PAPER 13

A DISCUSSION ON THE APPLICATION OF RECYCLED CONCRETE AGGREGATE IN THE BUILT ENVIRONMENT IN SOUTH AFRICA

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ABSTRACT

Civil infrastructure demands substantial quantities of natural aggregate, whose availability is increasingly challenged by depletion and by the environmental effects of its extraction and use. In response to these concerns, the use of recycled concrete aggregate (RCA) from construction and demolition waste has been gaining popularity in civil infrastructure. Despite considerable research, issues of variability, uncertain performance, and a lack of guidelines for characterisation and design continue to constrain the adoption of RCA.

This review presents a comprehensive overview of the available data on the known engineering properties of RCA in comparison with natural aggregate. RCA utilisation is discussed with reference to civil engineering applications. RCA is being used in unbound granular pavement layers, and to a lesser extent in bound layers. Beyond pavement applications, successful use of RCA has been reported in structural concrete, embankments, backfills and drainage systems. The available local and international literature suggests that, in controlled trials, RCA can achieve satisfactory performance across a range of applications; however, it is generally regarded as a cost-effective material for non-specialised applications and is not commonly used in high-value or critical applications. RCA use can also be viewed in the context of recycling, downcycling and upcycling. Much of the RCA in use is currently downcycled, particularly in unbound applications such as subbases, base courses and low-grade fill. True recycling, by contrast, occurs when the performance properties of the material are identical or very similar to those of natural aggregate. There is emerging potential to upscale the use of RCA in higher-value applications, where both performance and durability can be optimised by beneficiation techniques such as surface treatment to meet specific construction criteria. The sustainability benefit of RCA therefore rests not on its use alone, but on how well the material retains its original value across its lifecycle.

This paper highlights the need for a performance-based design framework that accounts for material variability and the associated performance uncertainties, to enable the safe and reliable application of RCA in the built environment in South Africa.

1. INTRODUCTION

The construction sector is one of the most resource-intensive industries in the world, consuming vast quantities of natural aggregate and generating roughly one-third of all solid waste (Akhtar & Sarmah 2018). Official national statistics indicate that 4.48 Mt of construction and demolition wastes (C&DW) was delivered to disposal sites in 2017, though independent estimates for the same year reveal much higher figures of of 10.8 Megatonnes (Mt) via a per-capita multiplier method and 20.2 Mt via material-lifetime analysis (Berge et al., 2022). The discrepancy, a factor of two to five, reflects the informal waste-management practices typical of developing economies, but it also reflects a systemic absence of measurement effort (De Villiers et al. 2024). What is not measured is not managed. The pressure is now immediate. However, Amadi & Mahachi 2025 state that landfilling is still the primary disposal option for C&DW in South Africa and the big metropolitan landfills that serve Johannesburg and Cape Town have less than five years of available airspace remaining. The country is running out of space with the model of disposal it relies on.

RCA reduces C&DW volumes going to landfill and simultaneously reduces demand for quarried virgin aggregate. Ohemeng & Ekolu 2020 found that producing one tonne of coarse RCA costs around 40% less than an equivalent tonne of natural aggregate, with an environmental benefit approximately 97% higher. Even so, local adoption remains minimal. The reasons include technical uncertainty about RCA's variable properties(Bester et al. 2017), the complete absence of South African national standards that would give engineers a specification basis (Gebremariam et al. 2025), and poor supply-chain visibility (Silva et al. 2017).

The case for RCA must be made with a clear sense of scale. Even at full recovery, the C&DW generated locally, estimated at 12.2 to 24.3 Mt each year, is modest against the roughly 77.9 Mt of coarse and fine aggregate that South Africa's construction sector consumes annually (De Villiers et al. 2024). RCA is therefore not a wholesale substitute for natural aggregate and presenting it as one would overstate the case. Its value lies instead in targeted, well-specified use that directs a reliable waste stream into the applications where it performs well and where the diverted volumes make a real reduction in landfill pressure.

The obstacle to that targeted use is not the underlying technology, which is well established internationally, but the absence of a local framework for applying it. South Africa has no national standard for RCA, no agreed test methodology and no consolidated evidence base, so a practising engineer has no defensible basis on which to specify the material, however sound the global case. This review sets out to close that gap. It draws the scattered evidence together under four themes. These are material properties and variability (including latent cement content); beneficiation methods and their local viability; performance in structural concrete and in pavement layers; and the life-cycle cost and carbon case. A short policy and research agenda closes the paper.

2. MATERIAL PROPERTIES, VARIABILITY AND LATENT CEMENT CONTENT

2.1 Disparity between RCA and natural aggregate

RCA differs from natural aggregate not merely in origin but in structure.

A layer of old hardened cement paste, the adhered mortar (AM), remains bonded to each aggregate particle after crushing. This mortar is porous, absorptive and weaker than the underlying original aggregate, which raises water absorption and lowers specific gravity and density. The effects cascade through the concrete mix, so that workability drops, strength is reduced, shrinkage increases and durability is compromised (Behera et al. 2014).

Two interfacial transition zones (ITZ) define the structural weak points of recycled aggregate concrete (RAC), one between the original aggregate and the adhered mortar, and a second between the old mortar and the new cement paste Figure 1. Both are more porous than in conventional concrete, and both are crack-initiation sites under load (Alibeigibeni et al. 2025). The size and density of the AM layer depends on parent concrete strength, the crushing method, and recycling history (Bai et al. 2020).

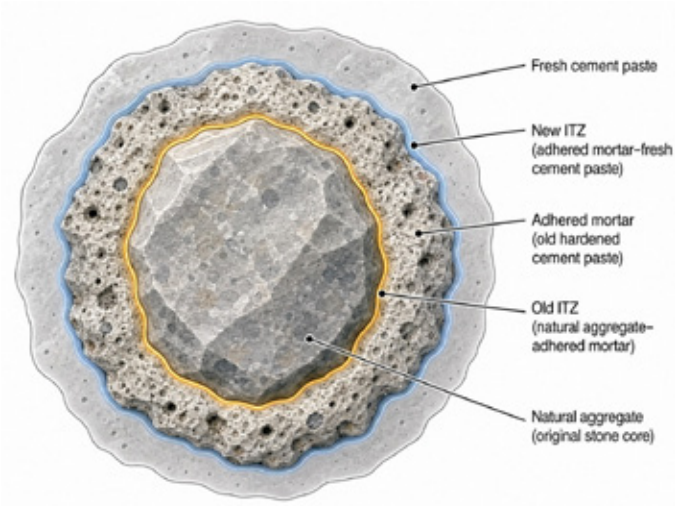


FIGURE 1: *Schematic of a recycled concrete aggregate particle showing the adhered mortar and the dual interfacial transition zone (after Fanijo et al. 2023)*

Parent concrete grade is particularly important. Gholampour & Ozbakkaloglu 2018 showed that the use of RCA from a parent concrete of 110 MPa produced RAC with long-term qualities comparable to those of standard concrete. Gebremariam et al. 2024 further verified this trend on a broader scale, indicating that RAC obtained from high-strength parent concrete (≥80 MPa) can perform equally or better than conventional concrete, while source material of lower strength leads to RCA with more pronounced AM-related deficiencies. This is directly relevant to South African conditions, where the country's building stock includes structures built under widely varying specifications, with pre-1990s construction typically in the range of 20–30 MPa based on mix design practices of the era. Demolition of this older stock will yield lower-grade RCA, and specifications written for South Africa should account for this rather than importing thresholds derived from high-strength European demolition waste.

2.2 Variability: the critical challenge for South African conditions

Variability, not any single material deficiency, is what makes RCA hardest to specify in practice. Unlike quarried aggregate, RCA can vary substantially between demolition sites, and even within a single consignment where selective demolition was not practised. Global evidence on within-batch variability is instructive, although the findings are not uniform. Pacheco et al. 2019 found that full replacement of natural aggregate with RCA did not increase compressive strength variability beyond what is normal for natural aggregate concrete (NAC), but the intermediate replacement ratios, around 50%, introduced more variability than either extreme. The mechanism is blending, whereby partially absorptive RCA particles mixed with non-absorptive natural aggregate create heterogeneous effective water-to-binder ratios that neither all-RCA nor all-natural mixes experience. Gaurav et al. 2023 showed that the appropriate statistical distribution for RAC compressive strength changes with curing age and replacement level, with Weibull models outperforming normal distributions for high-replacement mixes at early age.

In South Africa, variability is compounded by non-selective demolition practices, which crush structural concrete together with masonry, plaster, ceramic tiles, and asphalt. This produces highly heterogeneous fine fractions that downstream processing cannot rectify. For instance, attempting to manage this erratic material through pre-soaking (a common strategy for beneficiation) backfires, as the highly porous plaster and brick contaminants trap excess water, leading to a significant deterioration in both fresh and cured properties (Bester et al. 2017). The study concludes that recycled fine aggregate carries much greater negative impact than coarse in the South African C&DW context, and that the pre-soaking procedure for fine fractions warrants special attention.

The quality thresholds and beneficiation methods discussed later in Section 3 apply primarily to coarse RCA. Fine RCA from mixed South African demolition waste presents additional challenges that are directly relevant to the block and paver applications detailed in Section 4.1 as the most accessible near-term structural entry point, and a separate process specification for fine RCA is needed for the housing and low-cost construction sector.

2.3 Latent Cement Content: an under-examined variable

One property of RCA that receives less attention than it warrants is Latent Cement Content (LCC). Partially hydrated and unhydrated cement particles, primarily dicalcium silicate (C_2S), remain embedded within the adhered

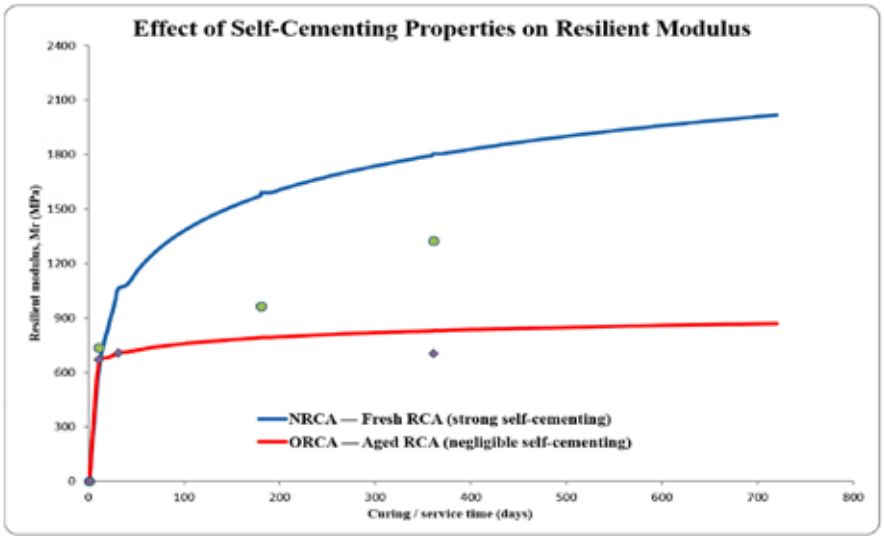


FIGURE 2: *Progressive stiffness gain of recycled concrete aggregate with curing time, driven by latent cement content (after Wang et al. 2024)*

mortar. When wetted or compacted, as in pavement base layers, these particles reactivate, and the RCA layer gains strength over time through self-cementation.

Jitsangiam et al. 2015 reported this through XRD and SEM analysis, showing that high-grade RCA samples transformed from unbound material into effectively stabilised material over varying curing periods. Wang et al. 2023 linked self-cementing intensity directly to pavement resilience. Wang et al. 2024 tracked microstructural improvement over 720 days and showed that RCA sub-base and base layers progressively stiffen without any cement addition (Figure 2), a significant cost advantage for large-volume road construction. For South African pavement management, that 720-day window, roughly two years of service, implies that conservative design-opening moduli should be specified, with a scheduled condition survey at 24 months to verify and record the stiffness gained in service.

Cheng et al. 2024 found that severe re-cementation in 13-year-old in-service pavements produced strength comparable to cement-treated base but also increased the probability of reflective cracking. South African pavement design guidelines will need to incorporate this phenomenon explicitly.

South Africa has an early domestic literature on self-cementation in C&DW materials. Paige-Green (2010) conducted a preliminary study of self-cementation in recyclable cementitious materials within the South African road network, finding meaningful self-cementing potential in demolition waste and stabilised road materials while flagging the risk of over-stabilisation. The most substantial South African work is that of Rudman, whose laboratory programme on RCA and masonry C&DW (Rudman & Jenkins 2015) culminated in a doctoral dissertation on the self-cementation of RCA in roads (Rudman 2019). That body of work established, through X-ray diffraction (XRD) analysis and unconfined compression, monotonic and cyclic testing, that residual dicalcium silicate (C_2S) in the fine fraction and adhered mortar is the primary origin of self-cementation, that pH is a workable indicator of self-cementing potential, and that conventional short-term testing without curing substantially underestimates structural capacity.

3. BENEFICIATION: METHODS WITH LOCAL APPLICABILITY

There are two approaches to solve the adhered mortar problem, either by removing the mortar or by densifying it. The whole spectrum of methodologies has been assessed for both strategies by Tam et al. 2021 and Shi et al. 2016. The critical question for South Africa is not which method is theoretically best but which is scalable and commercially viable locally. Table 1 compares the four principal approaches. Two stand out for near-term applicability, namely accelerated carbonation and the incorporation of supplementary cementitious materials (SCMs).

Accelerated carbonation improves aggregate quality and sequesters CO_2 at the same time. CO_2 reacts with calcium hydroxide and calcium silicate hydrate in the mortar to generate thick calcium carbonate, filling the pores and strengthening the top layer (Behera et al. 2014). Zhan et al 2020 confirmed through XRD, thermogravimetric analysis (TGA) and scanning electron microscopy (SEM) that carbonation improves both interfacial zone (ITZ) microhardness and the bond strength between treated RCA and fresh cement paste. As noted in Section 3.3, carbonation reacts with unhydrated cement phases as well as calcium hydroxide, so latent cement content (LCC) acts as an active reactant, and RCA with higher LCC benefits proportionally more from carbonation, which makes a strong case for characterising LCC before any investment in carbonation processing capacity. Pu et al. 2023 compared carbonated RCA against traditional two-stage crushing and heating treatment using life cycle assessment (LCA) and found lower energy demand and environmental impact for carbonation across all categories. Industrial CO_2 is potentially available from Sasol's synthetic fuels operations and from certain steel-processing facilities in South Africa, although the logistics and cost of supplying CO_2 to RCA processing plants have not yet been established in published South African literature.

SCM incorporation, the addition of fly ash, ground granulated blast-furnace slag (GGBS) or silica fume to RCA, improves ITZ quality from the binder side without modifying the aggregate. Qureshi et al. 2020 showed that the combination usage of SCM and steel fibre significantly enhanced strength and durability. The mechanism is two-fold: a pozzolanic reaction in which the reactive silica and alumina in fly ash, GGBS or silica fumes consumes the calcium hydroxide that concentrates at the ITZ during cement hydration, converting it into additional calcium-silicate-hydrate gel, combined with a physical filler effect in which the fine SCM particles pack into the ITZ pore structure and block capillary pathways. Together these densify the ITZ and reduce its permeability, which is the basis for the strength and durability gains measured (Qureshi et al., 2020). The commercial viability of SCM-enhanced RAC is clear because both fly ash and GGBS are available as industrial by-products in South Africa. SCM incorporation requires no capital investment in aggregate processing plant and is the appropriate starting point for early-market adoption.

Mechanical abrasion and acid pre-soaking are technically effective globally but face practical constraints in South Africa. Savva et al. 2021 identified an optimal three-hour abrasion treatment window requiring process control and plant investment that South Africa's nascent RCA industry cannot yet support at scale. Acid pre-soaking (Ouyang et al. 2020, Tam et al. 2007) requires chemical handling infrastructure that the local regulatory environment makes commercially difficult. Both methods are viable for research and quality-improvement trials but are unlikely near-term commercial pathways.

TABLE 1: *Beneficiation methods: a comparative assessment for South African conditions*

Method	Mortar reduction	Water absorption reduction	Strength improvement	Local scalability (SA)	Source
Drum abrasion	High (~40%)	Moderate	Moderate	Low — plant investment required; process-control demanding	Shi et al. 2016; Savva et al. 2021
Acid pre-soaking	Moderate	High (avg. 24.5%)	Moderate	Low — chemical handling/disposal constraints in SA context	Tam et al. 2007; Ouyang et al. 2020
Accelerated carbonation	Moderate (densification)	High; amplified by LCC	High; sequesters CO_2	Medium — potentially viable where CO_2 and throughput available; SA logistics unestablished	Zhan et al. 2020; Pu et al. 2023
SCM incorporation	N/A (binder-side)	N/A (ITZ improvement)	High (durability)	High — fly ash and GGBS available domestically; no plant required; lowest entry barrier	Qureshi et al. 2020

Carbonation and SCM incorporation address different parts of the problem and are complementary. The most pragmatic near-term approach is SCM incorporation at the mix-design stage, with carbonation treatment held as a medium-term investment once processing scale develops.

4. APPLICATIONS IN THE BUILT ENVIRONMENT

4.1 Structural concrete

The most consistent finding in the structural concrete literature is that up to 20–30% replacement of natural aggregate with RCA has no statistically significant effect on compressive strength, provided the RCA meets basic quality thresholds. Thomas et al. 2018 established this range across both strength and durability testing. Kazmi & Lu 2024 reviewed evidence from multiple countries across mechanical performance, economic outcomes, and national standards and found that 20% is the replacement ratio that consistently balanced all three and should serve as the default starting point for national standards in countries lacking local data. At above 30% the strength drops are more predictable, but can be compensated by adjustment of the water to binder ratio, use of SCMs or pre-treatment.

At the level of the structural member, Deresa et al. 2020 reviewed experimental results of reinforced RAC beams and columns and found structural performance comparable to or marginally below NAC equivalents for flexure, shear and seismic loading i.e. the conservative end of existing structural design approaches can accommodate RCA without fundamental revision.

The 20% level indicates a quality requirement. Thomas et al 2018 and Kazmi et al. 2024 both use the figure for RCA that satisfy particular requirements, that is, water absorption below 5% and Los Angeles abrasion loss below 40%. These thresholds should be specified and verified at the source-qualification stage, with batch re-testing for large or extended contracts. Where RCA does not meet them, the replacement ratio should be reduced to 10–15% and SCM enhancement applied to compensate. Given South Africa's mixed-waste demolition practice, this lower-grade case may be common rather than exceptional. This is consistent with, not contradictory to, the variability evidence in Section 2.2, as Pacheco et al. 2019 address statistical spread at a given replacement ratio, whereas this 20% figure addresses mean strength retention conditioned on source quality (Section 2.1), and is a conservative default for unverified or mixed-quality RCA rather than a ceiling on RCA performance generally.

Fine RCA from South African demolition waste raises additional considerations. As noted in Section 2.2, pre-soaking fine RCA fractions introduces excess water and degrades concrete properties (Bester et al. 2017), so recycled fine aggregate carries a greater penalty than coarse RCA. Low-cost housing and block or paver production, identified as the most accessible near-term structural entry point (Olubambi et al. 2025), nonetheless depend on fine fractions. Simon et al. 2025, in a South African review of low-strength concrete bricks and blocks, report evidence from international studies that fine and coarse aggregate replacement at around 25% and 50% respectively has little impact on compressive strength, with higher coarse replacement levels reducing strength unless compensated by increased cement content, fine-aggregate adjustment, or improved curing, figures obtained without any RCA pretreatment.

They also note that masonry content in the recycled fraction can raise later-age strength through further hydration of residual cement, a direct, product-scale expression of the latent cement effect discussed in Section 2.3, and report RCA at roughly 10% below the cost of virgin material in the Cape Town market. The block and paver route is therefore promising, but specifiers should not assume that performance data for coarse RCA transfers directly to it, and a parallel process specification for fine RCA does not yet exist in South Africa. The 20% coarse RCA threshold is well supported, but it is meaningful only when paired with minimum quality verification and explicit guidance on what to do when the thresholds are not met.

4.2 Pavement and road construction

Road construction is the most appropriate near-term entry point for large-volume RCA use in South Africa. Pavement sub-base and base layers (Figure 3) are subject to quality-control requirements that scale with road category, as high-category and national roads apply stringent control with little tolerance for variability, while lower-category roads permit more. RCA is therefore more plausibly suited to lower-category roads than national roads, though firmer category-specific recommendations require more local variability data than currently exists. Where conditions permit its use, sub-base and base layers are where LCC transitions from a design uncertainty into a performance advantage.

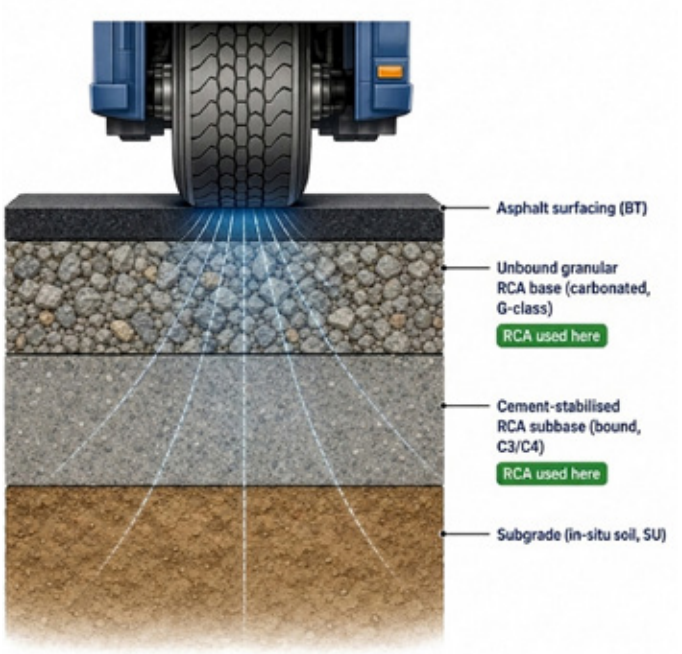


FIGURE 3: *Typical flexible pavement structure, indicating the base and sub-base layers suited to recycled concrete aggregate*

The global pavement evidence is consistent and now spans review, mechanism and field scales. At review level, Fanijo et al. 2023 and Khan et al. 2024 found RCA suitable across all pavement layer types and confirmed adequate california bearing ratioio (CBR), compressive strength and resilient modulus against typical road specifications in multiple jurisdictions, with performance closely tied to production method and mortar content. The mechanism behind that performance is the self-cementing stiffening documented by Wang et al. 2024, whose RCA sub-base and base layers reached resilience comparable to lightly stabilised materials over 720-day curing without any cement addition. Field studies then confirm the laboratory trend. Pouranian et al. 2025 reported a Florida DOT programme in which RCA outperformed standard lime rock base on deflection, rutting resistance, smoothness and ride quality over several years. The evidence converges on a single conclusion, that where self-cementing RCA is used in base and sub-base layers, long-term performance exceeds opening-condition predictions.

The only South African testing that directly addresses pavement specification is Pitso et al. 2024, which evaluated RCA from local demolition sources against the G5 classification. The results were positive, with RCA

performing adequately as an unbound material and cement addition at 2–3% producing results suitable for treated layers. This is laboratory-based and drawn from a limited range of sources, so it is a starting point rather than a standard. Rudman's doctoral work (Rudman 2019) provides the local experimental evidence for self-cementation behaviour in roads, but its geographic scope is narrow, and the phenomenon remains systematically uncharacterised across South Africa's demolition stock and climate zones.

Cheng et al. 2024 observation on reflective cracking risk from severe re-cementation warrants explicit attention in South African design practice. Incorporating LCC-informed design assumptions from the outset, rather than retrofitting after anomalies appear, requires long-term field trials across South Africa's climate zones.

5. COST AND LIFE-CYCLE EVIDENCE

The economic case for RCA in South Africa rests on a thin evidence base. Ohemeng & Ekolu 2020, the most directly applicable local cost analysis, found the long-term production cost of coarse RCA to be approximately 40% below that of natural aggregate, with a per-tonne environmental benefit roughly 97% higher. These figures derive from a single study and should be read as indicative rather than settled. The important qualification is that the net financial benefit of RCA production in isolation is negative, because revenue from RCA sales alone does not cover production costs once landfill-avoidance savings and reduced haulage are excluded. The market will not solve the adoption problem on its own, as the signal requires a policy-created incentive, such as landfill pricing, a procurement requirement or carbon pricing, each a lever within government's direct control.

The life-cycle evidence is more consistent, with two variables to decide whether recycled aggregate concrete has a net environmental advantage: transport distance and cement content. Where the demolition source and the new project are close, the carbon savings are real (Visintin et al. 2020), a condition South Africa's metropolitan areas generally satisfy. Cement dominates the carbon footprint regardless of aggregate type, and Sabău et al. 2021 found that replacing 25% of cement with fly ash cut emissions by up to 17%, a benefit additive to RCA rather than an alternative. However, two cautions apply to these life cycle claims. First, Hasheminezhad et al. 2024 showed the choice of functional unit (volumetric, gravimetric or performance-adjusted) materially changes the outcome, with performance-adjusted comparisons the more defensible. Second, Zhang et al. 2019 noted that CO_2 uptake through natural carbonation is routinely omitted, so published figures are likely conservative. The environmental case for urban-proximate, SCM-enhanced RCA is therefore well supported, while the financial case depends on policy activation. Both point to the same binding constraint as the absence of government-level intervention, in the form of national standards, procurement requirements or pricing instruments such as landfill levies or carbon pricing, rather than a lack of informal best-practice guidance, as the obstacle to widespread adoption. This is consistent with international evidence that stardadization and government intervention, rather than technical readiness, are what drive recycled-aggregate market development (Gebremariam et al. 2025, Silva et al. 2017).

6. CONCLUSIONS AND RECOMMENDATIONS

This paper has reviewed the state and potential of recycled concrete aggregate (RCA) in the South African built environment. Three contributions follow from the synthesis. First, it explicitly links latent cement content (LCC) characterisation, carbonation treatment potential and pavement design uncertainty. Second, the beneficiation comparison in Table 1 frames method selection against local scalability rather than laboratory performance, a distinction that matters for practitioners who cannot import European processing infrastructure. Third, it establishes that the binding constraint on RCA adoption in South Africa is regulatory rather than technical.

The technical case for RCA is largely established. The 20% figure is a conservative default for RCA of unverified or mixed source quality, which is the typical South African case as it is not a ceiling on RCA performance in general, since RCA derived from high-strength, well-characterised parent concrete has been shown to sustain full or near-full replacement without performance loss (Section 2.1). Coarse RCA can replace up to 20% of natural aggregate in structural concrete with no significant loss of strength where the quality thresholds are met, namely water absorption below 5% and Los Angeles abrasion loss below 40%, and where they are not, the replacement ratio should drop to 10-15% with supplementary cementitious material compensation. For pavement sub-base and base layers, the G5 results of Pitso et al. 2024 provide a starting basis, subject to the long-term field performance data that does not yet exist. A parallel specification for fine RCA, relevant to the housing and block or paver sector, is also needed.

Despite this technical readiness, local adoption remains minimal, and the underlying material is not the limiting factor. What this review cannot resolve, on the available evidence, is whether the binding constraint is regulatory in a strict sense, that is, the absence of national standards, specifications and policy instruments, or whether it is engineers' risk-averse response to that absence, that is, a reluctance to specify RCA in the absence of guidelines against which to defend a design decision. The two are difficult to separate in practice, since the absence of standards is plausibly what sustains the perception of risk: without a specification basis, an engineer has no defensible benchmark against which to qualify RCA, regardless of how the material itself performs. South Africa has no dedicated national standard governing RCA use in either structural concrete or pavements. International experience is consistent on this point, that standardisation and government intervention, not technical readiness, drive recycled-aggregate market development Silva et al. 2017, and developing countries need locally calibrated standards rather than the direct adoption of European norms (Gebremariam et al. 2025). The technical knowledge base for a first-generation South African standard is substantially established in the global literature. Integrating RCA into the built environment requires design blueprints to be reimagined judiciously. Furthermore, scaling its use in South Africa demands that procurement standards and specifications originally written for conventional materials be carefully adapted for well-characterized alternative materials.

On this basis, the following recommendations are offered, ordered by their effect on adoption. Standards development is first-order as the others either enable the standard or create the demand that makes investment in RCA supply chains rational.

1. Develop best-practice guidelines and SANS standards for the use of RCA in specific applications of the built environment.
2. Incentivize RCA use in public road construction. Rather than a procurement mandate, which would be difficult to enforce given inconsistent local RCA availability and quality, incentives such as preferential tender scoring, tax relief or rebates for contractors who use a specified minimum percentage of unbound sub-base aggregate as RCA, where locally available, would create the demand signal that commercial supply currently lack, a softer version of the mechanism by which several European countries seeded their recycled-aggregate markets (Silva et al. 2017).
3. Monitored road pavements trials spanning 5 to 10 years across diverse climatic zones, capturing the wet, dry, and moderate regions that

characterise the South African context are essential to generate the empirical performance data conservative design engineers require.

4. Systematically characterise LCC and variability in South African demolition concrete. Sampling demolition sites across major metropolitan areas, building eras, and structural types would resolve the central design uncertainty identified in this review and determine the feasibility and consistency of carbonation treatment for South African RCA.
5. Reform construction and demolition waste data collection. A mandatory C&DW audit on demolition permits, requiring the separation, weighing and reporting of concrete, masonry and other fractions, would close the two- to fivefold gap between official disposal statistics and actual volumes within a few years.

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