

Construction and Demolition Concrete Waste Management in Gauteng: Challenges and Strategic Interventions for Circular Construction.

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Abstract

This paper investigates the challenges of construction and demolition (C&D) concrete management in Gauteng Province, South Africa, and proposes strategic interventions aligned with circular economy principles. A qualitative-dominant mixed-methods design was adopted, comprising semi-structured interviews and open-ended questionnaires with nine construction professionals (contractors, site managers, waste handlers) who have practised for a minimum of five years across multiple sites in Gauteng (Benoni, Springs, Roodepoort, Germiston, Parktown, Rosebank and Johannesburg). Data were analysed using thematic analysis following Braun & Clarke's six-phase framework. Construction-phase waste is driven by over-ordering, miscalculations, and a "build-first, manage-later" culture. Demolition-phase waste is exacerbated by lack of pre-demolition audits, inadequate site security, and failure to separate rebar from concrete. Common barriers across both phases include misconceptions that recycled concrete is weak or short-lived, high transport costs, absence of nearby recycling facilities, low Building Information Modelling (BIM) awareness, and inconsistent enforcement of the National Environmental Management: Waste Act (large projects monitored, small projects ignored). The modest sample (n=9) and geographic focus limit generalisability; quantitative waste audits are needed. Integrated strategies include mandatory pre-demolition audits, landfill taxes, decentralised recycling infrastructure, SME-friendly BIM training, and municipal provision of waste storage containers. This study provides the first empirical application of the COM-B behavioural framework to C&D concrete waste in an African urban context, distinguishing construction-phase from demolition-phase barriers.

Keywords: Circular economy, concrete waste management, construction and demolition waste, South Africa, sustainable construction

1. Introduction

The construction industry is a major contributor to environmental degradation through extensive resource consumption, waste generation, and high energy use (European Commission, 2023; UNEP, 2026). Globally, the sector accounts for over 30% of natural resource extraction, 25% of solid waste, and 40% of greenhouse gas emissions (European Commission, 2023), while also contributing nearly 50% of global material extraction, 37% of global emissions, and 28% of global energy consumption (UNEP, 2026). Gauteng Province, South Africa's economic hub with over 16 million residents (Cowling, 2024), exemplifies this challenge. Rapid urbanisation drives numerous construction and demolition (C&D) activities, generating substantial concrete waste from over-ordered ready-mix and washout on construction sites, to reinforced concrete slabs and columns from demolition sites (Alazaiza *et al.*, 2024; Simon, Beushausen and Alexander, 2025).

Concrete is one of the most dominant waste streams in South Africa's construction sector. Phuluphedziso (2022) found that concrete and brick account for a significant proportion of waste on Gauteng

construction sites. Nationally, Berge and Von Blottnitz (2022) estimate that C&D waste will increase significantly, with concrete representing the largest fraction. Most of this waste is landfilled, contributing to pollution, landfill overflow, and resource depletion. Poor planning, over-ordering, weak supervision, and inadequate site management exacerbate the problem. The absence of pre-demolition planning further compounds demolition-phase waste (Fitchett and Rambuwani, 2022).

The environmental impacts of poor C&D waste management are extensive. Estokova, Fabianova and Ondova (2022) note that the construction sector substantially contributes to greenhouse gas emissions through inefficient material use. Unmanaged concrete waste also generates dust pollution, poor air quality, and unsafe conditions for surrounding communities (de Jager and Kubanza, 2025). Economically, waste increases project costs through unnecessary procurement, transport, and disposal. Circular economy principles offer a critical pathway to improve sustainability (Velenturf and Purnell, 2021). Despite growing international attention, adoption of sustainable C&D concrete waste management in South Africa

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remains limited due to technological, behavioural, infrastructural, and regulatory barriers (Ishola and Gumbo, 2026; Aseni et al., 2025). The problem is that concrete waste is increasingly generated on C&D sites in Gauteng due to poor handling, inadequate supervision, poor planning, and lack of pre-demolition waste recovery strategies, contributing to environmental degradation and health risks (Fitchett & Rambuwani, 2022).

This research investigates the root causes of concrete waste in Gauteng's C&D sectors and proposes practical strategies to reduce waste and promote sustainability. The objectives are: (1) identify primary causes of concrete waste generation; (2) examine environmental and operational impacts; (3) assess current management practices; (4) evaluate strategy effectiveness; (5) identify barriers; (6) assess stakeholder awareness; and (7) recommend context-specific strategies. The hypothesis is that ineffective planning, poor supervision, low awareness, and recycling barriers are key contributors, and that targeted strategies can significantly reduce waste. This paper reports on a qualitative-dominant mixed-methods study using semi-structured questionnaires and thematic analysis. Limitations include a small sample (n=9), limited time and geographic focus on Gauteng. The originality lies in the first empirical application of the COM-B behavioural framework to C&D concrete waste in a South African urban context. The findings benefit policymakers, contractors, and industry bodies.

2. Literature Review

2.1. Defining Construction and Demolition Concrete Waste

C&D waste is the stream arising from construction, renovation, and demolition activities (Alazaiza et al., 2024). Concrete waste has two distinct types. Construction-phase waste includes over-ordered ready-mix, washout, and off-cuts, typically fresh and uncontaminated. Demolition-phase waste includes reinforced concrete from foundations, columns, and slabs, heterogeneous, often contaminated with steel, brick, soil, and hazardous materials, requiring mechanical processing (Alazaiza et al., 2024). This distinction matters because policies and technologies effective for fresh construction waste may be unsuitable for demolition waste. This paper addresses both categories, recognising that their causes differ but management solutions overlap under circular economy principles (Simon et al., 2025; Velenturf & Purnell, 2021).

2.2. Construction-Phase Concrete Waste: Causes and Patterns

Construction-phase concrete waste arises from operational inefficiencies on active building sites, including new builds and renovations. Unlike demolition waste generated from teardowns,

construction-phase waste stems from over-ordering, poor inventory management, inaccurate quantity forecasting, and inadequate supervision (Phuluphedziso, 2022). Fitchett and Rambuwani (2022) describe a "build-first, manage-later" culture where waste management is an afterthought, leading to over-pouring, material damage, and excessive off-cuts.

De Villiers et al. (2024) note that South Africa generates an estimated 12.2–24.3 million tonnes of C&D waste annually, while the national demand for aggregate and supplementary cementitious materials is 77.9 million tonnes, a significant gap that underscores the potential for recycling. Simon et al. (2025) observe that the traditional linear approach using virgin materials prolongs environmental challenges, contributing to increased energy usage and CO₂ emissions.

2.3. Demolition Practices and Concrete Waste Generation

Demolition activities present unique challenges distinct from construction-phase waste. Key demolition-specific issues include lack of pre-demolition audits, systematic surveys to identify reusable and recyclable materials, mandatory in several European countries and Cape Town, but not in Gauteng (Fitchett & Rambuwani, 2022). Without audits, valuable concrete is contaminated during uncontrolled demolition. Inadequate site security allows unauthorised access and illegal dumping, increasing contamination. Failure to separate rebar from reinforced concrete requires mechanical processing that many small contractors lack, sending mixed waste to landfill (Alazaiza et al., 2024). Contamination with hazardous materials (asbestos, lead paint) must be removed before recycling, and decontamination costs discourage recycling (Amadi & Mahachi, 2025). These demolition-specific barriers are largely absent from general C&D literature focused on construction-phase waste.

2.4. Construction Culture and Behavioural Barriers

A critical driver of concrete waste is the prevailing cultural approach. Fitchett and Rambuwani (2022) describe a "build-first, manage-later" mentality where timelines and cost pressures override sustainability, treating waste as unavoidable. The same applies to demolition: "demolish-first, manage-later" means no planning for material recovery. Ngcobo et al. (2024) confirm that ineffective project management is a critical challenge.

Phuluphedziso (2022) notes that many teams lack formal waste management training and effective communication, leading to over-pouring and miscommunication. Aseni et al. (2025) identify entrenched resistance to change, limited awareness, and fragmented industry practices as significant

behavioural barriers to circular economy adoption. Marsh et al. (2021) apply the COM-B model (Capability, Opportunity, Motivation) and Theoretical Domains Framework, finding that many professionals lack capability (skills and knowledge), opportunity (resources and time), and motivation (incentives and cultural support) to implement waste-reducing strategies.

2.5. Technological and Policy Interventions

Building Information Modelling (BIM) can reduce waste by improving design coordination, quantity estimation, and real-time decision-making, reducing over-ordering (Liphadzi et al., 2022). For demolition, BIM can model existing buildings to plan selective demolition sequences and estimate recoverable volumes. However, BIM adoption in South Africa remains uneven, particularly among SMEs, due to cost, skills shortages, and lack of awareness. Constraints to clients' acceptance of recycled materials (2024) identifies lack of recycling facilities, resistance to change, absence of appropriate technology, limited availability of materials, and lack of proper standards as key barriers.

Recycling concrete waste is another area of interest. Dun et al. (2021) found waste concrete powder performs comparably to traditional grouts. Simon et al. (2025) note that while successful international practices exist, South Africa's recycling rate needs improvement. De Villiers et al. (2024) quantify that the annual demand for aggregate and supplementary cementitious materials (77.9 Mt) far exceeds available CDW (12.2–24.3 Mt).

At the policy level, the National Environmental Management: Waste Act (NEMWA) No. 59 of 2008 mandates waste reduction, but compliance is inconsistent (Nzima & Koranteng, 2022). Municipal enforcement is weak (Berge & Von Blottnitz, 2022), and unlike Europe, South Africa lacks landfill taxes or recycling subsidies (Hasselsteen et al., 2026). Hasselsteen et al. (2026) compare the UK's landfill taxation and Extended Producer Responsibility (EPR) with the UAE's innovation-led approach, offering transferable lessons.

International best practices, such as the EU's Waste Framework Directive and Japan's pre-demolition audit requirements, offer transferable lessons, including enforceable recovery targets and economic incentives. Amadi and Mahachi (2025) confirm that landfill taxes, penalties for illegal dumping, and taxes on virgin material use are among the most effective policy interventions.

3. Research Methodology

This study adopted an interpretivist research philosophy, recognising that waste management

practices are shaped by social, cultural, and organisational contexts. Interpretivism focuses on practical, real-world problem-solving (Merli et al., 2020). A qualitative-dominant mixed-methods design was employed, combining semi-structured interviews and open-ended questionnaires to enable in-depth understanding of behavioural, operational, and institutional factors. An exploratory design captured rich stakeholder insights. The target population comprised construction professionals in Gauteng's demolition and construction sectors, including contractors, site managers, supervisors, and site-based workers. A purposive sampling strategy selected participants with direct concrete waste management experience. Selection criteria were: (a) minimum five years' continuous experience in the South African construction industry; (b) direct involvement in demolition, waste handling, site supervision, or construction management; and (c) operation across multiple Gauteng sites (Benoni, Springs, Roodepoort, Germiston, Johannesburg). Purposive sampling was appropriate because the research problem requires in-depth, context-specific insights from information-rich cases, with the five-year threshold ensuring sufficient practical exposure.

Data were collected over three weeks through telephonic and in-person engagements. The semi-structured questionnaire covered causes of concrete waste, material handling, recycling awareness, technological adoption (BIM), policy compliance, leadership, and education. A purely quantitative approach would fail to capture contextual details such as why contractors hold misconceptions or how the "build-first" culture operates. The qualitative-dominant design allows open-ended responses that capture nuance and unexpected themes, while the sample of nine respondents provides sufficient breadth to identify recurring patterns. Data were analysed using thematic analysis following Braun and Clarke's (2006) six-phase framework: familiarisation, initial coding, theme generation, theme review, theme definition, and write-up. Two researchers independently coded 20% of the data, achieving 87% inter-coder agreement. The questionnaire was pilot-tested with two professionals to ensure clarity and relevance. Ethical compliance followed University of the Witwatersrand guidelines: informed consent, anonymisation, and secure data storage. Clearance certificate protocol number CEM: EC/08/25/FG3/2427203/, Status: Approved, minimum risk.

4. Findings and Discussion

4.1. Findings

The questionnaire responses from nine construction professionals across Benoni, Springs, Roodepoort, Germiston, Parktown, Rosebank and Johannesburg revealed seven dominant themes. Table 1 summarizes

Table 1: Themes, sub-themes, representative quotes, and frequency (n=9)

Theme	Sub-themes	Example quote	Frequency
1. Poor planning and demolition protocols	Over-ordering, miscalculations; lack of pre-demolition audits; inadequate site security; no waste recovery plan	"Miscalculations by foremen ordering more concrete, suppliers supply in bulk." (Respondent 5, online)	7/9
2. "Build-first, manage-later" culture	Waste obstructs workspace; cleanup neglected due to fatigue or lack of resources; cost and schedule prioritised	"It creates piles of waste on sites which later are not effectively managed." (Germiston respondent)	8/9
3. Misconceptions about recycled concrete	Perceived as weak, low grade, short lifespan, contaminated, unsuitable for structural use	"Recycled concrete is perceived as being weaker than traditional concrete... full of contaminants." (Respondent 2, online)	8/9
4. Recycling infrastructure barriers	No nearby facilities; high transport costs; lack of municipal support; no storage containers for small projects	"Facilities are not enough close by for the majority of communities." (Benoni respondent)	9/9
5. Low technological adoption (BIM)	Unfamiliarity with BIM; lack of knowledge, skills, training; some recognise potential for accurate quantity estimation	"BIM is not known, people don't use it, they don't know it." (Roodepoort respondent)	9/9
6. Inconsistent policy enforcement	National Waste Act applies to large projects but ignored for small works; many professionals unaware of the Act	"For bigger projects it is effective, but for smaller projects people don't even know about it." (Germiston respondent)	8/9
7. Leadership and education gaps	Leadership influences behaviour, but few have received formal training or stakeholder collaboration	"No educational programs have been introduced to me." (8/9 responded "No")	8/9

the themes, sub-themes, representative quotes, and frequency of mention.

Poor planning was the most frequently cited cause. One participant noted, "Miscalculations by foremen ordering more concrete, suppliers supply in bulk" (Respondent 5). Another cited "non-compliance from unregistered construction companies dumping waste at convenient locations" (Respondent 1). The Benoni respondent added, "Not having proper equipment to store the material, disposing at convenient areas around them." Eight respondents described the "build-first, manage-later" culture. The Germiston company stated, "It creates piles of waste on sites which later are not effectively managed." A Roodepoort participant added, "It creates extra work and people will be tired to clean after." Eight respondents reported misconceptions that recycled concrete is weak or short-lived. Respondent 2 said, "Recycled concrete is perceived as weaker than traditional concrete... full of contaminants." All nine identified infrastructure deficits as a major barrier, with the Benoni respondent noting, "Facilities are not enough close by for the majority of communities." All nine were unfamiliar with BIM; the Roodepoort participant stated, "BIM is not known, people don't use it, they don't know it." Eight observed inconsistent policy enforcement, noting the Waste Act is effective for bigger projects but ignored for smaller ones. Eight

of nine said leadership influences sustainable behaviour, but eight also reported no educational programs or stakeholder collaborations had been introduced.

4.2. Discussion

Applying the COM-B model (Marsh, Brent & De Kock, 2021) reveals systemic deficits. Capability deficits include lack of BIM knowledge, recycling methods, and misconceptions about recycled concrete quality. Opportunity deficits include absence of nearby recycling facilities (all nine respondents), high transport costs, lack of municipal storage containers, and weak policy enforcement that allows smaller projects to operate with impunity. Motivation deficits include the "build-first" culture (eight respondents), prioritisation of speed and cost over sustainability, absence of financial penalties for landfilling, and lack of economic incentives. These categories reinforce each other: low capability reduces motivation, while limited opportunity makes sustainable practices impractical even when capability exists.

The findings align with Phuluphedziso (2022) and Fitchett and Rambuwani (2022) on poor planning and construction culture. However, this study extends prior work by providing demolition-specific insights (lack of

pre-demolition audits, rebar separation, contamination) largely absent from general C&D literature. Infrastructure barriers confirm Berge and Von Blottnitz (2022), and the BIM awareness gap aligns with Liphadzi, Musonda and Onososen (2022). The two-tier enforcement reality documented here provides empirical evidence for what previous literature had only suggested.

This study makes three contributions. First, it is the first empirical application of the COM-B model to C&D concrete waste in an African urban context. Second, it explicitly distinguishes construction-phase from demolition-phase waste, revealing barriers unique to demolition. Third, it documents two-tier policy enforcement empirically. Based on these findings, the following recommendations are offered: mandatory pre-demolition waste audits for all demolition permits (Gauteng municipalities); introduction of a landfill tax with recycling rebate (National Treasury/DEFF); investment in decentralised recycling infrastructure

such as mobile crushing units (municipalities/private sector); mandatory CPD training on C&D waste management (industry bodies); expansion of university curricula to include circular economy and design for deconstruction; municipal provision of waste storage containers for small contractors; and strengthening policy enforcement across all project scales through random inspections and integration with permitting systems (Figure 1).

5. Conclusion and Further Research

This research concludes that ineffective C&D concrete waste management in Gauteng arises primarily from a reactive construction culture, insufficient planning, limited technical and regulatory capacity, and persistent misconceptions about recycled materials. Using the COM-B framework, the study demonstrates

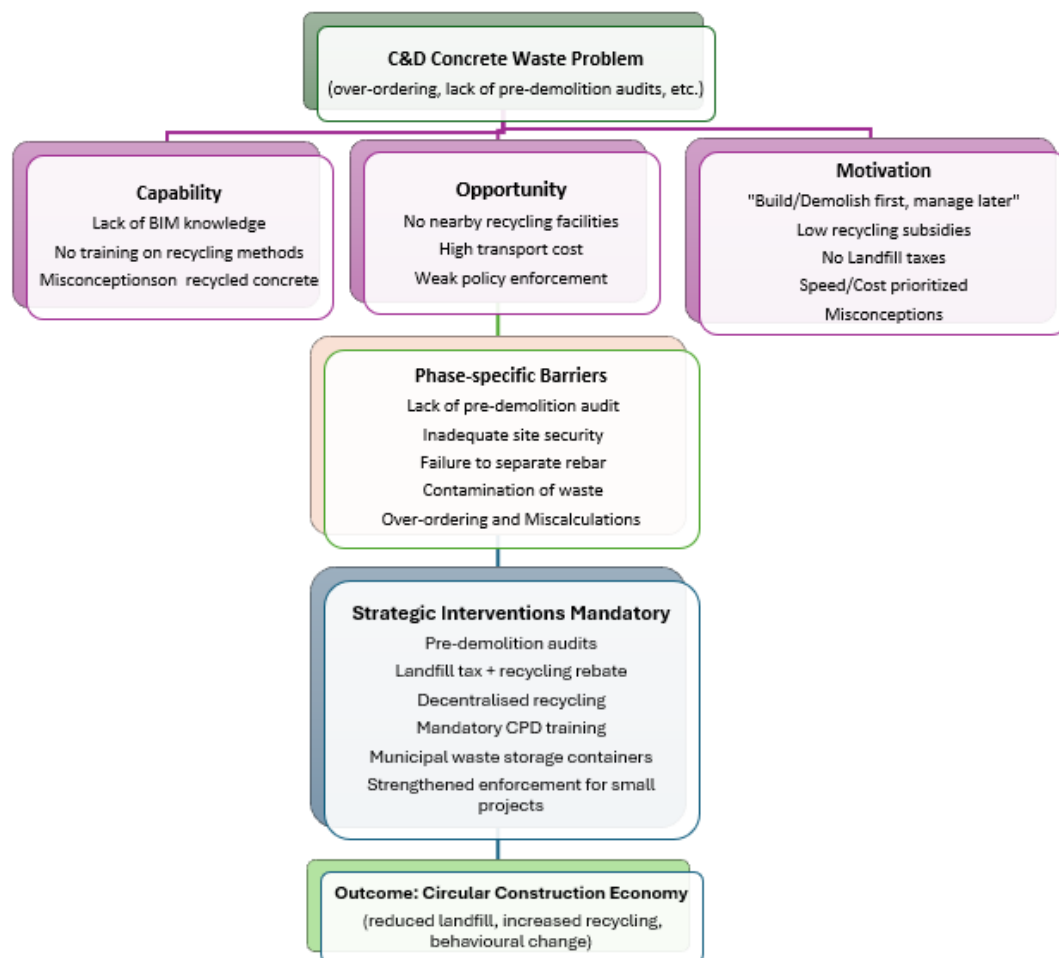


Figure 1: Conceptual Framework: Com-B Model for C&D Concrete Waste (adapted from Marsh, Brent & De Kock, 2021)

that sustainable waste management requires simultaneous improvements in capability (training, awareness, skills), opportunity (infrastructure, enforcement, incentives), and motivation (leadership, culture, economic drivers). While the National Environmental Management: Waste Act provides a strong legislative framework, its enforcement remains inconsistent – largely benefiting large contractors while neglecting smaller and informal projects. However, findings indicate a clear willingness among professionals to adopt improved practices, provided they receive institutional support through education, financial incentives, infrastructure development, and stronger leadership engagement. A holistic, collaborative approach integrating behavioural change, regulatory reform, technological innovation, and multi-stakeholder participation is essential to align South Africa's construction sector with circular economy principles and the Sustainable Development Goals.

Further research should include: (1) quantitative waste audits to measure demolition waste volumes, disposal costs, and recycling rates; (2) cost-benefit analyses of

recycling versus landfilling in Gauteng; (3) longitudinal studies assessing the long-term impact of policy interventions and training programmes; (4) investigation of the informal sector's role in C&D waste recovery; (5) pilot studies of digital waste tracking platforms; and (6) comparative studies across South African provinces to identify region-specific barriers and best practices.

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