

A ROADMAP FOR IMPROVED CIRCULAR CONSTRUCTION

BY

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ABSTRACT

The construction industry contributes significantly to environmental degradation, accounting for substantial global energy use, material waste, and greenhouse gas emissions. In South Africa, the industry generates large amounts of construction and demolition waste, with only a small portion being recycled or recovered. As the country's population is projected to increase significantly by 2035, the demand for infrastructure will increase, intensifying the waste and environmental challenges. In this research, the urgent need to transition from a linear economy to a circular economy model in South Africa's construction sector is addressed, promoting sustainability and resource efficiency. The main aim of this study was to provide a framework for advancing circular construction practices by augmenting the knowledge, attitudes, and practices of construction professionals .

A pragmatist mindset was adopted for the research and an abductive methodology was implemented, with an explanatory sequential mixed-methods design. The data collection commenced with a quantitative survey followed by qualitative interviews with construction experts in the Free State and Gauteng Provinces. The study generated several exciting findings, the primary of which are the following:

- Construction professionals in South Africa are well-versed in circular construction practices.
- Construction professionals value circular construction practices for improving resource efficiency and sustainability with positive attitudes towards them.
- Key knowledge categories, positive attitudes, and best practices for circular economy building in construction were identified in the research.
- Circular construction adoption is driven by cost reduction, regulatory compliance, and client expectations, with cost reduction being the most significant motivation.
- Barriers to circular construction include lack of experience, financial constraints, and limited resources that hinder the widespread implementation of circular methods, notwithstanding hopeful sentiments.
- Circular construction practices are implemented unevenly, with some being more widely adopted than others.

- A positive attitude towards circular economy practices enhances the likelihood of using circular construction methods.
- Knowledge of circular economy practices strongly predicts positive change in adopting circular building methods.
- The perceived importance of circular economy practices predicts the potential to adopt circular construction.
- Contrary to expectation, familiarity with circular economy construction practices had a slightly negative impact on predicting the potential to adopt circular construction practices, and barriers to circular economy construction practices fail to moderate the predictive relationship between attitude towards circular economy construction practices and potential to adopt circular construction practices.

Based on this study, the South African dimension is added to the circular economy theoretical body of knowledge in construction, and advice is provided for policy-makers, industry leaders, and experts. Based on the study, a detailed roadmap is presented with pragmatic, concrete measures to improve circular construction processes. These measures encompass enhancing stakeholder participation, broadening training initiatives, and promoting policy reforms that facilitate sustainable development. The purpose of the proposed plan is to guide South Africa's construction sector towards enhanced sustainability and resource efficiency, thereby diminishing its environmental impact and fostering long-term viability.

Keywords: Circular construction, Circular economy, KAP, South Africa, Sustainability.

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DEFINITION OF KEY TERMS

Attitude: Attitudes are emotional responses to objects shaped by personal ideas, values (Bohner & Wanke, 2002), individual experiences, inter-personal relationships (Kerin *et al.*, 2009), socialisation processes, and engagement with reality (Donahue & Miller, 2006).

Circular construction: The incorporation of circular economy (CE) principles in construction is termed circular construction (CC), the aim of which is to eradicate waste generation at every phase, including planning, procurement, design, occupancy, and refurbishment (Geissdoerfer *et al.*, 2017).

Circular economy: Circular economy, or CE, is an economic model that reduces resource use and waste generation to generate goods and services sustainably (Corona *et al.*, 2019). Rashid *et al.* (2013) characterise CE as an essential pre-requisite for advancing sustainable manufacturing and enhancing the economic and environmental performance of developing nations.

Knowledge: refers to the theoretical or practical understanding of a subject (Gau *et al.*, 2018).

Linear economy: This is a type of business model that followed the First Industrial Revolution that can be stated as "take the resources you need, manufacture the things for sale and profit, and dispose of what you do not need" (Sariatli, 2017).

Practice: Practice refers to how people demonstrate their knowledge and attitude through their actions (Kaliyaperumal, 2004).

Sustainability: Sustainability refers to meeting the present generation's needs without compromising future generations' ability to meet their own needs. It involves balancing environmental, social, and economic considerations to ensure long-term well-being and resilience for human and natural systems.

LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviations/acronym	Words
BIM	Building Information Modelling
C&DW	Construction and Demolition Waste
CBA	Cost-Benefit Analysis
CC	Circular Construction
CCP	Circular Construction Practices
CE	Circular Economy
EMF	Ellen MacArthur Foundation
GHG	Greenhouse Gas
KAP	Knowledge, Attitude and Practice
LCA	Life-Cycle Assessment
SC	Sustainable Construction
SD	Sustainable Development
SDG	Sustainable Development Goal
SMEs	Small and Medium-Sized Enterprises
UNEP	United Nations Environment Programme
WRAP	Waste Resources Action Programme
ZCB	Zero Carbon Building

CHAPTER 1: RESEARCH BACKGROUND

1.1. INTRODUCTION

The construction industry is widely recognised as a major contributor to global environmental crises, accounting for approximately 39% of energy-related CO₂ emissions and producing billions of tons of solid waste annually (Gasparri *et al.*, 2023). Historically, the sector has operated under a linear “take–make–dispose” model, which has led to unsustainable patterns of resource depletion, escalating landfill pressure, and ecological degradation (Rao *et al.*, 2025). These challenges are exacerbated by global population growth, which intensifies construction activity and resource demand (Global Market Insight [GMI], 2024).

In response to these unsustainable practices, Circular Economy (CE) principles have emerged as a strategic framework for reducing the environmental impact of construction. Circular Economy focuses on minimising waste and maximising the reuse and recycling of materials across the project lifecycle (Rao *et al.*, 2025). Within the construction sector, these principles are embodied in Circular Construction (CC), which involves rethinking design, production, operation, and demolition processes to reduce material waste and enhance resource efficiency (Ossio *et al.*, 2023).

Recent systematic reviews have reaffirmed that CE strategies such as reducing, reusing, and recycling offer viable and sustainable pathways for transforming construction practices (Rao *et al.*, 2025). Forecasts project that the global circular construction waste market will reach USD 41.9 billion by 2030, underscoring both its environmental value and economic potential (Goodland & Walsh, 2024). Empirical evidence also highlights that CC can significantly reduce supply chain emissions while promoting economic competitiveness (Goodland & Walsh, 2024).

Despite these benefits, the adoption of CC remains limited in developing contexts, including South Africa, due to persistent regulatory, infrastructural, and economic barriers (Goodland & Walsh, 2024). Furthermore, the rise of digital tools such as

Building Information Modelling (BIM) and product traceability systems presents new opportunities for supporting CE, yet their application in South Africa is still nascent and under-explored (Rao *et al.*, 2025; Saka *et al.*, 2024).

South Africa, in particular, is facing pressing demographic and environmental pressures. Statistics South Africa (StatsSA) (2022) estimates that the country's population will increase by approximately 10 million by 2035, triggering a surge in construction activity and, consequently, a dramatic rise in construction waste (GMI, 2024). Construction and demolition (C&D) waste already accounts for 13% of the 42 million tons of solid waste produced nationally, yet only a small portion is currently recycled or recovered (BigRentz, 2024). Compounding the issue, many landfills in South Africa impose low or no tariffs on C&D waste, further disincentivising sustainable disposal and favouring linear practices (GreenCape, 2022).

At the global level, policy support and technological innovation are accelerating the shift toward CE, including the use of BIM-integrated machine learning (ML) systems for predictive waste management (Saka *et al.*, 2024). However, within the South African construction sector, research and implementation efforts continue to focus primarily on waste management post-generation, rather than adopting holistic lifecycle-based approaches that characterise circular construction (Goodland & Walsh, 2024).

Critical knowledge gaps remain in the areas of stakeholder coordination, lifecycle material recovery, and the development of tailored CE roadmaps suitable for South Africa's unique infrastructural and regulatory landscape. Most studies on CE in the country focus broadly across multiple industries, offering limited insights specific to the construction domain (Ichebadu & Mahachi, 2025). Furthermore, where research has been conducted in the built environment, the emphasis has largely been on managing C&D waste after it has already been generated—rather than examining circularity across the entire lifecycle, from planning and design to deconstruction.

To address these gaps, there is a pressing need for integrative research that considers all stages of the construction process and the professionals involved at each phase. Such an approach is crucial for formulating a comprehensive roadmap that promotes circular construction in South Africa. The roadmap should aim to enhance knowledge, shape attitudes, and improve the practices of stakeholders by encouraging the uptake of circular principles throughout the industry.

1.2. STATEMENT OF THE PROBLEM

South Africa's construction industry is on a trajectory of rapid expansion, largely driven by population growth and its associated rising infrastructural needs (StatsSA, 2022). However, this growth seems to come at an environmental cost where construction and demolition (C&D) waste of over 5.2 million tonnes continue to be landfilled, contributing significantly to soil, air, and water pollution (Amadi & Mahachi, 2025).

While global best practices in circular economy (CE) are progressively being mainstreamed in countries like the UK, Finland, and China, South Africa lacks a dedicated and integrative roadmap tailored to its construction context (Shooshtarian *et al.*, 2025). In other words, despite the growing global emphasis on circular construction (CC) as a solution to the environmental and resource crises driven by linear construction practices, the South African construction industry remains significantly behind in adopting these principles.

Compounding the problem is the inadequate incentivisation for recycling C&D waste such as minimal landfill tariffs which acts as a major barrier to circularity (GreenCape, 2022). Moreover, policy initiatives remain fragmented, often focusing primarily on post-consumption C&D waste rather than holistic lifecycle circularity (Amadi & Mahachi, 2025).

As Mhlanga, Haupt and Loggia (2023) and Papamichael *et al.* (2023) noted, there is a clear gap in research that adopts an integrative perspective probing circular

practices across design, construction, deconstruction, and stakeholder engagement phases tailored to South Africa's built environment. Without a cohesive strategic roadmap, South Africa risks perpetuating a “take-make-dispose” model that undermines climate and sustainability objectives (Ogunkamide *et al.*, 2022).

Existing research in South Africa tends to treat CE at a macro or multi-industry level with limited application to the building industry and even less attention paid to embedding circularity across the full building lifecycle from design and material selection to construction, operation, and end-of-life management (Rantsatsi *et al.*, 2023).

These gaps point to a critical need for a locally relevant, evidence-based roadmap that promotes circular construction practices throughout the value chain. Without such a framework, the South African construction sector risks persisting with unsustainable practices, undermining national environmental targets and the global sustainable development agenda. Therefore, this study seeks to fill this critical void by developing a practical, sector-specific roadmap aimed at equipping construction professionals with the tools and protocols necessary to embed circular economy principles effectively—thus reconciling environmental stewardship with economic resilience across all stages of the building lifecycle.

1.3. PRIMARY RESEARCH QUESTION

What roadmap can enhance circular construction practices (CCP) by improving the knowledge, attitudes, and practices (KAP) of construction professionals in South Africa?

1.3.1. Secondary Research Question 1

What knowledge is required to enhance circular economy practices in construction projects?

1.3.2. Secondary Research Question 2

What attitudes among construction professionals would foster increased circular economy practices in projects?

1.3.3. Secondary Research Question 3

What are the exemplary circular economy practices currently being implemented in construction projects?

1.3.4. Secondary Research Question 4

How can the KAPs of construction professionals be improved to enhance circular construction practices?

1.3.5. Secondary Research Question 5

What specific steps and actions should the roadmap include to improve circular construction practices in South Africa?

1.4. AIM AND OBJECTIVES OF THE STUDY

The aim and objectives of the research are detailed in this section.

1.4.1. Aim of the Study

The aim of the research was to develop a roadmap that could enhance circular construction practices (CCP) by improving the knowledge, attitudes, and practices (KAP) of construction professionals in South Africa.

1.4.2. Objectives of the Study

The objectives of the study are stated in this section.

1.4.2.1. Research Objective 1

Identify the knowledge required to enhance circular economy practices in construction projects.

1.4.2.2. Research Objective 2

Assess the attitudes among construction professionals that would foster increased circular economy practices in projects.

1.4.2.3. Research Objective 3

Identify exemplary circular economy practices currently being implemented in construction projects.

1.4.2.4. Research Objective 4

Evaluate how the KAPs of construction professionals can be improved to enhance circular construction practices.

1.4.2.5. Research Objective 5

Propose specific steps and actions for a roadmap that will improve circular construction practices in South Africa.

1.5. DELIMITATION OF THE STUDY

Delimitation refers to the boundaries of a study (Simon, 2011). The geographic study area was construction projects in the Gauteng and Free State Provinces. Although not exhaustive, data were collected from construction professionals such as quantity surveyors, architects, construction managers, and project managers. The study was also focused on various projects, such as the construction of new buildings, the refurbishment of existing structures, and the demolition of old buildings.

1.6. LIMITATION OF THE STUDY

Data were collected from construction professionals in two of the nine provinces: Gauteng and the Free State. Gauteng was selected for its high volume of construction projects, while the Free State was chosen for its accessibility to the researcher. Although the study's limited geographical coverage could be regarded as being a constraint on the generalisability of the findings, the selection of these provinces offered a balanced representation of South Africa's diverse settings – Gauteng reflects an urban environment, while the Free State captures a rural context. This combination enhanced the representativeness of the sample, thereby supporting the generalisability of the findings across both rural and urban settings in South Africa.

1.7. ASSUMPTIONS

The underlying assumptions were three-fold. The first was that the significance of CE building practices will escalate over time, driven by the escalating environmental impact of building construction projects. Secondly, despite the growing relevance of the topic for all construction professionals, some might not fully appreciate their role in CE practices. Thirdly, the perspectives of construction experts on sustainable building methods were presumed to reflect accurately the reality of such practices in South Africa.

1.8. RESEARCH METHODOLOGY SUMMARY

This section contains a summary of the research methodology.

1.8.1. The Research Philosophy

A pragmatic research philosophy was adopted for the study.

1.8.2. The Research Design

An explanatory, sequential mixed-methods design was adopted for the research, which is a type of explanatory research (Saunders *et al.*, 2019). This design begins with quantitative data collection and analysis, followed by qualitative data collection and analysis to interpret and explain the quantitative results further. The quantitative phase involved a survey, and the qualitative phase consisted of interviews. Further details of the research design are provided in Chapter 3, Section 3.1.

1.8.3. The Research Approach

Since a mixed-methods design was adopted for the research, an abductive approach was followed, where deductive and inductive reasoning were used to address quantitative and qualitative aspects.

1.8.4. The Target Population

The target population of respondents consisted of professionals involved in construction projects in Gauteng and the Free State Provinces.

1.8.5. Sampling

Two samples were used. The first sample, selected using simple random sampling, was used for the population (construction professionals involved in various

construction projects). The second sample, selected using purposive sampling, was relatively small for the in-depth interviews. Details of the sampling methods are discussed in Chapter 3.

1.8.6. Instrumentation and Data Collection

Two types of instruments were used in line with the mixed-methods approach. Firstly, a structured questionnaire based on a Likert Scale was used to assess the knowledge, attitudes and practices of respondents with regard to circular construction. Secondly, an open-ended interview guide was used to understand how the knowledge, attitudes and practices of construction professionals with regard to circular construction could be improved. Further details of the instrumentation and data collection are discussed in Chapter 3.

1.8.7. Data Analysis

The quantitative data were analysed statistically to determine the interplay among the knowledge, attitudes, and practices of construction professionals in relation to circular construction. The qualitative data were thematically analysed. Chapter 3 contains further details of the data analysis.

1.9. IMPORTANCE OF THE STUDY

Based on this study, contributes are made to theory, policy, practice and research advancements in the following ways. Firstly, significant practical contributions are made towards the actualisation of the United Nation's Sustainable Development Goals (SDGs) in the South African built environment, particularly those related to responsible consumption and production (SDG 12), climate action (SDG 13), and sustainable cities and communities (SDG 11). Construction CE practices are essential for achieving these specific SDGs because they are focused on avoiding waste during the designing phase, reducing waste production during the building phase, maintaining the quality and worth of materials throughout the use of the building, and

ensuring the re-use or recycling of construction materials at the end of the building's useful life (Ganiyu *et al.*, 2020). The second practical contribution is the development of a unique roadmap for implementation in the South African built environment. The roadmap offers a structured and comprehensive, yet simple (user-friendly), guideline for the construction industry to adopt circular economy practices.

In terms of theory, the findings of the study also enriches the KAP framework by incorporating a circular economy perspective into the construction setting. This theoretical advancement is achieved by integrating the dimensions of KAP within the circular economy context. In addition, the findings of the study enrich the literature about the state of awareness, knowledge and understanding of construction professionals about circular construction and perceived barriers in South Africa. Secondly, developing a unique roadmap is the first of its kind in the South African built environment.

Lastly, potential CC barriers were identified in the study that could inform the development of policies and strategies designed to meet the specific needs of the South African construction industry towards more sustainable and circular practices, which benefit the environment, the economy, and society.

1.10. OUTLINE OF CHAPTERS

Chapter 1: This chapter contains the background to the study, which includes the aim, objectives, scope, summary of the research methodology, limitations, and assumptions.

Chapter 2: This chapter consists of a detailed literature review about the research topic and research gaps.

Chapter 3: In this chapter, the most suitable methodology for this study is identified and justified the procedures adopted to collect and analyse data, and the ethical considerations are also discussed.

Chapter 4: In this chapter, the data analysis and the study findings are discussed thoroughly.

Chapter 5: This chapter contains conclusions and recommendations based on the research findings.

1.11. CHAPTER SUMMARY

In this chapter, the focus of the study on the environmental impact of the construction industry is introduced, emphasising the need for a shift from a linear to a circular economy in South Africa. The aim to develop a roadmap for improving circular construction practices by enhancing the knowledge, attitudes, and practices of construction professionals is outlined. The chapter also contains a description of the research objectives, questions, methodology, and scope, while highlighting the contributions of the study to theory and practice. In the next chapter, the relevant literature about circular economy practices in the construction industry is reviewed.

CHAPTER 2: REVIEW OF RELEVANT LITERATURE

2.1. INTRODUCTION

The construction industry is one of the largest consumers of raw materials globally, generating significant amounts of waste and contributing to environmental degradation. In response to these challenges, a circular economy has emerged as being a promising approach to minimise waste, optimise use of resources, and promote sustainability within the construction sector. Circular construction, a subset of the circular economy, is focused on designing out waste, keeping materials in use for as long as possible, and regenerating natural systems. However, adopting CCP remains limited, particularly in developing contexts, such as South Africa, where the construction industry faces unique socio-economic and regulatory challenges. In this chapter, the existing literature about circular economy principles and their application within the construction industry is reviewed.

2.2. CIRCULAR ECONOMY

The CE concept has been gaining attention since the late 1970s (EMF, 2014; Geissdoerfer *et al.*, 2017), and most of the work and research has been carried out by the Ellen MacArthur Foundation (Bygballe *et al.*, 2019). While many definitions of CE can be found in the literature, the contribution by Geissdoerfer *et al.* (2017) appears to capture the essence of the concept. According to Geissdoerfer *et al.* (2017: 6), CE is: "A regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, re-use, re-manufacturing, refurbishing, and recycling".

Several authors criticise the CE concept by considering the impact that CE might have on the environment (Zink & Geyer, 2017). According to Velenturf *et al.* (2019), greater energy demand will be required to circulate more materials in different forms. Adding to that, "de-growth", which is "defined as an equitable downscaling of production and consumption that increases human well-being and enhances ecological conditions at

the local and global level, in the short and long term" (Schneider *et al.*, 2010: 2), is seen as a threat because it prioritises the social and environmental well-being over the growth of the economy.

Despite these arguments, Prasanta *et al.* (2020) believed that CE optimises economic, environmental, and social elements in organisations so that the entire society is converted into a more sustainable proposition with the involvement of relevant stakeholders. This view aligns with the circular economy model depicted in Figure 2.1, which emphasises the efficient use of resources by reducing raw material consumption, minimising waste, and lowering emissions. The figure illustrates the key stages of the circular economy, including sustainable design, production, distribution, consumption, and re-use or repair. It also highlights the importance of proper collection and waste management, with residual waste being minimised through strategies such as recycling and re-use. This closed-loop system promotes a shift away from the traditional linear economy model and encourages the regeneration of natural resources, while reducing environmental impact.



Figure 2.1: The circular economy model – less raw material, less waste, fewer emissions

Source (European Parliament Research Service, 2023).

2.3. CIRCULAR CONSTRUCTION PRACTICES

The construction industry severely impacts the environment (Ding *et al.*, 2018), and with industries flourishing, more infrastructure and services tend to be required to support the growing economy. This puts pressure on natural resources, affecting the environment and those who occupy it in many ways. The South African construction industry accounts for 23% of greenhouse gas (GHG) emissions and 18 metric tonnes of carbon dioxide per year (Simpeh & Smallwood, 2018). The detrimental environmental effects of the construction industry include land use, noise, solid waste, dust, generation of toxins, air and water pollution, unpleasant odours, climate change and harmful emissions (Chuai *et al.*, 2021).

2.3.1. Opportunities for Circularity in the Construction Industry

A significant portion of construction waste dumped in landfills can be easily reclaimed for other uses through alternative recovery methods that integrate a circular economy throughout all construction phases (Advisory Board, 2017; Geissdoerfer *et al.*, 2017; EMF, 2013a). This approach is suitable for reducing resource depletion. According to Ying and Li-jun (2012), the construction industry can reduce resource depletion and environmental damage by selecting materials with low environmental impact and considering their potential for re-use or recycling.

Prefabrication and modular building can improve resource efficiency and diminish waste production during construction (Geldermans & Rosen-Jacobsen, 2015). These methodologies facilitate the construction of standardised components that can be readily dis-assembled and repurposed in subsequent projects. This reduces material waste and improves the circularity of the building sector (Geissdoerfer *et al.*, 2017). During the operational phase, incorporating energy-efficient building designs can diminish the overall environmental effect of structures, save running costs, and improve living conditions (Natural Resources Canada, 2015). Furthermore, the implementation of measures for effective water management, including rainwater

collecting and greywater recycling, can enhance sustainability and promote a circular economy within the building sector (Diaz-Elsayed *et al.*, 2019).

Upon the conclusion of a building's lifespan, demolition must be orchestrated meticulously to optimise the retrieval of components for repurposing or recycling (Kanters, 2018). This method enables enhanced opportunities for material repurposing and recycling relative to traditional demolition techniques, promoting increased sustainability. In a standard residential building, approximately 25% of the materials can be readily re-used, although up to 70% can be recycled (Bohne & Waerner, 2014).

Furthermore, digital technologies such as building information modelling (BIM) can be used to reduce construction material waste and promote circularity in the industry (Sakao *et al.*, 2018) by facilitating effective communication and seamless integration between design and construction (Gayathri *et al.*, 2013). Consequently, it can be inferred that circular construction can be executed through several methods, including: (i) minimising non-renewable material usage, (ii) utilising recycled materials, (iii) prohibiting use of toxic and non-recyclable materials, and (iv) employing durable materials.

Table 2.1 shows a list of different CC practices according to the different life-cycle stages. However, this this distinction is not final because most of these practices can be performed at different life-cycle stages, but were listed in their core phase.

Table 2.1: Circular construction practices

Life-Cycle Stage	Circular Construction Practice	Reference
Project design	Flexible and adaptable designs to accommodate future changes to the building, such as remodelling.	Leising <i>et al.</i> (2018); Mangialardo and Micelli (2018); Maerckx <i>et al.</i> (2019); Eberhardt <i>et al.</i> (2019b); Rasmussen <i>et al.</i> (2019); Eberhardt <i>et al.</i> (2019c)
	The use of BIM to assess the possibility of materials for re-use.	Akanbi <i>et al.</i> (2018); Akanbi <i>et al.</i> (2019a,b)

	Conduct a cost-benefit analysis (CBA) using recycled materials.	Eberhardt <i>et al.</i> (2019a); Eberhardt <i>et al.</i> (2019b); Hossain and Ng (2018)
Manufacture	Manufacturing of building materials using recovered resources.	Nubholz <i>et al.</i> (2019)
	Transfer ownership of materials to a manufacturer after their intended use in the first building.	Swift <i>et al.</i> (2017); Leising <i>et al.</i> (2018)
Construction	Off-site construction to avoid material cut-offs and to optimise time.	Adams <i>et al.</i> (2017); Mangialardo and Micelli (2018)
	The use of existing materials, components and building for new project(s).	Smol <i>et al.</i> (2015); Sanchez and Haas (2018); Mangialardo and Micelli (2018); Rasmussen <i>et al.</i> (2019)
	Minimise waste during construction.	Esa <i>et al.</i> (2016); Adams <i>et al.</i> (2017)
Operation	Preventative maintenance of building components so that they last longer.	Adams <i>et al.</i> (2017)
	Design buildings to include greywater and rainwater harvesting systems to save water.	Pimentel-Rodrigues and Siva-Afonso (2019)
End of life	Smart demolition (dismantling), thereby allowing for the re-use of high-grade building materials.	Adams <i>et al.</i> (2017); Hopkinson <i>et al.</i> (2019)
	Appropriate disposal of materials that cannot be re-used.	Ghisellini <i>et al.</i> (2018); Maerckx <i>et al.</i> (2019)

2.3.2. Built Environment Professionals in Fostering Circular Construction

Janssens *et al.* (2021) underscored the necessity for professionals in the built environment to identify and leverage opportunities that provide a diverse service. The increase in environmental deterioration caused by the construction industry has resulted in the expansion of sustainability legislation. As a result, developers globally are concentrating on achieving sustainability in their construction projects. Professionals in the built environment can provide supplementary services related to sustainability for competitive advantage.

Kanters (2020) identified the client as the primary catalyst of CC. In the study, multiple factors were revealed that influence a client's decision to adopt circular construction principles in their project(s). The elements encompass the client's awareness, financial availability, reputation, and project risk. Based on the study, it was found that architects regarded themselves as being essential consultants in circular construction building design by providing guidance and elevating aspirations. The dependent variables for the architect were the client's scope, versatility, availability of materials and construction techniques. The importance of a contractor who can erect a building according to the design principles was also mentioned in the study.

Furthermore, Stephan and Athanassiadis (2018) ascertained that circular economy (CE) in the construction sector is more attainable with the involvement of its specialists by establishing incentives for the production of circular construction building products (Chang & Hsieh, 2019). Buren *et al.* (2016) asserted further that professionals contribute significantly to the circularity of the building business. Olanrewaju and Anahve (2015) identified architects, structural engineers, civil engineers, service engineers, and quantity surveyors as being essential specialists in construction projects. Consequently, building professionals, including architects, engineers, and contractors, are crucial for optimising utilisation of material and recycling across the design phase and supply chain (Van Sante, 2017). This can be accomplished by integrating waste reduction measures into the design, as emphasised by Govindan and Hasanagic (2018).

2.3.3. Drivers of Circular Construction

The implementation of circular construction building techniques is determined by various essential factors that influence the actions and choices of industry participants. The role of government policies, market dynamics, resource constraints, and overarching social and environmental issues as critical factors in the shift towards circular construction in South Africa is examined in this section.

The South African government has advocated sustainable growth and resource efficiency (South *et al.* Plan, 2013). Policies and regulations concerning waste management, recycling, and sustainable construction methods can propel the circular economy within the construction sector.

The South African Department of Science and Technology (2020) reported that various analysts perceive the crisis instigated by the COVID-19 pandemic as an opportunity to explore innovative solutions, with several nations actively enacting bold strategies to promote the development of a circular economy. Consequently, customers and clients progressively pursue sustainable and environmentally responsible construction solutions. Aligning with client preferences and securing a competitive edge can facilitate the implementation of circular economy principles, providing enterprises with additional profit opportunities (Lewandowski, 2016).

Similar to several other nations, South Africa encounters resource limitations and escalating material expenses (Windapo & Cattell, 2013). Implementing circular processes can diminish dependence on virgin resources, save materials, and reduce expenses related to waste management and raw material acquisition. Diyamandoglu and Fortuna (2015) observed that materials salvaged from deconstruction provide superior economic value compared with new materials, provided that these materials are not sent for recycling. Gaspar and Santos (2015) and Ferreira *et al.* (2015) have similarly shown that upgrading existing buildings is a more advantageous economic and environmental option than new construction. Consequently, the prospect of cost reduction and resource optimisation might serve as a significant impetus for adopting circular economy ideas within the construction sector.

Lastly, circular approaches can yield advantageous social and environmental effects. The South African government sanctioned the National Waste Management Plan for 2020, which addresses waste management challenges, mitigates pollution, and fosters sustainable development, all of which are critical priorities. The circular economy in the construction sector can foster job creation, enhance skills

development, and yield improved environmental consequences, aligning with certain Sustainable Development Goals (SDGs).

2.3.4. Barriers to Circular Construction

The implementation of circular construction building processes, akin to drivers, is affected by various significant obstacles that influence the behaviours and actions of industry stakeholders. In this section, how insufficient awareness and comprehension, a disjointed value chain, regulatory limitations, economic factors, inadequate infrastructure and logistics, and behavioural obstacles impede the shift to circular construction building in South Africa is examined.

A first significant impediment is the insufficient awareness and comprehension of the circular economy idea, its implications for environmental protection, and the advantages of CE among customers and experts in the construction business (Rizos *et al.*, 2015). Numerous parties, such as developers, contractors, and suppliers, might lack familiarity with the ideas and advantages of the circular economy, which might impede its adoption.

The construction sector generally has multiple role-players and a convoluted or disjointed value chain, comprising material suppliers, contractors, architects, and waste management firms. The restricted implementation of digital technology in the construction industry and significant dependence on manual processes exacerbate complexity and superfluous tedium in project management (Delgado & Oyedele, 2021; Bello *et al.*, 2021). The disjointed structure of the value chain in the South African construction sector (Saidu & Shakantu, 2017) complicates the establishment of effective collaboration and co-ordination that is necessary for circular economy practices among the plethora of stakeholders.

Current legislation and policies might not expressly endorse or incentivise circular economy activities within the building sector (Govindan & Hasanagic, 2018). The absence of explicit norms and procedures can generate ambiguity and deter

investment in circular solutions. To support the circular economy model, waste management and recycling regulations might require revision.

Economic issues significantly influence decision-making in the building business. Implementing circular economy methods might necessitate an initial investment in novel technologies, processes, or infrastructure, which might be hindered because of apprehensions over cost-effectiveness (Rizos *et al.*, 2016).

The effective execution of a circular economy in building depends on proficient collecting, sorting, and recycling infrastructure (Florin *et al.*, 2015). Nonetheless, the availability and accessibility of such infrastructure might be constrained in specific sections of South Africa, especially in rural or distant places. Inadequate logistics and transportation networks can impede the delivery of materials and products within the circular economy.

Finally, the attitudes and conduct of stakeholders within the construction industry can impede the adoption of circular economy ideas. Although certain individuals might be inclined to embrace circular economy principles, certain stakeholders exhibit reluctance to alter their conventional business operations or might lack awareness of the necessary steps to implement such changes. They might also view green practices as an extra burden or workload (Chan *et al.*, 2014). Enhancing awareness, promoting teamwork, and facilitating behavioural changes are essential for addressing these difficulties.

2.4. CIRCULAR ECONOMY AND SUSTAINABLE DEVELOPMENT GOALS

In this section, the Sustainable Development Goals (SDGs) are analysed from a broad viewpoint, and the relationship between the circular economy and the SDGs relevant to the study is examined further.

2.4.1. Sustainable Development Goals

The Sustainable Development Goals (SDGs) are a global framework established by the United Nations in 2015 to address pressing challenges such as poverty, inequality, climate change, and environmental degradation (Mishra *et al.*, 2024). The Sustainable Development Goals (SDGs) are 17 inter-connected objectives that outline a holistic approach for achieving a more sustainable and equitable future by 2030 (Sharifi *et al.*, 2024). Işık *et al.* (2024) contend that the objectives of the Sustainable Development Goals encompass the eradication of poverty and hunger, the enhancement of health and well-being, the provision of quality education, the attainment of gender equality, access to clean water, the alleviation of climate change, and the promotion of peace, justice, and resilient institutions. In the SDGs the necessity of integrating social, economic, and environmental sustainability is emphasised, fostering global partnerships to stimulate initiatives among governments, civil society, and the corporate sector to achieve these objectives (Sorooshian, 2024).

The circular economy is intrinsically linked to the Sustainable Development Goals (SDGs) by promoting sustainable production, consumption, and resource management practices that enhance global sustainability (Vann Yaroson *et al.*, 2024). The circular economy advances SDG 12, underscoring responsible consumption and production by reducing waste, extending product life-cycles, and recycling resources (Yong *et al.*, 2024). In addition, the circular economy advances SDG 13 by mitigating carbon emissions through improved resource efficiency and facilitating climate action (ESCAP, 2024). Furthermore, circular economy principles promote employment creation and stimulate innovation, advancing SDG 9 (industry, innovation, and infrastructure) (Costa, 2024). The emphasis on mitigating environmental effects and promoting sustainable systems corresponds with SDG 11 (sustainable cities and communities), guaranteeing the conservation of natural resources and the protection of ecosystems (Ebekoziem *et al.*, 2024). Implementing circular economy methods expedites advancement towards several Sustainable Development Goals by promoting economic, social, and environmental sustainability.

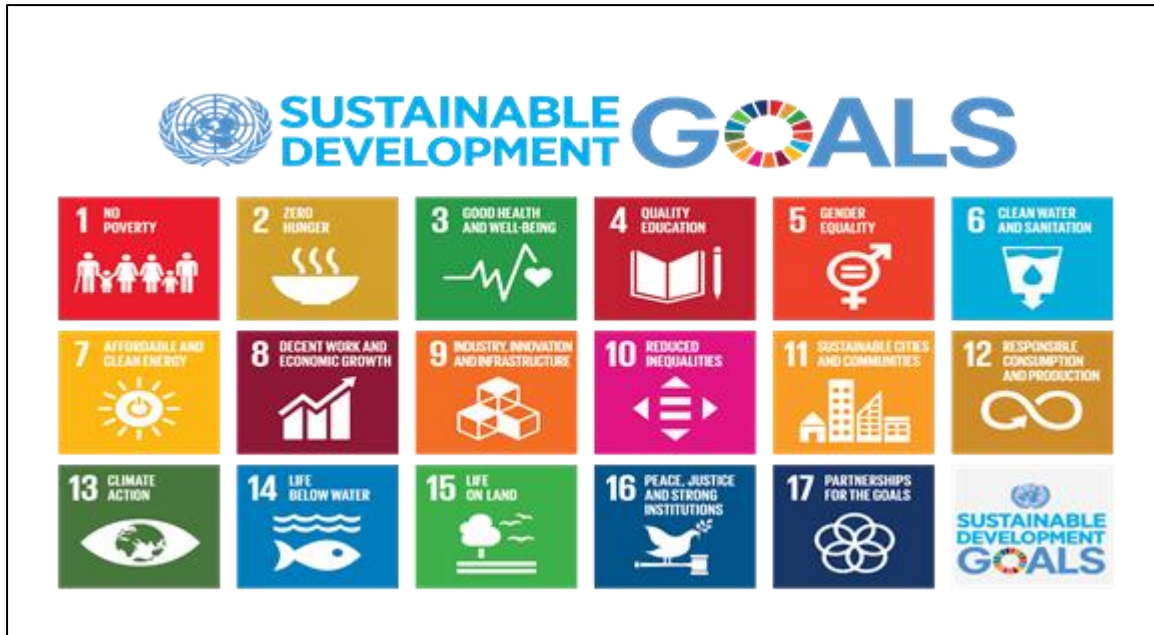


Figure 2.2: The 17 Sustainable Development Goals

Source: (United Nations, 2015)

2.4.2. Sustainable Construction

The focus of this section is on sustainable construction.

2.4.2.1. The Nature of Sustainable Construction

The nature of sustainable construction, also known as green or eco-friendly building, can be derived from synthesising its definitions. According to Jackson (2021), sustainable construction can be defined as utilising recyclable and renewable materials in construction projects, while simultaneously reducing the amount of energy used and the amount of waste produced. For the US Environmental Protection Agency (2021), green building is the practice of developing structures and procedures that are ecologically responsible and resource-efficient throughout a building's life-cycle, from site selection to design, construction, operation, maintenance, renovation, and deconstruction. This method broadens and enhances the traditional architectural design considerations of economy, usefulness, durability, and comfort. Green buildings are sometimes referred to as sustainable or high-performance buildings.

From the point of view Go Construction (2020), sustainable construction means making use of materials and resources that are both recyclable and renewable, taking care during building projects to minimise the amount of waste produced and the amount of energy consumed, and safeguarding the natural environment that is located in the vicinity of the construction site. Therefore, to be considered as being sustainable, a construction project must ultimately create an environment or building that is friendly to the natural environment.

The above and many other definitions of sustainable construction emphasise environmental responsibility, resource efficiency, and societal impact. Therefore, sustainable construction is operationally defined as: the process of designing, building, and managing structures using methods, materials, and practices that minimise environmental impact, optimise resource efficiency, and enhance societal well-being throughout the entire life-cycle of a building, from planning and construction to maintenance and eventual deconstruction.

2.4.2.2. Importance of Sustainable Construction

Jackson (2021) eloquently alludes to the importance of sustainable construction as follows:

The construction industry, by its nature, is one of the top users of natural resources. With the growing concern of finite natural resources and climate change, there is increasing pressure in the construction industry from the government and some private sectors to minimise their environmental impact. While there are some challenges involved in embracing sustainable construction methods, there are also a lot of great benefits in adopting these methods.

Specifically, Jackson (2021) observes that the construction industry significantly impacts the environment by contributing 36% of energy usage and 40% of CO₂ emissions world wide, while heavy machinery relies greatly on fuels and inefficient use

of electricity that leads to unnecessary combustion. Furthermore, improper disposal of hazardous waste contributes to environmental and human health issues.

According to Jackson (2021), sustainable construction is crucial in addressing these concerns. In addition, Chen *et al.* (2010), and Yu and Kim (2011) cited many advantages regarding building sustainability. Some of these were shorter construction times, decreased average construction costs, improved health and safety at work, re-use of materials, reduced construction site pollution, and reduced environmental pollution and emissions. Moreover, according to the South African Constitution, every South African, born or unborn, has the right to live in a clean and safe atmosphere. To this end, everyone involved in a construction project is advised to follow sustainable building strategies and materials (Van Reenen, 2014).

2.4.2.3. Sustainable Construction Principles

According to Sadler (2021), some cardinal principles must be considered in any construction project from the early stages. These relate to sustainable design, durability, energy efficiency, waste reduction, water conservation, and building materials.

Sadler (2021) elaborated that the preliminary planning and design of a building significantly influence the reduction of energy consumption and pollution. Therefore, the sooner sustainable construction is embedded into the design, the more sustainable a building will be. This approach will ultimately result in enduring, ecologically sustainable advantages inside the construction. Therefore, the materials, transport, water, energy, and waste must be evaluated to ensure sustainable building objectives.

Sadler (2021) stated further that using durable materials and products in building construction minimises the frequency of replacements or repairs, yielding reduced maintenance requirements, and environmental and economic advantages. Enhancing energy efficiency decreases expenses by decreasing use of fuel, hence reducing CO₂

emissions. This approach ultimately reduces the impact of the construction sector on climate change. Energy efficiency in construction pertains to all components of a building. To ensure energy efficiency, utilising energy-efficient technology, materials, and construction processes must be considered.

According to Sadler (2021), if buildings were designed to be more flexible and capable of re-use, the need for demolition would decrease significantly. The problem with demolition is that it generates a large amount of waste. Therefore, construction companies must carefully evaluate the environmental impact of the materials used in their projects. To effectively reduce waste, it is essential to prioritise low-impact materials that are sustainably sourced and repurposed from other projects and to integrate sustainable recycling practices throughout every phase of the construction process (Sadler, 2021).

Regarding water conservation, Sadler (2021) averred that, as water becomes increasingly scarce, with pollution and climate change significantly affecting its availability, the construction sector must manage water consumption carefully during building activities. This situation means that the industry must implement strategies that promote sustainable water practices, reducing unnecessary water use and fostering conservation throughout all stages of the construction process (Sadler, 2021).

Lastly, Sadler (2021) considered using sustainable building materials to be imperative to ensuring circular construction. Sustainable materials are those that do not negatively affect the environment and avoid the use of non-renewable resources. Building with these eco-friendly materials helps to reduce costs and contributes positively to environmental protection (Sadler, 2021).

The principles above align closely with the social (Hussin *et al.*, 2013; Vallance, Perkins and Dixon, 2011), economic (Timofti *et al.*, 2020; Salama & Hana, 2018) and environmental (Moldan *et al.*, 2012; Ekins, 2011; Eichholtz *et al.*, 2010) principles.

Social sustainability means pursuing human livelihoods today should not undermine future generations' ability to fulfil their needs. In other words, the construction industry must be ethical, moral, and legal towards its stakeholders, including employees, suppliers, and the communities where construction projects occur (Hussin *et al.*, 2013; Vallance, Perkins and Dixon, 2011).

Environmental sustainability comprises climate systems, working environments and ecosystems (Moldan *et al.*, 2012). According to Ekins (2011), environmental sustainability maintains essential environmental functions and thus keeps the capital stock capacity to fulfil those functions. For Simpeh and Smallwood (2018), environmental sustainability related to building projects is concerned with preventing any irreversible and harmful effects of construction activities on the environment and ensuring the responsible use of resources.

Economic sustainability is a widely recognised idea that involves economic activities, ensuring long-term financial stability and contributing to social progress (Salama & Hana, 2018). In the construction sector, economic sustainability is focused on cost savings throughout a project's life-cycle, primarily achieved by lowering utility costs and reducing expenses related to operations and maintenance (Salama & Hana, 2018). To fully realise the financial benefits of sustainable construction, it is crucial to account for social and environmental costs appropriately (Moldan *et al.*, 2012; Ekins, 2011; Eichholtz *et al.*, 2010).

2.4.3. Improving Sustainability Performance through CC Practices

Human-generated waste has become a worldwide concern since it directly impacts the environment, society, and economy and, therefore, overall sustainability (Tan *et al.*, 2015). Therefore, waste management is essential to sustainability within the construction industry. This will help to manage the amount of waste that goes to landfills (Di Foggia & Beccarello, 2021) and the adverse effects of that.

Sadler (2021) emphasised the importance of sustainable construction in building design, stating that early incorporation of sustainable practices leads to more eco-friendly buildings. Durable materials minimise maintenance requirements and energy consumption, reducing costs and CO₂ emissions. Buildings should be flexible and re-used to reduce demolition and waste generation. The construction sector must manage water consumption carefully, promoting sustainable practices throughout the construction process. Sustainable building materials are crucial for circular construction, as they do not impact the environment negatively and avoid non-renewable resources. These eco-friendly materials contribute to cost reduction and environmental protection.

According to Akanbi *et al.* (2017), CC provides economic and environmental sustainability and benefits through using salvaged construction materials that involve directly re-using materials and components, which needs low energy consumption compared with the energy and material resources required for material recycling. Re-using an entire building is more environmentally and economically sustainable than just re-using materials and components.

2.4.3.1. Social Opportunities

Within the three pillars of sustainability, the economic and environmental are usually focused on the most (Murray *et al.*, 2017). According to several authors (Murray *et al.*, 2017; EMF, 2017; Moreau *et al.*, 2017), the social opportunities of sustainability regarding circular economy are often ignored and, therefore, remain unknown. However, the Ellen MacArthur Foundation (2013) found that society can benefit from CE activities, job creation, educational opportunities, and improved employment conditions. CC can also offer social opportunities that justify its sustainable development. For instance, collaboration between clients and project teams can help to extend a commercial relationship (Persson, 2015).

2.4.3.2. Economic Opportunities

Circular construction can stimulate economic growth without depleting resources because lower material costs and enhanced revenue from trash sales leads to the likelihood of it happening. Moreover, CC can generate employment opportunities without exerting undue strain on resources (Sadler, 2021; Ghisellini *et al.*, 2016; Persson, 2015; Jun & Xiang, 2011; Zhu *et al.*, 2010). Ellen MacArthur Foundation (2013a, 2014) also suggested that a move towards reparability and maintenance of products, and preventative maintenance in the construction industry would create more jobs. Moreno *et al.* (2015) noted that increased income from waste sales, higher resource productivity, and reduced material costs linked to the CE provide economic opportunities.

2.4.3.3. Environmental Opportunities

CC has numerous potential environmental advantages that can be achieved. These advantages include: "conservation of natural resources (especially non-renewable resources such as water, fossil fuels, and minerals), reduced environmental impacts through efficient energy and material and less water discharge, avoidance of toxic materials, the extended life-cycle of landfill sites, and recovery of the local ecosystem" (Geng *et al.*, 2012: 221). CC can also reduce environmental pollution through efficient waste management and resource minimisation, which will reduce the environmental challenges that are faced currently (Preston, 2012; Zhu *et al.*, 2010).

2.5. ROADMAP APPROACH IN IMPROVING CIRCULAR CONSTRUCTION

Roadmaps offer effective planning and a concise view of a particular research field, comprising a rigorous compilation of information and imagination that drives transformation in a field (Thora & Beverly, 2014). Examples include product roadmaps and industry roadmaps. Another definition of a roadmap was provided by Kim *et al.* (2015), who described roadmaps as common analogies for planning and describing the use of scientific and technical resources, elements, and structures throughout time. The roadmap process involves finding, assessing, and selecting strategic options to

accomplish intended objectives to formulate a roadmap that summarises and conveys the outcomes of crucial business choices.

Table 2.2 below contains a summary of four analysed roadmaps. Although they are all focused on the construction industry, and most on CE, they do not concentrate on incorporating construction practices that can lead to circularity in the industry and the different role-players that need to be involved.

Table 2.2: Summary of roadmaps

Project	Core Value	Focus Industry	Reference
Sustainability Roadmap	Strategic initiative to promote sustainable development	Construction Industry	China State Construction International Holdings Limited (2021)
EU Roadmap Series – Part 3: Waste and Circularity	The role of Waste and Circularity in decarbonising the EU's built environment	Construction Industry	World Green Building Council (2022)
Brussels Construction Industry Roadmap towards a Circular Economy	<ol style="list-style-type: none"> 1. Voluntary measures by construction businesses 2. Comprehensive regulation for circular construction public buildings by 3. Reforming all relevant local planning regulations to include circular principles 	Construction Industry	Brussels Regional Programme for a Circular Economy (2019)
Roadmap for Enabling Circular Economy Potential in Infrastructure	Pathways that lead to better knowledge and understanding of the circular economy in infrastructure	Construction Industry	Global Infrastructure Hub (2021)

The aim of the roadmap proposed in this study is to further the transition to a circular economy in the construction industry. The roadmap presents a clear strategic pathway for improved circular construction practices.

2.6. THE THEORETICAL FRAMEWORK

This study is underpinned by the Knowledge, Attitude and Practice (KAP) Theory.

2.6.1. Overview of the KAP Theory

The KAP Theory originated from the convergence of the Learning Theory of Bandura (1976) and the Diffusion of Innovation Theory of Roger (1995). In the Learning Theory, Bandura (1977) indicated that learning in the social context takes place through observing, modelling, and imitating the behaviours, attitudes, and emotional reactions of others. Roger (1995) maintained that members of a social system accept innovation through four stages: knowledge acquisition, persuasion, decision, and confirmation. According to Liao, Nguyen and Sasaki (2022), the KAP Model is widely used in social research to assess the relationship among knowledge, attitudes, and practices.

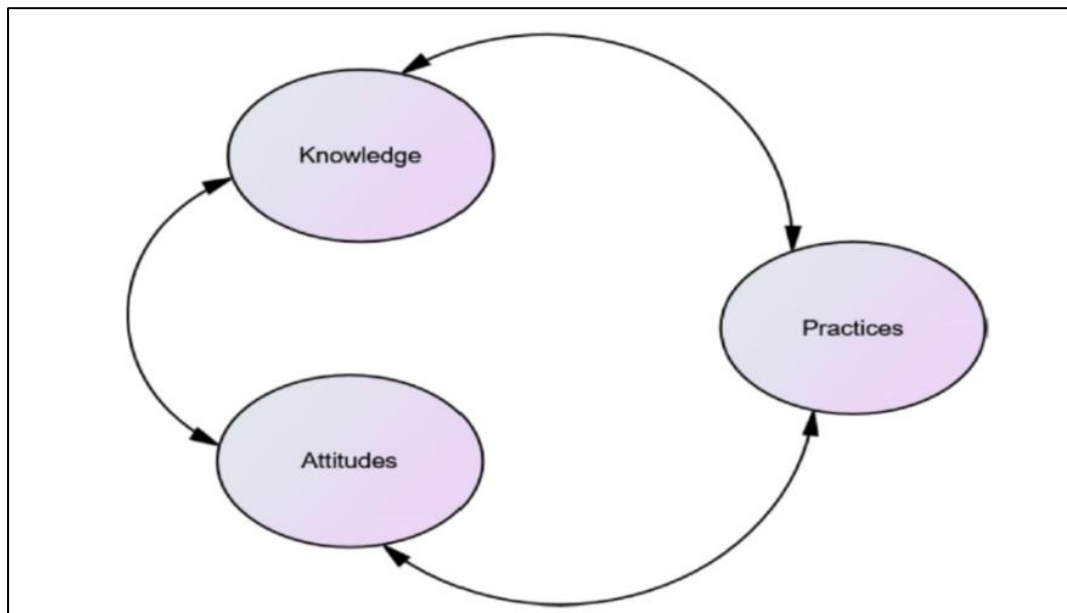


Figure 2.3: KAP Framework

Source: Etwaroo et al. (2023:5)

The KAP Theory is illustrated by Etwaroo, Goburdhun and Ruggoa (2023: 5) in Figure 2.3. In their study, Etwaroo *et al.* (2023: 5) sought to determine the knowledge, attitude and practices regarding food additives of Small and Medium-sized Enterprises (SMEs) in provision of food in Mauritius. In the study, practices and challenges of micro and small enterprises regarding good practices for additives in food manufacturing were identified. Subsequently, the results from the study were used by local food manufacturers, food suppliers, and policy-makers as a foundation for changes to applicable national regulations and innovation in the food sector.

2.6.2. The Application of KAP Theory in Construction

Researchers, such as Pan and Pan (2020), have used such a framework to ascertain the knowledge, attitudes and practices towards zero carbon buildings (ZCBs) in Hong Kong. The findings of the study revealed that stakeholders generally have a low level of knowledge, a relatively negative and ambivalent attitude, and poor practices concerning zero carbon buildings (ZCB) in Hong Kong.

In South Africa, the findings of a study by Owojori, Mulaudzi and Edokpayi (2022) demonstrated the role of KAP Theory in understanding the challenges of waste management. The findings of the study revealed insufficient knowledge and awareness of solid waste management and indicated that students' waste management practices do not align with the CE framework. Based on the study, significant barriers to CE implementation were also highlighted, such as a lack of knowledge, awareness, appropriate facilities, and financial constraints.

According to the KAP Theory, changes in an individual's behaviour result from three sequential processes: knowledge creation, attitude formation, and behaviour development (Fan *et al.*, 2018). In the present study, the KAP Framework was used to explore what construction professionals know about CC (knowledge), their perceptions of CC (attitude), and how they apply CC in the real world (practice). This information is crucial for designing targeted interventions to promote the consideration of CC practices throughout the life-cycle of various construction projects.

2.6.3. The Conceptual Framework for the Study Based on the KAP Theory

As stated in Section 2.6.2 above, the KAP Theory was used to guide this study. The framework is based on the KAP Framework of Ibrahim *et al.* (2022), with the belief that circular construction practices can be improved in South Africa through a three-stage process illustrated below.

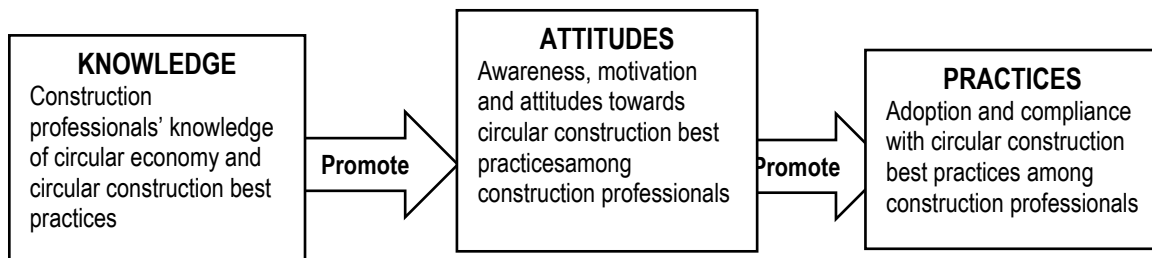


Figure 2.4: KAP Conceptual Framework for circular construction

2.7. CHAPTER SUMMARY

The literature shows that there is a growing awareness of the construction industry and how it produces much waste and consumes resources. Considering clients/developers becoming more environmentally friendly for various reasons, such as to gain a competitive advantage, it is crucial, therefore, that construction professionals are all knowledgeable about CC because they work as a team. A roadmap helps to illustrate pathways to the incorporation of circular construction practices, and research to compile such roadmaps can be conducted through KAP studies, which are of growing interest in the construction industry.

CHAPTER 3: THE RESEARCH METHODOLOGY

3.1. INTRODUCTION

In this chapter, the research methodology embraced to advance circular construction practices in South Africa is explained. The renowned Research Onion of Saunders *et al.* (2016) was the cornerstone of this study, serving as the primary guiding methodological framework. This framework, comprising methodological choice, research strategy, data collection and analysis method, and sampling technique, is detailed and discussed in the context of this study, underscoring its significance and role in the research process.

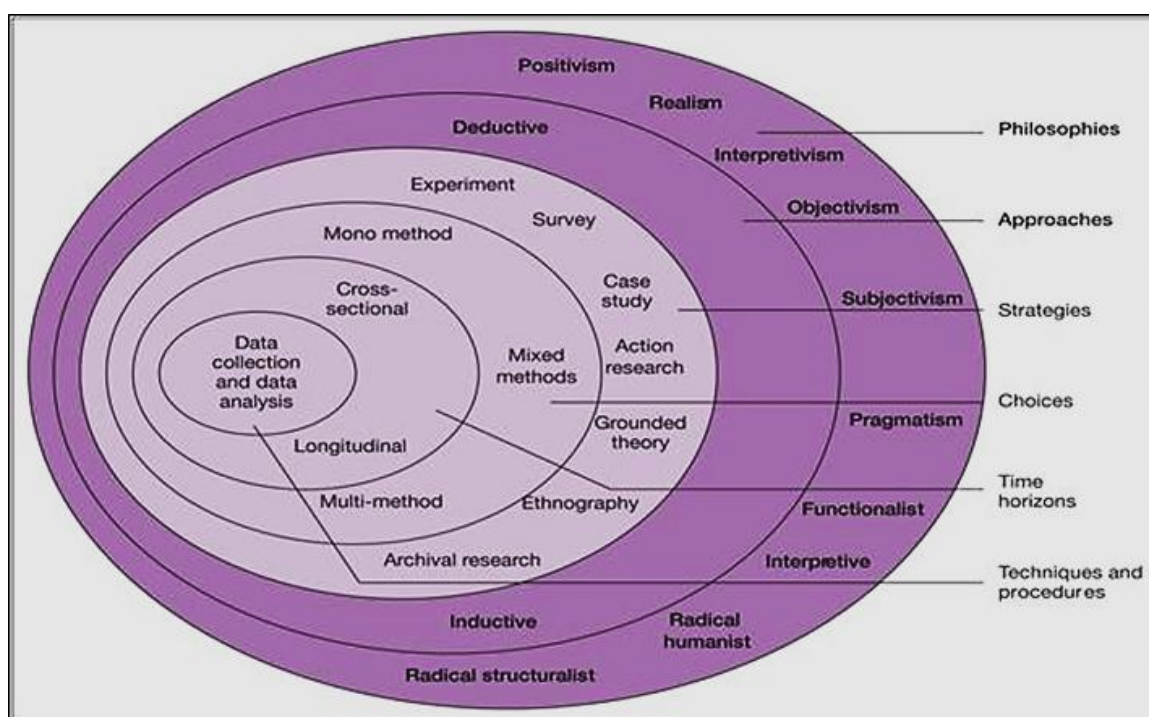


Figure 3.1: Research Onion

Source (Saunders & Bristow, 2023)

3.2. RESEARCH PHILOSOPHY

The initial layer of the Research Onion contains diverse research philosophies, such as positivism, interpretivism, objectivism, and pragmatism (Saunders *et al.*, 2019). A pragmatic mindset was adopted for this study, consistent with a mixed-methods

approach, facilitating a flexible, problem-solving orientation appropriate for the complexities of circular construction techniques. From a pragmatist perspective, it is recognised that knowledge is not absolute but somewhat influenced by the circumstances of its use. This philosophy facilitates the utilisation of textual (qualitative) and statistical (quantitative) data, producing insights directly relevant to real-world issues.

The pragmatist philosophy facilitated a thorough examination of the intricate phenomenon of circular building. The core principle states that knowledge is acquired by activity and actual problem-solving rather than being confined to qualitative or quantitative metrics. A pragmatist approach was adopted for this study to facilitate the creation of a roadmap for circular building practices, emphasising the practical ramifications of knowledge, attitudes, and practices (KAP) among construction professionals. The complexity of the subject was embraced in the research without oversimplification, recognising that solutions to circular building challenges are multi-faceted (Feilzer, 2010).

A principal advantage of pragmatism is its dismissal of the rigid separation between qualitative and quantitative approaches, asserting that the selection of methodology should be determined by what most effectively addresses the research objectives (Feilzer, 2010). This attitude aligned with the aim of the study to examine both quantitative data (surveys) and qualitative insights (interviews) to comprehend the implementation of circular economy principles in the construction sector. Easterby-Smith *et al.* (2012) asserted that pragmatism facilitates the precise measurement of attitudes and awareness, while simultaneously offering the depth required to encapsulate more subjective experiences.

Brierley (2017) contended that pragmatism is particularly beneficial for examining human behaviour and attitudes, which is crucial for comprehending how construction professionals interact with circular construction building techniques. The pragmatism philosophy of this study validated the employment of diverse data collection methods,

guaranteeing the incorporation of both quantitative and qualitative data to yield comprehensive and practical insight into circular construction practices in South Africa.

3.3. RESEARCH APPROACH

The second layer of the Research Onion pertains to research techniques. Saunders *et al.* (2019) asserted that research encompasses inductive and deductive methodologies. The deductive approach is used to evaluate a theory, but the inductive approach is used when a researcher begins data collection to investigate a phenomenon. According to Bhattacharjee (2012), integrating both inductive and deductive methodologies aligns research with the idea of pragmatism, constituting an abductive approach.

An abductive technique was employed for this study. Initially a deductive approach was employed, using questionnaires to evaluate the knowledge, attitudes, and practices of construction professionals concerning circular construction methods. The inductive method was used subsequently through qualitative interviews with construction experts to enhance understanding and elucidate the knowledge, attitudes, and behaviours related to CC. This methodology is grounded in the research of Blackstone (2012) and Gray (2013), who asserted that integrating both methodologies yields a comprehensive understanding of the phenomenon being examined. This was to guarantee that, when discoveries from deductive research are limited, the inductive investigation offers greater elucidation.

3.4. RESEARCH STRATEGY

The third layer of the Research Onion pertains to research strategy. An explanatory sequential design was used for this study, recognised by Creswell and Plano Clark (2018) as a successful method for integrating quantitative and qualitative data to enhance comprehension of a research issue. The technique was chosen to examine the knowledge, attitudes, and practices (KAP) of construction professionals regarding the circular economy in South Africa.

The research was executed in two steps, commencing with a survey methodology for collecting quantitative data. Surveys were administered to construction experts in the Gauteng and Free State Provinces to gather their perspectives and experiences regarding circular construction techniques. The selection of these provinces was predicated on logistical practicality, ensuring that the study remained feasible within the constraints of time and resources. The focus of the initial phase was on producing quantitative data, which offered a comprehensive insight into KAP about circular construction.

The second phase involved qualitative interviews to elucidate and examine the insights derived from the survey data. This phase offered an enhanced comprehension of the themes and patterns arising from the quantitative analysis, enabling a thorough examination of the elements affecting circular construction methods. The integration of these two methodologies enabled the researcher to comprehend various perspectives and attain a comprehensive understanding of the circular economy in the building industry.

An explanatory sequential design was employed for the study, leveraging the advantages of quantitative and qualitative methodologies, with each phase informing the subsequent phase. This technique guaranteed that the data gathered was extensive and detailed, facilitating a comprehensive examination of the problems and prospects for circular construction in South Africa.

3.5. RESEARCH CHOICES

The fourth layer of the Research Onion pertains to research selections. Saunders *et al.* (2019) asserted that a researcher may select any singular quantitative method, qualitative method, or a combination of both. The researcher selected the explanatory sequential mixed-methods design for the investigation. Creswell (2017) asserted that the collection of both closed-ended quantitative, and open-ended qualitative, data is beneficial and yields more substantial evidence. Quantitative data describe

large populations through surveys, and qualitative data give value over quantity to a person's text or words (Bryman, 2016). The choice of mixed methods helped the researcher to gain more insight into topics and obtain more diverse perspectives on KAP.

3.6. RESEARCH TIME HORIZON

It is the view of Bell, Bryman and Harley (2022) that research can be conducted in a short time, in the form of a cross-sectional study, or over a long period, in the form of a longitudinal study. Owing to the time limitation of the full-time Master's Degree Programme in Construction Management, this study was cross-sectional.

3.7. STUDY POPULATION

In this study, the population included construction professionals such as quantity surveyors, architects, engineers, construction managers, and project managers, all of whom were actively involved in various stages of construction projects. These participants were drawn from both the Gauteng and Free State Provinces.

The aim of the study was to capture insights from professionals with experience or knowledge of circular construction (CC) practices. The sample was strategically selected to include professionals involved in project planning, design, construction, and deconstruction phases. This diversity of roles allowed for a more comprehensive understanding of the knowledge, attitudes, and practices related to circular construction.

A total of 90 questionnaires was completed, as shown in Table 3.1. The respondents were selected based on their involvement in the construction industry within the two provinces, ensuring that the researcher could gather and analyse data efficiently within the constraints of the research timeline. Each participant is assumed to be involved in or at one stage has been involved in all the phases of construction (Design,

construction, deconstruction, planning) due to the inherently integrative nature of their professional responsibilities.

Table 3.1: Sample size

Sample	No.	Phases engaged in
Architects	9	Design, construction, deconstruction, planning
Quantity Surveyors	20	Design, construction, deconstruction, planning
Engineers	21	Design, construction, deconstruction, planning
Project Managers	24	Design, construction, deconstruction, planning
Construction Managers	16	Design, construction, deconstruction, planning

The aim of the interviews was to investigate the use of circular economy concepts in diverse construction projects and identify the problems that professionals encountered in applying these practices. In-person and telephone interviews were conducted with 25 respondents, as illustrated in Table 3.2, to collect the requisite data. The interviews were conducted once and semi-structured questions were used to facilitate comprehensive conversations. This method facilitated the acquisition of comprehensive qualitative data that might elucidate and augment the results from the quantitative survey.

Table 3.2: Interviews with construction professionals

Interviewees	No.	Phases engaged in
Architects	4	Design, construction, deconstruction, planning
Quantity Surveyors	6	Design, construction, deconstruction, planning
Engineers	4	Design, construction, deconstruction, planning
Project Managers	5	Design, construction, deconstruction, planning
Construction Managers	6	Design, construction, deconstruction, planning

3.8. SAMPLING TECHNIQUE

Sampling is a method for selecting individuals from a broader population for research purposes (Bryman & Bell, 2015), and sample techniques are categorised into probability and non-probability (Taherdoost, 2016). Simple random sampling was employed to select construction experts engaged in diverse construction projects for a quantitative survey. This approach guaranteed that all individuals from the target group had an equal chance of being selected, reducing bias and offering comprehensive representation of the sector (Kumar, 2018).

For the qualitative sample, purposive sampling was employed to identify specific, information-rich individuals who could provide deeper insights and understanding related to circular construction practices (Bernard, 2018). This method was suitable for selecting participants with significant experience or expertise, enabling the researcher to explore the phenomenon in more detail.

3.9. PRIMARY DATA COLLECTION

In this section, the techniques and methods used in collecting and analysing the data are explained.

3.9.1. Primary Data Collection

In this section, how primary data were collected is presented.

3.9.1.1. *The Construction and Use of Questionnaires*

A Likert Scale questionnaire, called the Circular Construction, Knowledge, Attitude, and Practice Scale (CCKAP), was developed to assess the knowledge, attitudes, and practices of construction professionals regarding circular construction. The questionnaire was chosen for its ability to generalise opinions from a sample population (Creswell, 2014). The development of the scale occurred in two phases:

firstly, relevant literature was reviewed to identify items for inclusion and, secondly, the psychometric properties of the scale were evaluated using Cronbach's alpha to assess the reliability and validity of the quantitative data.

The questionnaire was administered online and face-to-face to reach a broad range of respondents and ensure a satisfactory response rate (Bryman, 2015). Initially, a web link to the survey was sent to potential respondents, followed three weeks later by a reminder email to encourage participation. For face-to-face distribution, the researcher delivered the questionnaires, either waiting for completion or arranging a collection date. All completed questionnaires were entered manually into the online database, and responses were collected electronically.

3.9.1.2. The Use of Interviews

Interviews followed the survey. The open-ended interviews followed the survey based on the information analysed from the questionnaires. They were conducted by telephone, video, and face-to-face to obtain rich data. The key respondents were also construction professionals such as quantity surveyors, architects, engineers, project managers, and construction managers. The aim of the interviews was to collect information from construction professionals noted for their track record of excellent knowledge, exemplary attitudes, and circular construction practices. This process aided the researcher in determining when circular construction practices can be incorporated into different building projects, such as new construction projects, refurbishments, and demolition, as well as evidence of the waste produced from these.

3.9.2. Secondary Data

As a first step in the data collection for this study, a thorough review of literature was conducted from secondary sources related to the topic, such as books, journals, conference papers, and dissertations, to gain a theoretical understanding of the topic, as Creswell (2014) advised. Most research information was accessed through the Central University of Technology Library and affiliated databases.

3.10. DATA ANALYSIS

The numerical data collected through the QuestionPro platform, which included both online and face-to-face questionnaires, were extracted and then imported into SPSS for statistical analysis. Descriptive statistics, such as frequencies, percentages, and rankings, were generated to provide a summary of the responses. In addition, inferential statistics were applied, specifically correlational analysis, to explore possible linkages among the knowledge, attitudes, and practices (KAP) of respondents concerning circular construction.

A thematic analysis of the qualitative data collected through interviews was conducted. The interview data, initially captured on QuestionPro, were extracted and then analysed following the steps outlined by Leedy and Ormrod (2014). The data were transcribed and organised into categories based on recurring themes. Coding was applied to the data using qualitative analysis software (such as ATLAS.ti) to identify key patterns. These themes were then analysed in depth to comprehend knowledge, attitudes, and experiences of professionals regarding circular construction. This qualitative analysis complemented the quantitative findings, offering richer insights into the barriers and drivers of circular construction practices.

3.11. RELIABILITY AND VALIDITY ISSUES

According to Creswell (2014), research is valid when the researcher adopts specific procedures to ensure the accuracy of the findings. Harper, Molenaar and Cannon (2016) described reliability as the consistency and reproducibility of results using the same steps. To ensure reliability and validity, the steps outlined below were followed.

3.11.1. Reliability and Validity of Quantitative Data

According to Creswell (2014), the questions and results of a survey must encompass various aspects of the subject matter. In addition, as defined by Whiston (2016),

validity involves collecting data that aligns with the intended purpose of the measuring instruments. Furthermore, Whiston (2012) defined validity as obtaining data acceptable for the intended use of the measuring instruments. In this study, participants were requested to provide their knowledge, attitude, and practices regarding CC. The survey required the respondent to know a phenomenon to provide their insight. Cronbach's test was done to check the reliability and validity of the questionnaire results.

Table 3.1 illustrates and categorises the levels of internal consistency in a measurement instrument based on Cronbach's alpha coefficient (α). Cronbach's alpha is a statistic used to assess the reliability or internal consistency of a set of scale or test items. The table shows that a Cronbach's alpha of 0.9 or higher indicates "Excellent" internal consistency, while values between 0.8 and 0.9 are considered "Good". An alpha between 0.7 and 0.8 is "Acceptable", whereas values from 0.6 to 0.7 are "Questionable". Lower levels of internal consistency are reflected by an alpha between 0.5 and 0.6, which is deemed "Poor", and any alpha less than 0.5 is considered "Unacceptable". Figure 3.3 provides a guide for researchers to evaluate the reliability of their instruments, where higher values of Cronbach's alpha are preferred for more consistent results. Thus, Cronbach's alpha was adopted in the study to check the reliability of the quantitative data and the formula in Figure 3.3 was used.

Table 3.3: Cronbach's test

Cronbach's alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.6$	Poor
$0.5 > \alpha \geq$	Unacceptable

Source: Tavakol and Dennick (2011)

Cronbach's alpha formula:

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$

N = the number of items.

\bar{c} = average covariance between item-pairs.

\bar{v} = average variance.

3.11.2. Reliability and Validity of Qualitative Data

Methodological triangulation entails using a variety of qualitative and quantitative methodologies. Validity is established when the findings from each approach are the same (Guion *et al.*, 2011). As previously stated, questionnaires and interviews were employed in this study to gather data and enhance the quality of the research findings. With the interviewees' consent, all interviews were recorded, as Gray (2013) recommended, to establish a permanent record of the dialogue and provide more credible evidence. The data were analysed using the triangulation approach.

Singh *et al.* (2021) contended that triangulation augments data validity and reliability by cross-verifying information from other sources, perspectives, or methodologies. It entails employing various data collection methods, including interviews, observations, and document analysis, to investigate the same phenomenon (Beecham *et al.*, 2018). The advantage is that comparing findings from diverse methodologies enables researchers to discern consistencies and inconsistencies, thereby mitigating biases and enhancing the precision of the conclusions (Alam & Asmawi, 2024). In other words, triangulation offers a more thorough comprehension of a study issue by incorporating several perspectives, reflecting the complexity of the subject (Singh *et al.*, 2021).

3.12. THE RESEARCH PROCESS

The flow-chart diagram representing the research process that was followed is shown in Figure 3.2.

Figure 3.2 shows that the research began with problem identification (Stage 1), where construction waste in South Africa and the need for a circular economy (CE) were identified. This stage helped to understand the construction industry's environmental impact and the need for circular construction. Following this, research objectives were stated (Stage 2). A review of literature about circular economy ideas, construction waste management, and sustainable practices was conducted in Stage 3. The review led to the development of a theoretical framework and helped to identify knowledge gaps that could be addressed in the research. In Stage 4, quantitative data were collected through surveys of construction professionals in Free State and Gauteng regarding their circular building knowledge, attitudes, and practices. These data were analysed in Stage 5 to identify trends, insights, and understanding of attitude gaps that prevented circular construction building.

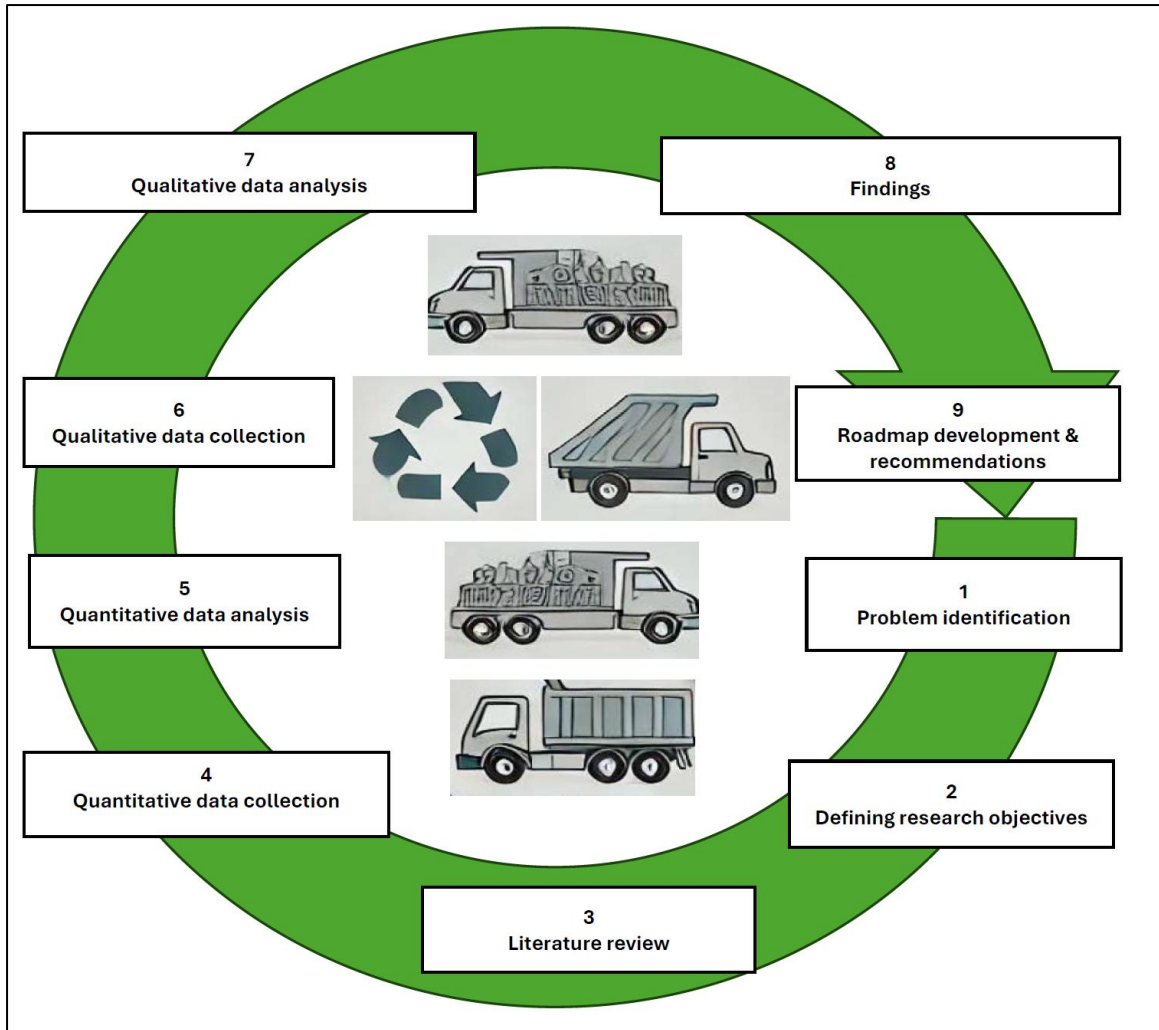


Figure 3.2: The research process followed to explore the CC problem

After the quantitative phase, construction professionals were interviewed to obtain qualitative data (Stage 6). The interviews addressed circular building problems, facilitators, and best practices. In Stage 7, the qualitative interview data were analysed. This process helped to clarify how information, attitudes, and behaviours might foster circular construction creation. In Stage 8, the investigation moved to findings after evaluating both datasets. The results revealed knowledge gaps, positive attitudes, and best practices for circular construction building. Economic disincentives and insufficient regulatory aid hindered circular construction. The investigation was finished in Stage 9, with a circular construction roadmap and recommendations.

3.13. ETHICAL CONSIDERATIONS

Ethical issues are essential at every stage of research (de Vaus, 2014). This research was performed with ethical approval from the Central University of Technology (CUT) under clearance number FRIC:31/08/2023(1). Ethical guidelines were rigorously followed throughout all stages of the research, encompassing data collection, analysis, and reporting findings from both questionnaires and interviews.

An essential ethical consideration was to assure the safety and welfare of all participants (Creswell, 2014). No individuals experienced injury or risk throughout their participation in the research. The voluntary nature of participation was strictly maintained, with no compulsion or fraud employed to elicit replies (Creswell, 2014). Participants were thoroughly appraised of the goal, scope, and objectives of the study.

The principle of informed consent was adhered to during the research. Participants received comprehensive information about the research before signing consent forms verifying their voluntary participation. They were also appraised of their freedom to withdraw from the study at any moment without repercussions. Confidentiality was rigorously upheld, guaranteeing that participants' identities remained anonymous during the research. All data obtained through questionnaires and interviews were used exclusively for this research.

Together with confidentiality during the investigation, stringent steps were enacted to safeguard the data after the research was concluded. All data were archived securely. Physical copies of questionnaires were stored in secured cabinets, while digital records were encrypted to avert unwanted access. These measures guaranteed the confidentiality and protection of the data during and after the research procedure.

Participant interactions were executed with respect and transparency during data collection, according to ethical rules, integrity and transparency were upheld during the study procedure, guaranteeing that data collection, analysis, and reporting were conducted honestly and accountably.

3.14. CHAPTER SUMMARY

In this chapter, a comprehensive account of the research methodology utilised in this study was presented, including the research philosophy, approach and strategy. The data collecting and analysis methodologies were also delineated, encompassing both quantitative and qualitative approaches, employed to gain insights from construction experts in South Africa. Ultimately, essential ethical aspects, assuring the safety, confidentiality, and integrity of the research process were explained in the chapter.

CHAPTER 4: RESULTS AND DISCUSSION

4.1. INTRODUCTION

In this chapter, the results of the data analysis are presented and discussed. The chapter includes, among other aspects, presentation and discussion of the response rate, survey results regarding the respondents and organisational demographics, knowledge areas that would increase CE practices, attitudes that would increase CC practices, and exemplary CE practices.

4.2. RESPONSE RATE

Once the questionnaire design was completed, a survey was conducted among construction experts in the Free State and Gauteng Provinces. The survey lasted approximately 27 weeks. Out of the 180 surveys distributed, 90 were returned, achieving a response rate of 50%. Based on the research instruments prepared for the study, 25 interviews were conducted with construction professionals.

4.3. SURVEY RESULTS

4.3.1. Age Group

Figure 4.1 illustrates the distribution of individuals across different age groups. The largest segment, constituting 33% of the population, fell into the "Under 30 years" category, indicating that this age group was the most prevalent. The next largest group was "31-35 years", comprising 27% of the population, followed by "36-40 years" at 21%. The "41-45 years" category represented 12%, while the smallest group, "More than 40 years", constituted only 7% of the population. This distribution suggests a relatively young demographic, with the majority of respondents being under 35.

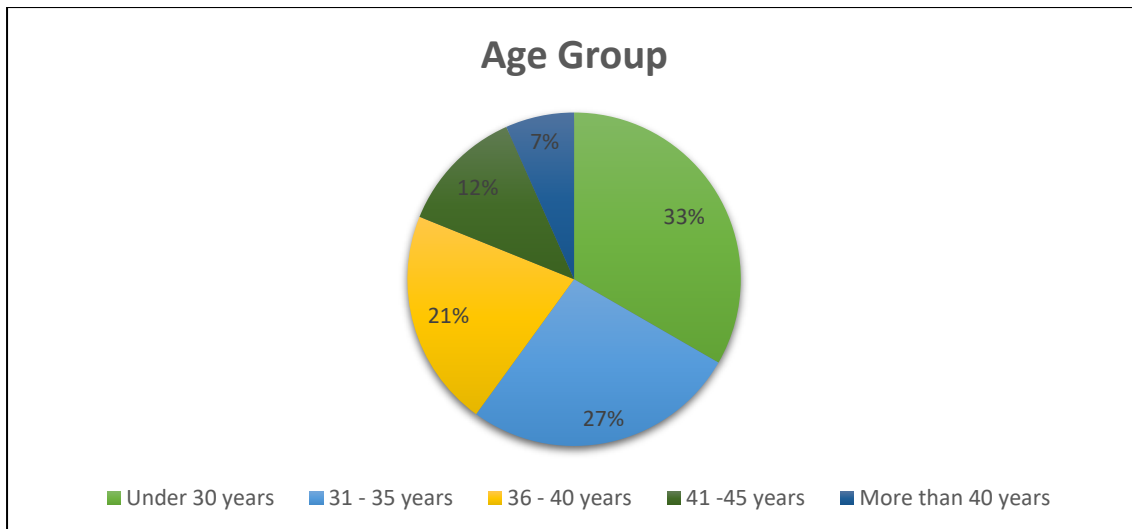


Figure 4.1: Age group of the participants

4.3.2. Gender

The data presented in Figure 4.2 show the gender distribution of the sample population. Of 90 individuals, 46 (51%) were male, while 44 (49%) were female. The gender distribution was almost equal, with only a slight majority of males over females. This close balance indicates that the sample was gender-diverse, representing males and females well.

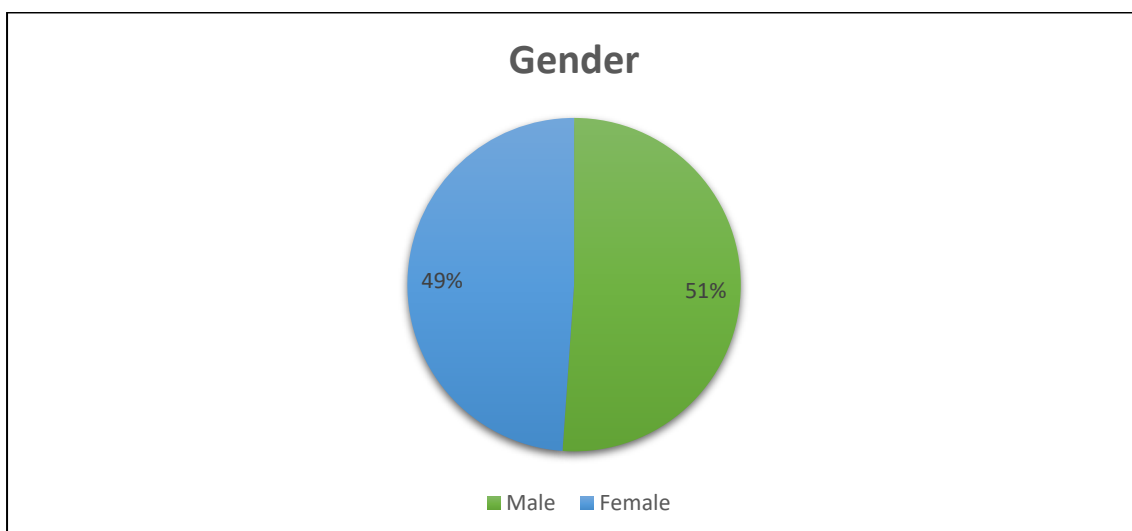


Figure 4.2: Gender of the participants

4.3.3. Highest Level of Education

The data in Figure 4.3 show that, out of the total sample population, the majority held advanced qualifications. Specifically, 37 individuals (41%) had an Honours Degree or Post-Graduate Diploma, making this the largest group. The Bachelor's Degree/Advanced Diploma and the Master's Degree groups each included 24 individuals, representing 27% of the sample for each group. A smaller percentage, 4 individuals (4%), had a Diploma or Advanced Certificate. Only one individual (1.0%) fell under the "Other" category. Notably, there were no individuals with a Doctorate, representing 0% of the sample. This distribution highlights a highly educated population with an intense concentration at the post-graduate level but a noticeable absence at the doctoral level.

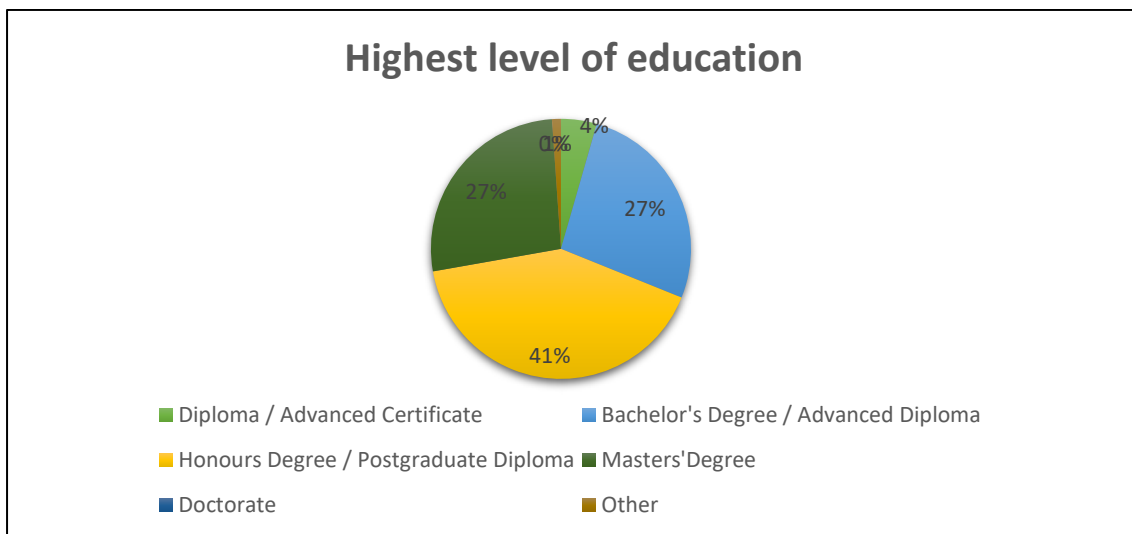


Figure 4.3: Education background of the participants

4.3.4. Profession

Figure 4.4 illustrates the distribution of 90 professionals across various roles. Project managers constituted the largest group, being 27% of the total, which equated to 24 individuals. Following closely were engineers, who accounted for 23% or 21 professionals. Quantity surveyors represented 22% of the total, with 20 individuals in

this role. Construction managers constituted 18% of the group, meaning there were 16 professionals in this category. Finally, architects constituted the smallest group, representing 10% or 9 individuals. This distribution highlights the prominence of project managers in the professional setting, while indicating that architects play a more specialised or limited role.

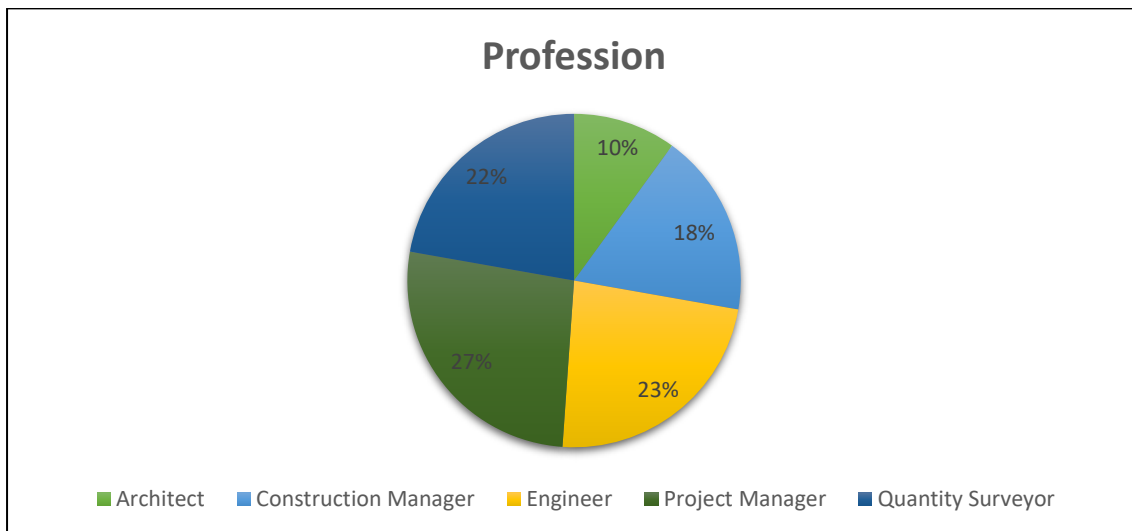


Figure 4.4: Profession of the respondents

4.3.5. Nature of Organisation

The data presented in Figure 4.5 illustrate the distribution of professionals between public/government and private organisations. Of 90 respondents, 39 worked in public/government organisations, representing 43%. In contrast, 51 professionals were employed in private organisations, constituting the majority of 57%. This indicates that more professionals in the surveyed group were associated with the private sector, perhaps reflecting a greater prevalence of, or preference for, employment in private organisations within this context.

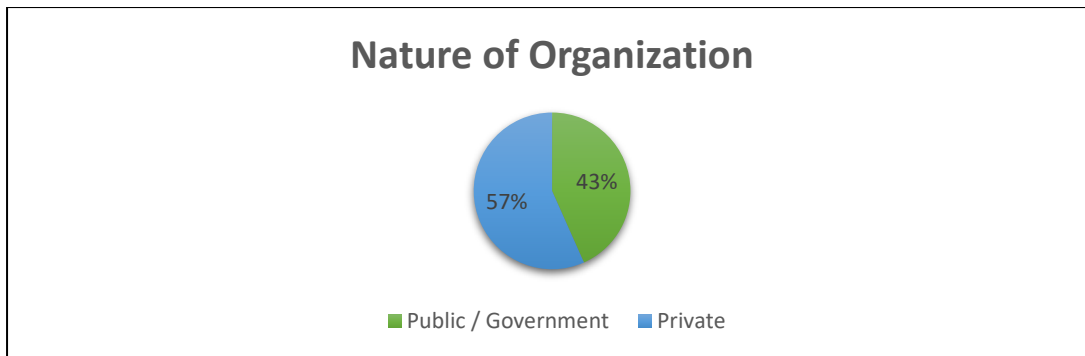


Figure 4.5: Nature of organisations of the respondents

4.3.6. Work Experience

Figure 4.6 illustrates the distribution of work experience, indicating that 28 individuals, or 31%, had between 6 and 10 years of experience, making this the largest group. This is followed by 21 individuals (23%) with less than 5 years of experience. Those with 11 to 15 years of experience constituted 22%, represented by 20 individuals. Sixteen individuals, or 18%, had 16 to 20 years of experience, while the smallest group comprised 5 individuals, or just 6% of the total, with over 20 years of experience. This distribution shows a balanced workforce concentrating on mid-career professionals, providing a blend of fresh perspectives and seasoned expertise.

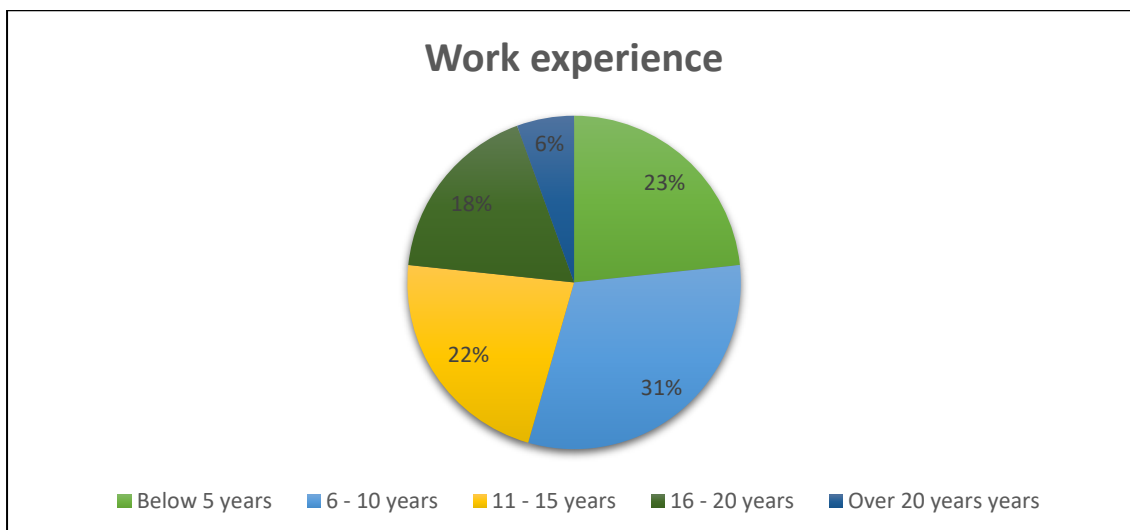


Figure 4.6: Work experience of the respondents

4.4. RESULTS OF THE SELF-ADMINISTERED SURVEY QUESTIONNAIRE

4.4.1. Knowledge Areas that would Increase CE Practices

- Question: Kindly indicate your level of knowledge of the following circular construction practices.

Respondents were asked to rate their knowledge using 7-point Likert Scale where: (1) = Completely no knowledge; (2) = No knowledge; (3) = Almost no knowledge; (4) = Neutral; (5) = Knowledgeable; (6) = Very knowledgeable; (7) = Highly knowledgeable.

Table 4.1 illustrates the knowledge of the respondents based on their practices. "Flexible and adaptable designs" was ranked the highest with a mean score (MS) of 5.42, indicating strong support for designing buildings that accommodate future changes. This was closely followed by "smart demolition", with an MS of 5.38, emphasising the importance of dismantling buildings in a way that allows for re-using high-grade materials. The "use of Building Information Modelling (BIM)" for assessing material re-use was also scored highly (MS = 5.29), reflecting the value placed on technology in promoting sustainability. Other practices, such as manufacturing with recovered materials and appropriate disposal of non-re-usable materials, were also ranked prominently, highlighting a general preference for methods that enhance material re-use and minimise waste. Lower-ranked practices, such as "off-site construction", suggest that, while still necessary, they might not be as critical from the respondents' perspectives.

The Cronbach's alpha for the construct of "Knowledge of circular economy construction practices" was 0.919, indicating high internal consistency and reliability. This suggests that the items used to measure this construct were highly correlated and reflected the underlying concept of knowledge of circular economy construction practices consistently. Such a high Cronbach's alpha value signifies that the survey or measurement instrument is reliable for assessing the respondents' knowledge in this area.

Table 4.1: Knowledge

Practice	Likert Scale							MS	Rank
	1	2	3	4	5	6	7		
Flexible and adaptable designs to accommodate future changes to the building, such as remodelling	0	0	1.19	8.33	51.19	26.19	13.1	5.42	1
Smart demolition (dismantling), thereby allowing for the re-use of high-grade building materials	0	1.16	2.33	6.98	52.33	20.93	16.28	5.38	2
The use of Building Information Modelling (BIM) to assess the possibility of re-using materials	0	0	3.57	8.33	57.14	17.86	13.1	5.29	3
Manufacturing of building materials using recovered materials	0	0	3.45	12.64	50.57	19.54	13.79	5.28	4
Appropriate disposal of materials that cannot be re-used	0	0	4.6	11.49	51.72	19.54	12.64	5.24	5
Transfer ownership of materials to the manufacturer after their intended use in the first building	0	1.23	6.17	11.11	50.62	23.46	7.41	5.11	6
The use of existing materials, components and buildings for new project(s)	0	0	3.41	15.91	55.68	17.05	7.95	5.10	7
Conducting a cost-benefit analysis (CBA) of using recycled materials	0	1.22	2.44	21.95	48.78	19.51	6.1	5.01	8
Preventative maintenance of building components	2.25	0	3.37	17.98	56.18	15.73	4.49	4.91	9

Practice	Likert Scale							MS	Rank
	1	2	3	4	5	6	7		
so that they last longer									
Minimising waste during construction	1.14	0	3.41	20.45	61.36	11.36	2.27	4.84	10
Design buildings to include greywater and rainwater harvesting systems to save water	2.27	0	3.41	25	52.27	12.5	4.55	4.81	11
Off-site construction to avoid material cut-offs and to optimise use of time	3.45	0	8.05	18.39	50.57	14.94	4.6	4.76	12

4.4.2. Attitudes that would Increase CC Practices

- Question: How effective are the following factors in enabling the adoption of circular construction practices?

Respondents were asked to rate the effectiveness using a 7-point Likert Scale where: (1) = Very ineffective; (2) = Moderately ineffective; (3) = Slightly ineffective; (4) = Neutral; (5) = Slightly effective; (6) = Moderately effective; (7) = Very effective.

The results shown in Table 4.2 indicate that cost reduction was perceived as the most effective factor, receiving the highest mean score. This was followed by legal regulations, with 45.35% of respondents rating it as slightly effective, with 44.71% of respondents rating it as slightly effective, and client expectations, which was considered highly effective. Company reputation, with 48.84% of respondents rating it as slightly effective, and competitive advantage and investor expectations were viewed as moderately effective. Ethical reasons were considered to be the least effective factor among those listed. However, ethical reasons still received a mean score above the midpoint, indicating a recognition of their importance in influencing circular construction practices.

Table 4.2: Attitudes

Factor	Likert Scale							MS	Rank
	1	2	3	4	5	6	7		
Cost reduction	0	0	0	4.65	38.37	30.23	26.74	5.79	1
Legal regulations	0	2.33	0	4.65	45.35	18.6	29.07	5.65	2
Client expectations	0	0	0	7.06	44.71	27.06	21.18	5.62	3
Company Reputation	0	1.16	0	4.65	48.84	22.09	23.26	5.6	4
Competitive advantage	1.15	0	0	8.05	47.13	26.44	17.24	5.48	5
Investor expectations	0	1.16	0	12.79	43.02	22.09	20.93	5.48	6
Ethical reasons	0	0	0	14.12	43.53	24.71	17.65	5.46	7

- Question: Please indicate the extent to which the following factors negate or constrain the ability of construction professional to advise on the adoption of circular construction practices for prospective green/sustainable developments.

Respondents were asked to rate the extent using a 7-point Likert Scale where: (1) = Extremely small extent; (2) = Very small extent; (3) = Small extent; (4) = Moderate extent; (5) = Large extent; (6) = Very large extent; (7) = Extremely large extent.

The findings are shown in Table 4.3. The highest average score indicates that the limited availability of resources to participate in climate change practices was seen to have the most significant influence. Subsequently, the project team's deficiency in expertise and knowledge of CC procedures and the client's lack of enthusiasm were identified as noteworthy contributing causes.

Furthermore, based on the study, it was identified that attending training and workshops incurred supplementary expenses, and lack of engagement from the project team, and limited influential capacity were also observed to have an impact, but to a significantly smaller degree. For example, 27.16% of respondents rated the limited availability of resources as having a moderate extent of constraint, while 28.4% rated it as having a large extent. In addition, 30.95% of respondents noted the lack of skill and knowledge of CC practices as having a moderate extent of constraint.

These findings emphasise the significance of tackling resource constraints, improving expertise and understanding, and cultivating stakeholder interest to participate actively in circular construction methods.

Table 4.3: Factors

Factor	Likert scale							MS	Rank
	1	2	3	4	5	6	7		
Limited resources to engage in CC practices	0	1.23	4.94	27.16	28.4	23.46	14.81	5.12	1
Lack of skill and knowledge of CC practices on the part of the project team	1.19	0	3.57	30.95	27.38	22.62	14.29	5.08	2
Lack of interest by the client	1.18	0	5.88	34.12	28.24	17.65	12.94	4.93	3
Attending training and workshops for the project team incurs additional costs	1.22	2.44	7.32	30.49	24.39	23.17	10.98	4.88	4
Lack of interest by the project team	1.19	2.38	7.14	30.95	26.19	20.24	11.9	4.87	5
Less/little influential ability	2.44	2.44	7.32	34.15	29.27	14.63	9.76	4.68	6

Respondents were asked to rate the importance using a 7-point Likert Scale where: (1) = Not at all important; (2) = Not important; (3) = Slightly not important; (4) = Moderately important; (5) = Important; (6) = Very important; (7) = Extremely important.

The results in Table 4.4 show that minimising waste during construction was rated as the most significant practice, with the highest mean score. This was followed closely by preventative maintenance of building components to extend their lifespan, and appropriate disposal of materials that cannot be re-used.

Other highly ranked practices included designing buildings with greywater and rainwater harvesting systems, and smart demolition to allow for the re-use of high-grade building materials. Practices, such as off-site construction to avoid material cut-offs, using existing materials for new projects, and conducting a cost-benefit analysis of recycled materials, were also considered necessary, although slightly less. For instance, 34.94% of respondents rated minimising waste during construction as being slightly effective, with a significant portion rating it as moderately to very effective. Preventative maintenance and appropriate disposal also received high ratings, indicating strong support for these practices among respondents.

Table 4.4: Practice

Practice	Likert scale							MS	Rank
	1	2	3	4	5	6	7		
Minimise waste during construction	0	0	0	9.64	34.94	26.51	28.92	5.75	1
Preventative maintenance of building components so that they last longer	0	0	0	6.17	40.74	27.16	25.93	5.73	2
Appropriate disposal of materials that cannot be re-used	0	0	0	9.72	38.89	25	26.39	5.68	3
Design buildings to include greywater and rainwater harvesting systems to save water	0	0	0	8.86	43.04	25.32	22.78	5.62	4
Smart demolition (dismantling), thereby allowing for the re-use of high-grade building materials	0	0	0	8.33	43.06	26.39	22.22	5.62	5
Off-site construction to avoid material cut-offs and to optimise use of time	1.19	0	0	8.33	42.86	27.38	20.24	5.55	6
The use of existing materials, components and buildings for new project(s)	0	0	0	12.05	43.37	24.1	20.48	5.53	7
Conducting a cost-benefit analysis	1.18	0	0	10.59	41.18	31.76	15.29	5.47	8

Practice	Likert scale							MS	Rank
	1	2	3	4	5	6	7		
(CBA) of using recycled materials									
The use of BIM to assess the possibility of re-using materials	1.19	0	0	11.9	42.86	25	19.05	5.46	9
Manufacturing of building materials using recovered resources	1.18	0	0	16.47	40	25.88	16.47	5.38	10
Flexible and adaptable designs to accommodate future changes to the building, such as remodelling	1.18	0	1.18	12.94	42.35	28.24	14.12	5.36	11
Transfer ownership of materials to a manufacturer after its intended use in the first building	1.19	0	1.19	22.62	39.29	26.19	9.52	5.15	12

Respondents were asked to rate the likelihood using a 7-point Likert Scale where: (1) = Extremely unlikely; (2) = Very unlikely; (3) = Unlikely; (4) = Slightly likely; (5) = Likely; (6) = Very likely; (7) = Extremely likely.

As shown in Table 4.5, the results indicate that respondents were most likely to attend a workshop that gives more insight into circular construction practices if paid for by someone else, with the highest mean score. This was rated as likely by 54.22% of respondents, and 27.71% rated it as very likely. This was followed by the likelihood of advising other consultants on the usefulness and relevance of circular construction practices, with 48.81% of respondents indicating it was likely, and advising clients on the same topic, with 50% rating it as likely. Paying for a workshop to gain insight into circular construction practices was less likely. However, it still received a mean score above the midpoint, indicating a moderate likelihood, with 54.76% rating it as likely.

Table 4.5: Behaviour

Behaviour	Likert Scale	MS	Rank
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	1	2	3	4	5	6	7		
Attend a workshop that gives more insight into circular construction practices if it is paid for by someone else	0	0	1.2	4.82	54.22	27.71	12.05	5.45	1
Advise other consultants on the usefulness/relevance of circular construction practices	0	1.19	3.57	9.52	48.81	22.62	14.29	5.31	2
Advise a client on the usefulness/relevance of circular construction practices	0	1.19	4.76	8.33	50	23.81	11.9	5.26	3
Pay for a workshop that gives more insight into circular construction practices	1.19	3.57	5.95	9.52	54.76	20.24	4.76	4.93	4

4.4.3. Exemplary Circular Economy Practices

- Question: In your understanding, which of the following stakeholders' decision-making authority has the most influence on the adoption of circular construction practices?

Respondents were asked to rate the influence using a 7-point Likert Scale where: (1) = Extremely uninfluential; (2) = Very uninfluential; (3) = Uninfluential; (4) = Slightly influential; (5) = Influential; (6) = Very influential; (7) = Extremely influential.

The results are shown in Table 4.6. The client/developer was considered to be the most influential stakeholder and had the highest mean score. The client/developer was rated as influential by 32.14% of the respondents, and by another 32.14% as very influential. This was followed by the architects, with 45.24% of the respondents rating them as influential. The quantity surveyor was also viewed as having significant influence, with 42.86% of the respondents rating them as influential. The engineer

(civil, structural, etc.) was viewed as influential by 42.86% of the respondents. Project managers and contractors were perceived as moderately influential, with 40.48% and 38.55% of the respondents rating them as influential, respectively. End users/tenants were considered the least influential among the stakeholders listed, with 39.74% of the respondents rating them as influential. These findings suggest that primary stakeholders in the planning and execution phases of projects, such as clients and architects, are perceived to have the most impact on implementing circular construction practices.

Table 4.6: Stakeholders

Stakeholder	Likert Scale							MS	Rank
	1	2	3	4	5	6	7		
Client/Developer	0	1.19	1.19	5.95	32.14	32.14	27.38	5.75	1
Architect	0	0	1.19	9.52	45.24	25	19.05	5.51	2
Quantity Surveyor	0	1.19	3.57	11.9	42.86	25	15.48	5.33	3
Engineer (civil, structural...)	1.19	0	0	17.86	42.86	20.24	17.86	5.33	4
Project Manager	3.57	3.57	1.19	19.05	40.48	23.81	8.33	4.94	5
Contractor	3.61	2.41	0	25.3	38.55	19.28	10.84	4.94	6
End-User/Tenant	3.85	3.85	5.13	20.51	39.74	19.23	7.69	4.77	7

Respondents were asked to rate the importance using a 7-point Likert Scale where: (1) = Not at all important; (2) = Not important; (3) = Slightly not important; (4) = Moderately important; (5) = Important; (6) = Very important; (7) = Extremely important.

The results are shown in Table 4.7. The construction stage was considered the most important, with the highest mean score, with 34.52% of the respondents rating it as essential and 25% as very important. This was followed closely by the design development stage, with 38.1% of respondents rating it as essential and 26.19% as extremely important. The documentation, procurement, and concept and viability stages were also significantly necessary. The completion and operation stage was also considered important, although it had the lowest mean score among the stages listed. These findings suggest that stages directly involved in the execution and

detailed planning of projects are perceived as being crucial for successful project outcomes.

Table 4.7: Stages of construction

Stages	Likert Scale							MS	Rank
	1	2	3	4	5	6	7		
Construction	1.19	0	2.38	11.9	34.52	25	25	5.54	1
Design development	1.19	0	1.19	14.29	38.1	19.05	26.19	5.5	2
Documentation and procurement	1.19	0	1.19	14.29	35.71	27.38	20.24	5.46	3
Concept and viability stage	1.19	0	1.19	14.29	39.29	22.62	21.43	5.44	4
Completion and Operation	1.19	1.19	2.38	14.29	42.86	16.67	21.43	5.32	5

Respondents were asked to rate the potential using a 7-point Likert Scale where: (1) = No potential; (2) = Very low potential; (3) = Low potential; (4) = Neutral; (5) = Moderate potential; (6) = High potential; (7) = Very high potential.

The highest average score in Table 4.8 shows that disposing of non-reusable materials appropriately had the most potential, with 46.58% of respondents rating it very high. This was followed by minimising waste during construction, with 42.68% rating it as having a large potential. Smart demolition techniques, which allow for the re-use of high-grade building materials, also ranked highly, with 46.58% of the respondents considering it very effective. Other highly-rated practices included incorporating greywater and/or rainwater harvesting systems into building designs and preventative maintenance of building components to extend their lifespan. Off-site construction, existing materials, and flexible designs for future changes showed considerable promise, though slightly less than the top practices. Practices, such as re-using materials in building and using Building Information Modelling (BIM) to assess re-use of resources were considered to have moderate potential. The least promising approaches were conducting a cost-benefit analysis of recycled materials, and transferring ownership of materials back to the producer after use.

Table 4.8: Practice

Practice	Likert Scale							MS	Rank
	1	2	3	4	5	6	7		
Appropriate disposal of materials that cannot be re-used	0	0	1.37	8.22	24.66	46.58	19.18	5.74	1
Minimise waste during construction	0	0	0	4.88	42.68	31.71	20.73	5.68	2
Smart demolition (dismantling), thereby allowing for the re-use of high-grade building materials	0	0	0	9.59	28.77	46.58	15.07	5.67	3
Design buildings to include greywater and rainwater harvesting systems to save water	0	0	0	8.64	39.51	32.1	19.75	5.63	4
Preventative maintenance of building components so that they last longer	0	0	0	10.98	36.59	34.15	18.29	5.6	5
Off-site construction to avoid material cut-offs and to optimise use of time	0	0	0	13.25	34.94	33.73	18.07	5.57	6
The use of existing materials, components and buildings for new project(s)	0	0	0	10.84	42.17	30.12	16.87	5.53	7
Flexible and adaptable designs to accommodate future changes to the building, such as remodelling	0	0	1.19	9.52	51.19	29.76	8.33	5.35	8
Manufacturing of building materials using recovered resources	1.19	0	2.38	16.67	35.71	28.57	15.48	5.33	9
The use of BIM to assess the possibility of re-using materials	0	0	2.41	12.05	48.19	30.12	7.23	5.28	10

Practice	Likert Scale							MS	Rank
	1	2	3	4	5	6	7		
Conduct a cost-benefit analysis (CBA) of using recycled materials	0	0	1.2	13.25	51.81	26.51	7.23	5.25	11
Transfer ownership of materials to a manufacturer after their intended use in the first building	2.41	1.2	4.82	18.07	37.35	24.1	12.05	5.07	12

Respondents were asked to rate their familiarity using a 7-point Likert Scale where: (1) = Not at all familiar; (2) = Not familiar; (3) = Somewhat not familiar; (4) = Neutral; (5) = Somewhat familiar; (6) = Familiar; (7) = Very familiar.

The results in Table 4.9 show that respondents were most knowledgeable about preventative maintenance of building components to extend their lifespan, which had the highest mean score, with 58.75% of the respondents rating it as familiar. This was followed by minimising construction waste, with 60.76% of the respondents rating it as familiar, and developing buildings with greywater and rainwater gathering systems, with 54.67% rating it as familiar. Off-site construction to prevent material cut-offs, optimise use of time, and appropriate disposal of non-re-usable materials also scored highly, reflecting the familiarity of the respondents. Other commonly known methods included using existing resources for new projects, and smart demolition to repurpose high-quality building materials. Medium familiarity was shown with using recovered construction materials and flexible designs to support future building alterations. The least familiar practices were transferring ownership of materials to a manufacturer after use, utilising BIM to assess possibilities of re-use, and conducting a cost-benefit analysis of recycled materials, which earned the lowest mean ratings.

Table 4.9: Practice

Practice	Likert Scale							MS	Rank
	1	2	3	4	5	6	7		
Preventative maintenance of building components so that they last longer	1.25	0	0	1.25	27.5	58.75	11.25	5.75	1
Minimise waste during construction	1.27	0	0	0	29.11	60.76	8.86	5.73	2
Design buildings to include greywater and/or rainwater harvesting systems to save water	1.33	0	0	4	26.67	54.67	13.33	5.72	3
Appropriate disposal of materials that cannot be re-used	1.41	0	0	7.04	22.54	57.75	11.27	5.68	4
Off-site construction to avoid material cut-offs and to optimise use of time	1.23	1.23	1.23	2.47	27.16	55.56	11.11	5.64	5
The use of existing materials, components and buildings for new project(s)	1.25	0	1.25	1.25	35	50	11.25	5.64	6
Smart demolition (dismantling), thereby allowing for the re-use of high-grade building materials	2.78	0	0	6.94	26.39	54.17	9.72	5.56	7
Manufacturing of building materials using recovered resources	1.22	3.66	0	7.32	31.71	48.78	7.32	5.4	8
Flexible and adaptable designs to accommodate future changes to the building, such as remodelling	2.44	1.22	1.22	10.98	30.49	48.78	4.88	5.32	9
Transfer ownership of materials to a manufacturer after their intended use in the first building	2.47	4.94	0	12.35	24.69	49.38	6.17	5.25	10

Practice	Likert Scale							MS	Rank
	1	2	3	4	5	6	7		
The use of BIM to assess the possibility of re-using materials	3.66	2.44	2.44	10.98	29.27	46.34	4.88	5.18	11
Conduct a cost-benefit analysis (CBA) of using recycled materials	2.44	3.66	3.66	10.98	29.27	45.12	4.88	5.16	12

4.5. ANALYSIS OF SURVEY RESULTS

The findings in Table 4.10 show that attitude towards circular economy construction practices significantly improves the potential to adopt circular construction practices (Beta = 0.356; $p = 0.000$; $p < 0.05$). Barriers to circular economy construction practices predict a significant positive change in the potential to adopt circular construction practices (Beta = 0.169; $p = 0.025$; $p < 0.05$). Knowledge of circular economy construction practices contributes significantly to predicting positive change in the potential to adopt circular construction practices (Beta = 0.269; $p = 0.012$; $p < 0.05$). The perceived importance of circular economy construction practices also causes some significant positive contributions to predicting the positive variance in the potential to adopt circular construction (Beta = 0.275; $p = 0.003$; $p < 0.05$).

However, familiarity with circular economy construction practices made some insignificant negative contributions to predicting the change in the potential to adopt circular construction practices (Beta = -0.138; $p = 0.182$; $p > 0.05$). Furthermore, the potential to adopt circular construction practices failed to predict a significant change in the likelihood of engaging in project circular practices (Beta = 0.36; $p = 0.053$; $p > 0.05$).

The moderation analysis showed that barriers to circular economy construction practices fail to moderate the predictive relationship between attitude towards circular economy construction practices and potential to adopt circular construction practices (Beta = 0.236; $p = 0.053$; $p > 0.05$). Again, barriers to circular economy construction

practices failed to moderate the predictive relationship positively between familiarity with circular economy construction practices and the potential to adopt circular construction practices in a significant manner (Beta = -0.101; $p = 0.244$; $p > 0.05$). Barriers to circular economy construction practices failed to moderate the predictive relationship between the perceived importance of circular economy construction practices and the potential to adopt circular construction practices (Beta = 0.008; $p = 0.470$; $p > 0.05$). Furthermore, barriers to circular economy construction practices failed to moderate the nature of the predictive relationship between knowledge of circular economy construction practices and the potential to adopt circular construction practices (Beta = 0.037; $p = 0.402$; $p > 0.05$).

Table 4.10: Path coefficient

Statement	Std Beta	f-square	T statistics	P values
Attitude towards circular economy construction practices -> Potential to adopt circular construction practice	0.356	0.135	3.310	0.000
Barriers to circular economy construction practices -> Potential to adopt circular construction practice	0.169	0.052	1.954	0.025
Familiarity with circular economy construction practices -> Potential to adopt circular construction practice	-0.138	0.024	0.906	0.182
Knowledge of circular economy construction practices -> Potential to adopt circular construction practice	0.269	0.056	2.248	0.012
Perceived importance of circular economy construction practices -> Potential to adopt circular construction practice	0.275	0.092	2.763	0.003
Potential to adopt circular construction practice -> Likelihood to engage in project circular practices	0.236	0.059	1.619	0.053
Barriers to circular economy construction practices x Attitude towards circular economy construction practices ->	-0.180	0.027	1.368	0.086

Statement	Std Beta	f-square	T statistics	P values
Potential to adopt circular construction practice				
Barriers to circular economy construction practices x Knowledge of circular economy construction practices -> Potential to adopt circular construction practice	0.037	0.001	0.247	0.402
Barriers to circular economy construction practices x Perceived importance of circular economy construction practices -> Potential to adopt circular construction practice	0.008	0.000	0.076	0.470
Barriers to circular economy construction practices x Familiarity with circular economy construction practices -> Potential to adopt circular construction practice	-0.101	0.013	0.692	0.244

Source: Researcher's field work (2024)

- Mediation analysis:

Statement	Beta	T statistics	P values
Knowledge of circular economy construction practices -> Potential to adopt circular construction practice -> Likelihood to engage in project circular practices	0.063	1.329	0.092
Perceived importance of circular economy construction practices -> Potential to adopt circular construction practice -> Likelihood to engage in project circular practices	0.065	1.185	0.118
Attitude towards circular economy construction practices -> Potential to adopt circular construction practice -> Likelihood to engage in project circular practices	0.084	1.468	0.071
Familiarity with circular economy construction practices -> Potential to adopt circular construction practice -> Likelihood to engage in project circular practices	-0.033	0.690	0.245

Source: Researcher's field work (2024)

In all instances, the potential to adopt circular construction practices does not help to transmit better the impact of knowledge about circular economy construction practices, the perceived importance of circular economy construction practices, attitude towards circular economy construction practices, and familiarity with circular economy construction practices, on the likelihood to engage in project circular practices.

Table 4.11: Coefficient of determination

Statement	R-square adjusted
Likelihood to engage in project circular practices	0.045
Potential to adopt circular construction practice	0.519

Source: Researcher's field work (2024)

The findings in Table 4.11 show changes in attitude towards circular economy construction practices, perceived importance of circular economy construction practices, familiarity with circular economy construction practices and knowledge about circular economy construction practices collectively account for 51.9% improvement in the potential to adopt circular economy construction practices when the effect of other factors that can cause changes in the potential to adopt circular construction practice was held statistically constant. These factors could collectively cause a 48.1% change in the potential to adopt circular economy construction practices among the surveyed firms if similar conditions persist.

Also, changes in the potential to adopt circular economy construction practices account for a 4.5% positive change in the likelihood of engaging in product circular practices when the effect of other factors that can cause changes in the likelihood of engaging in product circular practices was held statistically constant. These unaccounted factors could collectively cause a 95.5% change in the potential to adopt circular economy construction practices among the surveyed firms if similar conditions persist. Figure 4.7 shows the estimated structural model.

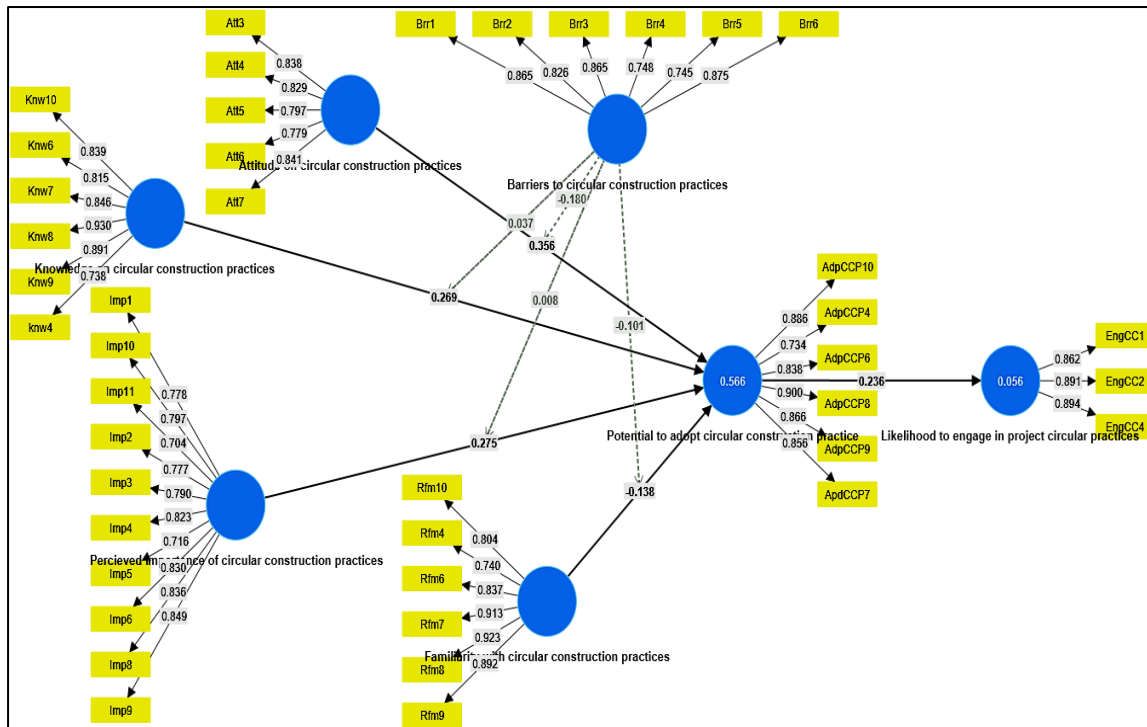


Figure 4.7: Estimated structural model

4.6. RESULTS FROM THE INTERVIEWS

This section contains the findings derived from the analysis of data collected during interviews. Several interviews were conducted with construction professionals who were engaged in projects in the Free State and Gauteng Provinces. The aim of these interviews was to collect insights from experts who are acknowledged for their remarkable expertise, exemplary attitudes, and dedication to circular construction processes. The interviews were captured in audio format and later transcribed using ATLAS.ti Software. The transcriptions were examined to find recurring themes across the interviews, offering valuable insights into the research questions.

4.7. DEMOGRAPHIC BACKGROUND

4.7.1. Age Group

Figure 4.8 below illustrates the age distribution of the interview participants. The largest segment consisted of participants in the 31-35 age group, representing 44% of

the total respondents. This was followed by the 36-40 age group, constituting 32% of the respondents. In contrast, the "Under 30 years" group was the smallest, accounting for just 4% of the participants. The 41-45 age group included 12% of the participants, while the "More than 45 years" category represented 8% of the participants. Overall, Figure 4.8 shows a skew towards individuals in their 30s, with fewer participants in the younger and older age groups.

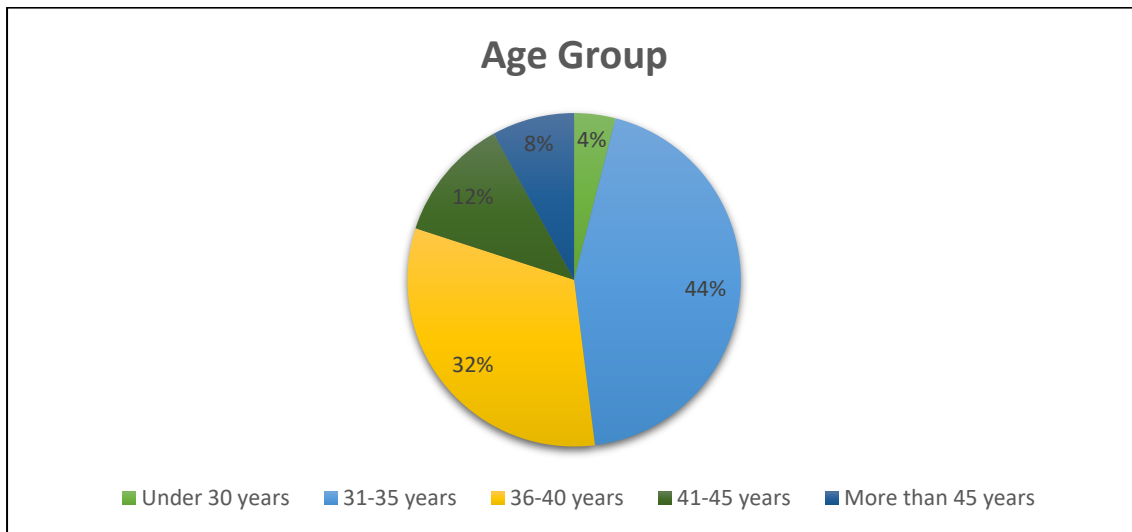


Figure 4.8: Age group of participants

4.7.2. Gender

Figure 4.9 shows the gender distribution of the participants. Of a total of 25 participants, the chart shows 16 males as the majority, and nine females, representing the minority. The data shows a greater proportion of male participants in comparison with female participants, with males representing approximately 64% of the total, while females represented approximately 36%.

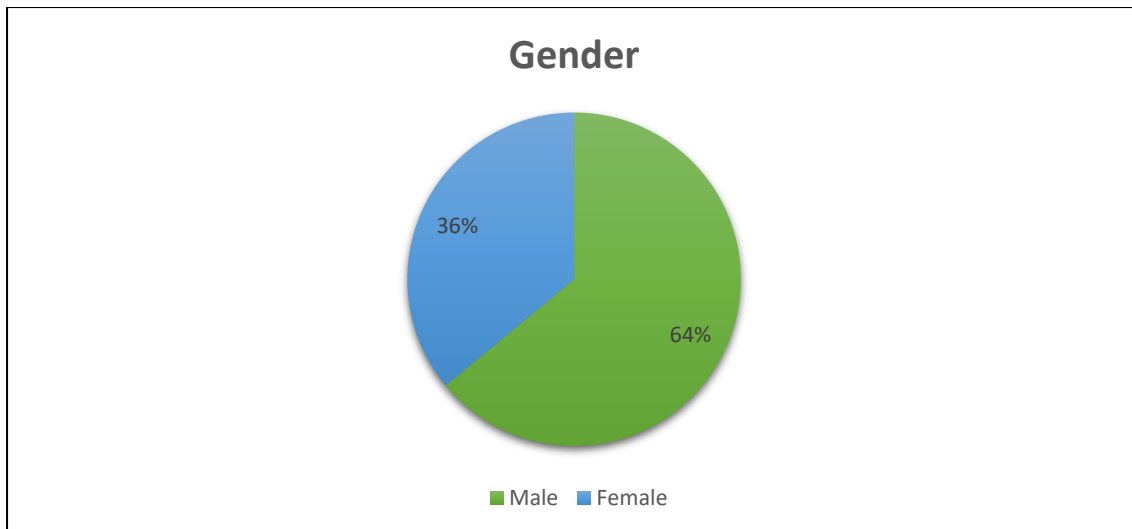


Figure 4.9: Gender of participants

4.7.3. Highest Level of Qualification

Figure 4.10 shows the distribution of the participants' educational qualifications. Individuals with Honours Degrees or Post-Graduate Diplomas constituted the largest sector, accounting for 48% of all participants. This is followed by those with Bachelor's Degrees, who constituted 32% of the participants. Participants with a Master's Degree constituted 12% of the group, while those with an Advanced Diploma accounted for 8%. Notably, there were no participants with a Diploma or Doctorate or in the "Other" category, indicating that the interview population consisted primarily of people with under-graduate and early post-graduate degrees.

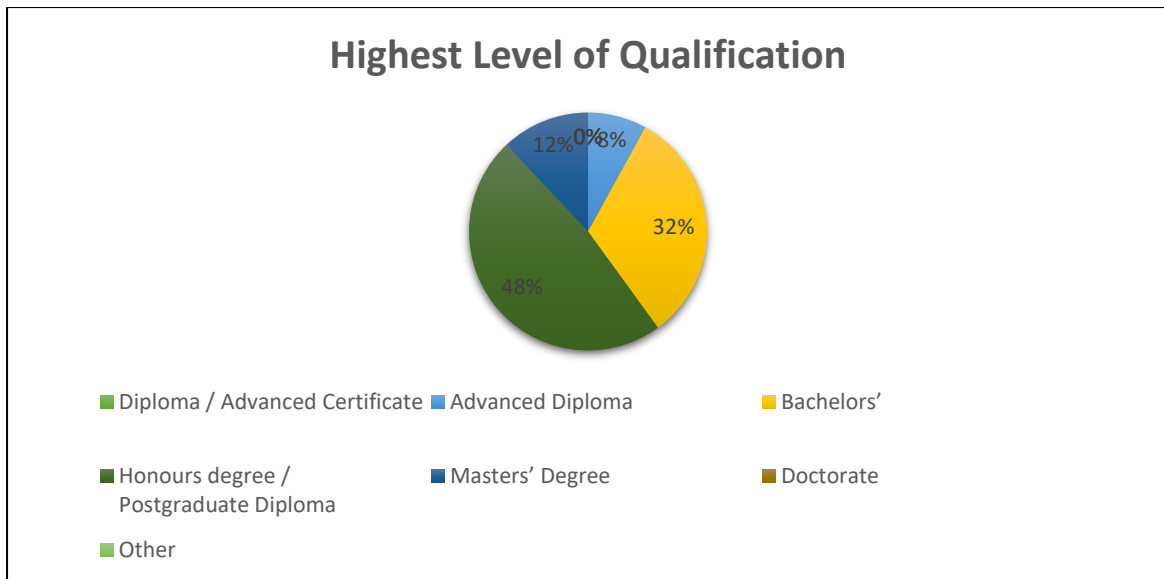


Figure 4.10: Qualifications of the participants

4.7.4. Profession

The diagram in Figure 4.11 shows the distribution of participants among five distinct occupational positions in the construction sector.

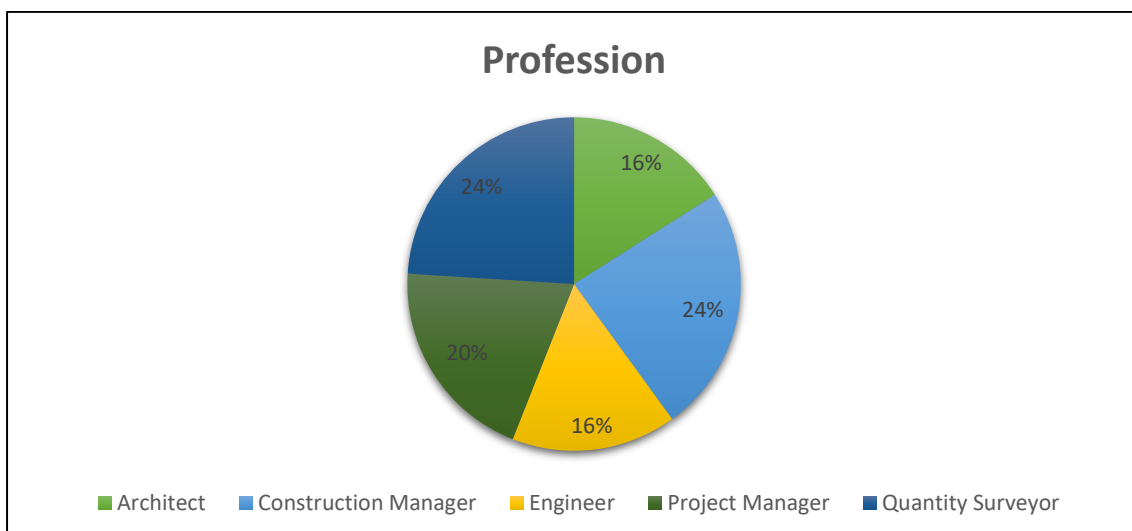


Figure 4.11: Profession of the participants

Construction managers and quantity surveyors were the most dominant professions among the participants, each accounting for 24% of the total participants. Project

managers closely resembled to the findings of the survey, accounting for 20% of the respondents, indicating a significant presence in this field. Architects and engineers constituted 16% of the respondents, indicating a slightly lower presence than other roles.

4.7.5. Nature of Organisation

Figure 4.12 shows that 16 participants were employed in public/government organisations, which constitutes most of the chart, and represent a considerable proportion of the total. Meanwhile, 9 respondents were employed in private enterprises, constituting a lower proportion. The data show that most participants were employed in the public sector, with approximately 64% working in public/government positions, while 36% were engaged in private roles. The distribution of respondents to the survey showed a more prominent representation of public-sector employment.

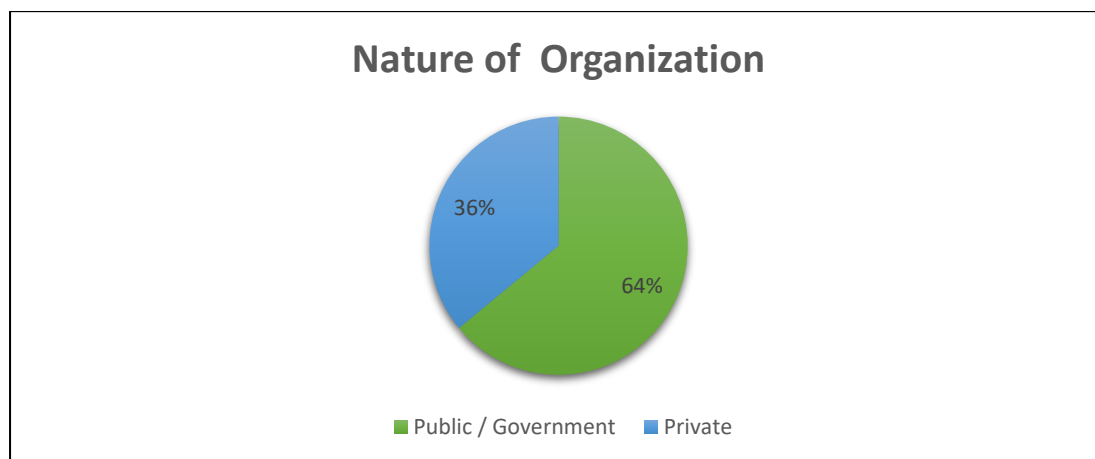


Figure 4.12: Nature of organisation in which participants were employed

4.7.6. Work Experience

The distribution of participants based on their job experience within the construction business is shown in Figure 4.13. Most participants, 44% of the total, had 11-15 years of experience, making it the most prevalent range of experience. This was followed closely by individuals with 6-10 years of experience, constituting 36% of the participants. This group represented a substantial proportion of professionals who

were in the middle of their careers. The cohort with a tenure of 16-20 years comprised 12% of the participants, whilst both the "Below 5 years" and "Over 20 years" cohorts each included 4% of the participants. Generally, the diagram shows a workforce encompassing a broad spectrum of expertise, with most participants possessing 6 to 15 years of professional experience.

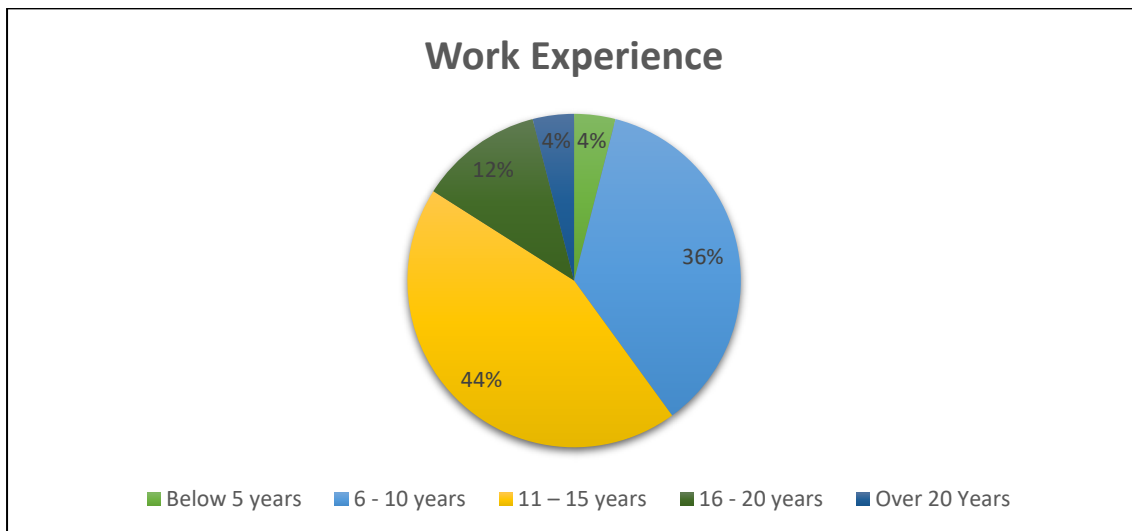


Figure 4.13: Work experience of participants

4.8. RESPONSES OF INTERVIEWEES

Interviewees were coded as shown in the table below.

Table 4.12: Coding of interviewees

Interviewee	Profession	Sector of Employment	Code
1	Architect	Private	ARCH (1)
2	Architect	Public	ARCH (2)
3	Architect	Public	ARCH (3)
4	Architect	Private	ARCH (4)
5	Engineer	Private	ENGR (1)

Interviewee	Profession	Sector of Employment	Code
6	Engineer	Public	ENGR (2)
7	Engineer	Private	ENGR (3)
8	Engineer	Public	ENGR (4)
9	Construction Manager	Public	CM (1)
10	Construction Manager	Public	CM (2)
11	Construction Manager	Private	CM (3)
12	Construction Manager	Public	CM (4)
13	Construction Manager	private	CM (5)
14	Construction Manager	Private	CM (6)
15	Project Manager	Public	PM (1)
16	Project Manager	Public	PM (2)
17	Project Manager	Public	PM (3)
18	Project Manager	Public	PM (4)
19	Project Manager	Public	PM (5)
20	Quantity Surveyor	Private	QS (1)
21	Quantity Surveyor	Public	QS (2)
22	Quantity Surveyor	Public	QS (3)
23	Quantity Surveyor	Public	QS (4)
24	Quantity Surveyor	Private	QS (5)
25	Quantity Surveyor	Public	QS (6)

4.8.1. Theme 1: Knowledge of Circular Construction Practices

The findings about defining circular construction showed a strong understanding among participants, with the majority correctly identifying its fundamental principles.

Most participants described circular construction as an economic model focused on minimising waste and maximising resource efficiency by creating closed-loop systems where products, materials, and resources are continuously re-used, repaired, and recycled. QS (6) defined the circular economy as:

“An economic system aimed at eliminating waste and the continual use of resources, where products are designed to be reused, repaired, or recycled, thereby closing the loop and reducing the environmental impact.”

This understanding reflects the growing awareness and importance of sustainable practices in economic development.

Upon inquiry regarding their familiarity with circular construction practices and their distinctions from traditional linear methods, most experienced participants asserted that, in circular construction, material re-use and recycling, waste minimisation, and life-cycle design to enhance sustainability and resource efficiency are prioritised. One participant, PM (3), remarked:

“Circular construction seeks to close the loop by designing edifices that can be readily disassembled and materials that can be re-used or recycled, in contrast to traditional construction, which frequently leads to the disposal of materials post-use.”

This response signifies a shift towards a more sustainable approach in the construction industry, highlighting environmental stewardship and long-term resource management.

The feedback from participants was predominantly favourable regarding the prospective advantages of implementing circular construction principles in South Africa. Most respondents, including CM (3), emphasised the substantial advancements in sustainability that may be realised. CM (3) further asserted that:

“The adoption of circular construction practices will significantly improve sustainability in South Africa by minimising waste and fostering the efficient utilisation of resources.”

This viewpoint highlights the capacity of circular practices to mitigate the environmental effects of the construction sector, which has been recognised historically for its resource-intensive and wasteful characteristics. Notably, emphasising recycling and re-using resources can foster a more sustainable industry consistent with global environmental objectives.

In addition, participants highlighted the economic advantages, including cost reductions through material efficiency and the prospects for innovation in architectural design and construction methodologies. CM (6) reiterated these views as follows:

“Circular construction practices can foster a more resilient and adaptable industry, facilitating South Africa's transition to a green economy.”

This comment highlights the wider implications of circular construction building, namely, its contribution to economic resilience and environmental accountability. The answer highlighted the difficulties in executing these techniques, including the necessity for policy endorsement, education, and industry co-operation. These aspects determine that the long-term advantages surpass the challenges, as circular construction building is consistent with sustainable development objectives and can substantially diminish the industry's carbon footprint. The participants unanimously agreed that adopting circular construction techniques in South Africa is essential for a more sustainable future in the construction sector.

When asked about their methods for staying up to date with the newest trends, practices, and innovations in the construction industry's circular economy, most respondents emphasised the significance of ongoing education. Several individuals

cited participation in business conferences, workshops, and seminars as essential for remaining informed. These events facilitate networking and direct interaction with specialists who are advancing circular economy practices. Furthermore, participants highlighted the significance of online platforms, including webinars and virtual conferences, which have become more accessible and provide extensive information about the latest technologies and global case studies. Professional organisations and industry journals were often referred to as being essential resources, offering insights into emerging technologies, materials, and sustainable practices influencing the future of building. ARCH (3) stated:

“I subscribe to multiple industry newsletters and journals concentrating on sustainability and the circular economy in construction. This enables me to remain apprised of nascent trends and technology. I engage in internet forums and discussion groups where professionals exchange their experiences and thoughts.”

This comment highlights the proactive strategies that most participants employ to remain informed in a swiftly changing domain. For example, several participants recognised the dedication of projects to reducing waste through recycling construction materials and the re-utilisation of existing structures whenever feasible. Some participants indicated using sustainable materials, such as recycled steel and environmentally-friendly concrete, which diminish the carbon footprint of a project. Moreover, some respondents highlighted incorporating modular construction approaches, facilitating the re-use or repurposing of components in subsequent projects, thereby prolonging the lifespan of resources. Others saw initiatives to integrate energy-efficient designs, such as natural lighting and ventilation systems, which diminish energy usage and foster a healthier indoor environment.

4.8.2. Theme 2: Attitudes towards circular construction practices

The participants emphasised that implementing circular construction processes is essential for multiple reasons. Waste minimisation is crucial as it diminishes the volume of building debris directed to landfills, thereby preserving natural resources

and reducing disposal expenses. The environmental impact of projects can be reduced significantly through the re-use and recycling of materials, fostering a more sustainable construction sector. Secondly, prolonging the lifespan of material is essential as it optimises resource utilisation, postpones the necessity for fresh material extraction, and eventually diminishes the energy consumption linked to producing new materials. This methodology facilitates a transition from a linear to a more sustainable construction paradigm. Finally, the participants underscored that reducing environmental effects is essential for conserving ecosystems and minimising pollution.

Participants emphasised multiple essential reasons for the significance of circular construction building in the future of the construction sector. They highlighted that circular construction can substantially decrease waste and mitigate the environmental impact of construction activities by re-using and recycling resources. This method preserves natural resources and reduces carbon emissions in accordance with global sustainability objectives. Furthermore, participants indicated that circular construction enhances economic efficiency by reducing material expenses and generating new company prospects in recycling and materials innovation. Furthermore, it promotes resilience by advocating the creation of flexible structures that can be adapted to evolving requirements, prolonging the lifespan of constructed settings. Participants asserted that circular construction building embodies a progressive strategy that fosters a more sustainable, economical, and resilient construction sector, guaranteeing enduring advantages for both the environment and the economy.

Participants recognised numerous obstacles in adopting circular construction practices. A significant problem is the prevailing lack of awareness and comprehension of circular construction processes among industry stakeholders, resulting in opposition to change. A further problem lies in the current supply chain, which is primarily linear and ill-suited to accommodate the intricacies of circular processes, including material recovery and recycling. ENGR (1) observed:

“Numerous individuals in the industry are entrenched in their practices and fail to recognise the benefits of transitioning to a circular model.”

Moreover, legislative obstacles and the absence of standardised norms for circular construction building hinder the shift, compounded by financial limitations, as the initial expenses related to adopting circular technologies might be substantial. ENGR (4) stated:

“The initial expenses are considerable and, in the absence of adequate incentives, companies find it challenging to rationalise the transition.”

Participants recommended enhancing education and awareness to address these difficulties and to foster a culture that prioritises sustainability throughout the industry. They proposed formulating explicit rules and incentives to promote circular practices, investing in research and innovation to develop effective recycling technologies, and facilitating collaboration among stakeholders to exchange information and resources.

Participants emphasised the essential roles that governments, industry associations, and corporations must play in advocating and incentivising circular construction methods. Governments must take the initiative by establishing explicit legislation and regulations that require sustainable construction techniques, while offering tax incentives and subsidies to promote circular methodologies. QS (4) proposed that:

“Governments should implement regulations mandating companies to integrate a specified percentage of recycled materials in their projects.”

Industry groups can expedite the shift by instituting standardised rules and frameworks for companies, providing training programmes, and developing networks to exchange best practices and innovations. Companies are anticipated to adopt circular building methods proactively by investing in research and development, and co-operating with industry stakeholders to provide creative solutions. ARCH (2) underscored that:

“Companies must adopt change and invest in new technologies that facilitate circularity.”

Participants expressed divergent opinions regarding the preparedness of professionals in their sector to assume critical roles in the emerging paradigm of circular construction building. Despite increasing awareness and interest in sustainable techniques, many professionals still lack the knowledge and ability to adopt circular construction building fully. A participant observed:

“There is enthusiasm; however, a considerable skills gap persists.”

Some participants require supplementary training and education to comprehend and execute circular methods proficiently. Moreover, the conventional mindset within the industry, frequently resistant to change, presents an obstacle. Nevertheless, participants expressed optimism, asserting that professionals can adjust to the changing requirements with appropriate training and incentives. CM (6) stated:

“Younger professionals exhibit a greater receptiveness to innovation and a strong inclination towards adopting sustainable practices, which bodes well for the future.”

Participants recognised multiple challenges obstructing their profession's readiness to play substantial roles in projects integrating circular construction building methods. A key issue is the absence of thorough education and training programmes dedicated to circular construction processes, resulting in professionals being inadequately prepared to implement these practices successfully. PM (4) remarked:

“Our existing education system fails to prioritise circular construction, resulting in graduates being ill-equipped for these emerging requirements.”

The conventional, linear methodology is firmly established in industry practices, resulting in a reluctance among experienced professionals to change. ENGR (3) observed:

“There exists a profound adherence to traditional methods, hindering the transition towards circularity.”

Moreover, insufficient co-ordination and communication among many stakeholders can hinder the incorporation of circular processes into construction projects. Financial limitations and restricted access to resources and technology provide considerable obstacles, as smaller enterprises might struggle to invest in the essential tools and infrastructure for circular construction building.

4.8.3. Theme 3: Current practices and implementation of CE principles

To understand current construction practices and implementation of CE principles, participants were requested to respond to the question of whether any circular construction methodologies were employed in their current project. If not, what were the justifications for this?

The reply from ENGR (4) was:

“We utilised recycled materials for the building's structural components and engineered specific elements for future disassembly and re-use.”

Another participant, CM (5), stated:

“We prioritised waste reduction by employing prefabricated components, which substantially decreased on-site waste.”

ARCH (2) stated:

“We adhered to green building certifications that require the incorporation of circular practices, guaranteeing that our project complies with environmental standards.”

In addition, PM (3) presented an instance where timber flooring was substituted with ceramic tiles. According to PM (3), they had no intentions of recovering any materials. However, at the construction manager’s request, the wood was meticulously extracted and stored for future use.

These responses demonstrate a dedication to sustainability and an awareness of the benefits of circular construction.

In contrast, participants who reported the absence of circular construction building techniques provided multiple justifications for their choice. For example, QS (6) stated:

“The budgetary limitations precluded the incorporation of extra expenses related to procuring recycled materials and designing for deconstruction.”

CM (4) remarked:

“Our team possessed inadequate knowledge and expertise in circular construction principles, hindering effective integration of these practices.”

QS (6) remarked:

“Existing building codes and regulations do not facilitate or encourage the adoption of circular practices, rendering their implementation difficult.”

Participants were also asked whether any obstacles were faced while integrating circular construction building principles their current project. In response, a notable problem was the elevated initial expenses linked to procuring recycled materials and investing in design for disassembly. QS (2) observed:

“The preliminary expenses associated with sustainable materials exceeded those of conventional alternatives, imposing a financial burden on the project budget.”

Furthermore, there were logistical challenges, including the co-ordination with suppliers capable of delivering certified, recycled materials and the verification that these materials adhered to quality standards. Another obstacle cited was the building team's deficiency in experience and training, which hindered the successful implementation of circular methods. Regulatory and permitting challenges were noted since several participants indicated that current building codes inadequately supported or incentivised circular construction, complicating compliance and approval procedures.

Participants had much to say when asked how they effectively addressed and surmounted difficulties, and what insights and knowledge were acquired from these experiences. A participant stated:

“We concentrated on establishing robust partnerships with suppliers specialising in recycled materials, negotiating improved rates, and securing a reliable supply chain.”

Another participant stated:

“We organised workshops and training sessions to acclimate our team to circular construction principles and techniques, which markedly enhanced our capacity to implement these practices effectively.”

Furthermore, participants emphasised the significance of interacting with regulatory authorities and obtaining requisite approvals at the outset of a project. This proactive strategy ensured compliance and garnered support for sustainable measures. A participant stated:

“By proactively engaging with local authorities and illustrating the long-term advantages of circular construction, we successfully mitigated regulatory challenges.”

The participants also acknowledged the significance of flexibility and adaptability in project management. As one individual noted:

“The experience taught us to be innovative and resourceful in identifying solutions, which has enhanced our team's resilience and progressive mindset in sustainable construction.”

Participants were also requested to answer the following questions: Have you engaged in any further construction projects that integrated circular construction principles? If so, could you elucidate your role and the particular procedures employed?

The participants provided several interesting answers that confirmed CC practices. For example, PM (3) affirmed the following, emphasising the participant's active participation in advancing sustainability:

“Indeed, I have participated in a residential development project that incorporated comprehensive recycling and re-use strategies. As a project manager, I supervised the incorporation of recovered wood and recycled steel into the building frameworks. We employed modular building methods to minimise waste and facilitate the re-use of resources in subsequent projects. This method reduced waste and demonstrated the viability and advantages of circular construction building in residential projects.”

ARCH (3) detailed their participation in a commercial office building project, stating:

“I acted as the principal architect on a project that sought to attain LEED Platinum certification. We concentrated on planning for deconstruction, employing materials that could be effortlessly removed and recycled at the conclusion of the building's existence. Furthermore, we established water recycling systems and procured materials locally to minimise the carbon imprint. This position necessitated a profound comprehension of sustainable design principles and a dedication to incorporating these practices throughout all phases of the project.”

Another question to the participants was: what methods do you implement to guarantee adherence to circular construction principles across all projects from inception to completion? The answers indicated the necessity of regular training sessions for the team to be informed about the newest sustainable practices and technology, thereby upholding a high quality of knowledge and skill. For instance, PM (1) underscored the significance of preliminary planning and stakeholder involvement, asserting:

“We initiate by incorporating circular construction objectives into the project brief and ensure that all stakeholders, including clients, contractors, and suppliers, are in accord with these aims. This method guarantees that all participants are dedicated to the principles from the beginning, promoting more seamless execution during the project lifespan.”

Another essential element entails rigorous monitoring and assessment. This ongoing surveillance facilitates immediate modifications and guarantees that the project achieves its sustainability objectives. The reply from one participant was:

“We perform regular site inspections and audits to ensure adherence to circular construction standards, and we utilise performance metrics to monitor progress and pinpoint areas for enhancement.”

When participants were asked whether they have faced opposition or difficulties when advocating circular building techniques to project stakeholders, and how they mitigated these issues, most participants identified initial opposition frequently arising from the unfamiliarity of stakeholders with circular construction building principles, and apprehensions over possible increased costs or alterations to current workflows as being the most critical problems. They also stated that a significant obstacle encountered was persuading stakeholders of the financial benefits of circular operations. PM (3) eloquently summarised as follows:

“We provided comprehensive case studies and cost-benefit evaluations that showcased successful implementations in analogous projects, illustrating both the environmental benefits and economic viability. This strategy of utilising scientific information and highlighting environmental and economic advantages alleviated opposition and cultivated a more favourable disposition towards adopting circular construction techniques.”

Most participants noted that incorporating circular construction building necessitates a paradigm shift by prioritising sustainability and resource efficiency over conventional linear practices. They acknowledged that transition would require ongoing education, and adjustment to emerging technology and approaches. To this end, CM (3) stated:

“Embracing circular construction practices will transform our work by necessitating a deeper understanding of life-cycle analysis and sustainable design principles. It

will compel us to generate innovative concepts and collaborate with individuals from diverse disciplines to identify universally effective solutions.”

Participants were made aware that the integration of circular construction will profoundly influence their responsibilities, necessitating new skills, technology, and collaboration strategies to fulfil the requirements of a more sustainable building sector. They were also told that these factors would promote a more innovative professional environment, resulting in more sustainable and resilient construction techniques. They were then asked to make comments on this scenario. The different professional groups provided insightful comments.

For instance, architects concurred that their future responsibilities will chiefly entail re-evaluating design ideas to emphasise sustainability, adaptability, and the utilisation of recyclable or re-usable resources. Specifically, architects appear to recognise the importance of adopting a collaborative approach and working closely with other professionals, particularly the customer, to ensure that each structural component is designed with durability and minimal environmental impact in mind. For example, ARCH (3) emphasised:

“It is not solely about constructing aesthetically pleasing edifices, but also about ensuring that every building component is engineered for longevity, disassembly, and re-utilisation.”

However, engineers emphasised their role in designing structural systems and materials for energy-efficient, resource-conscious, and repurposable systems. They stressed incorporating sophisticated technologies, such as BIM, to increase long-term material and system efficiency and to advance sustainability. Quantity surveyors stressed the importance of knowing the cost-effectiveness of sustainable materials and procedures to ensure financially viable circular construction projects. They also admitted that their procurement duties will change to support sustainability. On the other hand, project managers agreed that managing stakeholders, resources, and schedules will help to achieve sustainability goals without compromising quality or

efficiency. They stressed the importance of a culture of continual learning and adaptation to keep up with circular manufacturing technologies and processes. Finally, construction managers agreed that their main role is to implement sustainable methods on-site, maximising resource use and minimising waste. They stressed the importance of synchronising all construction activities with circular concepts, including on-site logistics management, quality control, and safety.

4.9. DISCUSSION

4.9.1. Objective 1: Knowledge Areas that would Increase CC Practices

The survey and interview results reveal that construction professionals in South Africa possess a robust understanding of essential circular construction principles. A significant proportion of respondents demonstrated familiarity with strategies such as employing building information modelling (BIM) for assessing material sustainability, utilising smart demolition methods that facilitate material re-use, and incorporating adaptability and flexibility in design. For example, 57% of survey respondents indicated awareness of BIM applications, while over 60% expressed acquaintance with waste minimisation measures in construction. The results reveal that many industry professionals have a thorough understanding of the core principles of circular construction.

This understanding is corroborated by the qualitative data, which illustrate that professionals regard circular construction as a strategy that prioritises sustainable building design, reduces waste, and enhances resource efficiency. This highlights global trends that underscore the importance of these principles in the shift towards a more sustainable construction industry (Adams *et al.*, 2017; Ghisellini *et al.*, 2016). Interviews indicated that circular construction building is regarded as an innovative strategy that prioritises durability, economic efficiency, and ecological sustainability.

Nonetheless, there exist knowledge deficiencies in more specialised fields. Professionals possess limited familiarity with advanced circular practices, such as

thorough cost-benefit assessments (CBAs) on the use of recycled materials or the transfer of material ownership to producers post-consumption, as was evident in the quantitative and qualitative data. This indicates that, despite a relatively high overall knowledge of circular practices, further education and training are essential to equip professionals with the requisite skills for the effective implementation of more intricate circular economy initiatives (Akinade *et al.*, 2019). These inconsistencies highlight the need for continuous professional development focused on particular elements of circular construction that the industry has yet to grasp completely. While the findings indicate that professionals possess awareness of the circular economy, based on a study conducted by Adams *et al.* (2017), a persistent deficiency in their understanding of how to use circular economy principles in their operations was revealed.

4.9.2. Objective 2: Attitudes that would Increase CC Practices

The majority of construction professionals considers circular construction building approaches to be vital for improving resource efficiency and sustainability within the sector, and their perspectives on these activities are predominantly positive. The study results revealed that critical criteria, such as cost reduction, regulatory compliance, and customer expectations, significantly impact the implementation of circular construction. The primary incentive was identified as cost reduction, with 38.37% of respondents deeming it to be highly influential. This finding aligns with the prevailing trend in the literature, which constantly highlights financial advantages as the principal motivation for embracing sustainable construction approaches (Vries *et al.*, 2015).

The interviews corroborated this viewpoint by revealing that many professionals assert that adopting circular construction processes can lead to considerable long-term cost savings, waste minimisation, and enhanced sustainability in project outcomes. Participants emphasised that circular construction building aligns with environmental goals and offers concrete economic benefits, such as improved material efficiency and decreased operational expenses. This view underscores the increasing recognition of circular construction building as an ecologically sustainable and economically feasible strategy (Ghisellini *et al.*, 2016).

Nonetheless, certain challenges were recognised despite the predominantly positive outlooks. The extensive implementation of circular practices is hindered by obstacles such as insufficient experience, budgetary limitations, and restricted resources, as demonstrated by the survey and interview findings. A considerable number of respondents recognised the substantial initial expenses linked to the adoption of circular construction methods as a major impediment. Moreover, the requirement for supplementary specialised knowledge and training was often regarded as being an impediment to the full incorporation of circular practices into initiatives. These issues represent significant impediments to global research, highlighting financial and knowledge-based barriers as major obstacles to the adoption of circular construction (Akinade *et al.*, 2019). Specific measures, such as financial incentives, legislative assistance, and enhanced investment in education and training, will be essential to overcome these challenges.

4.9.3. Objective 3: Exemplary CC Practices

The adoption of circular construction methods within the South African construction sector is inconsistent, with certain practices being more widely embraced than others. The survey findings revealed that experts possess extensive knowledge and have adopted methods concerning resource efficiency and waste minimisation, such as minimising material waste during construction and including systems for greywater and rainwater collection. For example, 54.67% of respondents expressed awareness of water conservation methods, but 60.76% acknowledged familiarity with pollution reduction in building activities. These techniques align with international best practices in circular building and reflect an increasing commitment to sustainability (Ghisellini *et al.*, 2016).

The qualitative data provided further insights into the practical implementation of circular construction principles. Interviewees presented instances of successfully executed procedures, such as the repurposing of building materials from prior projects, the minimisation of off-cuts, and the incorporation of recycled materials in new

construction elements. The case studies provided by participants illustrate that circular building is more prevalent in some industry sectors, especially where clients and project teams emphasise sustainability.

Nonetheless, there remain areas where implementation is limited. The survey and interview data revealed that techniques, such as conducting cost-benefit evaluations of recycled materials, planning structures for future disassembly, and transferring material ownership to producers, were less commonly implemented. Advanced circular practices were recognised as being substantial obstacles to widespread implementation owing to financial limitations, inadequate client engagement, and a deficiency of competence. The respondents recognised the potential benefits of these approaches. Nevertheless, the substantial initial expenditures and operational complexities often deter their widespread adoption. This aligns with findings from earlier studies highlighting the financial and technological challenges associated with circular construction building (Akinade *et al.*, 2019; Hosseini *et al.*, 2018).

The prevailing trend demonstrates an increasing inclination towards adopting circular processes, especially as more professionals gain familiarity with the principles and acknowledge the long-term advantages despite the associated obstacles. The South African construction industry, with its capacity to enhance the use of circular construction technologies, could foster optimism and greatly advance global sustainability objectives through financial incentives, policy reforms, and training initiatives.

4.9.4. Nexus between Quantitative and Qualitative Findings

The following sections shows how the quantitative and qualitative insights dovetail to drive the KAP roadmap that emerged from the study.

4.9.4.1. Knowledge Areas to Increase CC Practices

Quantitative evidence from the study shows that knowledge of CE practices such as flexible/adaptable design, smart demolition, BIM reuse strongly predicts the potential to adopt CC methods ($\beta = 0.269$, $p = .012$) (see Table 4.10). However, familiarity with those practices showed a slight, non-significant negative effect on actual adoption potential ($\beta = -0.138$, $p = .182$) (see Table 4.10), suggesting that mere exposure doesn't guarantee uptake. From the qualitative insights, experts explained that although they "know" smart demolition techniques, real-world uptake stalls when resource constraints and lack of regulatory clarity intervene ("We have the BIM models...but no budget to act," CM [4]) (see Section 4.8.1). This fleshes out why knowledge scores high yet familiarity alone doesn't always translate into practice. The KAP linkage is that, knowledge is necessary but not sufficient. Practical barriers must be addressed for knowledge to convert into practice.

4.9.4.2. Attitudes to Increase CC Practices

Quantitative evidence from the study shows that positive attitudes such as cost-reduction, regulatory compliance, client expectations are the strongest predictor of adoption potential ($\beta = 0.356$, $p < .001$) (see Table 4.10). The mediation analysis shows this attitude \rightarrow adoption link has a trend toward improving active engagement, though marginal (indirect $\beta = 0.084$, $p = .071$) (see Table 4.10). On the other hand, the qualitative insights shows that interviewees repeatedly cited "cost savings" and "client demand" as the tipping point: "If the client insists on achieving green-certification, then suddenly everyone learns to recycle concrete" (ENGR [1]) (see Section 4.8.2). Moreover, ethical motives, while recognized, rarely drove actual implementation without a business case. The KAP linkage here is that, attitudes, especially when aligned with economic incentives translate more reliably into practices than knowledge alone.

4.9.4.3. Practices in Action

Quantitatively, the composite likelihood to engage in circular practices is only weakly predicted by adoption potential ($\beta = 0.236$, $p = .053$) (see Table 4.10), and the overall model explains just 4.5 % (see Table 4.11) of its variance. Qualitatively, participants described a spectrum of actual practices: from attending externally funded workshops to advising clients and mentoring peers, with the strongest “practice” being participation in paid workshops (see Section 4.8.3). KAP linkage suggest that converting potential to real-world practice remains the weakest link emphasizing the need for systemic supports like funding, regulation, and client directives.

4.10. CHAPTER SUMMARY

In this chapter, the findings from the research were presented. The results indicated an increasing awareness of circular construction building principles among stakeholders, although they underscored substantial obstacles to broader implementation, such as elevated initial costs, integration difficulties, and the absence of standardised norms and legislative backing. Notwithstanding these challenges, the findings of the research indicated that circular processes provide enduring advantages, including less waste, lower environmental impact, and prospective cost savings. The findings underscore the necessity for enhanced co-ordination, and supportive laws and regulations to promote the transition to a more circular economy in construction. In the following chapter, a conclusion and recommendations are provide based on the findings and discussions in this chapter.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1. INTRODUCTION

In this chapter, the research findings are consolidated in relation to the objectives of the study and correlated with pertinent literature. The purpose of the study was to investigate the knowledge, attitudes, and practices related to CC in South Africa's construction sector. This chapter includes a comprehensive examination of the alignment between these findings and the existing literature, specifically regarding CE, KAP Theory, and principles of sustainable development. The chapter concludes with a roadmap for enhancing CC practices.

5.2. GENERAL CONCLUSIONS

Based on this study, it is concluded that, while circular economy principles have begun to be explored in the South African construction industry, significant barriers impede widespread application. Professionals are knowledgeable about circular methods, particularly in the domains of material re-use and waste reduction. The deficiency in advanced understanding of intricate circular techniques, such as cost-benefit evaluations of recycled materials, underscores the necessity for additional education and training. Although attitudes towards circular construction are predominantly positive, influenced by economic benefits such as cost savings, substantial obstacles, such as the inadequate specification of circular construction building materials, supply delays, and a lack of competence, negatively impact project results. The challenges are exacerbated by the absence of clear legislative frameworks, inadequate client demand, and the significant upfront expenses associated with implementing circular processes. Although certain outstanding circular economy initiatives, such as waste minimisation and material re-use, are being executed, more sophisticated practices encounter obstacles because of substantial initial expenditures and insufficient governmental backing. Consequently, there is a necessity for more comprehensive legal frameworks, financial incentives, and industry collaboration to surmount these obstacles and facilitate a more sustainable transition. Through targeted interventions and continuous professional development, the South African construction sector can markedly improve its implementation of circular processes, thereby advancing global

sustainability objectives while enhancing project efficiency and minimising environmental impact.

5.3. SPECIFIC CONCLUSIONS RELATED TO THE RESEARCH OBJECTIVES

5.3.1. Objective 1: To Identify the Knowledge Required to Enhance Circular Economy Practices in Construction Projects

The findings of the research indicated that construction professionals often comprehend fundamental principles of circular construction building, including waste reduction and building information modelling (BIM) for material repurposing. Nonetheless, substantial deficiencies exist in increasingly advanced domains of knowledge. Practices, such as lifetime analysis, intelligent demolition, and planning structures for future disassembly, are not broadly comprehended or implemented.

It is emphasised in the study that bridging these knowledge gaps is essential for enhancing the adoption of circular construction processes. Training programmes and educational activities centred on advanced circular economy methodologies are essential to equip professionals with the requisite skills to implement these practices efficiently. The absence of specialised knowledge will restrict the shift to circular construction in the industry.

5.3.2. Objective 2: To Assess the Attitudes among Construction Professionals that would Foster Increased Circular Economy Practices in Projects

The results presented in Chapter 4 indicate that most participants acknowledged the potential benefits of reducing waste, improving resource efficiency, and minimising environmental impact. This finding leads to the conclusion that attitudes toward circular construction among industry professionals are generally positive. However, it is also concluded that positive attitudes alone are insufficient to drive the adoption of circular practices because of high upfront costs, limited client demand, and a lack of regulatory support that often outweigh the perceived benefits of circular construction,

leading to slow progress in implementing these practices. Therefore, it is further concluded that more needs to be done to align attitudes with practical incentives that encourage the adoption of circular practices. To this end, financial incentives, regulatory frameworks, and client awareness campaigns are recommended to bridge the gap between positive attitudes and actual implementation. Also, the transition towards more sustainable building practices can be accelerated in the industry by creating an environment that supports circular construction.

5.3.3. Objective 3: To Identify Exemplary Circular Economy Practices Currently being Implemented in Construction Projects

The results presented in Chapter 4 revealed various examples of circular economy strategies, such as modular construction techniques, material recycling, and intelligent demolition processes that facilitate the re-use of high-quality resources. These techniques have effectively diminished waste and enhanced resource efficiency, rendering them exemplary templates for forthcoming initiatives. Nonetheless, the findings of the study also show that adopting more sophisticated circular practices, such as designing buildings for future adaptation, remains constrained. Moreover, financial limitations, logistical obstacles, and insufficient regulatory support significantly impede the adoption of these advanced procedures. Consequently, it is concluded that there are suitable best practices for implementing emulation in South Africa. However, there is a need to remove financial and logistical constraints, and regulatory support and incentives will be essential for expanding exemplary circular practices.

5.3.4. Objective 4: To Evaluate How the KAPs of Construction Professionals can be Improved to Enhance Circular Construction Practices

The findings presented in Chapter 4 indicate that, although professionals typically favour circular economy ideas, their knowledge and activities do not wholly correspond with these beliefs. The absence of practical experience and technical proficiency in executing circular construction building methods was a considerable obstacle to efficient implementation. Consequently, it is concluded that comprehensive training

and capacity-building programmes are necessary to address the knowledge and skills deficiencies revealed in the KAP assessment. It is determined in addition that these programmes must equip professionals with the tools and resources necessary to implement circular practices in their projects. Furthermore, encouraging collaboration among stakeholders and cultivating a culture of continuous learning is crucial for enhancing the adoption of circular construction building within the sector.

5.3.5. Objective 5: To Propose Specific Steps and Actions for a Roadmap that will Improve Circular Construction Practices In South Africa

The findings of the study indicate that a definitive and strategic framework is crucial for directing the South African construction sector towards enhanced circular construction methodologies.

This plan must encompass nine (9) essential milestones, including:

1. Perform a baseline evaluation to comprehend the present condition of circular economy activities within the construction sector.
2. Create specialised education and training initiatives to improve the expertise and competencies of construction professionals in relation to circular economy principles.
3. Establish a regulatory and policy framework to encourage the adoption of circular practices.
4. Promote exemplary circular economy practices to inspire and guide other companies.
5. Implement pilot projects to test and refine circular construction practices in real-world settings.
6. Develop standardised circular economy metrics and reporting methods to measure and report on circularity in construction projects.

7. Scale up and integrate circular practices by expanding successful practices across the construction industry.
8. Monitor, evaluate, and continuously improve the roadmap to remain relevant and practical.
9. Raise public awareness and engage communities to build broad support for circular construction through community engagement and public education.

This structured framework for action provides the roadmap to help the construction industry overcome the barriers identified in this study and make meaningful progress towards adopting circular economy principles.

5.4. RECOMMENDATIONS

Based on the research findings, a roadmap for implementation is recommended, followed by recommendations for future research.

5.4.1. Recommended detailed Roadmap to improve Circular Construction

This section provides a step by step guide on achieving the CE KPAs in the South African built environment.

5.4.1.1. Achieving the KPAs

By weaving together the quantitative and qualitative data through the Knowledge–Attitude–Practice (KAP) lens, three clear insights emerge to guide the roadmap.

Knowledge alone is not enough. Although respondents demonstrate strong awareness of circular-construction concepts, resource and regulatory obstacles prevent that awareness from translating into action. The interviews revealed that practical constraints such as budget limits, ambiguous policy guidance, or lack of mandated client requirements often stall even well-informed practitioners.

Attitudes, when aligned with incentives, drive uptake. Statistical analysis showed that positive beliefs about cost savings, client demand, and compliance significantly predict willingness to adopt circular practices. Qualitative evidence confirmed that when economic or regulatory imperatives exist, engineers readily shift from theory to application reinforcing the importance of tying circular-economy messaging to concrete benefits.

Practice remains the weakest link. Despite high knowledge and favourable attitudes, actual engagement in circular activities is limited. Workshop participation and pilot projects occurred episodically rather than systematically. This gap underscores the need for structured supports such as funded training, clear performance metrics, and policy mandates to convert intention into routine practice.

These quantitative “what” with qualitative “why,” are integrated to tailor a roadmap to reinforce positive attitudes and remove practical barriers, ensuring that knowledge truly informs attitudes, which in turn spur practices across South Africa’s circular-construction sector.

The framework for enhancing circular construction practices in South Africa can be delineated through a sequence of organised phases, steering the industry towards adopting circular economy concepts. This framework offers a detailed strategy to enhance circular building processes methodically in South Africa by focusing on critical aspects such as education, regulation, best practices, pilot initiatives, and industry-wide integration. The roadmap is presented in Table 5.1, accompanied by an animated figure in Figure 5.1.

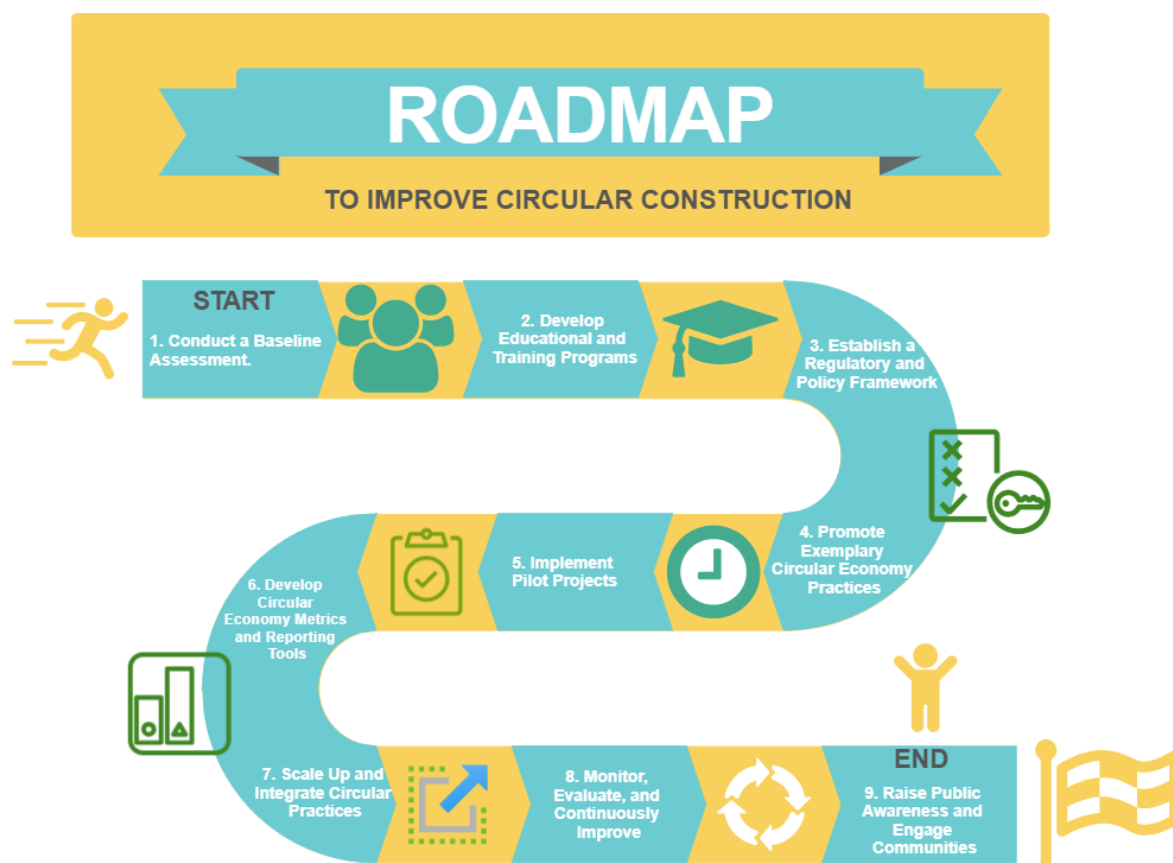


Figure 5.1: Roadmap to improve circular construction

Table 5.1: Roadmap for improving CE

STEPS	OBJECTIVE	ACTIONS
1. Conduct a Baseline Assessment	Understand the current state of circular economy practices in the construction industry.	<ul style="list-style-type: none"> Assess the knowledge, attitudes, and practices (KAP) of construction companies. Conduct stakeholder interviews and focus groups to identify significant barriers and enablers. Identify waste and resource utilisation tendencies in typical building projects.
2. Develop Educational and Training Programmes	Enhance the knowledge and skills of construction professionals regarding circular economy principles	<ul style="list-style-type: none"> Collaborate with industry and educational institutions to develop customised training programmes. Create certification programmes for circular construction methods.

STEPS	OBJECTIVE	ACTIONS
		<ul style="list-style-type: none"> Organise workshops, seminars, and webinars to discuss best practices and promote awareness.
3. Establish a Regulatory and Policy Framework	Create supportive policies and regulations that encourage the adoption of circular practices	<ul style="list-style-type: none"> Collaborate with politicians to incentivise companies to adopt circular processes, such as tax rebates or subsidies. Suggest regulations requiring recycling, re-use, and sustainable material procurement in construction projects. Create circular construction standards that meet national and international sustainability goals.
4. Promote Exemplary Circular Economy Practices	Showcase successful examples to inspire and guide other companies	<ul style="list-style-type: none"> Create a platform or database to exchange inspiring circular economy construction case studies. Honour circular construction building innovators with awards or public acknowledgement. Industry networks and alliances enable knowledge exchange.
5. Implement Pilot Projects	Test and refine circular construction practices in real-world settings	<ul style="list-style-type: none"> Partner with interested companies to implement circular economy pilot projects. Evaluate project performance, emphasising waste reduction, resource efficiency, and cost savings. Learn from pilot initiatives to develop strategy and roadmaps.
6. Develop Circular Economy Metrics and Reporting Methods	Create standardised methods to measure and report on circularity in construction projects	<ul style="list-style-type: none"> Create indicators and measures to evaluate construction project circular performance. Develop frameworks for companies to track progress towards circular economy targets. Add these criteria to industry reporting and sustainability assessments.
7. Scale Up and Integrate Circular Practices	Expand successful practices across the construction industry	<ul style="list-style-type: none"> Develop industry-wide circular construction guidelines and toolkits using pilot project insights. Encourage wider adoption by highlighting economic,

STEPS	OBJECTIVE	ACTIONS
		<p>environmental, and social benefits of circular processes.</p> <ul style="list-style-type: none"> Promote supply chain collaborations to ensure circular materials and technology.
8. Monitor, Evaluate, and Continuously Improve	Ensure the roadmap remains relevant and effective over time	<ul style="list-style-type: none"> Create a feedback mechanism to obtain industry stakeholders' input on the roadmap's development and impact. Continuously update the roadmap to reflect new insights, technology, and industry needs. Create a task force to implement and improve circular construction methods.
9. Raise Public Awareness and Engage Communities	Objective: Build broad support for circular construction through community engagement and public education	<ul style="list-style-type: none"> Raise awareness through campaigns about the advantages of circular construction for communities and the environment. Engage local communities in circular construction projects, especially in urban development and repair. Inform customers and end-users about sustainable building methods and how they can help.

5.4.2. Recommendations for Future Research

The limitations of the current study lead to suggestions for several avenues for future research. For example, unlike the current study, future research could explicitly investigate the obstacles to circular economy adoption, specifically examining the factors that impede the implementation of circular economy practices within the construction sector. This might involve analysing regulatory, financial, technical, and cultural challenges that hinder more comprehensive implementation, and investigating strategies to address these obstacles.

Future research could also examine the role of emerging technologies, including digital twins, blockchain, and artificial intelligence, in promoting circular construction practices. This research might involve investigating the integration of these

technologies into construction processes to enhance material tracking, waste management, and life-cycle assessments.

Assessing the economic impacts of CE adoption is essential for its encouragement. Comprehensive economic analyses are essential to quantify the financial benefits and costs of circular construction practices. Future research might concentrate on performing cost-benefit analyses, return on investment studies, and economic impact assessments to strengthen the business case for circular construction.

A cross-sectional design was adopted for the current study. A longitudinal study could be undertaken to evaluate the efficacy of the proposed roadmap together with other circular construction interventions. In this research, the advancement of executed roadmaps over multiple years could be monitored, assessing their efficacy, adaptability, and results in enhancing circularity in construction projects.

Finally, since the need for training in CE practices for construction professionals was identified in the current study, future research should be concentrated on determining the educational and training requirements for equipping current and prospective construction professionals with the skills and knowledge needed to implement circular economy practices effectively.

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APPENDICES

APPENDIX 1: QUESTIONNAIRE REQUEST LETTER

February 2024

Good day,

I am writing to request your assistance with an important research project, *A Roadmap for Improved Circular Construction*," being conducted by myself, Josephine Dzansi, a Master of Construction student at The Central University of Technology.

The insights you provide will contribute significantly to my understanding of current practices, challenges, and opportunities in the adoption of circular construction principles. Your valuable input will aid in advancing sustainable construction practices within the industry.

I can imagine this is a busy time of year for you, but I hope you will take some time to participate in my very brief survey. The questionnaire will require no more than 15 minutes to complete.

Participation in this survey is voluntary, and you have the right to withdraw at any time without providing a reason. All information shared during the survey will be kept confidential and used solely for research purposes. Your name and identity will not be disclosed in any publications or reports resulting from this survey.

If you're available and interested in participating, please confirm your availability by 29 February 2024.

Thank you in advance for your participation in this important research. If you have any questions about the survey administration, don't hesitate to get in touch with me at 084 505 6805 or jadzansi@gmail.com.

I trust that you will find this in order.

Friendly Regards



Josephine Dzansi

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Digitally signed by Prof FA Emuze Date:
2023.08.21 07:54:46 +02'00'

Supervisor: Prof. Fidelis Emuze

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Co-Supervisor: Dr. Rotondwa Nemakhavhani

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APPENDIX 2: QUESTIONNAIRE

SECTION A: DEMOGRAPHIC DATA						
<i>Please mark the appropriate answer with X in the applicable box.</i>						
1.	Please indicate your current age	1 Under 30 years	2 31-35 years	3 36-40 years	4 41-45 years	5 More than 45 years
2.	Please indicate your gender	1 Male			2 Female	
3.	Please indicate your highest level of qualification	1 Diploma / Advanced Certificate	2 Bachelors' Degree / Advanced Diploma	3 Honours degree / Postgraduate Diploma	4 Masters' Degree	4 Doctorate 5 Other
4.	Please indicate your profession	1 Architect	2 Construction Manager	3 Engineer	4 Project Manager	5 Quantity Surveyor
5.	Please indicate the nature of your organization	1 Public / Government			2 Private	
6.	Please indicate the number of years you have worked in the construction industry	1 Below 5 years	2 6 - 10 years	3 11 – 15 years	4 16 – 20 Years	5 Over 20 Years

Section B: Knowledge								
<i>Kindly indicate your level of knowledge with the following circular construction practices.</i>								
Practice	1 Completely no knowledge	2 No knowledge	3 Almost no knowledge	4 Neutral	5 Knowledgeable	6 Very Knowledgeable	7 Highly knowledgeable	
Flexible and adaptable designs to accommodate future changes to the building, such as remodeling	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
The use of Building Information Modelling	[1]	[2]	[3]	[4]	[5]	[6]	[7]	

(BIM) to assess the materials' possibility for reuse								
Conducting a Cost Benefit Analysis (CBA) of using recycled materials	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Manufacturing of building materials using recovered materials	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Transfer ownership of materials to the manufacturer after its intended use in the first building.	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Off-site construction to avoid material cut-offs and to optimize time	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
The use of existing materials, components and building for new project(s)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Minimizing waste during construction	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Preventative maintenance of building components so that they last longer	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Design buildings to include greywater and/or rainwater harvesting	[1]	[2]	[3]	[4]	[5]	[6]	[7]	

systems to save water								
Smart demolition (dismantling), thereby allowing for the reuse of high-grade building materials.	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Proper disposal of materials that cannot be reused	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
SECTION C: ATTITUDE								
C1: BELIEF IN (UNDERSTANDING OF) THE DRIVERS OF CIRCULAR CONSTRUCTION (CC)								
[Construction professional's belief or knowledge about the efficacy of drivers CC].								
How effective are the following <u>factors</u> in enabling the adoption of circular construction practices?								
Factor	1 Very ineffective	2 Moderately ineffective	3 Slightly ineffective	4 Neutral	5 Slightly effective	6 Moderately effective	7 Very effective	
Competitive advantage	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Company Reputation	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Legal regulations	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Cost reduction	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Investor expectations	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Ethical reasons	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Client expectations	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
C2: BARRIERS/ CONSTRAINTS TO CC								
[Construction professional's belief or knowledge about the barriers to CC]								
<i>Please indicate the extent to which the following factors negate or constrain the ability of the construction professional to advise on the adoption of circular construction practices on prospective green/sustainable developments.</i>								
Factor	1	2	3	4	5 Large extent	6	7	

	Extremely small extent	Very small extent	Small extent	Moderate extent		Very large extent	Extremely large extent
Lack of interest by the client	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Lack of interest by the project team	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Lack of skill and knowledge on CC practices on the part of the project team	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Additional costs in attending training, and workshops on the part of the project team.	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Less/little influential ability	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Limited resources to engage in CC practices	[1]	[2]	[3]	[4]	[5]	[6]	[7]
C3: PERCEIVED IMPORTANCE OF CC							
<i>Kindly rate the importance of the adoption of circular construction practices.</i>							
Practice	1 Not at all important	2 Not important	3 Slightly not important	4 Moderately important	5 Important	6 Very Important	7 Extremely important
Flexible and adaptable designs to accommodate future changes to the building such as remodelling	[1]	[2]	[3]	[4]	[5]	[6]	[7]
The use of BIM to assess the materials' possibility for reuse	[1]	[2]	[3]	[4]	[5]	[6]	[7]

Conducting a Cost Benefit Analysis (CBA) of using recycled materials	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Manufacturing of building materials using recovered ones	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Transfer ownership of materials to a manufacturer after its intended use in the first building.	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Off-site construction to avoid material cut-offs and to optimize time	[1]	[2]	[3]	[4]	[5]	[6]	[7]
The use of existing materials, components and building for new project(s)	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Minimize waste during construction	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Preventative maintenance of building components so that they last longer	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Design buildings to include greywater and/or rainwater harvesting systems to save water	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Smart demolition (dismantling),	[1]	[2]	[3]	[4]	[5]	[6]	[7]

thereby allowing for the reuse of high-grade building materials.								
Proper disposal of materials that cannot be reused	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
C4: ATTITUDE STRENGTH OR LIKELIHOOD TO ENGAGE IN PRO CC BEHAVIOUR								
<i>Kindly rate how likely you are to do the following:</i>								
Behavior	1 Extremely unlikely	2 Very unlikely	3 Unlikely	4 Slightly likely	5 Likely	6 Very likely	7 Extremely likely	
Advise a client on the usefulness/relevance of circular construction practices.	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Advise other consultants on the usefulness/relevance of circular construction practices	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Pay for a workshop that gives more insight into circular construction practices.	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
Attend a workshop that gives more insight into circular construction practices if it was paid for by someone else.	[1]	[2]	[3]	[4]	[5]	[6]	[7]	

SECTION D: PRACTICE

In your understanding, which of the following stakeholders' decision-making authority has the most influence on circular construction practice adoption:

Stakeholder	1 Extremely uninfluential	2 Very Uninfluential	3 Uninfluential	4 Slightly influential	5 Influential	6 Very influential	7 Extremely influential
Client/Developer	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Architect	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Quantity Surveyor	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Engineer (civil, structural...)	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Project Manager	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Contractor	[1]	[2]	[3]	[4]	[5]	[6]	[7]
End-user/ Tenant	[1]	[2]	[3]	[4]	[5]	[6]	[7]

At what stage of the project life cycle is your profession's contribution to circular construction practice adoption considered most important (critical):

Stages	1 Not at all important	2 Not important	3 Slightly not important	4 Moderate ly important	5 Important	6 Very Important	7 Extremely important
Concept and viability stage	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Design development	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Documentation and procurement	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Construction Stage	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Completion and Operation Stage	[1]	[2]	[3]	[4]	[5]	[6]	[7]

In your understanding, which of the following circular construction practices have the most potential to be adopted in construction projects:

Practice	1	2	3	4	5	6	7

	No Potential	Very Low Potential	Low Potential	Neutral	Moderate Potential	High Potential	Very High Potential
Flexible and adaptable designs to accommodate future changes to building such as remodelling	[1]	[2]	[3]	[4]	[5]	[6]	[7]
The use of BIM to assess the materials' possibility for reuse	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Conduct a Cost Benefit Analysis (CBA) of using recycled materials	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Manufacturing of building materials using recovered ones	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Transfer ownership of materials to a manufacturer after its intended use in the first building	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Off-site construction to avoid material cut-offs and to optimize time	[1]	[2]	[3]	[4]	[5]	[6]	[7]
The use of existing materials, components and building for new project(s)	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Minimize waste during construction	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Preventative maintenance of building	[1]	[2]	[3]	[4]	[5]	[6]	[7]

	components so that they last longer							
	Design buildings to include greywater and/or rainwater harvesting systems to save water	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	Smart demolition (dismantling), thereby allowing for the reuse of high-grade building materials.	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	Proper disposal of materials that cannot be reused	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Kindly rate your level of familiarity with the following circular construction practices.								
	Practice	1 Not at all familiar	2 Not familiar	3 Somewhat not familiar	4 Neutral	5 Somewhat familiar	6 Familiar	7 Very familiar
	Flexible and adaptable designs to accommodate future changes to the building such as remodelling	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	The use of BIM to assess the materials' possibility for reuse	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	Conduct a Cost Benefit Analysis (CBA) of using recycled materials	[1]	[2]	[3]	[4]	[5]	[6]	[7]

Manufacturing of building materials using recovered ones	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Transfer ownership of materials to a manufacturer after their intended use in the first building.	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Off-site construction to avoid material cut-offs and to optimize time	[1]	[2]	[3]	[4]	[5]	[6]	[7]
The use of existing materials, components and building for new project(s)	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Minimize waste during construction	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Preventative maintenance of building components so that they last longer	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Design buildings to include greywater and/or rainwater harvesting systems to save water	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Smart demolition (dismantling), thereby allowing for the reuse of high-grade building materials.	[1]	[2]	[3]	[4]	[5]	[6]	[7]

	Proper disposal of materials that cannot be reused	[1]	[2]	[3]	[4]	[5]	[6]	[7]
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APPENDIX 3: INTERVIEW REQUEST LETTER

April 2024

Good day,

I request your assistance with an important research project, *A Roadmap for Improved Circular Construction*," by myself, Josephine Dzansi, a Master of Construction student at The Central University of Technology, Free State.

Your insights will contribute significantly to understanding current practices, challenges, and opportunities in adopting circular construction principles. Your valuable input will aid in advancing sustainable construction practices within the industry.

This is a busy time of year for you, but I hope you will take time to participate in my brief interview. The semi-structured interviews are expected to not exceed 45 minutes. The interviews will be digitally recorded, and participants may also receive physical copies of the final transcripts if desired.

Participation in this interview is voluntary, and you have the right to withdraw at any time without providing a reason. All information shared during the survey will be kept confidential and used solely for research purposes. Your name and identity will not be disclosed in any publications or reports resulting from this survey.

The interviews are scheduled to take place from 14 April 2024 – 15 May 2024. If you're available and interested in participating, please confirm your availability by 13 April 2024.

Thank you in advance for your participation in this important research. If you have any questions about the interview process, don't hesitate to get in touch with me at 084 505 6805 or jadzansi@gmail.com. I trust that you will find this in order.

Friendly Regards



Josephine Dzansi

Student: Master of Construction


Department of Built

Environment Central

University of Technology

Email: jadzansi@gmail.com

Cell: 0845056805



Digitally signed by Prof Emuze
Date: 2023.08.21 07:54:17+02'00'

Supervisor: Prof. Fidelis Emuze

Professor: Department of Built Environment



Tel: 051 507 3089

A handwritten signature in black ink, appearing to read 'Rotondwa Nemakhavhani'.

Co-Supervisor: Dr. Rotondwa Nemakhavhani

Lecturer: Department of Built Environment

Tel: 051 507 3946

APPENDIX 4: INTERVIEW PROTOCOL

SECTION A: DEMOGRAPHIC DATA							
<i>Please mark the appropriate answer with X in the applicable box.</i>							
1.	Please indicate your current age	1 Under 30 years	2 31-35 years	3 36-40 years	4 41-45 years	5 More than 45 years	
2.	Please indicate your gender	1 Male			2 Female		
3.	Please indicate your highest level of qualification	1 Diploma / Advanced Certificate	2 Bachelors' Degree / Advanced Diploma	3 Honours degree / Postgraduate Diploma	4 Masters' Degree	5 Doctorate	6 Other
4.	Please indicate your profession	1 Architect	2 Construction Manager	3 Engineer	4 Project Manager	5 Quantity Surveyor	
5.	Please indicate the nature of your organization	1 Public / Government			2 Private		
6.	Please indicate the number of years you have worked in this organisation	1 Below 5 years	2 6 - 10 years	3 11 – 15 years	4 16 – 20 Years	5 Over 20 Years	

SECTION B: KNOWLEDGE

1. Can you briefly explain your understanding on term “circular construction”?
2. Which circular construction practices are you familiar with, and how do they differ from traditional linear construction practices?
3. Do you think that the adoption and implementation of circular construction practices in South Africa will improve the sustainability performance of the industry? Please provide the justification for your answer.
4. How do you keep yourself informed of the latest construction industry circular economy trends, practices, and innovations?
5. Are there any circular construction practices being implemented in this project that you are aware of?

SECTION C: ATTITUDE

1. Given the implementation of circular construction practices in this project, what is the significance of waste reduction, material lifespan extension, and environmental impact mitigation in your perspective?
2. In your opinion, why is circular construction important for the construction industry's future?

3. What challenges do you foresee in transitioning towards circular construction methods, and how can these challenges be overcome?
4. What role should governments, industry associations, and companies play in promoting and incentivising circular construction practices?
5. Do you believe that professionals in your field are ready to undertake important roles in this new era? Give reasons for your answer.
6. What are the factors militating against the preparation of your profession in playing significant roles on projects incorporating circular construction practices?

SECTION D: PRACTICE

1. Were any circular construction practices implemented on this project? If not, what are the reasons for this?
2. Were there any challenges or barriers encountered during the incorporation of circular construction practices into this project?
3. How did you and your team successfully navigate and overcome these challenges, and what insights and knowledge were gained from these encounters?
4. Have you participated in any other construction projects that incorporated circular construction principles? If so, can you describe your role and the specific practices implemented?
5. What measures do you take to ensure that circular construction principles are upheld across all of the projects you are involved in from start to finish?
6. Have you encountered resistance or challenges when proposing circular construction practices to project stakeholders, and how did you address these concerns?
7. Do you think the adoption of circular construction practice will impact the nature of your profession? Give reasons for your answer.
8. What aspects of your profession will significantly impact this era?

Do you have any further comments concerning the role of your profession in facilitating the improved adoption of circular construction practices?

****End of Interview****

Thank you