trustworthiness and ethical considerations were also discussed.

It was found that a multimethod qualitative method was most appropriate for the study. Observations, a desktop study and semi-structured interviews were used as the data collection methods. In terms of trustworthiness, the multimethod approach ensured the validity of the data. Finally, it was mentioned that ethical clearance was obtained from Stellenbosch University's REC.

4 OBSERVATIONS

This chapter contains the results from the observations in low-income communities. As the goal of the observations was to identify challenges in low-income communities, this chapter concludes with the prominent challenges identified in Kayamandi, Vrygrond, Hawston and Delft. The technical differences between various housing options as encountered in these communities are therefore not explored in depth.

4.1 Current Housing Status

This sub-subsection serves as a background to the current housing situation in four low-income suburbs in the Western Cape Province. This account is based on drives and walks through each township and observations made by the researcher. Figure 4 shows the locations where the observations were made. An informal approach was taken with the observations, which means that a check list was not used. Therefore, the theme of the observations at the different locations is similar but the results are not necessarily comparable since different things stood out from different locations.

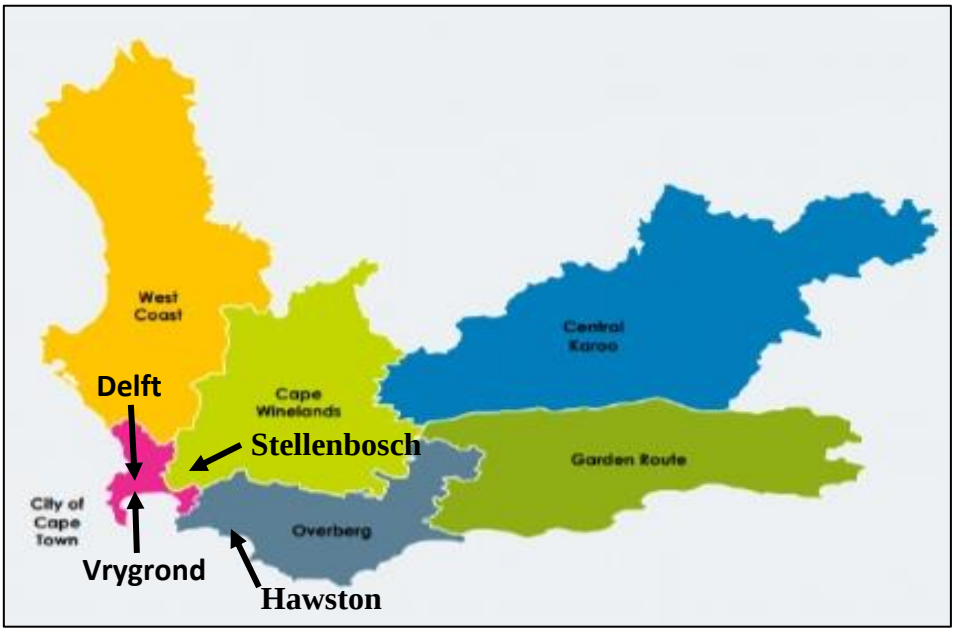

Figure 4: *Map of the Western Cape showing the locations where observations were made (adapted from Western Cape Government (2020)).*

4.1.1 Kayamandi, Stellenbosch (Cape Winelands district)

Kayamandi is situated on the outskirts of Stellenbosch and was established in 1941 (Rock, 2011). According to the 2011 census, Kayamandi had a population of approximately 25 000 (Statistics South Africa, 2011). The majority of the population (95 percent) in Kayamandi is classified as 'Black African' and the prominent language spoken is isiXhosa (Statistics South Africa, 2011). Many of the residents originated from the Eastern Cape, specifically from the previously known Transkei and Ciskei (Rock, 2011).

During a drive through Kayamandi, the researcher observed five types of residential units. The types of units are prefabricated concrete units, brick-and-mortar units, timber units (similar to a Wendy house), steel prefabricated units and informal houses (shacks). Based on the types of pipes present on the outside of the house, only the brick-and-mortar and steel prefabricated units have toilets. Communal toilets exist around the township, and it is assumed that the residents of the other types of houses use these communal toilets. The conditions and hygiene of these communal toilets are poor.

The most prominent characteristic of this township is the proximity of neighbouring houses to one another. This is not only a feature in informal houses but also at state-provided houses. This is confirmed in Figure 5, where it can be seen how these houses were built close to each other. In one instance, the window of one unit nearly opens into the neighbouring unit. Except for the discomfort, this holds a fire risk.

Another prominent feature is the quality of the houses. Poor quality was observed at the prefabricated concrete units, the timber houses and at the informal houses. At the prefabricated concrete houses, the concrete is starting to chip off at the joints, which leaves the joints exposed. At the timber houses, the wood is starting to dry from a lack of treatment. The informal houses exhibit poor quality due to a lack of proper building materials and a lack of skills. The majority of the brick-and-mortar and prefabricated steel units' quality is fair. However, it is suspected that these units were built more recently.

With Kayamandi being situated on a hill, the lack of vegetation, Stellenbosch's rainy winters and the absence of gutters on the units is problematic. When it rains, the soil surrounding the houses are swept away with the running water. Hence, exposed foundations were common observations at all types of units.

Figure 5: *An image showing the close proximity of houses in Kayamandi (Wium, 2021).*

In terms of design, the units also differ. The prefabricated concrete units consist of two rooms, whereas the prefabricated steel units and informal houses consist of only one room. Generally, the brick-and-mortar houses are larger than the other types of houses. All the other types of units are of similar size, except for informal houses, which differ in size. Informal houses of up to two storeys were observed. The height of the roof ridges also differed. Most houses' roof ridge is lower than the brick-and-mortar houses' roof ridge. All the houses are detached units, except for some brick-and-mortar units, which are semi-detached.

Something that was very striking is the deficiency of economic opportunities in this township. All the employment opportunities are in town or at the entrance of the township, far from the houses at the top of the hill. Also, no provision is made for economic opportunities. There is no community centre where entrepreneurs can sell items or external investors can invest in or start businesses. This leads to many residents of Kayamandi starting informal businesses from their house. However, a state-subsidised house is not of sufficient size to host a family and to use as a business space. Therefore, residents build informal houses onto the existing state-subsidised houses for them to stay in, while the state-subsidised house is being used as the business.

Other problems that are also prevalent in Kayamandi is littering, the lack of safety, substance abuse, shortage of schools and the absence of privacy (Mokoena & Steyn, 2021; Rock, 2011;

Vision Afrika, 2015). Kayamandi is not only unsafe due to crime but low laying electricity cables, poorly built structures and insufficient space between houses make it an unsafe environment.

4.1.2 Vrygrond, Cape Town (City of Cape Town)

Vrygrond is one of the oldest informal settlements in the Western Cape Province and is situated next to Muizenberg, approximately 20 kilometres from the Cape Town city centre (Von Kotze, 2014). According to the 2011 census, this community had a population of approximately 13 000 (Statistics South Africa, 2011). Poverty in this mixed-racial community is still an issue and leads to crime and violence within the community (Von Kotze, 2014). A mixture of houses exists in the community; from informal houses built with corrugated iron and timber (shacks), to properly constructed brick-and-mortar buildings.

The area of Vrygrond where observations were made, consisted of many detached and semi-detached brick-and-mortar state-subsidised houses. This is due to the RDP housing initiatives that took place in Vrygrond after 1994 (Von Kotze, 2014). These state-subsidised units are referred to as the matchbox-type houses; the term originating from the rectangular prism shape of the houses. These units were part of the first state-subsidised houses built after 1994. Many of these houses are expanded by either brick-and-mortar, timber and corrugated iron or only timber (similar to a Wendy house).

Vrygrond differs from Kayamandi in that the plots have distinguishable boundaries. The plot sizes are big, relative to the house, so many residents erect other units on the property. These additional units are being leased and provide a rental income to the property owners (Brueckner, et al., 2019). To maximise the rental income, property owners want to maximise the number of additional units on the property, which results in units being close to neighbours. As in the case of Kayamandi, this poses a fire risk. Figure 6 shows a typical yard in Vrygrond. At the back, the state-subsidised house can be seen and at the front, additional units were built for rental income.

Figure 6: *Additional units for backyard dwellers in Vrygrond (photo taken with permission).*

The majority of these additional units are shack-type structures; however, some properties have timber structures or shipping containers. Poor quality has been observed in these additional structures. This is a result of the materials used and the quality of workmanship. The plots in the observed area of Vrygrond also have access to services; however, it is unknown to which extent the additional units on the property have access to services. However, Brueckner et al (2019) have reported that backyard dwellers, in general, share the services with the property owners.

A small area of Vrygrond was observed by the student, but in this area many aftercare centres were seen. A community centre was also seen, which is also used as a school. This signifies a tendency towards education in this community and is also indicative of economic activity. However, unemployment, gangsterism and substance abuse are still concerns in this community (Von Kotze, 2014).

Less spaza shops were seen in Vrygrond in comparison to Kayamandi; backyard dwellings are more conspicuous in Vrygrond. A possible reason for this might be because the plots are large and additional units can be built, and that property owners make an income from rent and thus do not need to make an income from an informal business.

4.1.3 Hawston, Hermanus (Overberg District)

Hawston is a small fishing village just outside Hermanus between Fisherhaven and Onrus (Xplorio, n.d.; Western Cape Government, n.d.). Many residents are still dependent on the sea to make a living; however, many residents started working in Hermanus and other neighbouring towns (Xplorio, n.d.; South African History Online, 2019). According to the census of 2011, it has a population exceeding 8 000 with the majority (96%) of the population classified as 'Coloured'.

The part of Hawston that was under observation, is a new extension on the periphery of the village. These housing units are semi-detached and were built with concrete blocks. The size of the plots is large enough for the extension of the units (at least one extra room can be added) and for a car port. Many residents have already made improvements to their homes, such as adding a car port, planting vegetation, adding fences and paving the yard.

Figure 7 shows an example of the units present in this extension of Hawston. From this image, it is seen that the units are semi-detached. Furthermore, from this image it can also be seen that these units do not have gutters. However, to protect the foundations, concrete aprons were built around the buildings. Looking at the pipes that are present, it can be assumed that the units have toilets.

Merely based on the observations of the researcher, the units in Hawston are better compared to the different units present in Kayamandi and Vrygrond. The units in Hawston compare well to the brick-and-mortar units in Kayamandi; however, the aesthetics of the Hawston community exceeds Kayamandi's appearance. This small extension is in the vicinity of employment opportunities (Thusong Shopping Centre), medical facilities (Hawston Public Clinic) and schools (Hawston Primary School).

Figure 7: *An example of the units present in Hawston.*

4.1.4 Delft, Cape Town (City of Cape Town)

Delft is a neighbourhood established in 1989, and it is situated 34 kilometres from Cape Town, close to Kuils River (Waggie, 2008). This community is rife with social issues, such as unemployment and crime (Waggie, 2008). According to the 2011 Census, Delft has a population of approximately 152 000 (SDI&GIS: City of Cape Town, 2013). The population mainly consist of 'Coloureds' and 'Black Africans', comprising 73 and 25 percent respectively (Waggie, 2008).

Due to the size of Delft, various different housing typologies were witnessed during a drive through the community. The newer housing projects consisted mainly of brick-and-mortar double-storey row and semi-detached houses. However, prefabricated concrete units were also observed. Many of these houses were looking out onto a courtyard. In these more recent developments, houses were developed on small plots to promote densification. However, many of these houses were extended to the full extent of the plot, which is against the National Building Regulations (NBR). These extensions are mainly for extending the main house and not for backyard dwellers or other income-generating opportunities. Figure 8 shows how units are extended by brick buildings. Houses were also extended by corrugated sheeting and wood.

Figure 8: *Prefabricated unit with a brick-and-mortar extension.*

In older parts of Delft, single-storey detached houses were observed. These units were constructed with brick and mortar. The plots of these houses were bigger than those of the newer developments. Various housing typologies exist in these old parts of Delft. This include the old matchbox-type houses and the bigger 30 m^2 RDP houses. There are detached, semi-detached and row houses. These units were also constructed with brick and mortar. In these parts, extensions include shacks for either a spaza shop or for backyard dwellers. This is due to the larger plot sizes witnessed in these areas. The plot sizes of the matchbox type houses are larger than the plot sizes of the 30 m^2 RDP houses. Shipping containers were also witnessed, which were used for spaza shops. The overall quality of the houses in these older developments varied. This is dependent on the maintenance that was applied to these houses by the owner.

When driving through Delft, observations regarding the community were also made. Based on these observations, many noteworthy aspects were identified. From the number of adults that were on the streets during the time of observations (12:00 – 15:00), it can be concluded that unemployment is an existing problem. This was also stated by Waggie (2008). Furthermore, a majority of the houses have burglar bars at the doors and windows, which is indicative of security problems within the community. Washing lines are also situated in front of the house, which might result in problems with dignity and theft. In general, the aesthetics in the new developments are better than the in older developments. This may however be because these developments are relatively new and maintenance was not yet been required on these new units.

In terms of amenities, there are schools, medical centres, taxi ranks and a police station available in the community. Furthermore, Delft also has a shopping mall, which provides economic opportunities in the community. The taxi ranks available in Delft also give residents access to other areas for employment.

4.2 Challenges Identified

The aim of the observations was to identify challenges within subsidy housing developments, and ultimately to obtain criteria for the comparison of brick-and-mortar construction to prefabricated concrete construction. From these observations, the following challenges were identified:

a. Housing backlog
b. Unemployment
c. Housing quality
d. House size
e. Location of housing developments
f. Lack of economic opportunities
g. The need for extension of the dwelling
h. Social issues
i. Security
j. Privacy
k. Close proximity between houses
l. Littering

However, not all of these challenges can be rectified by choosing an appropriate construction method. Therefore, the challenges that can be directly rectified by the construction method, are the housing backlog, housing quality and the need for extension. Challenges that can be indirectly rectified are unemployment, house size, lack of economic opportunities, social issues and security.

The need for extension plays a big role in rectifying unemployment, house size, lack of economic opportunities, social issues and security. If a house can be easily extended, the opportunity is given to a beneficiary to address his/her economic situation, whether it is renting out a shack or starting a business. This will therefore address unemployment, which in turn addresses social and security challenges. Lastly, the extension to the house gives the ability to

address the matter of insufficient size of the house. Therefore, if a house can easily and affordably be extended, which is largely dependable on the construction method, many challenges can be indirectly addressed.

5 DESKTOP STUDY

The aim of this chapter is to investigate literature for the identification of non-technical and technical criteria for the comparison of brick-and-mortar and prefabricated concrete construction. The criteria found in this chapter are used in conjunction with criteria found from other data collection methods for the comparison of the construction methods.

5.1 Non-technical criteria

Referring to the primary research question in sub-subsection 1.2.1, reference was made to 'progressive communities'. Therefore, the solo non-technical criterion for determining the more suitable construction method (between brick-and-mortar and prefabricated concrete), is the ability of the construction method to create a progressive community. However, a gauge is required to measure the ability of creating a 'progressive community'. Therefore, this chapter aims to firstly, inform the reader what is meant by a 'progressive community' by creating a study-specific definition of the term. Secondly, this chapter aims at showing how a 'progressive community' is achieved. Lastly, the chapter aims at developing criteria for achieving a 'progressive community'. The construction method that best complies to these criteria is more advantageous to the beneficiaries.

5.1.1 Defining a 'Progressive Community'

It is important to define what a 'progressive community' is because the aim of the BNG Housing Policy (2004) is to promote sustainable human settlements. A sustainable human settlement is the result of the process of progressing a community. Various interpretations of progressive communities exist and it is thus important to outline exactly what is meant by a 'progressive community' in the context of this study. In a definition, it is necessary to specify what is included and excluded from the definition. To help with this, 'progressive community' is broken down into its two parts: 'progressive' and 'community'. Each part is defined separately and then these parts are synthesised to create the definition used in this study.

(i) The Meaning of 'Progressive'

In the general sense, 'progressive' as an adjective relates to gradual improvement (Dictionary.com, n.d.). Therefore, the meaning of 'progressive' is associated with positive change, except in medical terms, where it suggests worsening (Stöppler, 2021). However, the term 'progressive' is often used as a political concept in favour of social reform (Weinstein,

2006; Lexico, n.d.). For this study, the term 'progressive' is used as a general and political concept.

Weinstein (2006) argues that it is still difficult to give a single definition of the term 'progressive', even after taking a historical and philosophical look into this term. He investigated the meaning of 'progressive' from the 1700s until the 20th century to determine how the context of the term has changed over time (Weinstein, 2006). Weinstein (2006) also used the work of philosophers, such as Immanuel Kant and John Rawls, to help with a definition of the term.

Weinstein (2006) concludes with an indefinite attempt at the definition of 'progressive'. In his definition, he also refers to 'progressive' as supporting social reform; however, he goes further to say that social reform is achieved over time by the symbiotic relationship between individuals and the government (Weinstein, 2006). This view is supported by the Cambridge Dictionary's (n.d.) definition of 'progressivism', which states that it is a movement with the goal of supporting government to act in the interest of people. Pyles (2009, p. 7), in their explanation of 'progressive community organising', also highlights the interdependent relationship between marginalised individuals and an authority to bring about change. Additionally, Weinstein (2006) states that to measure progress, it is required to understand the milieu and circumstances. For instance, the measurement of progression in the 1700s varied from it in the 20th century, since the milieu and circumstances were different. Lastly, Weinstein (2006, p. 50) testifies that progression strives for 'change', 'assistance' and 'autonomy'.

Combining all these definitions, the term 'progressive' can be defined as a political concept which aims to, through the interdependent relationship between individuals and the government, create a basis of positive social reform, so that individuals can grow from this basis autonomously. In the context of this study, the interdependent relationship refers to the relationship between the government and the beneficiaries of subsidy houses. This should be a symbiotic relationship; therefore, communication between the two parties is imperative. This highlights the importance of public participation. Furthermore, the social issue that requires improvement, is the challenges related to subsidy housing. Addressing the challenges related to subsidy housing should aim to create a basis for beneficiaries to autonomously improve their lives. Therefore, having a house should lead to the advancement of the lives of beneficiaries. However, this should still be proven.

(ii) What is a 'Community'?

The definition of 'community' changed over time with the introduction of technology and globalisation and various definitions exist among different academics and disciplines (Pyles, 2009; Pahwa, et al., 2020). In 1955, Hillery (1955) already identified 94 definitions of 'community'. It is therefore important to define 'community' in the context of this study. To start off, the broad and universal definition of 'community' is determined, whereafter the definition is refined to suit the context of the study.

Pahwa et al.'s (2020) structural-functional-experiential (SFE) Model of Community is used as the basis for developing a broad definition of 'community'. This model was created by interviewing people with serious mental illnesses, SMIs, (such as Schizophrenia, Bipolar disorder and depression) to determine what their perspective and experience of 'community' is (Pahwa, et al., 2020). It is shown, by literature, that a general definition of 'community' can be developed on the structural-functional-experiential basis of this model, even though it was developed through interviews with people that suffer from SMIs.

Considering the SFE Model of Community, the structural dimension refers to the touchable facets of a community (Pahwa, et al., 2020). This includes people as a collective, family, friends and physical places, such as neighbourhoods and cultural spaces (Pahwa, et al., 2020). Pyles (2009) defines 'community' as a collection of individuals with shared connections, characteristics or criticisms, who are not limited by geographical proximity. It is seen that Pyles' (2009) definition of 'community' supports the notion of a touchable aspect to community, by referring to individuals and geographical places. However, Bradshaw (2008) and Pyles (2009) both agree that community is not limited to individuals in propinquity; rather, Bradshaw's premise is based on the immaterial facets of community.

Bradshaw (2008, p. 10) argues that, according to Bhattacharyya (2004), solidarity is the essence of a community and with the advancement of technology, 'community is now separate from place'. The functional element of the SFE Model of Community refers to the inherent additions that come with being in a community, such as assistance, opportunities, resources and socialising (Pahwa, et al., 2020). These are part of the immaterial facets of a community. Socialising within a community is also highlighted by Bradshaw (2008) and Seligman et al. (2011).

The experiential dimension is the last immaterial facet of the SFE Model of Community. This dimension relates to common encounters, grievances and identities among people (Pahwa, et al., 2020). For example, people staying in shacks can form a community, since they all share the same grievance of not having a house. This dimension of community is proven by Wilkinson (1991), Bradshaw (2008) and Pyles (2009).

Based on the evidence provided from other academic authors on the concept of community, it is proven that the SFE Model of Community is not only applicable to the definition of 'community' for people with SMIs. Therefore, the SFE Model of Community is used to formulate the definition of 'community' used in this study.

For this research, 'community' is defined as a group of people in geographic proximity, with shared circumstances and grievances that socialise and inherently supports one another. For the structural dimension, the definition refers to a group of people and a place in geographic proximity. Although all people without a home can be categorised as a community on the premise of shared circumstances, these groups of people do not socialise and therefore do not form a community. Bradshaw (2008) argued that non-place communities existed because of inexpensive and rapid travel and communication; however, people in low-income communities do not necessarily have access to it. That is why the definition only accounts for a place in geographic proximity, that is, a neighbourhood.

The functional dimension of community is also accounted for by the social interaction and support within the definition. Looking at low-income communities, the streets play an active role in the social interaction of residents, and it should thus be accounted for in this study's definition of 'community'. Furthermore, many local stores (spaza shops) are present in low-income communities, which indicates that support does exist in these communities.

Lastly, the experiential dimension is accounted for by including that a community has shared circumstances and grievances. This holds true for reality since residents in low-income communities suffer from the same circumstances and have the same challenges. It is therefore important to include this aspect in the study's definition of community.

Now that 'progressive' and 'community' were defined separately, these two terms can be combined to give a definition of a 'progressive community'. Therefore, a 'progressive community' is where the individuals in the community's socio-economic circumstances improve gradually and autonomously, as a result of government-assisted social reform. As an example, if the government provides housing for all individuals in the community and their

social and economic circumstances improve after the houses were built, then the community can be classified as a 'progressive community'.

5.1.2 Creation of a 'Progressive Community'

To determine which construction method is more suitable for subsidy houses in the creation of progressive communities, it is imperative to determine how a 'progressive community' is created. Since a community is focussed on people, an investigation into the social sciences is of importance, specifically sociology. This is important for developing criteria to determine whether a 'progressive community' is achieved or not.

A well-known and accepted social systems theory is the ecosystems perspective (Green & McDermott, 2010).The ecosystems perspective is based on a constant interaction between an individual and his/her environment and the adaptation of one to the other (Ahmed, et al., 2017). Queralt (1996) states that the ecosystem perspective is founded on a unified ecological system formed between individuals and their physical-social-cultural environments and that an influential relationship exists between the individual and environment.

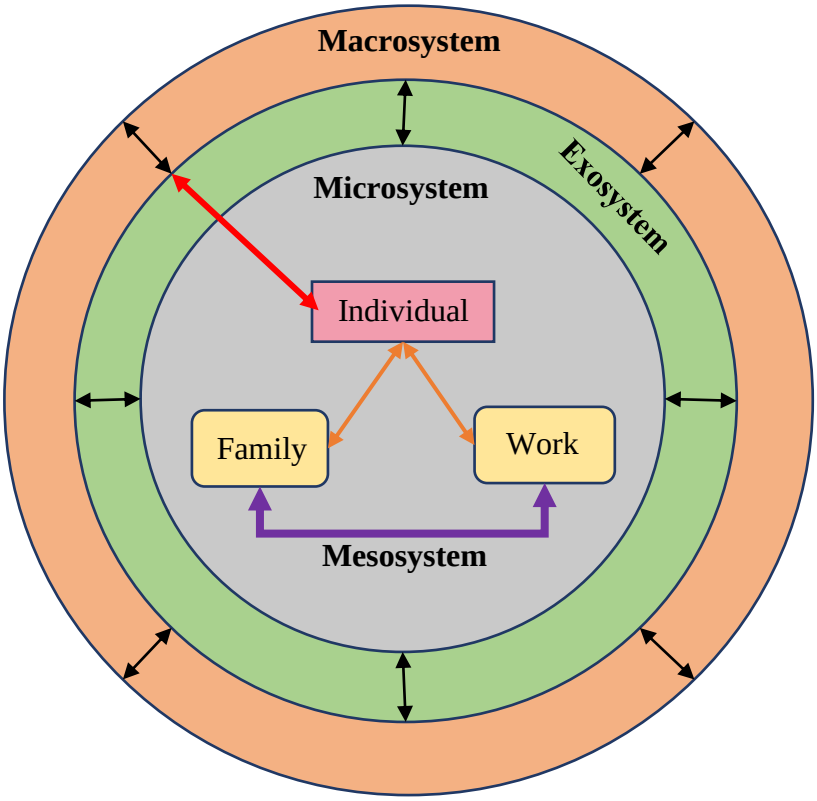

Figure 9: *Visual representation of Bronfenbrenner's ecological systems theory (Ahmed, et al., 2017).*

In Bronfenbrenner's (1979) book called 'The Ecology of Human Development', he explained different social structures in which people live (Ahmed, et al., 2017). Figure 9 shows these different social systems: the microsystem, mesosystem, exosystem and macrosystem (Bronfenbrenner, 1979; Ahmed, et al., 2017). However, this is based on Bronfenbrenner's first model; he later added another system called the 'chronosystem', but this system is not applicable to this study (Eriksson, et al., 2018). Bronfenbrenner's (1979) model is based on the principle of the ecosystem perspective, which means that there is a constant interaction between the different social systems.

The microsystem refers to all regular interactions an individual has with his/her immediate environment (Ahmed, et al., 2017; Eriksson, et al., 2018). That includes people and establishments that the individual often interacts with, such as family, friends, home and work (Ahmed, et al., 2017; Eriksson, et al., 2018). In Figure 9, this system is depicted as the grey circle. Referring again to Figure 9, within the microsystem, the orange bi-directional arrows can be seen between the individual and the microsystem components. These arrows illustrate that the individual can be influenced by the components but the vice versa also holds true (Leonard, 2011).

Interaction occurs between the components in a microsystem and these interactions influence the individual (Ahmed, et al., 2017). These interactions between components in a microsystem are called the 'mesosystem' (Bronfenbrenner, 1979; Ahmed, et al., 2017). For instance, the relationship between a spouse and a sibling can affect the individual, either positively or negatively. The spouse and the sibling are both components in the microsystem and have a direct interaction with the individual. In Figure 9, the mesosystem is indicated by a purple bi-directional arrow.

The exosystem contains other social structures or factors in which the individual is not directly involved but these social structures or factors are linked to a microsystem component (Bronfenbrenner, 1979; Ahmed, et al., 2017). In simpler terms, this can be compared to a stranger on Facebook with whom the individual has a mutual friend. This stranger has no direct interaction with the individual, but the stranger has direct interaction with a component in the individual's microsystem. The social structure is not limited to persons and can include the neighbourhood, mass media and discrimination (Ahmed, et al., 2017). In Figure 9 it is shown, by a black bi-directional arrow, that the exosystem influences the microsystem and vice versa.

Lastly, the macrosystem refers to the influence of cultural elements on an individual (Ahmed, et al., 2017). The macrosystem differs from the micro-, meso- and exosystem of an individual, because there is consistency. Basically, a macrosystem of a certain culture consists of fixed micro-, meso- and exosystems and interactions among these systems, a blueprint in essence, and when an individual belongs to this culture, he/she adopts this blueprint into his/her own development (Bronfenbrenner, 1979; Eriksson, et al., 2018). Socioeconomic, political, geographical and religious factors are examples of these cultures in a macrosystem (Ahmed, et al., 2017). For example, the individual's socioeconomic circumstances will influence the individual's relations with other components and will therefore influence the individual's development (Bronfenbrenner, 1979). In Figure 9, it can be seen that an individual's micro-, meso- and exosystem is contained within the blueprint of the macrosystem.

As stated with the definition of the ecosystem perspective, constant interaction occurs between an individual and his/her social structures or environments. From this, it can be deduced that a progressive community is related to the advancement of the individual. In conclusion, to achieve a 'progressive community', the focus is on the advancement of the individual. This is supported by Weinstein (2006) who stated, after investigating Immanuel Kant's (1784) book 'An Answer to the Question: "What Is Enlightenment? "', that an individual has the responsibility of self-improvement for its universal significance. This indicates a relationship between an individual and a greater entity. Community is in the exosystem; therefore, the relationship between the exosystem and the individual is important, as shown by the red bi-directional arrow in Figure 9.

5.1.3 A Holistic Human Approach to Housing

As stated in sub-subsection 1.1.1, looking at the housing problem holistically means that housing delivery should not only address the technical aspects, but also the non-technical (human) aspects. From the previous subsection it has been concluded that a progressive community can be created by advancing the individuals within the community. This subsection aims at identifying criteria for the advancement of an individual. Two outlooks are discussed for the improvement of an individual: well-being and motivation. These are discussed in this subsection.

(i) Well-being

There are eight symbiotic dimensions of well-being: physical, intellectual, emotional, social, spiritual, occupational, financial and environmental (Stoewen, 2017). Each dimension is defined in Table 3.

Table 3: *The eight dimensions of well-being and its definitions.*

Physical:	Physical well-being refers to the development of strong and healthy bodies and being able to perform daily activities without excessive exhaustion of or physical strain to the body (University of the Free State, n.d.).
Intellectual:	Intellectual wellness refers to being open to new ways of thinking and the continuation of acquiring new skills and knowledge (Botha, 2013; Strout & Howard, 2012). An intellectually well individual is mentally resilient and continuously searching for challenges (Botha, 2013).
Emotional:	According to Lerner (2019) of the National Centre for Emotional Wellness, emotional wellness refers to the acknowledgement, comprehension and acceptance of our emotions. Furthermore, it also refers to being resilient to challenges and change, by being able to convert negative emotions into positive emotions (Lerner, 2019). A person's mood and self-esteem are two significant aspects of emotional well-being (Schutte, et al., 2002).
Social:	According to Keyes (1998), social well-being is the assessment of a person's position and function in society. He further proves that social well-being consists of five dimensions; namely, social integration, social acceptance, social contribution, social actualisation and social coherence (Keyes, 1998). Furthermore, social well-being can also be described as the relationships with other people and the interaction within the relationships (Burke, et al., 2010).
Spiritual:	Being spiritually healthy means that an individual has found a purpose in life and adopted a set of values and beliefs (Briggs & Shoffner, 2006; Strout & Howard, 2012). This is associated with the belief in and admiration of someone or something greater than one's being (Horton & Snyder, 2009).

Occupational: Occupational wellness is related to performing work, paid or unpaid, that provides an individual with a sense of satisfaction (Strout & Howard, 2012; Washington State University, n.d.). Occupational wellness is realised when a healthy work-life balance is achieved (Horton & Snyder, 2009; Washington State University, n.d.).

Financial: Brüggen et al. (2017) defines financial well-being as the perception that an individual's current and future desired living standards can be met. Furthermore, financial well-being is associated with the effective management of one's finances (Rath, et al., 2010) and financial freedom (Brüggen, et al., 2017).

Environmental: Environmental well-being is related to the relationship between an individual and his/her environment, which includes the management of this environment (Horton & Snyder, 2009). Satisfaction with one's environment and acting to conserve the environment for the future, is also part of environmental well-being (Amaya, et al., 2018; Horton & Snyder, 2009).

These dimensions form part of the non-technical criteria against which the construction methods are compared. The other part of the non-technical criteria is motivation, and is discussed in the next sub-subsection.

(ii) Motivation

Maslow's hierarchy of needs is used as the model for motivation. This model was proposed by Abraham Maslow, a psychologist, in 1943 and this model is still in use today (Pride, et al., 2014; Kenrick, et al., 2010). The application of this model varies and include business (Pride, et al., 2014), medicine (Jackson, et al., 2014) and counselling (Lonn & Dantzler, 2017). The model has also been criticised and adjusted by different authors (Kenrick, et al., 2010; Nain, 2013); however, the original version is still widely used and is used for this study.

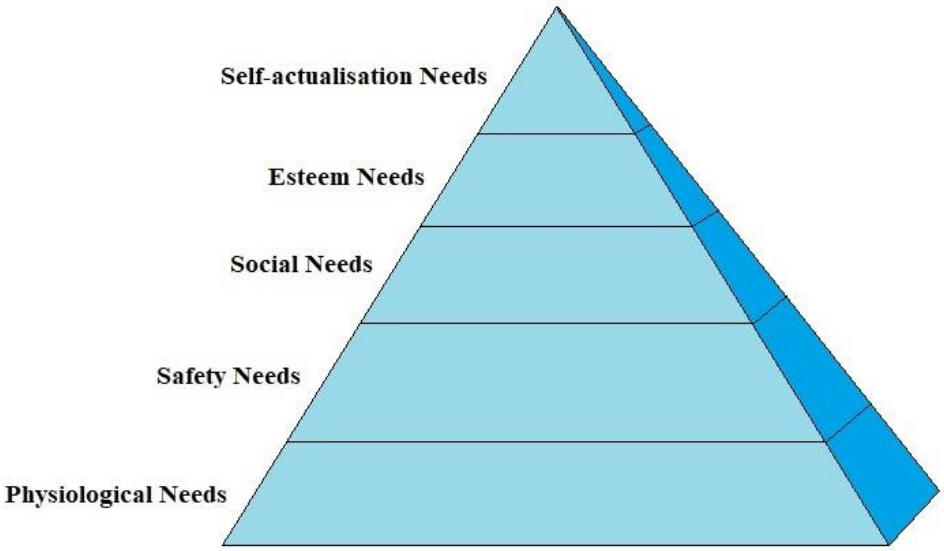

Figure 10: *Maslow's Hierarchy of Needs (Pride, et al., 2014).*

Maslow's theory is based on the assumption that humans have certain needs they want satisfied (Pride, et al., 2014). Maslow identified five categories of needs and stated that the lower-level needs must be satisfied before the upper-level needs can be satisfied, which gave rise to the hierarchical pyramid as shown in Figure 10 (Pride, et al., 2014; King-Hill, 2015). Therefore, humans are motivated by the lowest unsatisfied needs and have the desire to move up the hierarchy (Pride, et al., 2014; McLeod, 2018). However, the lower-level needs do not have to be satisfied completely before an individual is motivated to satisfy the next higher-level needs (Pride, et al., 2014; McLeod, 2018). Additionally, humans do not move through the hierarchy uni-directionally but will move up and down between different levels (McLeod, 2018). The categories of needs identified by Maslow are physiological, safety, social, esteem and self-actualisation (Pride, et al., 2014). Refer to APPENDIX A: Explanation of Maslow's Hierarchy of Needs for an explanation of the needs and how they are categorised.

The satisfaction of Maslow's needs is the other part of the non-technical criteria against which the construction methods are compared. Therefore, the construction method that best satisfies these needs, is a more suitable construction method.

5.1.4 Summary

The non-technical criterion which construction methods are compared to, is the ability of the construction method to promote a progressive community. However, to do the comparison, it is necessary to determine what a 'progressive community' is and how it can be achieved. This was done in this subsection.

It was found in this chapter that a 'progressive community' is where the individuals in the community's socio-economic circumstances improve gradually and autonomously, as a result of government-assisted social reform. Furthermore, it was shown that a progressive community can be achieved by focussing on advancing the individuals in the community. To advance an individual, two viewpoints were considered: well-being and motivation. From these two viewpoints, criteria were identified that can create a progressive community. These criteria are the eight dimensions of well-being and Maslow's needs.

5.2 Technical Criteria

This subsection aims to obtain technical criteria, from literature, against which the two construction methods are compared. The criteria are split into four categories: constructability, environmental performance, house design and post-construction. These four categories are subsequently discussed.

5.2.1 Constructability

The constructability category refers to criteria which involves the whole construction process of the specific method. This includes the construction pyramid of time, cost and quality and other factors such as the labour or skills required, resource availability (Theart, 2014), logistics, the procurement model (Hanekom, 2011) and safety on site (Jurgens, 2008). The definitions of these criteria are summarised in Table 4.

Table 4: *Definitions of the constructability criteria.*

Skills/Labour:	This refers to the level of skills and type of labour force required for the specific construction method.
Resource Availability:	Resource availability refers to the availability and accessibility of material, labour and skills (Theart, 2014).
Logistics:	Logistics refers to the storage, handling, transportation and delivery of resources on site in a tactical and economical manner (Fadiya, 2012).
Construction Time:	The construction time refers to the elapsed time from the start of site work to the completion of the project (Nkado, 1995). For a housing unit, the construction time is the total

	construction time divided by the projected number of houses to be built (Theart, 2014).
Construction Quality:	It is associated with the presence of defects in the end-product caused by the constructor during the construction process (Buys & Le Roux, 2013). This is specifically applicable to the walling system.
Construction Cost:	The cost refers to all costs associated with purchasing land, building the top structure, providing civil services and electricity (Theart, 2014). The subsidy amount provided by the state is R168 853 per house (Western Cape Government, 2021).
Procurement Model:	It is related to the type of contract used in the project. Furthermore, it includes the process which forms, administers and fulfils the contract (Department of National Treasury, 2012).
Construction Safety:	This refers to general safety during construction and the risks of incidents occurring on site.

5.2.2 Environmental Performance

This criterion was identified by Theart (2014). Although this criterion does not address any of the challenges of the subsidy housing sector, it is a criterion to be cognisant of, nonetheless. The environmental performance of a house is associated with the amount of construction waste and the environmental impact of the construction materials used in the process (Theart, 2014). The environmental impact of the construction materials is associated with the cement content of these materials since cement is a large producer of greenhouse gases. Furthermore, the thermal performance of the house also contributes to the environmental performance of the house since an energy efficient house will result in lower energy costs. Thermal performance is however discussed under the post-construction criteria.

5.2.3 House Design

This sub-subsection contains criteria for the house design against which the construction methods are to be compared. Two criteria have been identified for this category, namely

alteration capability (Theart, 2014) and aesthetics (Botes, 2013). Table 5 summarises the definitions of these criteria.

Table 5: *Definitions of the house design criteria.*

Alteration Capability:	This refers to the ability of a constructed house to allow for low-cost and low-energy alterations (Theart, 2014). This is to account for beneficiaries' changing needs (Theart, 2014).
Aesthetics:	Aesthetics involves the acceptance by the beneficiaries of the exterior and interior of the constructed house. This is based on the preferences of the beneficiaries.

5.2.4 Post-Construction

This category accounts for factors after the house has been constructed and is occupied by the resident. Many of these factors are related to safety and comfort for the occupants. Acoustic performance is covered in the performance criteria of Agrément South Africa (2010), and water penetration is covered in SANS 10400 (1990). Lastly, durability and thermal performance were obtained from Theart (2014) as criteria for comparison. The definitions of the criteria are contained in Table 6.

Table 6: *Definitions of the post-construction criteria.*

Acoustics:	The acoustic performance of the walls refers to their ability for sound insulation and absorption (Chaya, 1979).
Durability:	Durability refers to the service lifespan and the maintenance requirements of the walling system (Theart, 2014).
Water Penetration:	This refers to the ingress of water through the external walls, such as rain or the washing of walls. This is related to dampness and condensation on interior walls.
Thermal Performance:	The thermal performance is related to the walling system and to the house design. In the case of the walling system, the thermal resistance is of importance since it affects the thermal mass (Theart, 2014).

5.2.5 Summary

The aim of this subsection was to consult literature for the identification of technical criteria for the comparison of the two construction methods. The identified criteria were categorised into construction, environmental performance, house design and post-construction criteria.

5.3 Chapter Summary

The aim of this chapter was to identify technical and non-technical criteria for the comparison of brick-and-mortar and prefabricated concrete construction. In this chapter, this was done by performing a desktop study.

The solo criterion for measuring the non-technical performance of a construction method, is its ability to create a progressive community. However, a gauge is required to measure the ability of creating a progressive community. The development of this gauge began by identifying a study-specific definition of a 'progressive community'. However, to develop this gauge, it was required to determine how a 'progressive community' can be achieved. By using Bronfenbrenner's (1979) ecosystems perspective, it was gathered that, in order for the community to progress, it was imperative that the individuals within the community are progressed. Therefore, the focus was shifted from attempting to progress the community to attempting to progress the individual. To progress the individual, two viewpoints were used: human well-being and human motivation. If an individual's well-being was being looked after and the individual was motivated to excel in different aspects of his/her life, then the individual would progress. To improve the well-being of an individual, the eight dimensions of well-being need to be addressed: physical, intellectual, emotional, social, spiritual, occupational, financial and environmental. Furthermore, to motivate an individual, Maslow's Hierarchy of Needs Theory was used. These two viewpoints led to the creation of criteria for progressing an individual, and as stated by Bronfenbrenner's (1979) ecosystems perspective, would lead to the creation of progressive communities. In conclusion, the construction method that best satisfies the eight dimensions of well-being and Maslow's five needs, is the more suitable construction method for the progression of communities.

In terms of technical criteria, various sources of literature were studied to determine criteria. This included the housing standards mentioned in subsection 2.4. The challenges identified from literature and observations also assisted in identifying technical criteria.

6 INTERVIEWS

The aim of this chapter is to share the results from the content analysis of the interview data. The chapter begins by identifying codes and code groups, by means of classical content analysis, that frequently occur in the interview data. Thematic analysis is used to identify codes and code groups that are, or can potentially be, addressed by the construction method. These codes and code groups are discussed in more detail.

6.1 Results of the Semi-Structured Interviews

The methodology for the data analysis is presented in sub-subsection 3.2.2. The qualitative data analysis was performed with the assistance of ATLAS.ti version 9 for Windows software. The aim of the interviews was to obtain information on the needs and preferences of the beneficiaries, specifically in terms of house design. Ultimately, it was required to identify criteria for the comparison between brick-and-mortar and prefabricated concrete construction, based on the results of the interviews. Therefore, the codes and code groups, which are themes that regularly occurred in the interviews, were used to identify criteria.

Classical content analysis was used for determining prevalent codes and code groups in the interview data. Table 7 shows the prevalent codes and code groups, together with the definition of each code and code group. The codes or codes groups that were chosen do not necessarily reflect challenges in the subsidy housing sector; rather, they represent themes that regularly occurred.

Table 7: *Definition of the identified codes and code groups.*

[1]	**Size and spacing:**	This code group includes references to the erf size, house size and family size. It also includes size of rooms.
[2]	**Community living:**	Any reference to the living conditions in the community, which include the environment, residents and the amenities in the community, is included in this code group.
[3]	**Costs:**	This code was used to mark any quotation that referred to costs, budget or subsidy amount or how it is affected.

[4]	**Alteration capability:**	This code group refers to the altering of a subsidy house. Any reference made to the ease of alteration, skills required for alteration, material availability or the position of the house on the erf for alteration purposes, was marked under this group.
[5]	**Housing options:**	This code group includes references to different housing tenures and typologies used in subsidy housing.
[6]	**Housing quality:**	Any reference made to the quality of doors, floors, walls, roofs, windows, foundations, plumbing, ventilation, construction or materials, was added to this code group.
[7]	**Regulatory involvement:**	This code group includes quotations referring to the involvement of politics and the prescriptive nature of subsidy housing developments in terms of design.
[8]	**Extension need:**	Quotations that implied the need of beneficiaries to extend their house, were included in this code. This was often paired with 'alteration capability [4]' and 'income mechanism [13]'.
[9]	**Aesthetics:**	The aesthetics referred to any quotations that mentioned the visual aspect of the exterior, interior or shape of a subsidy house.
[10]	**Acceptance/perception:**	Any reference to the approval or disapproval of a construction method based on the perception of the beneficiaries, was included in this code.
[11]	**Social issues:**	This code group includes mentions of domestic violence, gangsterism, poverty, sexual abuse, substance abuse and theft.
[12]	**Densification:**	Quotations that referred to creating higher density housing developments were included in this code.
[13]	**Income mechanism:**	Interviewees' responses that mentioned the use of the property for generating an income, such as having

		backyard dwellers or a spaza shop, were included in this code.
[14]	**Public participation:**	Any reference made to the prior interaction of the government with communities of potential housing developments, was marked by this code.
[15]	**Education:**	This code refers to all responses, by the interviewees, stating that education is required for the introduction of prefabricated concrete to housing projects.
[16]	**Skills/labour:**	Quotations that included the creation of employment or the development of skills, were referenced in this code group.
[17]	**Land acquisition:**	This code group was influenced by the mention of affordability or availability of land.
[18]	**Safety:**	Under this code, many references were made to the passive surveillance of people over the street to ensure the safety of children on the street and other safety issues.
[19]	**Maintenance:**	Lastly, this code includes references to the maintenance of houses and the education of maintaining houses.

The codes and code groups not only contain information on the house design, but they also contains information about challenges in the subsidy housing industry, from the viewpoint of architects and urban designers, government officials and housing activists. These challenges assist in the identification of criteria for comparing the brick-and-mortar and prefabricated concrete construction methods.

With the assistance of ATLAS.ti, a frequency table of each code and code group, according to participant group, was developed. The result of this is shown in Figure 11. From this graph, it is shown that size and spacing was the dominant code group and maintenance was the least mentioned code.

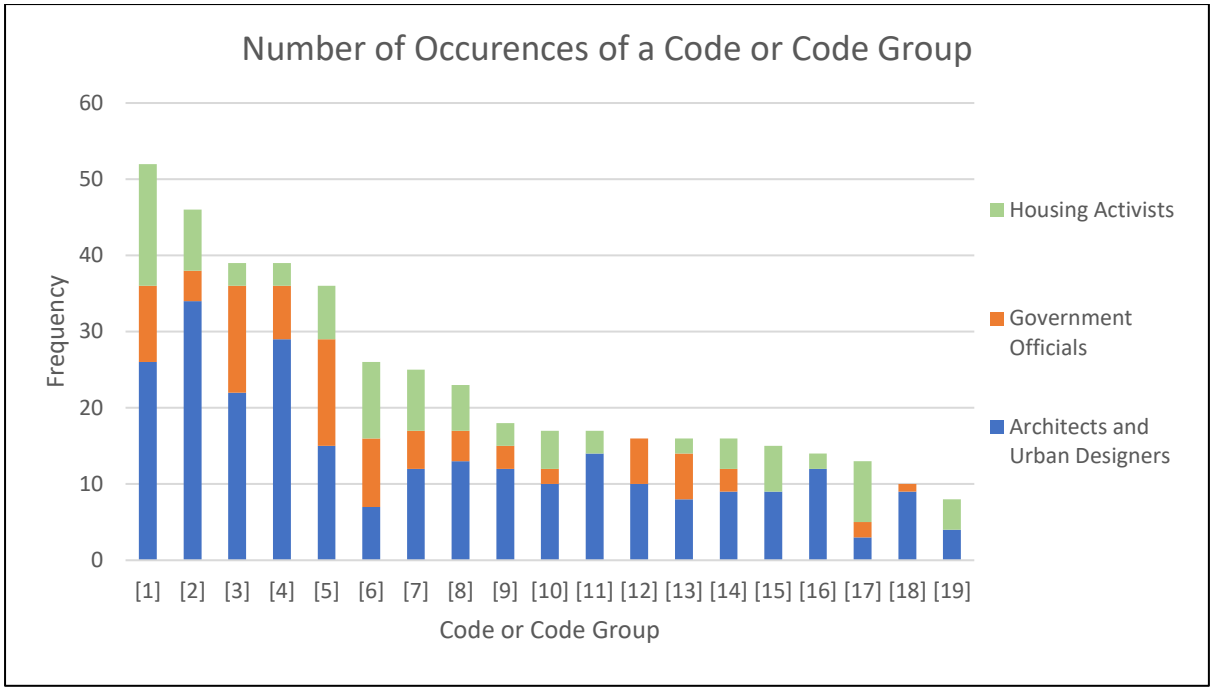

Figure 11: *The frequency of a code or code group based on the participant group.*

Since the goal of the interviews was related to the design of the house, it is seen (in Figure 11) that the majority of the codes and code groups refer to either the design of the house or urban design. However, challenges were also identified. The challenges that can be addressed by the construction method, are identified in the next subsection.

6.2 Criteria for Comparison

In this subsection, a simple thematic analysis was performed to identify codes and code groups that can be categorised under the same theme. A theme is a grouping of codes or code groups that has similar features (Schurink, et al., 2021). Therefore, the theme under consideration is the codes and code groups that are, or can potentially, be addressed by the construction method. These are briefly discussed in the order of frequency.

6.2.1 Costs [3]

From the identified criteria, cost is the code with the largest frequency. Reference to the costs was made 39 times in the 12 interviews. Two main themes were identified in the qualitative data: firstly, the budget constraint on the design of the house and secondly, the comparison of brick-and-mortar and prefabricated concrete costs.

Firstly, many interviewees agreed that the budget of a housing subsidy limits the design of the house. This includes the size of the house. As proof, excerpts from interviews are included.

> '*But with only the funds we have available, you end up building like the norms and standards say; a 40 square metre house.*' – Participant 2 (architect).
>
> *'I understand that it must be difficult to build a decent house with the small amount of money that the state subsidises.'* – Participant 12 (housing activist).
>
> '*So that minimum norms and standards is basically, if I can say, designed around that subsidy or allowance that we have.*' – Participant 7 (government official).

Secondly, interviewees also mentioned the price difference between brick-and-mortar and prefabricated concrete construction. From government officials and architects, it was concluded that brick-and-mortar construction is the cheapest. Quotes from the interview transcripts are added as proof.

> *'At this stage, I think that prefabricated concrete is still too expensive and more expensive than building with bricks. Actually, building with concrete blocks is the cheapest.'* – Participant 6 (architect and urban designer).
>
> *'The 140 mm block is the cheapest building method at this stage.'* – Participant 8 (government official).

Furthermore, it was stated by Participant 8 (government official) that the government is willing to use alternative building technologies; however, the prices are too high for these systems. He further stated that it is due to a lack of the number of suppliers of prefabricated concrete construction systems.

6.2.2 Alteration Capability [4] (includes [8] and [13])

In Table 7, it is shown that alteration capability constitutes references to alteration ease, alteration skills, material availability and the position of the house on the plot. However, the codes of 'extension need' and 'income mechanism' can also be included under the code group of 'alteration capability' since it is closely related. Therefore, this sub-subsection starts by discussing 'extension need', then the code group 'alteration capability' and lastly the 'income mechanism'.

The code group 'alteration capability' is related to the construction method; however, it needs to be shown that a need exists to alter or extend the house. From the Figure 11 it is seen that the code 'extension need' has 23 incidents in the interviews. To further prove this, excerpts from interviews are given.

> *'you have got families and extended families in the beneficiary list of claimants. And you know, with extended families, come extension of houses*' – Participant 1 (architect and urban designer).

> '*Stand-alone, because stand-alone houses give one in the near future the opportunity to improve in the structure that he/she has been given by the government*.' – Participant 11 (housing activist).

Now that it was shown that the need exists to extend or alter homes, the alteration capability of the homes can be investigated. 'Alteration ease' is the first code in the code group 'alteration capability' that is discussed. 'Alteration ease' refers to how easy the house can be extended or altered. Various interviewees mentioned that it should not be difficult to extend or alter the house and that the design should allow for it.

> *'All I am saying is, design so that the guy can extend, so that he can easily continue. Put in a door beforehand or put in a lintel so that he can later put in a door himself.'* – Participant 4 (architect).

Furthermore, the skills required to extend or alter the house are also questioned. To facilitate the extension of homes, low skills should be required. From the interviews, two quotations are used as proof.

> '*they ask you that one question: "Can the guy across the road build it?".*' – Participant 2 (architect).

> *'can you make it your own, can you build it yourself, do people have easy skills to do it,'* – Participant 6 (architect and urban designer).

Material availability is another factor to consider for the extension of homes. To ease the process of extending or altering a subsidy house, the material should be readily available. It has been stated by Participant 8 (government official) that the availability of suppliers of prefabricated concrete is scarce. Another factor is the consistency of supply. This was referenced by Participant 8.

> *'Most of the guys [alternative building technology manufacturers] is in the market for only a short period of time, then they disappear. Then you are lost when it comes to fixing. You just do not get the same product again to fix it.' –* Participant 8 (government official).

Lastly, the position of the house on the plot influences its alteration capability. The house should be placed at such a location to ensure that extension is possible. In the interview with Participant 12 (housing activist), it was stated that the position of homes on site prohibited the efficient extension of the house. Furthermore, the position of the house on the site also contributes to the living conditions in the community, by enhancing the aesthetics and passive surveillance. The majority of the interviewees stated that the house should be placed at the front of the plot. This ensures that shacks can be built at the back, without necessarily affecting the aesthetics of the community. Furthermore, it provides passive surveillance.

Lastly, due to lack of income, some residents take the opportunity to generate an income from their property. However, to generate this income, it is necessary to extend the house or build other structures on the property, if the erf size allows it. Therefore, the better the alteration capability of the house, the easier it is to use the property as an income-generating mechanism. From the interviews, it was clear that provision is made for this in the designs, as stated in the excerpts below.

> '*we have in some projects encouraged for economic opportunities for people to accommodate backyarders, for instance.*' – Participant 7 (government official).

> '*In that sense, it [the shape of the house] provides that increase of opportunity to allow for economic growth in that area.*' – Participant 2 (architect).

> '*they should be in a position, the owner, in the near future be able to use it [the property] as an economical enabler' –* Participant 10 (housing activist).

From this sub-subsection, it was found that the need exists among beneficiaries of affordable housing to extend or alter the house. Furthermore, provision should be made for this by choosing a construction method which enables the house to be easily altered. Lastly, enabling the ease of alteration of the house can lead to economic opportunities for the beneficiaries. Therefore, alteration capability is an important factor to consider for comparing construction methods.

6.2.3 Quality [6]

As stated in Table 7, this code group is influenced by reference to the quality of all the parts of the house. After analysing the data, quality issues were found at all elements of the house and with the materials and construction of the house. As proof, references to the quality issues of the roof, poor construction, poor materials and walls are shown.

> '*the roofs are leaking*.' – Participant 11 (housing activist).
>
> *'there was this one case where we had done regular inspections, I was the inspector for low-cost houses, where the house was 200 mm out from being square.'* – Participant 9 (government official).
>
> '*The majority of the houses have been poorly built, cheap materials being used, cheap labour being used,'* – Participant 11 (housing activist).
>
> '*all those houses have cracks, all those houses are in shambles.'* – Participant 11 (housing activist).

Other issues include plumbing, foundations and windows. It was however stated by Participants 7 and 9 that it is ensured that materials are SABS approved by internal inspectors.

6.2.4 Aesthetics [9]

This sub-subsection refers to the aesthetics of the house and not the aesthetics of the community. However, the interviewees stated how the front façade of the house contributes to the living environment of the community. Any reference made to the exterior, shape and interior of the house, was recorded in this code group. After analysing the data, it was found that only one quotation with reference to the interior, is relevant to the construction method. The quotation is applicable to prefabricated concrete construction.

> '*I cannot change it, I cannot hang a portrait against the wall, that type of thing.*' – Participant 6 (architect and urban designer).

6.2.5 Acceptance/perception [10]

The acceptance of a construction method by the beneficiaries is imperative, and it is based on their perception of the construction method. In all occurrences of this code, brick-and-mortar is perceived as the best building method and is therefore the preferred construction method.

> '*I would say, unquestionably, everyone would prefer the brick-and-mortar.' –* Participant 10 (housing activist).

Furthermore, the perception exists among beneficiaries that any other construction method is inferior to brick-and-mortar. Therefore, using another construction method might create feelings of degradation and inferiority among beneficiaries.

> *'The perception of the people was that if it was not built with blocks or bricks, it is not superior.*' – Participant 3 (architect).

> '*the final consumer might feel, what you call, might look degraded because this method [prefabricated concrete construction]; it is not a method that they grew up accustomed to.*' – Participant 10 (housing activist).

However, education and public participation was identified to assist in creating awareness of other construction methods, which is imperative for the implementation of these construction methods within these communities. Participant 11 (housing activist) stated that alternative building technologies have been introduced to them, but that education of these systems have not been prioritised. Other references also serve as proof.

> '*alternative [building methods] is not yet in their mindset unless there can be an aggressive education.*' – Participant 11 (housing activist).

> '*Delivering the right products is a public participatory process' –* Participant 1 (architect and urban designer).

It has however been stated that the government is not always involved in the public participatory process. This is problematic for the implementation of prefabricated concrete construction. Proof of this is shown by the quotes below.

> '*In this whole program, in this whole system [housing delivery process], beneficiaries are not the priority. Beneficiaries are not the priorities in this whole deal. They are not.*' – Participant 11 (housing activist).

> *'They [the government] do not interact with the owner or the end-consumer at all. And that is wrong. It is wrong.' –* Participant 6 (architect and urban designer).

In conclusion, to introduce prefabricated concrete as a means of providing affordable housing, education and public participation are vital. This will assist in the acceptance of other construction methods by changing the perception of the beneficiaries.

6.2.6 Skills/labour [16]

It has been found in literature that job creation and skills development are two challenges that are faced in construction methods. The interviews validated this. Job creation was referenced 11 times and skills development five times. It has been highlighted by the interviewees that job creation is a major issue facing prefabricated concrete construction. Proof of this is shown in the quotations below.

> '*It [prefabricated methods] can provide more houses, but then it does not tick the other box, which is creating jobs.*' – Participant 10 (housing activist).

> '*They [brick manufacturers] are saying, guys, we are providing jobs. Come to our warehouses and see. Now you are taking those jobs away by doing this, that can maybe be done by a machine for the panels or whatever. Then you have got two or three people operating the crane, whatever the case may be.*' – Participant 2 (architect).

Furthermore, interviewees also stressed the skills and experience required for the construction or extension of the house.

> '*Because you show them the benefits and the costs and the speed and they get excited and they are happy, but then they ask you: "Who knows how to use this material? Can you train people on how to use the material?".*' – Participant 2 (architect).

> *'You cannot use unskilled labour for a skilled job.*' – Participant 4 (architect).

Therefore, the conclusion is made from the interviews that job creation is, especially in prefabricated concrete, a challenge the government seeks to address. Additionally, the skill requirement is also a factor to consider when choosing a construction method.

6.2.7 Maintenance [19]

When choosing a construction method, the maintenance requirements is also a factor to consider. The maintenance requirements are related to costs and education. This was referenced by Participants 4 and 11.

> '*They [the beneficiaries] do not realise the financial implications of receiving a house…It results in an educational task.*' – Participant 4 (architect).

> '*I am not sure whether it is fair what I am going to say, they [the beneficiaries] are not really educated on how to well look after their own houses, after they have been given by government.*' – Participant 11 (housing activist).

In conclusion, educating the beneficiaries of maintenance requirements and the financial implications thereof, is of benefit to the beneficiary. Also, a construction method that offers cheap maintenance and requires low-skill labourers, should be chosen.

6.3 Chapter Summary

The aim of this chapter was to analyse the interview data and to show these results to the reader. Content analysis was performed to analyse the data. After codes and code groups had been identified, they were first analysed quantitatively (classical content analyses) and then qualitatively (thematic analyses).

From the classical content analysis, 19 codes and code groups were identified that are prevalent in the interview data. Seven of these codes and code groups were then categorised into a theme, as part of the thematic analysis process. The theme under consideration is the codes and code groups that are, or can potentially be, addressed by the construction method. Therefore, the codes and code groups that are part of this theme were costs, alteration capability, quality, aesthetics, acceptance/perceptions, skills/labour and maintenance. These were then discussed by quoting phrases from the interviews.

7 RESULTS AND DISCUSSION

The aim of this chapter is to compare the construction methods based on the technical and non-technical criteria. Therefore, the suitable construction method for the construction of subsidy houses is identified in this chapter.

7.1 Consolidation of Challenges

Challenges of subsidy housing developments have been identified in subsections 2.1 and 4.2. However, not all of these challenges can be addressed by selecting an appropriate construction method, for example corruption. Table 8 identifies the challenges that are affected by the construction method, whether directly or indirectly.

Table 8: *Identified challenges to be addressed by the construction method.*

Challenges
Housing Backlog
Housing Quality
Unemployment
Social Issues
Security
The Need for Extension
House Size
Economic Opportunities

From Table 8, the housing backlog, housing quality, unemployment and the need for extension can be directly addressed by the construction method. However, by addressing the challenge of unemployment, social issues and security are indirectly addressed. This is because social issues are a result of poverty and security-related crime too. Furthermore, by addressing the need for extension, the insufficient house size and the lack of economic opportunities are also addressed. The ability to extend the house, provides the opportunity to increase the living space and to use the property as an income-generating mechanism. These challenges form part of identifying the construction method that is more suitable for creating a ‘progressive

community', the non-technical criterion. Therefore, the effects of these identified challenges on the well-being and motivation of an individual, are discussed in the next subsection.

7.2 Technical Criteria

The aim of this subsection is to compare the brick-and-mortar walling system to the prefabricated concrete walling system. To accurately compare these two construction methods, the technical criteria identified from the literature need to be consolidated with the criteria obtained from the semi-structured interviews. The consolidated criteria are used to perform the comparison. The subsection concludes by showing which construction method technically performs better in the construction of subsidy houses.

7.2.1 Consolidation of Technical Criteria

This sub-subsection aims to consolidate the technical criteria found from literature with the criteria from the interviews. Table 9 shows the criteria from the literature review and the interviews. As seen from Table 9, all the criteria identified from the interviews, overlap with criteria from literature.

Table 9: *Consolidation of the criteria from literature to the criteria from the interviews.*

Literature Review	Interviews
Skills/Labour	Skills/Labour
Resource Availability	
Logistics	
Construction Time	
Construction Quality	Quality
Construction Cost	Costs
Procurement Model	
Safety	
Environmental Performance	
Alteration Capability	Alteration Capability
Aesthetics	Aesthetics Acceptance/Perception
Acoustics	
Durability	Maintenance

Literature Review	Interviews
Water Penetration Thermal Performance	

Note that 'acceptance/perception' is included in the 'aesthetics' criterion from the literature. Referring to Table 5, it is seen that the acceptance of the house by beneficiaries, is included in the definition of 'aesthetics' from the literature; therefore, the 'acceptance/perception' code is consolidated with 'aesthetics' from the literature. Furthermore, referring to Table 6, maintenance was included in the definition of 'durability'; therefore, 'maintenance' from the interviews is included in this criterion. Therefore, the technical criteria identified from literature accounts for the criteria identified from the interviews, and are thus adequate to use for the technical comparison of the construction methods.

7.2.2 Technical Comparison of the Construction Methods

In this sub-subsection, the construction methods are compared to each other on the abovementioned consolidated technical criteria. As stated in the Scope, this comparison is only applicable to the walling system.

(i) Skills/Labour

Investigating this criterion, the comparison of the construction methods is done on two factors: employment creation and skills development and training (Windapo, et al., 2021). These factors are also in accordance with South Africa's Expanded Public Works Programme (EPWP), which is a programme aimed at addressing unemployment (Department of Public Works, 2005).

Brick-and-mortar construction is a labour-intensive method and makes use of skilled and unskilled labourers to perform the work (Sweis, et al., 2008). McCutcheon (1995) describes labour-intensive construction as the substitution of equipment with labour. However, quality and efficiency are still of great importance in this substitution (McCutcheon, 1995). Furthermore, a skilled labourer is associated with a qualification and a specific level of competence (Windapo, 2016). Some skilled labour force included in brick-and-mortar construction are carpenters, roofers, bricklayers, plasterers and painters (Windapo, 2016). Unskilled labourers are associated with manual labour, and they perform activities such as removing debris, digging trenches and erecting scaffolding (Webb, 2021). To build a masonry

wall, an approximate ratio of 60 percent semi-skilled labourers (classified as skilled in this study) to 40 percent unskilled labourers is required (Schreuder & Wium, 2016).

The labour involved in prefabricated concrete is split into two groups: the labour involved in the production of the concrete elements and the construction workers placing the elements on site. The process of manufacturing prefabricated concrete elements is automated to a large extent; however, some casting procedures require a skilled and unskilled workforce (Cobute, 2021). At the manufacturing plant, a majority of the workforce consists of skilled labourers (Schreuder & Wium, 2016), such as casting machine operators, forklift and cable tensioner operators. However, on site, the placement of prefabricated concrete elements and the placement and removal of props make use of a greater percentage of unskilled workforce (Schreuder & Wium, 2016).

In terms of skills development and training, prefabricated concrete is more suitable as a construction method (Windapo, et al., 2021). In the manufacturing process, since the employees are permanently appointed, skills are transferred from the skilled labourers to the unskilled labourers with time (Cobute, 2021). Based on the wall quality issues mentioned in sub-subsection 2.1.3, the development of skills through brick-and-mortar construction is questionable. This is proven in Buys and Le Roux's (2013) study that showed that substandard artisan and labourer skills are ranked 1st and 6th respectively as the causes of defects in construction.

The conventional construction method is a better method in terms of employment creation, since it is labour-intensive. With automation being prevalent in the manufacturing process of the concrete elements, many employment opportunities are lost. Also, the placement of the prefabricated concrete elements on site is not labour intensive (Van Jaarsveld, 2018).

However, the conventional brick-and-mortar building method is criticised for not creating sustainable employment (Theart, 2014). There are two reasons for this. The first is because 30 percent of the contract value needs to be sub-contracted to local small, medium and micro enterprises (SMMEs) (Ramaphosa, 2019). These SMMEs will temporarily make use of local labour to complete the project; however, when the project is complete, these labourers will become unemployed again. The second reason for not creating sustainable employment, is the lack of transfer of skills. Due to the short timeline of training programmes, labourers are not guaranteed of sustainable employment (Theart, 2014).

In contrast, prefabricated concrete construction is more suitable for creating sustainable employment, since employees at the manufacturing plant are appointed permanently. To address the low level of employment opportunities created by prefabricated concrete construction, a manufacturing plant can be created on site. If less automation is used, more employment opportunities can be created for the duration of the project. Also, since skills are mainly transferred during the manufacturing process, this could be beneficial to creating sustainable employment for labourers.

(ii) Resource Availability

As stated in Table 4, resource availability is associated with the accessibility of labour, skills and materials. Excluding discouraged job seekers, the official unemployment rate is between 20 to 30 percent; therefore, there is no shortage of labour in South Africa (South African Market Insights, 2020). Windapo (2016) also stated that there is no shortage of skilled workforce in the construction industry. Furthermore, she found that contractors do not find it very difficult to source masons for projects (Windapo, 2016).

In terms of skill availability, Bhorat et al. (2016) found that, in 2012, the secondary labour sector consisted of 61.5 percent medium-skilled labourers (which include skilled construction workers) and 20 percent unskilled labour. This is positive for the construction of a masonry wall and the manufacturing of prefabricated concrete elements since both these processes require more skilled labourers than unskilled labourers. However, these figures are based on employed labourers (Bhorat, et al., 2016). Windapo (2016) stated that unskilled labourers dominate the labour market, which implies that the majority of unskilled labourers are unemployed. Therefore, the construction method that employs more unskilled workers should be favoured, since the availability of unskilled labourers (which many of are unemployed) surpasses the availability of skilled labourers.

In terms of material availability, the accessibility of concrete blocks was investigated for the brick-and-mortar construction method and for the prefabricated concrete construction method, the availability of precast concrete manufacturers was investigated. Concrete blocks are readily available from concrete brick manufacturers, distributors and chain hardware stores. Concrete blocks are thus very accessible, even in rural areas. Building sand and concrete is also available from chain hardware stores.

From Agrèment SA's list of certified walling and building systems, the building systems in the Cape Town-area were investigated (refer to the Scope of the study). The addresses of 18 systems were located in the Cape Town region. These results were then filtered to find prefabricated concrete building systems that are certified for the construction of dwelling units. From this, only five walling and building systems are certified in the Cape Town region. It may be that the material for prefabricated concrete construction is not easily obtainable, especially in rural areas. This was confirmed by Participant 8 (government official) in the interviews, stating that there is a lack of suppliers of prefabricated concrete in the Western Cape Province.

(iii) Logistics

For brick-and-mortar construction, obtaining suppliers of materials is generally simple since material is easily available. This also facilitates the timeous delivery of materials since distances that need to be travelled are short. In terms of equipment required, a truck is used to deliver pallets of concrete blocks and cement and a forklift can be used to offload these pallets from the truck and place it at strategic places. Human labour is then used to move the cement and bricks individually once they are offloaded. Compact loaders can also be used to move pallets after they are offloaded. The delivery of building sand is typically the responsibility of the supplier, which delivers it with a tipper-truck.

Typically, prefabricated concrete elements are manufactured off-site and need to be transported to the site (Van Jaarsveld, 2018). The handling of prefabricated elements should be minimised; therefore, elements should be placed as they are offloaded from the delivery truck (Van Jaarsveld, 2018). Elements should thus be loaded onto the delivery truck in placement sequence (Van Jaarsveld, 2018). Suppliers of prefabricated concrete are limited in numbers and are concentrated in the Cape Town area in the Western Cape Province. A housing project in a town or rural area at some distance from Cape Town can be affected by the delivery distance since the probability of delays are greater. Also, due to transport restrictions in terms of size and weight of elements, a limited number of elements can be transported at a time (Van Jaarsveld, 2018). Incorrect quantities of elements can also affect the construction time since these elements are not accessible from local hardware stores due to their project-specific nature. In terms of equipment required on site, the elements are delivered by truck. However, depending on the element size, heavy equipment may be required for the offloading, moving and placement of elements. A telescopic handler, crane or mobile crane can be used for this function, depending on the site restrictions.

(iv) Construction Time

Construction time varies with the size of the project (Theart, 2014) and is influenced by various factors such as material of the structure, site conditions and weather conditions (Elhag & Boussabaine, 1999). Elhag and Boussabaine (1999) identified a total of 67 factors that influence time and cost in construction projects.

The speed of erection of prefabricated concrete buildings is a well-recognised fact (Jurgens, 2008; Schreuder & Wium, 2016; Van Jaarsveld, 2018; Karthigai Priya & Neamitha, 2018; Thompson, 2019). This is not only due to bigger wall elements being used but also because various processes can occur concurrently. While the elements are cast and cured in a factory, earthworks, civil services and foundations can be prepared on site. Brick-and-mortar is a more dependent sequential process since each process is dependent on the previous processes. To further accelerate the construction time and be financially viable, the use of similar precast elements is encouraged (Jurgens, 2008).

(v) Construction Quality

Construction quality is associated with defects for which the producer is responsible (Buys & Le Roux, 2013). The construction quality is low when many construction defects are present in the end-product. These defects are a result of errors in design, materials and workmanship (Buys & Le Roux, 2013). Since construction methods are compared, the focus is specifically on the defects of construction.

It is known that the conventional method of construction of RDP and BNG houses is the use of concrete blocks and mortar. From 2.1.3, it is shown from various authors that the walling quality in subsidy housing is a problem. It was also shown that the cause of this is poor workmanship, substandard materials and/or subsurface conditions (Buys & Le Roux, 2013).

In contrast, prefabricated concrete is cast and cured in a controlled environment, which means that a certain level of quality can be obtained (Cobute, 2021). The process of manufacturing is also a well monitored process, which ensures a high-quality product with a high-quality surface finish (Cobute, 2021). The elements are manufactured by a skilled labour force, which is associated with a positive impact on the performance criteria (Hussain, et al., 2020).

(vi) Construction Cost

In the calculation of construction cost, factors accounted for are labour, materials, plant, design costs, transportation, interest rates and the stability of the market (Elhag & Boussabaine, 1999; Theart, 2014). Supply and demand also drive the cost of a certain construction method.

In a detailed study by Samani et al. (2018) in the USA, it was shown that the construction cost of prefabricated concrete was higher than the cost of masonry. A 30 m^2 dwelling unit was used for the study, which is similar in size as the RDP houses pre-2004 (Samani, et al., 2018). Furthermore, labour costs were included in their calculations, but transportation costs were excluded (Samani, et al., 2018). In the South African context, if transport was included, the cost of prefabricated concrete would increase even more due to fewer prefabricated concrete factories in comparison to brickworks. From this, it can be derived that prefabricated concrete's cost can be expected to be higher.

Little accurate information from literature could be obtained on the general cost comparison of prefabricated concrete to brick-and-mortar buildings in South Africa. A study by Windapo et al. (2021) compared the conventional building system (*in-situ* concrete floor, brick-and-mortar exterior walls and timber roof trusses) to a sustainable building system. The sustainable building system's exterior walls consist of a Agrèment certified prefabricated concrete system, called the Banbric Building System (Windapo, et al., 2021). This walling system is constructed in a similar fashion as Vibracrete fencing walls. On the cost comparison between these building systems (floor, exterior walls and roof included), it was found that the sustainable building method was 15 percent more expensive than the conventional building method (Windapo, et al., 2021). However, this result was obtained for the whole building and not just the exterior walls.

Another example is a study by Grady et al. (2019) in which alternative building technologies (ABTs) are compared to the current construction method for affordable housing in Cape Town. One of the technologies considered made use of structurally insulated panels (SIPs). It was concluded from their study that ABTs are more expensive than the conventional construction method; however, a detailed cost-comparison was not done (Grady, et al., 2019).

Lastly, from the semi-structured interviews, it was found that brick-and-mortar construction is cheaper than prefabricated concrete construction. Participant 8 pointed out that this is due to a lack of suppliers of prefabricated concrete construction methods. Based on all these sources, it

can be concluded that a prefabricated concrete solution may be more expensive than construction using the conventional brick-and-mortar.

(vii) Procurement Model

In the thesis of Bolumole (2017), three factors are identified for choosing a procurement method. These factors are associated with the project objectives and constraints, project risks and the level of complexity of the project (Bolumole, 2017).

In a study by Guma (2018), it was found that the traditional and turnkey procurement methods are commonly used in housing projects, that is for brick-and-mortar construction. In the traditional approach, the client is responsible for the design and a contractor is used for the construction (Guma, 2018). Examples of standard contracts that incorporate the traditional approach, are the South African Institution of Civil Engineering's (SAICE's) General Conditions of Contract (GCC), International Federation of Consulting Engineers' (FIDIC's) Red Book and the Joint Building Contracts Committee's (JBCC's) Standard Contract. The traditional approach is the most used procurement method and is thus well-known among engineers and project managers (Bowmans, 2019).

In the turnkey procurement method, only a contractor is appointed by the client. Therefore, the contractor is responsible for the design and construction processes. An example of a standard contract is FIDIC's Silver Book (Fédération Internationale des Ingénieurs - Conseils, 2017). This contract ensures a higher certainty of the price and completion time (Guma, 2018). In Guma's (2018) study it was found that the turnkey procurement method was suitable for housing projects.

For prefabricated concrete, Hanekom (2011) suggests the use of design-build and contract management procurement approaches. With prefabricated concrete, the whole project team needs to be involved from the early stages of the project. These procedures suggested by Hanekom (2011) allow for that. It thus requires a more collaborative approach between designers, suppliers and contractors. However, experience in these approaches is rare since they are not currently used for mass housing in South Africa, and this can cause difficulties and problems during the project (Hanekom, 2011).

In conclusion, the use of prefabricated concrete will require a special procurement model, and more research should be done to incorporate the variability in design and the experience of clients.

(viii) Construction Safety

In 2016, it was reported that the South African construction industry had 1.5 to 2.5 fatalities per week (Thejane, 2017). The number of fatalities in South Africa is much higher compared to high-income countries (Vekinis, et al., 2010). Lack of supervision and poor workmanship are some of the main causes of accidents on site (Samuel, 2017).

A study by Memarian and Mitropoulos (2013) investigated accidents related to masonry construction. From this study, it was found that the assembly and dismantling of scaffolds, the laying of blocks and the handling of the material caused the most injuries on site (Memarian & Mitropoulos, 2013). These activities cause incidents of overexertion, being struck by objects and cuts from objects (Memarian & Mitropoulos, 2013).

It was stated in Samani et al. (2018), Van Jaarsveld (2018), Karthigai Priya and Neamitha (2018) and Thompson (2019) that the use of prefabricated concrete improves safety on site. However, Jurgens (2008) and Van Jaarsveld (2018) both stressed the importance of training all labourers in crane safety when using precast concrete construction. Nonetheless, it was found from Yashrri and Hanizam (2014) that the general aspects and the lifting process of precast concrete construction are at an acceptable safety level.

(ix) Environmental Performance

In a thesis by Brewis (2012), she calculated that the external walls of a low-cost house made of brick-and-mortar, generated the most waste and have the largest carbon footprint out of all the elements of a house. Concrete blocks generate a large amount of construction waste, and their high carbon footprint is due to the use of concrete, which has the largest environmental impact factor (Brewis, 2012).

In contrast, prefabrication is beneficial to waste minimisation (Van Jaarsveld, 2018; Yu, et al., 2021). Furthermore, Yu et al. (2021) also showed that the use of prefabrication reduced the emissions of greenhouse gases in China. However, an important factor to consider in the South African context, is transport. Since the manufacturers of precast elements is generally concentrated in Cape Town, when considering the Western Cape Province, the transport to rural areas in the Western Cape Province and Cape Winelands districts will play a significant role in the environmental impact of prefabricated concrete construction. Transport negatively affects the greenhouse gas emissions and resource depletion (Brewis, 2012).

In Table 10, the concrete volume in concrete blocks is compared to the volume of concrete in prefabricated concrete sandwich panels. This is done due to the large environmental impact of cement; therefore, the less cement used, the less the environmental impact. The mass of the concrete blocks and the number of blocks per elevation area of wall, was obtained from Algoa Cement Industries (2021). The thickness of the panel was obtained from a design by O'Hegarty et al. (2020) which has an outer width of 25 mm and an inner width of 40 mm, made of fibre reinforced concrete. This panel has a similar structural performance compared to standard sandwich panels (O'Hegarty, et al., 2020). In Table 10, it is shown that this specific design contains less concrete than a conventional concrete block. Additionally, fibre reinforced concrete uses marginally less cement than conventional concrete mixes (Gadge & Vidhale, 2013).

Table 10: *Comparison of concrete volume of concrete blocks and prefabricated concrete sandwich panels.*

Concrete blocks	**Mass**	**Blocks per area of wall**	**Mass per area of wall**	**Concrete density**	**Volume concrete per area of wall**
	kg/block	block/m^2	kg/m^2	kg/m^3	m^3/m^2
	12,700	12,500	158,750	2400	0,066
Prefabricated concrete sandwich panel	**Wall area of 40m^2 house**		**Thickness of panel**	**Volume concrete per 75m^2 wall**	**Volume concrete per area of wall**
	m^2		m	m^3	m^3/m^2
	75		0,065	4,875	0,065

In the last column of Table 10, the volume of concrete per elevation area of a wall is given. The values in this column are equivalent to the thickness (in metres) of a 1m x 1m solid concrete wall. Therefore, comparing a standard solid concrete wall of 125 mm (Peace Corps, n.d.) to concrete blocks and sandwich panels, it has larger environmental impact due to its higher concrete volume.

The environmental performance of prefabrication has been highlighted by Thompson (2019) and Yu et al. (2021). Furthermore, Samani et al. (2018) made specific reference to the lower environmental impact of sandwich panels to masonry buildings. However, for this study it has

been determined that sandwich panels have the least environmental impact compared to concrete blocks and solid concrete wall panels.

(x) Alteration Capability

This sub-subsection refers to the ability to alter the house as the needs of the occupants change. The ease of alteration is associated with the skill and equipment requirement, the accessibility of material and the modification ability of the elements comprising the construction method.

Considering brick-and-mortar, it was found from sub-subsection 7.2.2 (i) that semi-skilled bricklayers are required to build with brick-and-mortar. However, there is an abundant availability of bricklayers, especially in informal settlements, due to the temporary nature of brick-and-mortar construction work (Goldman, 2003). In terms of equipment, basic equipment and manpower can be used to construct with concrete blocks. All equipment required can be bought from a local hardware store. This is also true for the required material (concrete blocks, cement and building sand). The creation of openings in brick-and-mortar buildings can also be made with relative ease with the correct power tools and knowledge. Therefore, in the alteration of a brick-and-mortar building, the informal building sector can be used since this knowledge is widely available.

In contrast, the alteration of prefabricated concrete structures is not always possible without the initial design allowing for it. Furthermore, heavy equipment may be required for the movement and placement of the elements. Also, the elements are not readily available from any hardware store; therefore, it is not easily accessible. Lastly, elements cannot be modified for door or window openings. An element would have to be specifically designed for this modification. In summary, prefabricated concrete structures cannot be altered easily without it being designed for this function beforehand.

(xi) Aesthetics

In Botes' (2013) study about shipping containers for affordable housing, the importance of the visual aspect of housing was emphasised. In Botes' (2013) survey, a majority (88 percent) of the respondents stated that they would reside in a shipping container home if it looked like a brick house. Furthermore, beneficiaries have this view that a house should be constructed from brick and mortar (Botes, 2013) because higher class houses are built from brick and mortar (Grady, et al., 2019). It is believed by communities that any other material is inferior to brick-and-mortar houses (Grady, et al., 2019). However, in a survey by Grady et al. (2019), it was

found that brick and concrete are classified as quality materials by beneficiaries. This is beneficial to both construction methods considered in this study.

Residents are sceptical about new materials and technologies, and this creates a negative perspective on these construction methods (Department of Human Settlements, 2010). Grady et al. (2019) stated that by participating in the process of building a home with an alternative construction method, it can assist with the acceptance by the residents of the building technology. Furthermore, Botes (2013) stated that marketing alternative building methods (such as prefabricated concrete) to stakeholders can change their perspective. However, even after Botes (2013) had informed participants of the advantages of living in a house built from an alternative construction method (a shipping container in this case), the respondents still chose to stay in a brick-and-mortar house.

In conclusion, beneficiaries are sceptical of new construction materials and methods but are more likely to accept these materials and methods if the end-product looks like a brick-and-mortar house, and if they have been involved in the construction process.

(xii) Acoustics

As stated in Table 6, the acoustic performance of a wall refers to the wall's ability to insulate the room and to absorb sound within the room. Sound insulation refers to the minimising of sound transmitted from one room to another (Chaya, 1979). Sound absorption refers to the ability of the wall to absorb sound within a room, minimising echoes within the room (Chaya, 1979).

For sound insulation, a measure used to compare the attenuation of airborne sound of materials, is the sound transmission loss (STL) (Ballagh, 2004). The value, in decibels (dB), is a measure of the amount of sound energy absorbed by the wall; thus, the higher the value, the better the sound insulating properties of the wall. This is measured, in Hertz (Hz), at various frequencies.

A comparison, based on STL, between a 190 mm thick concrete block wall and two prefabricated concrete elements was done. The concrete block wall has the same thickness as described for a shared wall in a semi-detached dwelling (Western Cape Government: Professional and Project Management Services, 2018). The dimensions of the solid prefabricated concrete wall were 7000 x 1200 x 200 mm. The lightweight prefabricated concrete panel consisted of two 7000 x 1200 x 50 mm concrete exterior layers with a 100 mm thick polystyrene centre (Piana & Marchesini, 2012). The result from this comparison is shown

in Figure 12. The data for the concrete block wall was obtained from Ballagh (2004), and the data for the prefabricated units were acquired from Piana and Marchesini (2012). From Figure 12, it is seen that the solid prefabricated concrete wall performs better acoustically than the concrete block wall. Also, the STL of the lightweight prefabricated concrete panel STL is similar to the STL of the concrete block wall.

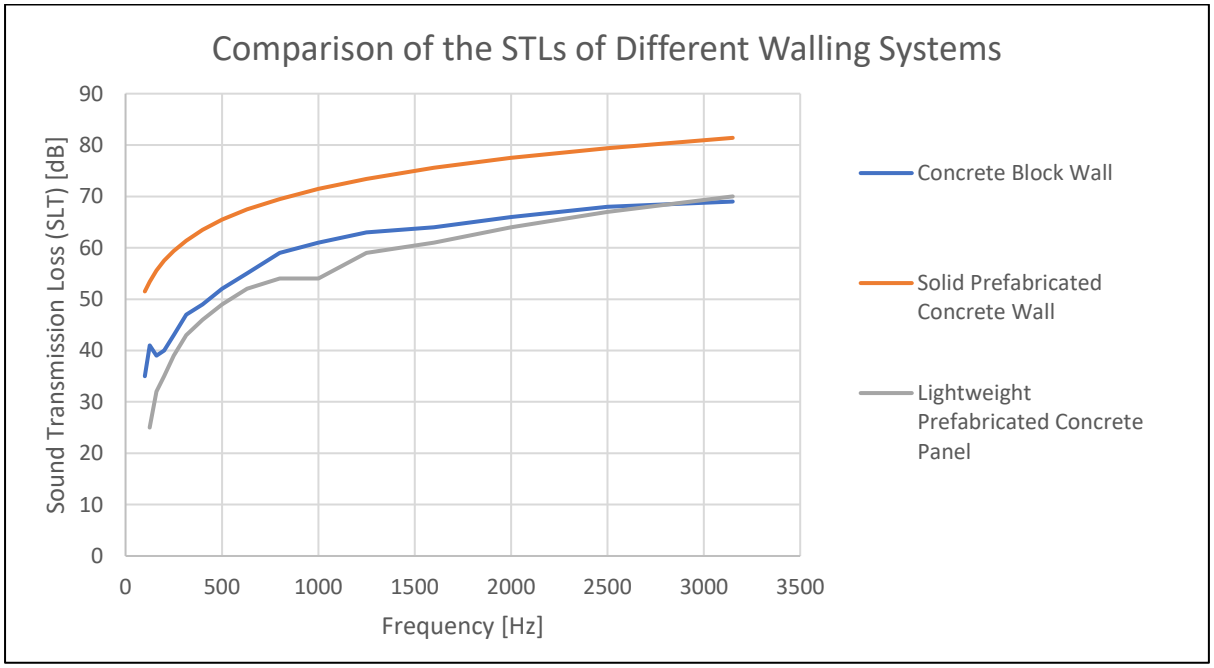

Figure 12: *Comparison of the STLs of different walling systems.*

For the comparison of sound absorption, the sound absorption coefficient is used (Li & Ren, 2011). However, this coefficient varies with frequency and complicates the comparison (Djikou, et al., 2018). A single value is required; therefore, the noise reduction coefficient (NRC) is used (Djikou, et al., 2018). This value is the average of the sound absorption coefficients at 250Hz, 500Hz, 1000Hz and 1600Hz (Djikou, et al., 2018). This coefficient has a value between zero and one; one indicating perfectly absorptive and zero perfectly reflective (Peng, 2017). Therefore, a value closer to one is desired. Table 11 compares the NRCs of a concrete wall (not necessarily prefabricated) and a wall made of concrete blocks with different surface finishes.

Table 11: *Comparison of the NRCs of a concrete wall and various concrete block walls (adapted from Chaya (1979)).*

Material	Surface Finish	Approximate NRC	Reduction Factor	Adjusted NRC
Concrete	All types	0,02	0%	0,02
Concrete Block	Coarse	0,28	55%	0,13
	Medium	0,27	55%	0,12
	Fine	0,26	55%	0,12

From Table 11, it is seen that a coarse concrete block wall's absorption capacity exceeds the other types, based on its higher approximate NRC. However, painting a concrete block wall reduces its absorption capacity (Chaya, 1979). Since the exterior walls of RDP and BNG houses are required to be painted (Gauteng Department of Human Settlements, 2018; Western Cape Government: Professional and Project Management Services, 2018), the NRCs have to be adjusted. The reduction factors in Table 11 account for the two coats of polyvinyl acetate paint, as required by the above specifications (Chaya, 1979). Applying the reduction factors to the approximate NRCs, the adjusted NRC values are acquired. The reduction factors are only applicable to the concrete blocks (Chaya, 1979). The NRC value for the concrete wall is applicable to all surface finishes (Chaya, 1979). Comparing the adjusted NRC values in Table 11, it is seen that a painted concrete block wall has a higher NRC than a concrete wall; therefore, in terms of affordable housing in South Africa, the brick-and-mortar house will have better sound absorption.

(xiii) Durability

The durability of the walling system is related to the service life and the maintenance requirements of the walls. Causes of durability issues include physical damage, temperature changes (Theart, 2014), poor workmanship and poor materials (Wallbaum, et al., 2012). This is judged in terms of frequency, effort and cost.

Generally, for brick-and-mortar buildings a service life of 100 years can be expected (McGarry & Madsen, 2019); however, due to the poor quality of workmanship and materials in subsidy housing, this number is negatively affected. Furthermore, the poor quality also affects the durability of the walls. From 2.1.3, problems with walls included cracks and the detachment of plaster. Depending on the cause of the problem, the rectification and maintenance of these

issues are easy, cheap and can be done by an unskilled labourer. However, a moving foundation can also be the cause of the cracks, and this is an expensive repair for a skilled individual. Additionally, the detachment of plaster can also be due to dampness, which is also a more expensive maintenance problem.

Prefabricated concrete wall panels generally have a design life of 50 years (Krentowski, et al., 2021). The quality of prefabricated panels is generally high due to the controlled environment of casting. However, due to external factors and the environment of the panels, problems do occur. These can include damage to the edges of precast elements, cracks in elements, corrosion of joints and the lack of sealant between panels (Krentowski, et al., 2021). Furthermore, in sandwich panels, the connections between the different layers also experience corrosion (Krentowski, et al., 2021). Corrosion issues are exacerbated by the broken edges and cracks of the wall panels since water can penetrate these gaps.

In terms of frequency, effort and cost, brick-and-mortar is the better option. Although prefabricated concrete does not require frequent maintenance and inspections, approximately every 10 to 20 years (Mohammed, 2018; Krentowski, et al., 2021), the maintenance is usually costly. Furthermore, inspections need to be done by professionals. Lastly, since corrosion cannot necessarily be seen by visual inspection, expensive equipment is required for a diagnosis (Krentowski, et al., 2021). For prefabricated concrete, a prevention-is-better-than-cure mindset is required for maintenance; however, this is in contradiction to the traditional mindset. With brick-and-mortar, maintenance is done once the problem is visual.

In contrast, maintenance on brick-and-mortar home will occur more frequently; however, these maintenance issues can typically be fixed by the occupants. The materials required for the rectification are also easily available and not too costly. However, a more comprehensive study will need to be done to quantify the long-term cost comparison between concrete block walls and precast concrete walls.

(xiv) Water Penetration

According to SANS 10 400 (1990), walls should undergo a rain penetration test. In this test, the walls are sprayed with water in a finely divided spray for a certain time period, depending on the mean annual rainfall and hourly mean wind speed at the location of the house (SABS, 1990). To pass this test, no moisture should be present on the inner surface of the wall at the end of the test (SABS, 1990). As stated by Ong (1988), horizontal and lateral water penetration

affect brick and concrete walls. This sub-subsection is concentrated on water penetration from external sources; thus, rising dampness is not included.

In unfinished concrete block walls, water penetrates at an early stage and causes leakage and dampness (Anand, et al., 2003). At low wind speeds (less than 50 km/h), Anand et al. (2003) stated that a plaster finish on the exterior side is sufficient to prohibit leakage and dampness. From this, a surface finish is imperative for the prevention of leakage and dampness. The norms and standards given by the Western Cape Government (2018) state that all external walls shall be plastered on both sides and the exterior should be painted. However, it was observed in the newly built units in Hawston that the interior walls were also painted. This is sufficient to prevent water penetration. However, as stated in sub-subsection 2.1.3, the poor quality of the construction and materials cause cracks in the walls and plaster. Therefore, the water resistance of these walls is compromised.

Due to the high-quality finish of prefabricated concrete, water will not penetrate through these panels because there are no cracks present. However, there are many joints present in prefabricated construction and these are weak points for water penetration. Joints are usually sealed to prevent water penetration; however, these seals need to be maintained. Cracks can also occur with time, which can compromise the water resistance ability of the prefabricated wall (Krentowski, et al., 2021).

In essence, prefabricated concrete walls are better for water resistance than brick-and-mortar walls in the South African context. This is due to the poor construction quality of brick-and-mortar houses and due to lesser maintenance required, to maintain its water resistance, of prefabricated concrete panels.

(xv) Thermal Performance

The thermal performance of a building is related to how well a building can keep cool in the summer and stay warm in the winter. Therefore, a building should be able to resist the passage of heat from a source of high temperature to a point of low temperature. Therefore, the walling material and the construction of the wall is of importance because thermal insulation needs to be a consideration. This is also beneficial to the environmental performance since when less fluctuations occur in the interior, then less heating is required to adjust the interior temperature to a comfort level.

A method for determining the thermal performance of a wall type, is to the compare the thermal resistance (R-value) of a material or composite materials (Lee & Pessiki, 2004). The higher the R-value, the better thermal insulator it is. In Table 12, the R-values of different walling systems are compared.

Table 12: *Thermal resistance of different walling systems.*

	150 mm Concrete Block Wall		**Sandwich Panel**		**125 mm Solid Concrete Wall**	
	Plastered	**Unfinished**	**Thermal Bridge**	**No Thermal Bridge**	**Lower Value**	**Upper Value**
R	m^2.K/W	m^2.K/W	m^2.K/W	m^2.K/W	m^2.K/W	m^2.K/W
	0,385	0,361	1,032	1,608	0,089	0,156

The value for the unplastered wall was obtained from Abdou and Murali (1994). Furthermore, the values for the sandwich panels were obtained from the finite element analysis of Lee and Pessiki (2004). The sandwich panels consisted of two 76 mm thick concrete exterior layers with a 51 mm insulation layer in the centre (Lee & Pessiki, 2004). In a sandwich panel, at some locations, the one exterior layer is connected to the other exterior layer by means of a solid concrete bridge. Figure 13 helps to illustrate the concrete bridge by showing the cross-section of a sandwich panel. The function of the concrete bridge is to place inserts for the handling and placement of these elements (Lee & Pessiki, 2004). These sections of solid concrete create a thermal bridge and affect the overall thermal performance of a wall (Lee & Pessiki, 2004).

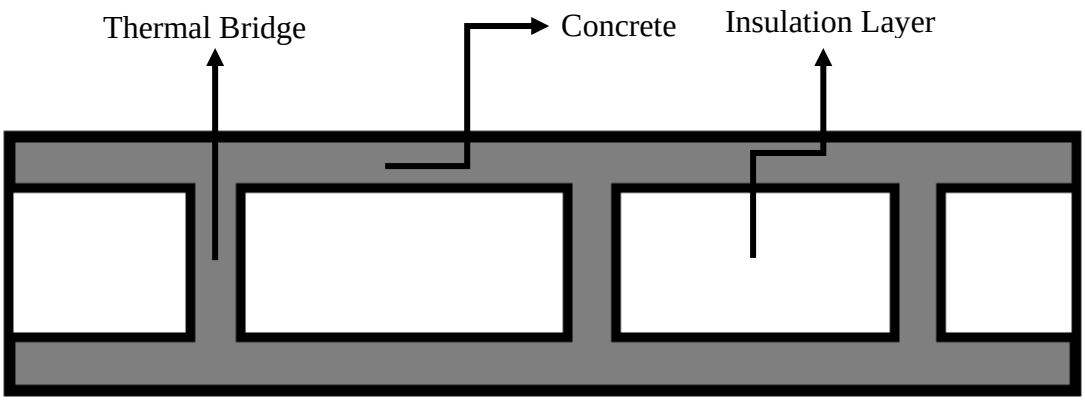

Figure 13: *Cross-section of sandwich panel with a thermal bridge.*

The value of the plastered concrete block wall, in Table 12, had to be calculated. From Gupta and Nathani (2016), this R-value is calculated by using the sum of all the R-values of its constituents. That is the R-value for plaster and the R-value of an unfinished concrete block wall. Take note that the convective heat transfer was ignored since it is reliant on various factors and can have a value between 0,4 and 0,04 for free air flow (Drysdale, 2011; Kosky, et al., 2013). To obtain the R-value of plaster, the thickness of the plaster layer needs to be divided by the thermal conductivity of the material. As stated in the Western Cape's Minimum Norms and Standards (2018), the exterior walls must be plastered a thickness of 12 mm on each side. Using this and the thermal conductivity value, obtained from Evangelisti et al (2015), for cement and sand plaster, an R-value of 0,012 m^2K/W was obtained. This results in a plastered wall R-value of 0,012 + 0,361 + 0,012 = 0,385 m^2K/W.

Referring to Table 12, a wall thickness of 125 mm was used for the determination of the R-values for a solid concrete wall (Peace Corps, n.d.). From Drysdale (2011), the thermal conductance of concrete varied between 0.8 and 1.4 W/m.K. The lower thermal conductance value gives a higher R-value and vice versa; therefore, the 'lower value' column in Table 12 refers to thermal conductance of 1.4 W/m.K and vice versa. Dividing the thermal conductance by the wall thickness and then calculating the reciprocal, equals the R-value. As seen from Table 12, the solid concrete wall has the lowest thermal resistance.

Table 12 shows that the sandwich panels have a better thermal performance than the brick-and-mortar and solid concrete wall. However, different materials have distinct thermal properties and an accurate conclusion with regard to thermal performance cannot be made without accurately comparing each system. It was however stated by Van Rooyen and Vosloo (2015) and by Mabuya and Scholes (2020) that the conventional subsidy house has a poor thermal performance.

7.2.3 Summary and Discussion

This sub-subsection aims to summarise the technical comparison between the brick-and-mortar and prefabricated concrete construction methods. The results of the comparison are summarised in Table 13, with the better alternative marked with an 'X' in each case. Table 13 is used as reference for the discussion to follow.

Table 13: *Summary of the comparison between the construction methods.*

	Brick-and-Mortar	Prefabricated Concrete
Skills/Labour		
Employment Creation	X	
Skills Development		X
Resource Availability		
Labour	X	X
Skills	X	
Materials	X	
Logistics	X	
Construction Time		X
Construction Quality		X
Construction Cost	X	
Procurement Model	X	
Construction Safety		X
Environmental Performance	X	X
Alteration Capability	X	
Aesthetics	X	
Acoustics		
Sound Insulation		X
Sound Absorption	X	
Durability	X	
Water Penetration		X
Thermal Performance	X	X

Looking at the 'skills/labour' criterion, it is shown that brick-and-mortar is more beneficial to employment creation due to it being more labour-intensive. On the other hand, at prefabricated concrete plants, skills are transferred from skilled to unskilled labourers, and it is thus more beneficial for skills development.

In terms of resource availability, brick-and-mortar construction is the more suitable option. In terms of labour, South Africa's high unemployment rate avails employment for both construction methods. Since more unskilled labourers are available and the conventional construction method is more labour-intensive, there are however more labour-opportunities for

brick-and-mortar construction. Lastly, materials for brick-and-mortar are also more readily available than prefabricated concrete due to the project-specific nature of prefabricated concrete and lack of suppliers.

Logistically, brick-and-mortar construction is easier and better understood. Prefabricated concrete element suppliers are scarce and, depending on the size of the elements, transport may be a challenge. Also, the handling of elements may require heavy equipment. In contrast, the materials for brick-and-mortar construction are easily acquired and manpower can be used to move elements.

In terms of the construction pyramid of time, quality and cost, prefabricated concrete performs well in terms of time and quality. However, it has been shown that prefabricated concrete construction is more expensive than brick-and-mortar construction. This is due to a lack of competition in the market. A long-term cost comparison was not made and is an item to consider.

The procurement model of brick-and-mortar construction is well understood, and clients, contractors, designers and agents have experience in this procurement model. In contrast, the procurement model for prefabricated concrete construction still requires development.

Prefabricated concrete construction is classified as the more suitable construction method for construction safety. It was however stressed by Jurgens (2008) and Van Jaarsveld (2018) that training of labourers in crane safety is imperative.

Depending on the type of prefabricated unit used, the environmental impact of the construction method is determined. If sandwich panels are used, prefabricated concrete construction performs the best in terms of concrete content. However, if solid concrete panels are used, the concrete content is more than the concrete content in concrete blocks; therefore, the environmental impact of brick-and-mortar construction is less. Another factor to consider is transport.

It has been shown that brick-and-mortar houses are easier to alter and extend than prefabricated concrete buildings. This is due to the availability of resources (skills, materials and equipment) and the creation of openings in walls. In contrast, prefabricated concrete units must be designed beforehand for the extension and alteration of the units.

Aesthetically, brick-and-mortar is the preferred construction method by the beneficiaries. However, beneficiaries are more likely to accept alternative construction methods if the end-

product looks like a brick-and-mortar building, and if beneficiaries are part of the construction process.

In terms of sound insulation, prefabricated concrete walls perform better; however, in terms of sound absorption, brick-and-mortar walls are more suitable. Therefore, prefabricated concrete walls are better at keeping outside noise out, whereas brick-and-mortar walls provide less echo in the room.

Although the frequency of maintenance for prefabricated concrete buildings is less compared to brick-and-mortar buildings, the equipment and expertise required to diagnose and perform repairs on prefabricated concrete buildings are expensive and specialised. Furthermore, for prefabricated concrete, a prevention-is-better-than-cure mindset is required for maintenance, which is in a contradiction to the traditional mindset of repairing a fault once it becomes visible.

Regarding water penetration, prefabricated concrete is the more suitable construction method in the Western Cape Province. Due to the poor construction quality of brick-and-mortar buildings, which result in cracks in the walls, the water proofing ability of the walls is compromised. In contrast, the higher quality of prefabricated concrete elements results in less cracks. Also, the lower frequency of maintenance required for prefabricated concrete buildings, ensures longer water resistance.

Lastly, the thermal performance of the building is dependent on the wall type. If solid concrete prefabricated elements are used, then brick-and-mortar walls perform better thermally. However, sandwich panels have the best thermal performance among solid concrete units and a concrete block wall.

An objective viewpoint is taken on the decision of which construction method is more suitable. To have a better understanding of which construction method is more suitable, a weighting system can be given to the criteria based on importance. For example, construction cost might be considered more important and would thus be weighted heavier than another criterion. This would be a fair method of determination.

Referring to the challenges identified in section 7.1, prefabricated concrete construction is more suitable at addressing the housing backlog and the housing quality. This is due to its faster construction time and higher quality. In contrast, brick-and-mortar construction is more suitable for addressing unemployment and the need for extension related challenges. The main contributing factor to this is its ease of alteration.

In conclusion, for the purpose of the research, it is decided that brick-and-mortar is the more suitable construction method for affordable housing in terms of the technical criteria. Based on its lower cost, resource availability and the ease of alteration and extending of the house, this decision is made. Additionally, this construction method is accepted among beneficiaries. It is however imperative that the construction quality be improved. However, it has to be determined which construction method performs better with the non-technical criterion.

7.3 Non-technical Criteria

As stated in subsection 7.1, the challenges from Table 8 form part of identifying the better non-technical construction method for the construction of subsidy houses. It is therefore required that the effects of these challenges on the well-being and motivation of an individual, are determined. The construction method that best addresses these challenges (Table 8), is therefore more suitable for creating a progressive community.

7.3.1 Well-being and Motivation: The Effects of the Challenges

In this sub-subsection, the identified challenges are compared to the eight dimensions of well-being and Maslow's needs. The results of this determines which construction method is more suitable for satisfying the non-technical criterion. Table 14 shows the eight dimensions of well-being with the shorthand indicator of each dimension.

Table 14: *The eight dimensions of well-being together with the indicator used in the first row of Table 15.*

Indicator	Dimension
P	Physical
I	Intellectual
Em	Emotional
So	Social
Sp	Spiritual
O	Occupational
F	Financial
En	Environmental

The effect of the challenges from Table 8 on the well-being and motivation of an individual, is discussed simultaneously. The results of the comparison of the challenges with the eight dimensions of well-being are reflected in Table 15, while the results of the comparison with Maslow's needs, are shown in Table 16. The top row of Table 15 corresponds to the shorthand indicators of the dimensions of well-being in Table 14.

Table 15: *The effects of subsidy housing challenges on the well-being of an individual.*

Challenge	P	I	Em	So	Sp	O	F	En
Housing Backlog	X	X	X	X	X	X	X	X
Poor Housing Quality			X				X	X
Unemployment	X	X	X	X		X	X	X
Social Issues	X	X	X	X		X	X	X
Safety	X		X				X	X
Need for Extension	X			X				
Insufficient House Size	X			X				
Economic Opportunities	X	X	X	X		X	X	X

Table 16: *The effects of subsidy housing challenges on Maslow's Hierarchy of Needs.*

Challenge	Physio-logical	Safety	Social	Esteem	Self-actualisation
Housing Backlog	X	X	X	X	X
Poor Housing Quality		X		X	X
Unemployment	X	X	X	X	X
Social Issues		X			X
Safety	X	X			X
Need for Extension	X	X	X	X	X
Insufficient House Size	X		X		X
Economic Opportunities	X	X	X	X	X

The effect of the housing backlog on the well-being and motivation of an individual, is the first challenge to be discussed. A housing backlog suggests the lack of housing to individuals; therefore, to determine the effects of the backlog on the well-being and motivation of an individual, reference is made to the benefits of living in a house, as discussed in subsection 2.2.

Not having a house means that an individual fails to benefit from the advantages of a house. As shown in Table 15 and Table 16, all eight dimensions of well-being and all Maslow's needs are influenced by the housing backlog.

Many of the dimensions of well-being are affected by quality sleep. With a house providing protection from the natural elements, it provides shelter, warmth and adequate sleep to a resident. Therefore, being homeless or staying in an informal dwelling may influence an individual's shelter and quality of sleep. Quality sleep is associated with better health (Bryant, et al., 2004), job satisfaction and emotional stability (Magnavita & Garbarino, 2017). This influences the physiological need and the physical, emotional and occupational well-being of an individual. Additionally, Maslow's safety need is influenced since an individual does not have shelter from weather conditions or external dangers, such as criminals.

Not living in a house, deprives an individual of a space to host other people and belonging to a community. This influences the environmental, spiritual and social well-beings and the social need. Not belonging to a community, deprives a person of the opportunity to manage the environment to the satisfaction of oneself and the community members; thus, affecting the person's environmental well-being. Furthermore, it was stated by De Souza (2016) that belonging to a community contributes to spiritual well-being.

Lastly, not living in a house, denies a person an income-generating mechanism. Therefore, an individual's financial well-being may suffer. Furthermore, new knowledge and skills are required to start a business and this inspires continuous learning, which will contribute to an individual's intellectual well-being (Xavier, et al., 2012). Business ownership is also related to a higher self-esteem (Carland Jr, et al., 1995; Roberts & Robinson, 2012). Therefore, the intellectual dimension of well-being and the esteem needs of an individual suffer.

Considering the housing quality, it is shown in Table 15 poor housing quality affects the emotional, financial and environmental well-being of a person. Living in a house of poor quality affects an individual's self-esteem, which is associated with emotional well-being and Maslow's esteem needs (Table 16). Poor quality houses require more maintenance and therefore influences one's financial and environmental well-being. Lastly, inadequate doors and windows jeopardises an individual's feeling of safety, as shown in Table 16.

The effects of unemployment and economic opportunities are identical because not only can the construction method create jobs but the ability to extend the house, also creates jobs. As

stated in sub-subsection 2.2.2, a house can be used as an income-generating mechanism and help create self-employment for beneficiaries.

Referring to both Table 15 and Table 16, unemployment negatively influences a person's well-being and motivation. Unemployment, which is accompanied by financial stress and instability, negatively impacts an individual's physical (Voßemer, et al., 2018), occupational and financial well-being (Table 15), in conjunction with the safety needs (Table 16). Furthermore, stress can also cause stress-induced insomnia, which negatively impacts an individual's physiological need of adequate sleep (Han, et al., 2012). Being unemployed, an individual is less exposed to intellectual challenges and the need does not arise to learn new skills, which impacts the intellectual dimension of well-being. Furthermore, unemployment affects a person's self-esteem and it thus influences the person's emotional well-being (Table 15) and self-esteem needs (Table 16) (Voßemer, et al., 2018). It was also stated by Voßemer et al. (2018) that unemployment affects an individual's social role, as shown in Table 15 and Table 16. Lastly, unemployment as a community challenge, affects the environment and thus affects the environmental well-being of an individual.

The effects of social issues on an individual differs, depending on the perspective from which it is observed. From the perspective of a victim, the individual's physical (physical abuse), intellectual (lack of schools), emotional (substance abuse), social (gangsterism), financial (theft), occupational (unemployment) and environmental (riots) well-being are influenced. This is shown in Table 15. In terms of Maslow's needs (Table 16), safety and social needs are impacted by social issues.

Being in an unsafe environment negatively impacts the physical, emotional, financial and environmental well-being of an individual, as indicated in Table 15. In terms of motivation, it influences the physiological and safety needs (Table 16). Being in an unsafe environment can cause a lack of sleep, which affects the physical and physiological aspects of a person. Additionally, the emotional wellness is affected by the constant feeling of being unsafe. To rectify this unsafe feeling, expensive safety measures are implemented, which influence an individual financially. Lastly, staying in an environment where all houses are enclosed and the street loses its social value, the environmental wellness of a person suffers.

The effects of inadequate size and spacing of subsidy houses, are shown in Table 15 and Table 16. With subsidy houses being small (older RDP houses consist of just one room), there is no space for everyone to sleep on a bed and occupants have to sleep on the ground (Manomano,

2013). This has an impact on the physical well-being and physiological needs of an individual. Social aspects of an individual are also influenced due to a lack of space to host other people.

The effects of the need for extension on the well-being and motivation of an individual are the result of its dependents' effects on the wellness and motivation of an individual. This is seen in both tables above. Furthermore, Maslow's need of self-actualisation is affected by all subsidy housing challenges, as seen in Table 16. This is because the deficiency needs must be satisfied before self-actualisation needs can be satisfied.

7.3.2 Summary and Discussion

In this subsection, it is shown how the identified challenges negatively impact the well-being and motivation of an individual and prevent community progression. However, these challenges can be rectified by choosing a suitable construction method. The non-technical comparison between the construction methods is shown in Table 17 and is used as referenced in the discussion below.

Table 17: *Non-technical comparison of the construction methods.*

Construction Method	Challenge	Number of 'Xs'		
		Well-being	Motivation	Total
Brick-and-Mortar	Housing Backlog	8	5	13
	Unemployment	7	5	12
	Social Issues	7	2	9
	Safety	4	3	7
	Need for Extension	2	5	7
	Insufficient House Size	2	3	5
	Economic Opportunities	7	5	12
Total				**65**
Prefabricated Concrete	Housing Backlog	8	5	13
	Housing Quality	3	3	6
Total				**19**

Although prefabricated concrete construction has the ability to address the backlog at a faster rate, both construction methods manage to address the backlog. Furthermore, it was stated in sub-subsection 7.2.3 that prefabricated concrete construction is also more suitable at addressing

the housing quality. However, brick-and-mortar construction is more suitable for addressing unemployment and the need for extension related ambitions. Therefore, counting the number of 'Xs' in Table 15 and Table 16 for the challenges, which each construction method addresses, it is found that brick-and-mortar construction addresses 65 factors of well-being and motivation, while prefabricated concrete only addresses 19. Similarly to the technical comparison, each criterion has an identical weighting and an objective viewpoint is taken on the decision of which construction method is more suitable. Therefore, it is concluded, in terms of the well-being and motivation of an individual, and ultimately the well-being and motivation of the community, that brick-and-mortar construction is a more suitable construction method. It is recognised that by allocating different weightings of importance to each criterion may result in a different outcome. Such an approach to develop weightings can form the basis of a follow up study.

7.4 Chapter Summary

The aim of this chapter was to perform the technical and non-technical comparison of the construction methods and determine which construction method is suitable for the construction of subsidy houses. It is found that brick-and-mortar is the better construction method for the construction of subsidy houses and the progression of the community. This decision is based on its lower cost, resource availability, ease of alteration and extending of the house and it addressing more challenges. In terms of the hypotheses of the study (refer to subsection 1.3), the null hypothesis (H_0) is correct.

8 CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

The goal of this research was to determine which construction method, between brick-and-mortar and prefabricated concrete, is more suitable for the construction of subsidy houses. A holistic approach was taken; thus, not only accounting for technical detail but also for the human aspects such as creating a progressive community. Therefore, the construction method is not purely chosen based on its technical advantages, but also on its non-technical characteristics.

The study began by putting the research question into context in Chapter 2. Therefore, challenges in the subsidy housing sector in South Africa were identified from literature sources. Chapter 2 further discusses the advantages of living in a house. The challenges and the benefits of living in a house were used in the non-technical comparison of the construction methods. Additionally, the scopes of the construction methods were defined to determine what each method consists of. It was determined that brick-and-mortar construction referred to the construction with hollow-core concrete blocks. For prefabricated concrete, it was stated that solid concrete units and composite units are included under this description, given that it contains cementitious material, and the units are manufactured in a different location to its final position. Lastly, the housing standards that govern the construction of subsidy houses were discussed. These standards were also consulted for identifying technical criteria for the comparison of the construction methods.

In Chapter 3, the research design and methodology were discussed. It was found that a multimethod qualitative research approach was suitable for the study. The multimethod approach ensured trustworthiness of the data. Three qualitative research methods were used for data collection: observations, a desktop study and semi-structured interviews. Interviews were conducted with three participant groups: architects and urban planners, government officials involved in housing and housing activists. Ethical clearance was obtained to conduct the interviews.

Chapter 4 presents the results from the observations made in four low-income communities. The communities where observations were made are Kayamandi, Vrygrond, Hawston and Delft. The goal of the observations was to identify challenges within these communities.

Twelve challenges were identified among these communities and included challenges such as poor quality of houses, insufficient house sizes and unemployment.

Chapter 5 contains the technical and non-technical criteria obtained from literature sources. The sole criterion for measuring the non-technical performance of a construction method, is its ability to create a progressive community. However, a gauge is required to measure the ability of creating a progressive community. This led to defining a 'progressive community' and determining how it can be achieved. It was found that considering the well-being and motivation of an individual, the community may progress. Therefore, the criteria for the non-technical criterion were the eight dimensions of well-being and Maslow's needs.

In terms of the technical criteria, 15 criteria were identified for the comparison of the construction methods. These criteria were classed into four categories: construction, environmental performance, house design and post-construction.

Chapter 6 discussed the results of the semi-structured interviews. Content analysis was used to code the interview data. To identify codes and code groups that frequently occurred, classical content analysis was used. From these, codes and code groups were identified that are, or can potentially be, addressed by the construction method. This was done by thematic analysis. Once these codes and code groups were identified, they were discussed by referencing to quotations in the interviews.

The study concluded by performing the technical and non-technical comparison of the construction methods. The technical comparison was performed on the consolidated criteria from the desktop study and the semi-structured interviews. Based on the technical comparison, brick-and-mortar construction was deemed the more appropriate method for constructing subsidy houses.

For the non-technical comparison, the challenges identified from Chapters 2 and 4 were consolidated and refined to include challenges that can be addressed by the construction method. The effects of these challenges on the well-being and motivation of an individual were determined. The non-technical comparison was based on which construction method best addressed the identified challenges. It was concluded that brick-and-mortar is the more suitable construction method to address the non-technical criterion.

In conclusion, brick-and-mortar construction is the more appropriate construction method for the construction of subsidy houses and the progression of a community. Therefore, the null hypothesis (H_0) is correct.

8.2 Limitations

The most significant limitation to the study was COVID-19 and its accompanied physical restrictions. Initially, it was intended to distribute questionnaires to beneficiaries of subsidy houses; however, due to COVID-19, Stellenbosch University's REC prohibited all in-person data collection methods. This resulted in changing the data collection methods to be performed online. However, due to economic circumstances of beneficiaries of subsidy house, they would not necessarily have access to smartphones, laptops and/or mobile data to take part in online research methods.

This led to the change of the participant group to people that are involved in subsidy housing but do not necessarily stay in a subsidised house, namely architects and urban planners, government officials involved in subsidy housing and housing activists. However, the participant groups lacked first-hand experience of staying in a subsidised house. Therefore, the quantitative data gathered from these participant groups could yield inaccurate quantitative results. However, due to the experience of the participant groups, valuable qualitative data could be gathered since the context of the data can be understood by the researcher (Rahman, 2017). This resulted in changing the research method from quantitative (questionnaires) to qualitative (online interviews).

8.3 Recommendations

This subsection begins with discussing the recommendations for implementing prefabricated concrete in construction. This sub-subsection is included due to prefabricated concrete construction's quicker construction time, improved quality and skills development, which can ultimately improve major challenges in South Africa, which is the housing backlog and unemployment. The subsection and chapter conclude with recommendations for future research.

8.3.1 For implementing Prefabricated Concrete in Construction

This sub-subsection aims at making three suggestions for implementing prefabricated concrete construction into the construction of subsidy houses. Due to the advantages of prefabricated

concrete, such as construction time, improved quality and skills development, it still has the ability to be implemented as a construction method for subsidy housing upon the improvement of its shortcomings. These three suggestions are briefly mentioned below.

The first suggestion is to improve the post-construction alteration capability of prefabricated concrete. This includes addressing the challenge of resource availability.

The second suggestion is to enhance the education and public participation processes regarding prefabricated concrete. It was stated in the interviews that beneficiaries are willing to accept new building technologies if they are adequately educated about these new technologies.

The last suggestion is to fully investigate the use of an on-site precast concrete manufacturing plant. Sandwich panels cannot be manufactured on site and will not be part of the solution. An on-site manufacturing plant however ensures the creation of jobs and skills transfer. Additionally, transport costs may be saved. Quality management needs to be addressed, as it will not be as beneficial as at a manufacturing plant. However, the environmental impact may increase, and other post-construction criteria are also affected, such as the thermal performance, since solid concrete panels are used.

8.3.2 For Future Research

This subsection briefly discusses the recommendations for future research. Three suggestions are made for future research.

The first suggestion for future research is to create a weighting system for each criterion (technical and non-technical). For this study, each criterion had the same weighting; therefore, the construction method with the most benefits were chosen as the better alternative. However, in reality, each criterion has a different level of importance to the beneficiaries. For example, the thermal performance of the house might be more important than the aesthetics of the house. Therefore, research can be conducted into the level of importance of each criterion, as obtained from the view of the beneficiaries, as well from government officials. While the weighting may not be the same for all regions and all locations, the principles of weighting need to take this into consideration.

The second recommendation for future research is to do a detailed cost analysis of prefabricated concrete construction for subsidy housing, including a life-cycle cost analysis. As part of this, factors should be identified that make the cost of prefabricated concrete more expensive than brick-and-mortar construction.

As stated in 8.3.1, prefabricated concrete remains an eligible construction method for the construction of subsidy houses; however, improvement is required at its shortcomings. The procurement method is such a shortcoming. Therefore, the last recommendation for future research is to develop a detailed procurement strategy for the construction of subsidy houses using prefabricated concrete. An ideal procurement strategy would incorporate the variability in design and the experience of clients.

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APPENDIX A: Explanation of Maslow's Hierarchy of Needs

This appendix explains the needs mentioned in Maslow's Hierarchy of Needs and how he categorised the needs. The needs identified by Maslow in his first model is physiological, safety, social, esteem and self-actualisation needs (Pride, et al., 2014). The physiological and safety needs are classified as basic needs, social and esteem needs are classed as psychological needs and self-actualisation needs are categorised as self-fulfilment needs (McLeod, 2018).

Physiological needs are the fundamental level of needs, and the human body cannot function without these (King-Hill, 2015; McLeod, 2018). These needs include food, water, air, shelter, warmth, clothing and sleep (Pride, et al., 2014; McLeod, 2018). These needs are imperative for human survival, and other needs cannot be satisfied until physiological needs are met (Pride, et al., 2014; McLeod, 2018).

Safety needs are associated with physical and emotional security (Pride, et al., 2014). These needs are satisfied through shelter from natural elements, security, freedom from fear, familiarity, stability and law (McLeod, 2018; Groenewald, 2021).

The social needs are related to a sense of belonging and the requirement for love, affection and personal relationships (Pride, et al., 2014; King-Hill, 2015; McLeod, 2018). These needs can be satisfied through personal relationships with a partner, friends, family and work colleagues (Pride, et al., 2014). These needs are also satisfied by belonging to a community or group of people (McLeod, 2018).

Esteem needs are categorised into two classes (McLeod, 2018; Groenewald, 2021). The first is having esteem for oneself, which is related to one's achievements, worth, independence and dignity (Pride, et al., 2014; McLeod, 2018). The other component is related to respect and recognition from others (Groenewald, 2021). This is related to status and appreciation (Groenewald, 2021).

The last needs category for this model, is self-actualisation needs. These needs are the most difficult to achieve and only few reach this level (Groenewald, 2021). Satisfying these needs differ from person to person (Pride, et al., 2014; Groenewald, 2021). This level of needs is related to developing and growing to reach one's full potential (Pride, et al., 2014). A self-actualised individual is less concerned with what others think and is focussed on self-fulfilment (Groenewald, 2021).

Maslow further categorised the needs into deficiency and growth needs (Groenewald, 2021). Deficiency needs occur when a need is not satisfied and then a desire is created to meet this need (Groenewald, 2021). This creates the motivation to meet a need and move up the hierarchy. The longer a person goes without satisfying the need, the more the desire grows to satisfy the need (McLeod, 2018). However, the motivation decreases the closer one becomes to satisfying the need (Groenewald, 2021).

Conversely, growth needs do not originate from a deficiency, but rather from a longing to develop and grow as an individual (McLeod, 2018; Groenewald, 2021). Motivation increases the closer the person is to satisfying the need. Therefore, the desire to grow and develop increases as growth occurs (Groenewald, 2021). The deficiency needs are the physiological, safety, social and esteem needs, and self-actualisation is the only growth need.

APPENDIX B: Interview Questions

Appendix B.1: Government Officials

As stated in my email, I am currently looking at prefabricated concrete for affordable housing and part of that is looking at the needs and preferences of the beneficiaries of affordable housing initiatives. In summary, I want to find out which factors are taken into account when planning a new affordable housing development and how you decide on a final development design.

I have compiled a general list of questions; however, I prefer to have a conversation and hear your thoughts on the questions. Therefore, the questions are more guidelines to which type of information I'm seeking.

Questions:

1. When planning a design for a new affordable housing development, what factors do you take into account? In other words, how do you decide what the physical properties of the house will be like? Do you even have control over that or is it regulatory? For instance:
   - Erf size
   - How many bedrooms will a unit have?
   - Will the unit have a bathroom or will communal toilets be used?
   - The size of a unit?
   - Whether the unit is single- or multi-storey?
   - Which walling system is used?
   - Which accessories are present within the unit, e.g. geysers, insulation in roof?
   - Which type of building material is used, e.g. brick, concrete, timber?
   - Which roof type is used and material for the roof?
   - Whether it be painted or not?

2. When designing an affordable housing unit, do you take the preferences and needs of the beneficiaries into account? Or are you strictly designing a unit based on regulatory documents? For instance, do you take the following into account:
   - Family size
   - Number of children
   - Number of elderly persons
   - Accessibility requirements
   - Preferred building material

- House design (refer to Q1)
- Living conditions, e.g. temperature of house

3. When designing these houses, do you make provision for the extension of the house? An example would be the location of the house on the erf or the roof of a semi-detached house? When you approve a design, do you ensure that this is possible?

4. How is decided on a design and what do you consider a successful design?

5. What social and economic factors do you consider when planning a new development? Do you ensure the development has the potential to unlock economic activity?

6. Can you please provide me with names of contractors you have previously worked with (this is to organise interviews with representatives of these companies)?

7. Any further comments or information you think can be helpful to my research?

Appendix B.2: Architects and Urban Planners

As stated in my email, I am currently looking at prefabricated concrete for affordable housing and part of that is looking at the needs and preferences of the beneficiaries of affordable housing initiatives. In summary, I want to find out which factors are taken into account when designing an affordable housing unit and I also want to know how a specific design is decided on.

I have compiled a general list of questions; however, I prefer to have a conversation and hear your thoughts on the questions. Therefore, the questions are more guidelines to which type of information I'm seeking.

Questions:

1. When starting a design for a new affordable housing development, what factors do you take into account, from an architect's perspective? In other words, how do you decide what the physical properties of the house will be like? Do you even have control over that? For instance:
   - Erf size
   - How many bedrooms will a unit have?
   - Will the unit have a bathroom or will communal toilets be used?
   - The size of a unit?
   - Whether the unit is single- or multi-storey?

- Which walling system is used?
- Which accessories are present within the unit, e.g. geysers, insulation in roof?
- Which type of building material is used, e.g. brick, concrete, timber?
- Which roof type is used and material for the roof?
- Whether it be painted or not?

2. When designing an affordable housing unit, do you take the preferences and needs of the beneficiaries into account? Or are you the specifications given in the tender document and you should design according to that? For instance, do you take the following into account:
   - Family size
   - Number of children
   - Number of elderly persons
   - Accessibility requirements
   - Preferred building material
   - House design (refer to Q1)
   - Living conditions, e.g. temperature of house
3. When designing these houses, do you make provision for the extension of the house? An example would be the location of the house on the erf or the roof of a semi-detached house?
4. How is decided on a design and what do you consider a successful design?
5. Can you please provide me with contractors you have worked with on housing developments (this is for me to make contact with them for interviews)?
6. Any further comments or information you think can be helpful to my research?

Appendix B.3: Housing Activists

I am currently looking at prefabricated concrete for affordable housing (RDP houses) and part of that is looking at the needs and preferences of the beneficiaries of affordable housing initiatives. In summary, I want to find out from you, from a community representative's point of view, what the house design preferences are of the beneficiaries of affordable housing initiatives.

I have compiled a general list of questions; however, I prefer to have a conversation and hear your thoughts on the questions. Therefore, the questions are more guidelines to which type of information I'm seeking.

Questions:

1. From a community representative's perspective, what are the preferences of community members for affordable houses in terms of the following physical properties of the house?
   - Erf size
   - How many bedrooms will a unit have?
   - Will the unit have a bathroom or will communal toilets be used?
   - The size of a unit?
   - Whether the unit is single- or multi-storey?
   - Which walling system is used?
   - Which accessories are present within the unit, e.g. geysers, insulation in roof?
   - Which type of building material is used, e.g. brick, concrete, timber?
   - Which roof type is used and material for the roof?
   - Whether it be painted or not?

2. Out of your experience of affordable houses being built in the community, are the needs and preferences of the beneficiaries taken into account? For instance, are the following taken into account?
   - Family size
   - Number of children
   - Number of elderly persons
   - Accessibility requirements
   - Preferred building material
   - House design (refer to Q1)
   - Living conditions, e.g. temperature of house

3. Do you think when these houses are designed, provision is made for the extension of the house? An example would be the location of the house on the erf or the roof of a semi-detached house or the material of the house.

4. What would you consider a successful design?

5. Any further comments or information you think can be helpful to my research?

APPENDIX C: Ethical Clearance

UNIVERSITEIT
STELLENBOSCH
UNIVERSITY

NOTICE OF APPROVAL

REC: Social, Behavioural and Education Research (SBER) - Initial Application Form

16 July 2021

Project number: 18781

Project Title: Comparison of prefabricated concrete construction methods on the RDP housing system in the City of Cape Town and Cape Winelands district.

Amended Project Title:

Dear Mr G Van der Watt

Co-investigators:

Your response to stipulations submitted on 16/07/2021 14:38 was reviewed and approved by the REC: Social, Behavioural and

Education Research (REC: SBE).

Please note below expiration date of this approved submission:

Ethics approval period:

Protocol approval date (Humanities)	Protocol expiration date (Humanities)
17 December 2020	16 December 2021

GENERAL REC COMMENTS PERTAINING TO THIS PROJECT:

The REC herewith approves the commencement of 'alternative two' proposed by the researcher during COVID-19 restrictions. The researcher is reminded to submit an amendment after

COVID-19 restrictions are lifted for review before changes are made to conducting the research.

INVESTIGATOR RESPONSIBILITIES

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

If the researcher deviates in any way from the proposal approved by the REC: SBE, the researcher must notify the REC of these changes.

Please use your SU project number (18781) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD

You are required to submit a progress report to the REC: SBE before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further year (if necessary).

Once you have completed your research, you are required to submit a final report to the REC: SBE for review.

Included Documents:

Document Type	**File Name**	**Date**	**Version**
Budget	**Tesis Begroting**	**21/09/2020**	**1**
Recruitment material	Application-Letter-for-Institutional-PermissionGvdW	**13/10/2020**	**3**
Recruitment material	Konsepbrief_van der Watt_G	**13/10/2020**	**2**
Informed Consent Form	Oral Consent	**13/10/2020**	**1**
Information sheet	Oral Consent Information Sheet	**13/10/2020**	**1**
Default	COVID-19 Protocol	**13/10/2020**	**2**

Research Protocol/Proposal	Projekvoorstel (Etiekaansoek) - REC Aanpassings	**02/12/2020**	**1**
Informed Consent Form	Written-Consent interview_van der Watt_G 1	**02/12/2020**	**4**
Data collection tool	Interview Guide_van der Watt_G	**02/12/2020**	**1**
Data collection tool	Questionnaires_van der Watt_G	**02/12/2020**	**5**
Default	Van der Watt_G_Response Letter	**02/12/2020**	**1**
Proof of permission	EBESA - Institutional Permission Letter	**22/04/2021**	**1**
Proof of permission	Scanned from a Xerox Multifunction Printer 2	**28/06/2021**	**1**
Proof of permission	Konsepbrief_van der Watt_G	**28/06/2021**	**1**
Proof of permission	Konsepbrief_van der Watt_G_Signed on Letter head	**28/06/2021**	**1**
Proof of permission	SKM_C36821050615090	**28/06/2021**	**1**
Proof of permission	Konsepbrief	**15/07/2021**	**1**
Proof of permission	M&A Signed Documents	**15/07/2021**	**1**
Default	Van der Watt_G_Response Letter 16_07_2021	**16/07/2021**	**2**

If you have any questions or need further help, please contact the REC office at cgraham@sun.ac.za.

Sincerely,

Clarissa Graham

REC Coordinator: Research Ethics Committee: Social, Behavioral and Education Research

National Health Research Ethics Committee (NHREC) registration number: REC-050411-032.

Principal Investigator Responsibilities

Protection of Human Research Participants

As soon as Research Ethics Committee approval is confirmed by the REC, the principal investigator (PI) is responsible for the following:

Conducting the Research: The PI is responsible for making sure that the research is conducted according to the REC-approved research protocol. The PI is jointly responsible for the conduct of co-investigators and any research staff involved with this research. The PI must ensure that the research is conducted according to the recognised standards of their research field/discipline and according to the principles and standards of ethical research and responsible research conduct.

Participant Enrolment: The PI may not recruit or enrol participants unless the protocol for recruitment is approved by the REC. Recruitment and data collection activities must cease after the expiration date of REC approval. All recruitment materials must be approved by the REC prior to their use.

Informed Consent: The PI is responsible for obtaining and documenting affirmative informed consent using only the REC-approved consent documents/process, and for ensuring that no participants are involved in research prior to obtaining their affirmative informed consent. The PI must give all participants copies of the signed informed consent documents, where required. The PI must keep the originals in a secured, REC-approved location for at least five (5) years after the research is complete.

Continuing Review: The REC must review and approve all REC-approved research proposals at intervals appropriate to the degree of risk but not less than once per year. There is **no grace period**. Prior to the date on which the REC approval of the research

expires**, it is the PI's responsibility to submit the progress report in a timely fashion to ensure a lapse in REC approval does not occur**. Once REC approval of your research lapses, all research activities must cease, and contact must be made with the REC immediately.

Amendments and Changes: Any planned changes to any aspect of the research (such as research design, procedures, participant

population, informed consent document, instruments, surveys or recruiting material, etc.), must be submitted to the REC for review and approval before implementation. Amendments may not be initiated without first obtaining written REC approval. The **only exception** is when it is necessary to eliminate apparent immediate hazards to participants and the REC should be immediately informed of this necessity.

Adverse or Unanticipated Events: Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research-related injuries, occurring at this institution or at other performance sites must be reported to the REC within **five (5) days** of discovery of the incident. The PI must also report any instances of serious or continuing problems, or non-compliance with the RECs requirements for protecting human research participants.

Research Record Keeping: The PI must keep the following research-related records, at a minimum, in a secure location for a minimum of five years: the REC approved research proposal and all amendments; all informed consent documents; recruiting materials; continuing review reports; adverse or unanticipated events; and all correspondence and approvals from the REC.

Provision of Counselling or emergency support: When a dedicated counsellor or a psychologist provides support to a participant without prior REC review and approval, to the extent permitted by law, such activities will not be recognised as research nor the data used in support of research. Such cases should be indicated in the progress report or final report.

Final reports: When the research is completed (no further participant enrolment, interactions or interventions), the PI must submit a Final Report to the REC to close the study.

On-Site Evaluations, Inspections, or Audits: If the researcher is notified that the research will be reviewed or audited by the sponsor or any other external agency or any internal group, the PI must inform the REC immediately of the impending audit/evaluation.