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Circular Construction Practices for Small Urban Projects

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Abstract

Small urban construction projects collectively influence substantial flows of materials, demolition waste, embodied carbon, local transport, and resource consumption, yet circular construction research and implementation are often associated with major developments capable of supporting sophisticated material passports, lifecycle assessment systems, specialized consultants, and extensive supply-chain coordination. This paper develops a conceptual–methodological framework for applying circular construction principles to smaller urban projects, including renovations, shop conversions, small commercial developments, residential additions, community facilities, and low-rise infill construction.

The framework prioritizes practical interventions that can be introduced without creating disproportionate administrative burdens: retention of existing structures, pre-construction material inventories, selective deconstruction, direct component reuse, procurement of recovered materials, modular detailing, reversible connections, design for adaptability, and local material-exchange networks. Existing research demonstrates that circularity in construction extends beyond recycling and that higher-value strategies such as reuse, adaptability, component recovery, and design for disassembly can preserve greater material utility.

A scenario-based analytical model is used to illustrate progressive improvements in material-value retention under increasingly circular project configurations. Because no primary construction-project dataset was supplied, all quantitative values are explicitly simulated and do not represent measured project outcomes. The analysis suggests that small projects can achieve meaningful circularity when design and procurement decisions are made before demolition and construction commence. The paper concludes that circular construction for small urban projects should be implemented as a proportionate decision hierarchy centered on retaining what already exists, recovering reusable elements, minimizing irreversible assemblies, sourcing locally available secondary materials, and documenting future recovery potential.

Keywords: circular construction, small urban projects, material reuse, design for disassembly, adaptive reuse, construction waste, urban mining, circular economy.

1. Introduction

The construction sector transforms large quantities of raw materials into buildings and infrastructure while simultaneously generating substantial demolition and construction waste. Conventional project delivery frequently follows a predominantly linear sequence in which materials are extracted, manufactured, transported, assembled, used, demolished, and eventually recycled, downcycled, or discarded. Circular-economy thinking challenges this pattern by seeking to maintain the functional and economic value of buildings, components, and materials for longer periods. Pomponi and Moncaster argue that the built environment requires a distinct circular-economy research framework because buildings operate at an intermediate scale between individual products and wider urban systems, creating technical, economic, social, and institutional challenges that cannot be understood through material recycling alone.

The relevance of circularity is particularly strong in cities because urban areas simultaneously contain large stocks of existing materials and continuous demand for renovation, redevelopment, maintenance, and infill construction. The concept of urban mining recognizes existing buildings as potential repositories of future resources rather than treating demolition exclusively as waste generation. Research examining the recovery potential of urban building stocks demonstrates that building components can become secondary construction resources when their quantity, location, condition, and recovery feasibility are understood. This perspective is important for small projects because secondary materials generated by one neighborhood renovation may be suitable for another nearby project, potentially reducing both material extraction and transport.

However, circular construction is often perceived as difficult for smaller developments. Major projects may be able to fund detailed lifecycle assessment, specialist deconstruction planning, digital material passports, product traceability platforms, and bespoke circular procurement systems. Small contractors, property owners, architects, and community organizations generally operate with shorter project schedules, smaller teams, tighter cash flow, limited storage space, and fewer opportunities to influence product manufacturers. Research reviewing circularity in the construction industry identifies persistent barriers involving knowledge, standardized practices, economic models, technical uncertainty, and coordination across the construction supply chain. These constraints suggest that circular construction for small projects must be designed around proportionality rather than administrative complexity.

A further conceptual problem is that circular construction is sometimes reduced to improved waste sorting or greater use of recycled materials. Such measures are useful, but they retain less value than preventing unnecessary demolition or directly reusing complete building components. Ghisellini, Ripa, and Ulgiati emphasize that circular construction seeks to maximize reuse and recovery while reducing waste generation across production, consumption, distribution, and material-recovery processes. Dams and colleagues similarly demonstrate that simple modular design, reusable materials, reversible mechanical connections, and adaptability can substantially improve circularity at the project-design stage. This indicates that circular performance is fundamentally influenced before construction waste is generated.

The present study therefore investigates how circular-economy principles can be translated into a practical framework for small urban construction projects. It proposes that smaller developments should prioritize a limited number of high-impact decisions: retain existing building fabric where feasible, survey materials before removal, distinguish deconstruction from demolition, identify direct reuse opportunities, reduce composite and permanently bonded assemblies, specify replaceable components, use secondary materials where performance can be demonstrated, and maintain basic records for future repair or disassembly. The study is conceptual rather than empirical because no actual construction-project dataset has been provided. The quantitative section uses simulated values solely to illustrate the expected direction of improvement under progressively circular construction strategies.

2. Objectives of the Study

2.1 Development of a Proportionate Circular Construction Framework

The first objective is to develop a circular-construction framework suitable for projects that do not have the financial, technical, or organizational resources of major developments. The framework emphasizes measures that can be incorporated into ordinary architectural design, procurement, demolition planning, and site management without requiring a highly specialized circular-economy management structure.

The objective is based on the principle that small-project circularity should be evaluated by material-value preservation rather than by the number of sustainability procedures adopted. A simple decision to retain an existing structural wall, reuse internal doors, or specify demountable partitions may create greater circular benefit than a technically elaborate reporting process that has little influence on material outcomes.

2.2 Examination of Material Retention Across Progressive Circular Practices

The second objective is to examine conceptually how different levels of circular construction may influence the retention of material value. Five configurations are considered: conventional linear construction, waste segregation and recycling, selective salvage and direct reuse, modular and reusable component design, and an integrated circular-construction strategy.

The analysis further seeks to distinguish recycling from higher-value circular practices. Recycling can retain material content, but direct component reuse generally preserves more of the manufacturing effort, embodied energy, functional utility, and economic value originally invested in a building element. The framework therefore gives priority to retention, adaptation, reuse, and recovery before recycling.

3. Review of Literature

3.1 Circular Economy and Material Value in the Built Environment

Pomponi and Moncaster identify the built environment as a critical field for circular-economy transition because buildings combine long service lives, high material intensity, multiple ownership structures, and interactions among design, construction, operation, and end-of-life decisions. Their framework highlights the need for interdisciplinary approaches linking technological, economic, environmental, social, behavioral, and policy dimensions. This perspective is particularly relevant to small projects because technical reuse decisions frequently depend on economic timing, contractor capability, storage, liability, and client acceptance.

Benachio, Freitas, and Tavares' systematic review demonstrates that construction-sector circularity includes a broad range of practices and that the absence of widely established implementation models remains a barrier. Munaro, Tavares, and Bragança similarly identify significant research attention to construction and demolition waste reuse while noting continuing limitations in holistic circular business models and practical assessment approaches. Together, these findings indicate that construction circularity requires a clearer translation from general principles into project-level decisions.

Material reuse has particular importance because it retains more embedded value than many recycling processes. Nußholz and colleagues argue that reused building materials can provide environmental benefits by avoiding impacts associated with production of equivalent virgin products, while also identifying institutional and market barriers to business models based on recovered materials. Research on modular-building reuse similarly demonstrates that direct component reuse can produce substantial environmental advantages relative to material recycling when building systems are deliberately designed for recovery.

3.2 Design for Disassembly, Adaptability, and Component Reuse

Circular construction cannot depend entirely on recovering materials from buildings that were never designed to be dismantled. Many contemporary assemblies rely on adhesives, composite products, concealed fasteners, wet construction, and interfaces that make separation technically difficult or economically unattractive. Design for disassembly seeks to address this problem by considering future separation, replacement, and recovery when components are initially selected and assembled.

Dams and colleagues developed a circular construction evaluation framework emphasizing simplicity, modularity, standardization, reusable materials, accessible mechanical connections, and adaptability. Their work demonstrates that circularity can be improved substantially through relatively straightforward design decisions rather than through technological complexity alone. A complementary circular-economy index for design for disassembly, deconstruction, and resilience similarly emphasizes the importance of decisions made across design, production, maintenance, and end-of-life stages.

Adaptive reuse extends the same principle from components to entire buildings. Foster's research on circular strategies for adaptive reuse demonstrates that extending the life and utility of existing buildings can reduce environmental impacts while preserving urban value. Sanchez and Haas further show that selective disassembly can support adaptive reuse by identifying combinations of deconstruction methods that preserve usable building components. For small urban projects, these findings imply that retaining an existing structure or interior element should be investigated before replacement becomes the default design response.

3.3 Small-Project Constraints and the Need for Local Circular Networks

Circular construction frequently requires coordination among owners, designers, demolition contractors, builders, suppliers, waste operators, regulators, and potential users of recovered materials. Small projects often lack the volume necessary to justify dedicated reverse-logistics systems. Reclaimed components may also become available at a different time from when another project requires them, creating storage and scheduling difficulties.

Research concerning construction and demolition waste identifies technical, economic, legal, behavioral, and information barriers to circular implementation. Problems include uncertain quality, inconsistent specifications, dismantling costs, sorting requirements, transport, recovery infrastructure, and the absence of stable markets for reused products. Standardization research further suggests that reuse can be constrained when dimensions, specifications, certification, and product information are insufficiently consistent to support confident secondary use.

These barriers are especially important at small project scale, yet small urban projects also possess an advantage: geographic proximity. Local salvage yards, construction-material exchanges, municipal reuse centers, neighborhood contractors, digital marketplaces, and coordinated project networks can shorten the distance between material recovery and reuse. Circular construction at small scale may therefore depend less on sophisticated global supply chains and more on strong local visibility of available materials.

4. Research Methodology

4.1 Conceptual Research Design

The study adopts a conceptual–methodological design based on structured synthesis of literature concerning circular economy in the built environment, adaptive reuse, construction and demolition waste, urban mining, component reuse, and design for disassembly. No completed building projects, contractors, architects, or clients were sampled as primary empirical subjects.

The analytical unit is the small-project circular intervention, defined as a practical design, procurement, demolition, or construction decision that can preserve existing material value or increase future recovery potential. The study concentrates on interventions that can realistically be considered within renovation, infill, small commercial, residential, and community-scale projects.

4.2 Circular Practice Assessment Framework

The framework categorizes circular construction into five operational domains: retention of existing assets, recovery planning, direct reuse, reversible design, and local circular procurement. These domains are intended to be simple enough for ordinary project teams to use during initial design and pre-construction review.

Table 1: Proportionate Circular Construction Framework for Small Urban Projects

Circular Practice Domain	Principal Linear Risk	Practical Small-Project Intervention	Expected Circular Benefit
Existing-asset retention	Useful fabric removed prematurely	Assess repair, adaptation, and partial retention before demolition	Extends building and component service life
Pre-construction recovery planning	Reusable elements destroyed during rapid demolition	Conduct a basic component and material inventory	Improves salvage visibility and sequencing
Direct reuse	Recoverable components sent to	Reuse doors, timber, fixtures, pavers, partitions,	Preserves embodied material and

Circular Practice Domain	Principal Linear Risk	Practical Small-Project Intervention	Expected Circular Benefit
	recycling or disposal	and suitable structural elements	manufacturing value
Reversible construction	New assemblies become difficult to separate	Use accessible mechanical fasteners and modular interfaces	Supports maintenance, replacement, and future recovery
Local circular procurement	Secondary materials overlooked because of fragmented supply	Identify local salvage sources and nearby reuse opportunities	Reduces virgin-material demand and transport requirements

The framework follows a value-retention hierarchy. It first asks whether an existing element can remain in service. If retention is impossible, the next question is whether the component can be removed intact and reused. Material recycling becomes important only after higher-value options have been reasonably evaluated.

4.3 Scenario Simulation and Material Value Retention Index

Five hypothetical project configurations were developed to illustrate progressive circularity. A conventional project represents predominantly linear procurement and demolition. The second scenario introduces waste segregation and recycling. The third adds selective salvage and direct reuse. The fourth incorporates modular reusable design and reversible connections. The fifth combines retention, recovery, reuse, circular procurement, and design for future disassembly.

The index is intentionally broader than waste diversion. A project can achieve a high recycling rate while still destroying components that could have remained in service. The simulated results therefore assign greater conceptual value to retention and direct reuse than to lower-value material recovery.

5. Analysis

5.1 Circularity Begins Before Demolition

The analysis suggests that the greatest opportunities for small-project circularity occur before demolition and procurement decisions become irreversible. If a contractor begins conventional mechanical demolition before reusable components have been identified, potential value may be lost within minutes. Similarly, if architectural specifications are completed before locally available reused materials are investigated, secondary products may be excluded simply because dimensions or quantities do not match a fixed design.

A basic pre-construction audit can therefore become a high-value intervention. The audit does not need to reproduce a complex digital material passport. For smaller projects, it may consist of a structured schedule identifying elements suitable for retention, reuse on site, sale, donation, external reuse, recycling, or disposal. Photographs, approximate dimensions, quantities, material types, and condition notes may be sufficient to support early decision-making.

This approach reflects the broader urban-mining principle that usable building resources must first become visible before they can be recovered. Research on building-component recovery emphasizes the importance of identifying technical reuse potential rather than assuming that all demolition output is homogeneous waste.

5.2 Simulated Material Value Retention Across Circular Strategies

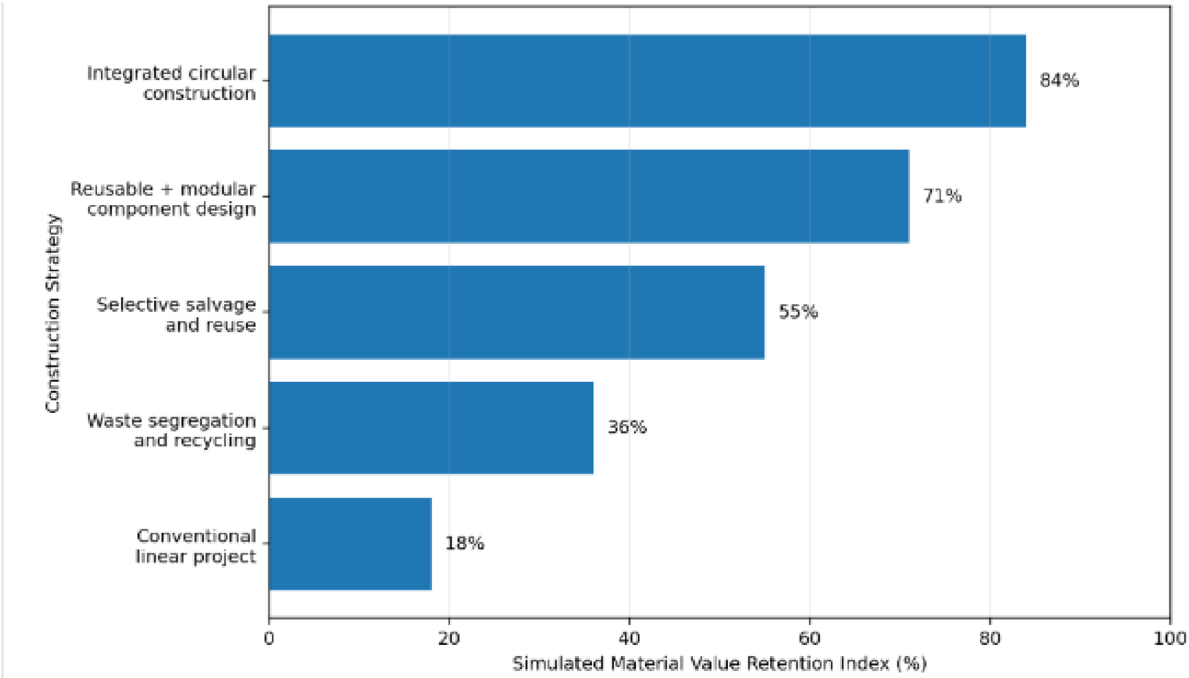
The scenario analysis compares progressive project configurations using an illustrative Material Value Retention Index.

Table 2: Simulated Material Value Retention Under Progressive Construction Strategies

Construction Strategy	Simulated Material Value Retention (%)	Principal Circular Mechanism
Conventional linear project	18	Limited recovery after conventional demolition
Waste segregation and recycling	36	Greater diversion into material-recycling streams
Selective salvage and reuse	55	Direct recovery of reusable components
Reusable and modular component design	71	Current reuse combined with future recoverability
Integrated circular construction	84	Retention, reuse, reversible design, secondary procurement, and recovery planning

The scenario illustrates why waste recycling should not be treated as the endpoint of circular construction. Moving from conventional disposal toward segregation and recycling increases simulated material retention from 18% to 36%. Introducing direct salvage raises the value to 55%, reflecting the greater utility preserved when complete components remain functional. Reversible modular construction increases the simulated index further because it protects both current materials and future recovery possibilities.

Graph 1: Material Value Retention Under Progressive Circular Construction Practices



The graph demonstrates a central proposition of the paper: circularity becomes stronger when the project shifts from managing waste after it has been generated toward preserving material value before it is lost. The values are illustrative and should not be interpreted as universal performance benchmarks.

5.3 A Practical Circular Sequence for Small Urban Projects

The analysis supports a simple sequence for small-project implementation. The project team should first identify existing building elements that can remain. Second, elements requiring removal should be inspected for direct reuse. Third, the proposed design should be adjusted where appropriate to accommodate available secondary materials rather than demanding that every reused component conform to newly manufactured dimensions.

New construction should then minimize unnecessary material complexity. Dry, reversible connections can be favored where performance and regulations permit. Standardized dimensions can improve future interchangeability. Components with shorter anticipated service lives should remain accessible for replacement without destroying adjacent long-life materials.

Finally, project documentation should record major reusable components and important connection methods. A sophisticated digital platform is not essential in every small project. Even a concise maintenance and recovery schedule can improve future circularity by informing later owners or contractors about where components are located and how they can be removed.

6. Discussion

6.1 Small-Project Circularity Should Prioritize High-Value Actions

The first implication is that smaller urban projects should avoid adopting circularity as a procedural checklist detached from actual material outcomes. A project with limited resources should prioritize decisions with the greatest potential to preserve existing value. Retaining a serviceable structural frame, masonry wall, floor system, or staircase may be more consequential than achieving marginal improvements in recycling of newly generated waste.

This value-retention logic is consistent with research demonstrating that reuse can provide greater environmental benefit than recycling because reuse preserves more of the original product function and avoids additional manufacturing processes. It also strengthens the economic case for circularity. Where salvage can reduce purchases of new materials, circular construction may become a cost-management strategy rather than solely an environmental obligation.

However, reuse should not be pursued blindly. Structural safety, contamination, fire performance, durability, code compliance, warranty, and suitability for the intended use must be evaluated. Circularity requires responsible retention of value, not uncritical reuse of every available material.

6.2 Design Flexibility Can Compensate for Irregular Secondary Supply

A second implication concerns design practice. New-product supply chains typically deliver standardized materials to match predetermined specifications. Reused-material supply works differently: available quantities, dimensions, finishes, and conditions may vary. If a design is entirely fixed before recovered materials are identified, reuse opportunities can disappear even when suitable resources exist locally.

Circular design for small projects should therefore include controlled flexibility. Door openings, cladding modules, landscape layouts, internal partitions, furniture, finishes, and noncritical architectural elements may sometimes be adjusted to accommodate secondary components. This reverses the conventional assumption that materials must always adapt to the design; in some circumstances, the design can adapt to available materials.

Dams and colleagues' research supports simplicity, standardization, modularity, and reversible connections as important enablers of circular construction. Standardization and flexibility are not contradictory. Standard modules can provide an underlying system while allowing reused components to be integrated within clearly defined tolerances.

6.3 Local Recovery Networks Are Essential for Small Urban Projects

The third implication is that small-project circularity depends heavily on local coordination. A major development may create sufficient material volume to establish dedicated recovery contracts. Small projects usually generate smaller quantities that can be economically unattractive when transported over long distances or stored for extended periods.

Local material exchanges can address this limitation by aggregating supply and demand across multiple projects. Salvage contractors, municipal reuse depots, online marketplaces, neighborhood construction firms, architects, demolition companies, and material banks can collectively create a more visible secondary-material market. Urban mining becomes practical when recovered resources can be matched with nearby demand at the correct time.

Policy and procurement can support these networks. Local authorities can facilitate reuse directories, deconstruction requirements for selected projects, temporary storage sites, standardized material documentation, and procurement rules that allow compliant secondary products to compete with new materials. Such measures can help circular construction move from isolated experimentation toward normal urban practice.

7. Conclusion

Circular construction offers a practical pathway for reducing resource extraction and construction waste while preserving more of the economic and functional value already embedded in urban buildings. For small projects, however, successful implementation depends on avoiding excessively complex systems that impose administrative burdens disproportionate to project scale. Circularity should instead be translated into a limited number of clear decisions made at the appropriate stage of design and construction.

The framework developed in this paper prioritizes retention of existing building fabric, pre-construction material assessment, selective deconstruction, direct component reuse, flexible procurement, reversible construction, and simple documentation for future recovery. These practices shift attention away from managing waste only after demolition and toward preventing valuable materials from becoming waste in the first place.

The simulated analysis illustrates the conceptual difference between conventional recycling-oriented practice and an integrated circular approach. Material-value retention increases progressively as projects move from linear construction toward salvage, reuse, modularity, and future disassembly. These numerical values are hypothetical and require empirical validation through actual project audits, material-flow analysis, lifecycle assessment, cost evaluation, and post-construction monitoring.

The broader conclusion is that small urban projects should not be considered too minor to contribute to circular construction. Their cumulative material flows are significant, and their comparatively simple organizational structures can sometimes allow rapid experimentation with reuse and adaptable design. When supported by local material networks, appropriate technical assessment, and proportionate procurement practices, small projects can become important building blocks in the transition from linear urban construction toward a more resource-efficient and regenerative built environment.

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