

STRATEGY OPTIMIZATION OF IMPROVING DEMOLITION MATERIAL REUSABILITY AND ADAPTABILITY ANALYSIS

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ABSTRACT

Globally, the construction sector imposes substantial pressure on natural resource consumption and environmental systems. Throughout the building lifecycle encompassing material production and transportation, construction operations, maintenance, and demolition, the industry generates considerable carbon emissions and waste outputs. Notably, a substantial proportion of construction and demolition waste (C&DW) is disposed through direct landfilling.

This linear "take-make-dispose" economic model results in both economic inefficiencies within the construction industry and exacerbated resource depletion with environmental degradation. The circular economy framework transforms traditional unidirectional material flows, optimizing economic value creation while minimizing resource consumption and environmental impacts. As an application of circular economy principles in building industry, circular construction aims to achieve material and product regeneration throughout building lifecycles, ultimately striving towards sustainable construction methodologies characterized by zero pollution and zero waste.

Circular construction necessitates systematic optimization across all building lifecycle phases including material production, component selection, design methodologies, construction practices, demolition processes, and recycling and reuse operations. Current building stocks predominantly employ conventional construction approaches, while rapid urbanization drives frequent building renewal and demolition activities that generate massive

C&DW volumes. Enhancing C&DW recycling and reuse constitutes a critical pathway for circular construction implementation.

Material circularity in construction primarily operates through two mechanisms: recycling and reuse. Material-level recycling (e.g., recycled concrete and steel production) demands advanced processing technologies and integrated supply chains, though accompanied by resource inputs and pollution during reprocessing. The latter primarily refers to product-level direct reuse of building materials and components, typically manifesting as design-stage material downcycling. Designer interventions can significantly enhance reuse rates. Compared to recycling, direct reuse of demolition materials and components represents a more resource-efficient and emission-reducing circular strategy.

China has developed theoretical foundations and practical implementations in construction material circularity, though current research predominantly focuses on material-level C&DW recycling, while practical applications remain limited by designer initiative constraints and homogeneous reuse approaches. A systematic theoretical framework and technical pathway for building component reuse remains underdeveloped, with insufficient diverse and innovative case practices.

Switzerland has established comprehensive theoretical and practical expertise in circular construction through multi-dimensional explorations in demolition practices, material management, and design optimization. This provides valuable references for China's demolition management and reuse strategies. This report examines Swiss experiences across three reuse process

phases (demolition, transition, and design), conducts comparative analysis with Chinese practices, evaluates adaptability of Swiss approaches, and proposes strategic recommendations for enhancing reuse rates in China.

Chapter 1 conducts comparative analysis of C&DW regulations in Chinese and Swiss standards, clarifies terminology distinctions between C&DW and demolition materials, and examines China's current demolition practices and waste management status through policy and literature review. It establishes the necessity and methodology for design interventions to improve reuse rates.

Chapter 2 systematically organizes Swiss circular construction experiences, summarizing theoretical frameworks, technological applications, and design strategies for demolition material reuse through literature review and case studies across three process phases.

Chapter 3 performs comparative analysis of Chinese and Swiss practices across design implementation, technological application, and policy standardization dimensions. It evaluates the adaptability of Swiss experiences to Chinese contexts and proposes strategic optimization recommendations.

Chapter 4 provides concise synthesis of preceding chapters.

Current Chinese research and practice in demolition material reuse demonstrate notable gaps compared to Swiss counterparts. From design practice perspectives, Swiss experiences expand reuse application boundaries through more possibilities for reuse materials and components

in design processes. Technologically, systematic theoretical frameworks and digital technology applications offer referential value for supplementing China's research and supporting practical implementations. Policy-wise, improved standards and specialized support mechanisms could address practical application barriers and promote architectural reuse practices. The theoretical paradigm shift from linear to circular approaches fundamentally transforms building lifecycle practices, facilitating construction industry sustainability.

To enhance building material reuse rates, China should adopt multidimensional strategies including industrial collaboration, technological innovation, and policy standardization. Pilot projects and industrial chain optimization could promote practical reuse applications and regional synergies. Industry-academia collaboration and international exchanges could advance digital technology development for reuse processes. Policy and standard improvements would drive standardized and normalized demolition material reuse practices in construction sector.

1. STATUS QUO OF DEMOLITION MATERIALS IN CHINA

1.1 C&DW and Demolition Material as Defined in Chinese and Swiss Standards

1.1.1 C&DW as defined by the Chinese standard *Technical Standard for Construction and Demolition Waste Treatment CJJ/T134—2019* refers to the sum of waste generated from construction and demolition activities

In the relevant Chinese standard, C&DW is defined as the aggregate of waste materials generated from all types of activities within the construction industry, excluding hazardous waste. Specifically, C&DW can be categorized at its source into five main types: engineering sediment, engineering mud, engineering waste, demolition waste, and decoration waste. Engineering soil pertains to the various types of abandoned soil produced during foundation excavation processes, while engineering mud refers to the mud generated during construction activities, with the former constituting the majority of construction waste.[1] Engineering waste, demolition waste, and decoration waste correspond to the waste materials generated during construction, demolition, and decoration processes, respectively.[2]

Therefore, it is evident from the relevant standards and policies that, based on the source classification of C&DW, demolition waste constitutes a specific category of C&DW. It originates from the demolition of buildings, structures, and other construction - related facilities and comprises the discarded materials generated during such processes.[2]

1.1.2 Demolition materials as defined by the Swiss standard *SIA 430: 2023 Avoidance and Disposal of Construction Waste*¹

The newly introduced Swiss standard SIA 430:2023 Avoidance and Disposal of Construction Waste (SIA 430:2023 Vermeidung und Entsorgung von Bauabfällen), which supersedes the 1993 SIA 430 Disposal of Construction Waste (SIA 430 Entsorgung von Bauabfällen), places emphasis on the circular economy concept. The revised standard highlights this theme, for instance, by introducing the concept of “reuse” and underlining the reuse potential of building components. It not only promotes the reuse of recycled components but also requires new designs to consider the possibility of reusing components post - demolition, aiming to return as much building materials and components as possible to the material cycle.[3] Besides these circular - economy - related additions, the new standard also features terminology changes, such as renaming “demolition waste” to “demolition materials” and adding “avoid” to the title. The inclusion of “avoid” in the title stresses that priority should be given to avoiding C&DW generation over managing waste that has already been produced, with the goal of extending a building's life cycle and reducing waste generation at the source.[4]

1.1.3 C&DW & Demolition Materials

As outlined in the C&DW - related norms of China and Switzerland, both place emphasis on recycling and properly disposing of C&DW to reduce its environmental impact. In the Chinese standard Technical standard for construction and demolition waste treatment, C&DW is classified by source

¹ Translations of normative names and related terms are derived from Reference [3]

as non - hazardous waste from various construction activities, with resource utilization prioritized as the disposal method.¹

In the Swiss standard Avoidance and Disposal of Construction Waste provisions, “demolition materials” are referenced with an emphasis on material reuse and recycling. These demolition - derived “materials” hold higher value and “reuse” potential than “waste”. This “reuse” is more straightforward than C&DW resource reuse and recycling, favoring direct reuse methods. Such practices simplify and speed up material and component reuse and recycling, extending their life cycles. They also prevent C&DW generation, reducing the amount of “materials” classified as “waste”, which decreases waste requiring disposal, lessening resource consumption and environmental impacts linked to resource reuse and recycling and other disposal methods.

This report's Chapter 1, Section 2, centers on China's building demolition and C&DW disposal situation, using the Chinese standard Technical standard for construction and demolition waste treatment definition of C&DW. Chapter 1 Section 3 and subsequent sections investigate building demolition material reuse strategies. They incorporate the Swiss standard Avoidance and Disposal of Construction Waste's new terms “demolition materials”/“demolition components” as descriptive objects, highlighting their direct reuse value and the significance of promoting such reuse from a building design perspective. The focus is on studying how to encourage the reuse of materials and components through architecture design, reducing

waste requiring disposal and resource - based absorption.

¹ Resource utilization ——methods by which C&DW is processed and converted into useful material. Reference [2]

1.2 Status Quo of Building Demolition and C&DW in China

1.2.1 Status Quo of Building Demolition in China

In recent years, with the continuous development of urban areas, the building construction area has been growing rapidly. According to statistics, the annual building construction area has exceeded 15 billion square meters, and the completed building area has reached approximately 4 billion square meters per year.[5] Due to the influence of urban planning, land value, economic potential, urban development, and other factors, the construction of new buildings necessitates the demolition of existing structures to obtain more construction space. Alternatively, the renovation of existing buildings can introduce new functions into the existing space. Regardless of whether it involves the demolition of existing buildings, the construction of new buildings, or the renovation of existing space, all these construction activities inevitably produce a significant amount of C&DW.

By 2020, the total floor area in China had reached approximately 66 billion square meters, with an increase of over 20 billion square meters between 2007 and 2020. The area of building demolition had rapidly increased from 700 million square meters in 2007 and has since stabilized at about 1.6 billion square meters per year.[6] According to related research, the average lifespan of demolished buildings is only 38 years, with the average lifespan of commercial and office buildings being even less than 30 years.[7] Based on relevant standard, the design service life of ordinary buildings and structures should reach 50 years.[8] Therefore, many of the demolished buildings are considered to be prematurely demolished. Some studies have shown that only 10% of the demolition activities are due to engineering

quality issues or illegal construction, while 90% of the demolitions are considered unreasonable.[9] The demolition of these buildings is primarily influenced by external factors such as economic interests, policy drivers, urban function renewal, land scarcity, etc.[7]

In addition to the substantial economic losses incurred by the massive demolition of buildings, this practice also represents a significant waste of resources. Assuming that the demolition of each square meter of old buildings generates 1 ton of C&DW, the demolition process alone produces approximately 1.6 billion tons of C&DW annually. Notably, the vast majority of demolished buildings had not reached the end of their intended service life.[9] Moreover, large-scale demolition and the resulting massive amounts of C&DW place a significant burden on the environment. The environmental impact during the production, transportation, and use of building materials cannot be overlooked. According to relevant studies, carbon emissions from the production stage of building materials account for 16.0% of the nation's energy-related carbon emissions and 41.8% of the total emissions from the entire building process.[10]

The increasing prevalence of buildings being demolished before reaching their designed service life has led to a significant conversion of building materials and components into waste, despite their remaining functional capacity. From a sustainability standpoint, this critical issue necessitates a dual-pronged strategic approach. Primarily, it is imperative to implement measures that prevent the premature demolition of buildings still in their lifespan, thereby effectively reducing demolition waste generation at its source. Subsequently, through the systematic optimization of demolition

management practices, coupled with the implementation of resource utilization methods and the establishment of material reuse and recycling systems, the service life of demolition-generated materials and components can be substantially extended, mitigating the substantial environmental impact.

Large-scale urban demolition and construction have resulted in challenges such as escalating C&DW generation, inefficient resource utilization, and exacerbated environmental impacts. In response, China has strategically shifted its urban construction paradigm from expansive redevelopment to a sustainable urban renewal model. This transition is manifested through rigorous controls on extensive demolition, new construction projects, and resident relocation initiatives. The current policy framework prioritizes the preservation, adaptive reuse, and systematic upgrading of existing built environments, while concurrently safeguarding distinctive urban identities and spatial morphologies.[11]

In contrast to the conventional practice of demolishing existing buildings to create space for new developments, building renewal represents a sustainable approach that enhances spatial quality and value while extending its service life. This process facilitates urban and societal development through the strategic renovation, rehabilitation, and functional optimization of existing spatial assets. The rationale for building renewal is twofold: firstly, numerous aging structures exhibit compromised safety standards and functional deficiencies that are incompatible with contemporary urban development requirements; secondly, the escalating scarcity of urban land resources has rendered many early-constructed buildings, now situated

within established commercial districts with prime locations and substantial land values, as ideal candidates for renewal. Through systematic renewal and reconstruction processes, these aging buildings can be transformed to accommodate modern spatial functions, reinvigorated with enhanced spatial utility, and adapted to meet evolving usage demands. This approach not only mitigates the environmental impacts and resource depletion associated with extensive demolition and reconstruction projects but also enables the activation of latent potential within underutilized urban spaces, thereby fostering the optimal integration and utilization of urban spatial resources.

On the other hand, with the continuous optimization of energy structures and the progressive advancement of energy-efficient technologies, a significant proportion of existing buildings are anticipated to undergo energy-saving retrofits in the foreseeable future. Statistical data indicate that carbon emissions generated during the operational phase of buildings constitute 21.6% of the nation's total energy-related emissions and account for 56.6% of emissions throughout the entire building lifecycle.[10] As outlined in the "14th Five-Year Plan for Building Energy Efficiency and Green Building Development," issued by the MOHURD in 2022, during the "13th Five-Year Plan" period, energy-saving retrofits were implemented for existing residential buildings, encompassing a total area of 514 million square meters, while public buildings underwent energy-saving renovations covering 185 million square meters. The national target for 2025 is to complete energy-saving retrofits for 350 million square meters of existing buildings.[12]

In contrast to complete building demolition, renewal processes involve

partial or zero structural demolition. The removal of specific building materials and components is contingent upon the technical requirements of renewal design specifications. Consequently, as urban construction transitions toward an organic renewal-dominated paradigm, the corresponding demolition methodologies, along with the composition and characteristics of deconstructed materials in existing building rehabilitation, maintenance, and retrofitting operations, will undergo fundamental transformations.

1.2.2 Classification of C&DW

C&DW at the source can be classified into five categories: engineering sediment, engineering mud, engineering waste, demolition waste, and decoration waste. According to Beijing regulations, engineering sediment and engineering mud are categorized as resource-recyclable waste, whereas engineering waste, demolition waste, and decoration waste are designated as disposal-oriented materials.[13] In 2023, Beijing produced 107 million tons of C&DW, with engineering sediment constituting 70% of the total, engineering mud representing a minor proportion, engineering waste accounting for 11%, demolition waste comprising 18%, and decoration waste contributing less than 1%. Engineering sediment dominates the waste stream, while demolition waste represents nearly 20% of the total volume.[1]

From the material composition perspective of C&DW, excluding soil-based materials such as sediment and mud, the remaining constituents can be categorized into concrete, bricks, masonry blocks, mortar, ceramic tiles, gypsum, glass, stone, ferrous/non-ferrous metals, bamboo, wood, polymers, textiles, asphalt, etc. In demolition waste streams, inert solid waste

components including concrete, masonry, and mortar collectively form the predominant category. Specifically, concrete and mortar account for 30-40% of the total, brick and tile fragments constitute 35-45%, ceramic and glass materials represent 5-8%, with remaining demolition byproducts comprising exactly 10% of the total volume. [14]

1.2.3 C&DW Treatment in China

Priority must be accorded to the resource recovery of C&DW. Waste unsuitable for material recovery requires regulated transportation to designated disposal facilities for compliant treatment.[15] The management of C&DW shall strictly comply with the tripartite principles of waste minimization, resource recovery, and environmental safety, coupled with enforcement of the "producer-responsible disposal" mandate. Particular operational emphasis must be placed on implementing advanced volume reduction strategies to curtail landfill deposition.[16]

Waste Minimization

Waste minimization constitutes a fundamental component of source-level C&DW prevention and reduction. This operational framework is achieved through systematic control of waste generation mechanisms encompassing eco-efficient planning, design-phase optimization, construction process engineering, and implementation of integrated construction and demolition management protocols.[17] The reduction principle, aligned with the Swiss SIA 430 standard's core tenet of C&DW avoidance, specifically targets the mitigation of project-originated waste emissions at generation sources. This methodology represents the primary operational tenet within hierarchical waste management systems.

Resource Utilizaiton

C&DW resource recovery encompasses the transformation of discarded materials into certified secondary raw materials. These processed materials are subsequently reintegrated into the construction value chain and allied industrial sectors. This circular economy practice mitigates environmental footprints while generating economic value streams, thereby facilitating strategic transitions in industrial ecosystem modernization and sustainable supply chain restructuring.

Resource recovery of soil-based C&DW (e.g., sediment and mud) is predominantly channeled into backfilling applications, encompassing engineered backfill operations, mine void remediation, terrain modeling through landscape piling, and lowland filling.[13]

Concrete, masonry, blocks, mortar, and other inert solid wastes undergo a series of manufacturing processes, such as crushing and screening, to be transformed into coarse and fine aggregates of various specifications. In addition to their use in backfilling and foundation construction, these aggregates are further processed into a variety of recycled products according to different specifications,[18] including recycled concrete, bricks, blocks, and mortar etc.[19] Gypsum, glass, and other materials, apart from being made into aggregates, can also be processed into products such as regenerated gypsum and glass through industrial production. These materials are used to generate recycled gypsum, recycled glass, and other recycled products. Materials of superior quality and less damage from demolition, such as stone and slate, also hold value for direct reuse. Metallic

materials, including rebar, steel, and other non-ferrous metals, can be converted into raw materials for the production of recycled steel and recycled metal products through processes such as recycling, cleaning, cutting, crushing, and smelting.[19]

Classification		Resource reuse and recycling (except landfill)
Inert Materials	concrete	aggregate-regenerated product
	brick	aggregate-regenerated product
	block	aggregate-regenerated product
	mortar	aggregate-regenerated product
	tile	aggregate-regenerated product
	gypsum	aggregate/raw material-regenerated product
	glass	aggregate/raw material-regenerated product
Metal	stone	reuse directly, aggregate-regenerated product
	steel	raw material-regenerated product
	other metal	raw material-regenerated product
Other material	Bamboo & Wood	reuse directly, aggregate-regenerated product
	plastic	aggregate/raw material-regenerated product
	fabric	reuse directly, raw material-regenerated product
	asphalt	aggregate-regenerated product

Table1Classification according to material composition and resource utilization methods

In addition to the extensive use of soil - based C&DW in backfilling and

restoration, other C&DW is mainly utilized as follows:

- Processed into coarse or fine aggregates. These can be further manufactured into recycled products like recycled mortar, bricks, and concrete based on aggregate specifications.
- Converted into raw materials for producing recycled products, including recycled plastics, steel, metals, plates, etc.
- Reused directly after basic processing, for example, stone, wood, components, and equipment.

In 2023, Beijing achieved resource utilization of 43% generated C&DW and 100% demolition waste, realizing zero landfill disposal. By 2023, Beijing's C&DW treatment capacity had reached 103 million tons annually.[1] Filing data from Beijing's C&DW Management and Service Platform indicates that 92 certified disposal sites were operational by December 2024. These facilities are classified into four categories: on-site resource utilization facilities, temporary resource utilization facilities, fixed resource utilization facilities, and temporary storage points.[20] Beijing's regulated recycled C&DW products principally comprise coarse/fine aggregates, recycled blocks, brick variants, inorganic binders, and reclaimed soils, with primary engineering applications encompassing foundation backfilling, structural enclosures, and municipal infrastructure development across transportation networks, green spaces, and public amenities.[21]

Environmental Safety

C&DW shall undergo rigorous source-segregation from domestic and hazardous waste streams. Throughout operational processing, full compliance with prevailing regulatory standards must be maintained. Targeted administrative controls, technological interventions, and specialized

equipment deployment shall be implemented to systematically mitigate pollutant discharge, thereby achieving complete environmental neutralization of C&DW impacts on ecosystems and public health.

C&DW Treatment and Management

C&DW disposal management encompasses comprehensive governance of its generation, source segregation, collection, transport, storage, and final resource recovery or regulated disposal. As exemplified by Beijing's municipal framework, the jurisdiction mandates integrated construction-demolition administration coupled with circular resource utilization protocols. The system enforces rigorous source monitoring through interoperable data platforms, implements intelligent transport monitoring systems, and enforces precise waste quantification controls. Beijing's regulatory classification system categorizes C&DW into two distinct streams: resource-grade materials (engineering sediment, construction mud) and disposal-grade materials (construction waste, demolition waste, decoration waste), each governed by type-specific utilization mandates.[13]

In accordance with established C&DW management policies, Beijing's treatment protocol incorporates the following critical components:¹

- Execute green demolition protocols, formulate C&DW management frameworks, and prescribe standardized disposal methodologies with transportation protocols.
- Implement in-situ sorting, systematic collection, and containment of construction waste.

¹ Reference [13][15]

- Maintain digital logs documenting waste typology, volumetric data, and material trajectory, submitting records through designated reporting channels.
- Accord operational precedence to in-situ resource recovery of construction waste.
- Coordinate licensed transport of non-recyclable C&DW to authorized resource recovery facilities or designated disposal sites.
- Conduct platform-based oversight of regulatory filing, material conveyance, and final disposition throughout the full lifecycle.
- Advance market integration and end-user adoption of recycled products.

Within C&DW management protocols, specific salvage-grade components including metals, equipment, windows & doors, panels, and conduit are categorically excluded from initial classification as "waste". These materials demonstrate inherent value exceeding conventional waste streams and align with the "demolition materials" definition under Swiss Standard SIA 430, qualifying for direct redeployment. Following specialized material recovery operations and value-added processing (dimensional modification, surface remediation, structural refurbishment), such materials and components are reintroduced into secondary material markets, thereby establishing complementary material recovery pathways parallel to conventional C&DW resource utilization systems.

C&DW and Building Demolition

Building demolition methodologies comprise four principal operational modalities: manual demolition, mechanical dismantling, blasting demolition and static demolition,[22] each demonstrating distinct project-specific applicability:

- Manual demolition is optimized for low-rise structures or projects requiring structural preservation.
- Mechanical dismantling is operationally viable for most buildings of certain scales and heights.
- Blasting demolition is strategically deployed for large – scale and tall buildings.
- Static demolition is mandated for projects with strict environmental, noise, and vibration requirements.

The methodological selection in building demolition exerts multilevel impacts on project timelines, budgetary allocations, and ambient environmental conditions, while fundamentally determining post-demolition material integrity and component functionality. This technical determination directly dictates their reusability coefficients. For instance, manual demolition methodology, while capital-intensive and laborious, preserves structural integrity for high-value direct reuse applications. Conversely, mechanical demolition expedites operational timelines with enhanced cost-efficiency, yet is more destructive to materials and components than manual methods

Current unrefined building demolition techniques compromise material integrity, markedly diminishing direct reuse viability and capacity of building materials, equipment, and components—whether intended for immediate application or after elementary reprocessing. This operational approach consequently yields predominantly low-value "waste" outputs rather than retaining materials' inherent utility as directly deployable "demolition resource". When C&DW undergoes secondary recycling procedures, mandatory resource-intensive processing occurs. While recycled materials demonstrate significant carbon mitigation advantages relative to conventional counterparts,[23] the preparation of aggregate materials,

refinement of secondary feedstocks, and fabrication of recycled commodities persist in requiring substantial resource expenditure while producing notable carbon outputs.

Enhancing the throughput of demolition materials entering reuse channels through design optimization and controlled demolition methodologies establishes more operationally efficient and ecologically sustainable material reuse pathways at the architectural design phase. This constitutes the core material reuse strategy investigated in the present study, which enables reduction of resource expenditure and greenhouse gas emissions during C&DW resource recovery processes, while realizing the reuse potential of demolition materials in a more sustainable way.

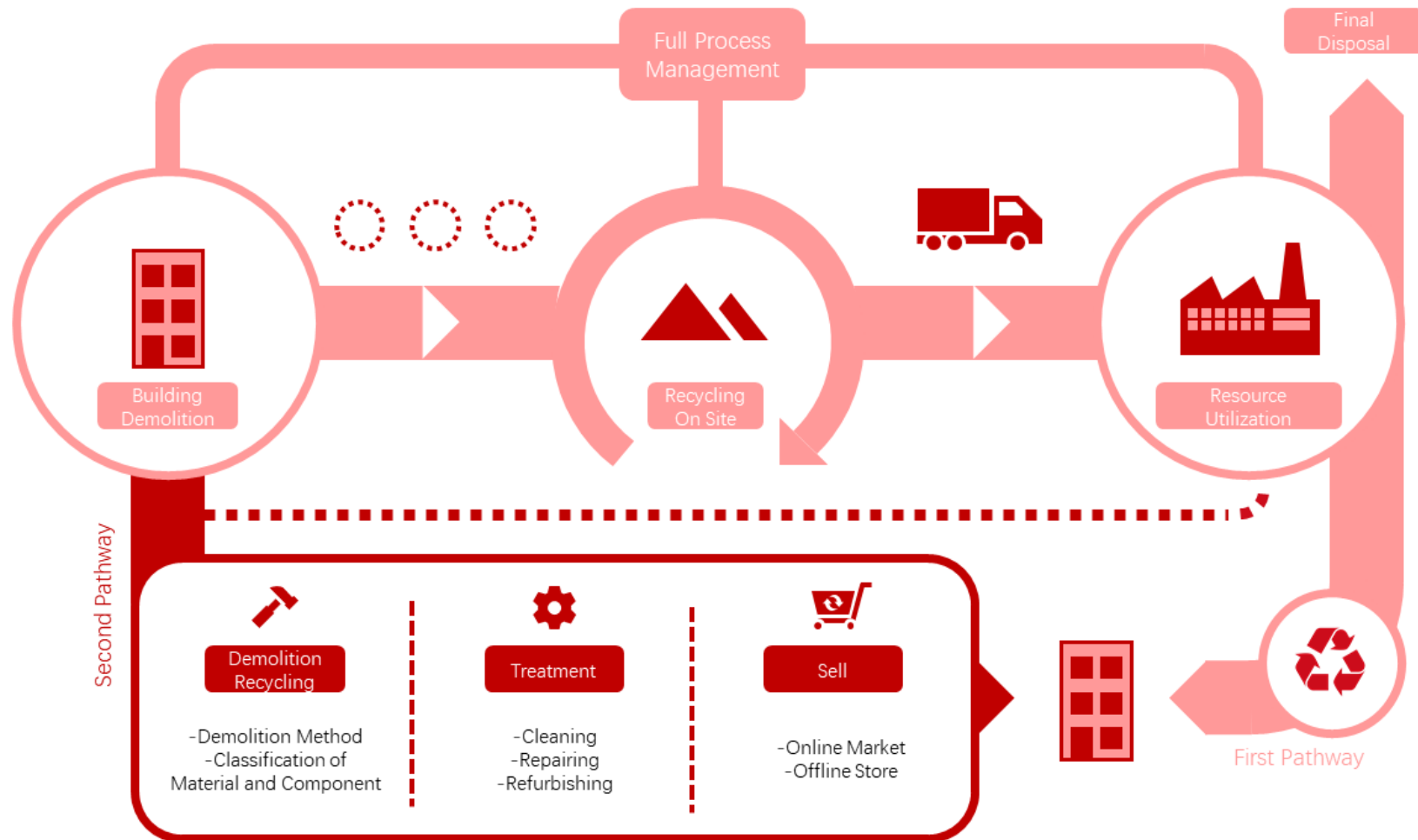


Figure1 Recycling and reuse pathways for demolition materials ©SUP Atelier of THAD

1.3 Reuse of Demolition Materials

1.3.1 Downcycling of Demolition Materials

Recycling and reuse materials predominantly represents downcycling processes, wherein material quality progressively deteriorates through successive usage cycles.[24] Concerning demolition-derived components, while these materials can be functionally reintegrated into new constructions following systematic dismantling and rehabilitation processes, their performance characteristics in design applications may diverge from those of virgin materials. This divergence originates from some principal determinants: inherent material property limitations, impairment sustained during demolition operations, and visual obsolescence. Illustratively, in high-performance architectural applications such as structural systems and building envelope assemblies, these materials often demonstrate compromised functional capacity.

Reuse materials are predominantly allocated to non-critical architectural applications. Representative materials include reprocessed bamboo, timber, brickwork, stonework, glazing units, ceramic tiles, fenestration components, and mechanical equipment. Typical utilization scenarios encompass landscape architecture within building precincts, decorative façade treatments, artistic installations, and interior spatial configurations.

Through historical design implementation, SUP Atelier has developed a resource-maximizing, locally-sourced inverse design methodology, implementing carbon mitigation innovations through material circularity protocols and waste discharge minimization strategies.[25][26]

The Tea Leaf Market of Zhuguanlong Project implemented systematic recycling of wood from village hazardous structures and residual feedstock from stone processing facilities during its design-construction phase. Material reuse was achieved through technical prototyping, material testing protocols, and collaborative knowledge exchange with indigenous artisans.[26]

The Taoli-Zhaoshan Village Center Project implemented systematic disassembly and repurposing of original façade red bricks, retaining wall rubble stones, heritage timber roof trusses, decommissioned plant machinery, and residual stone materials from adjacent carving workshops. This material recovery strategy successfully reduced virgin material consumption, while maintaining architectural performance parameters to establish a distinctive rural architectural vernacular.[25]

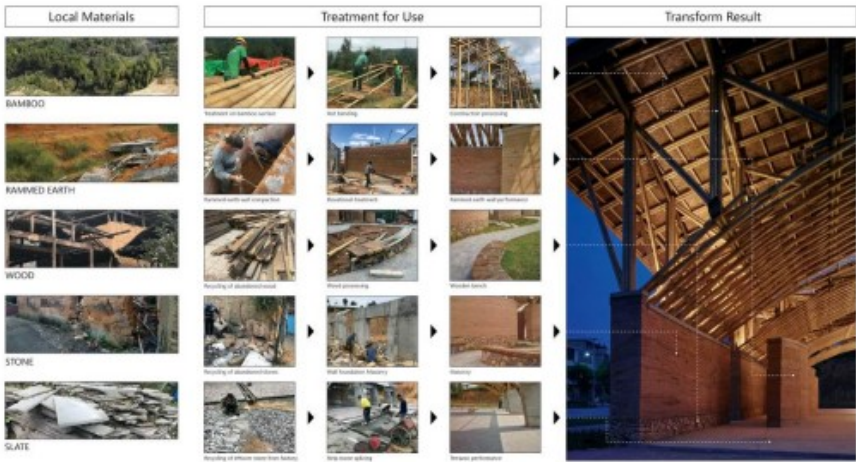


Figure2 Reuse strategies in Tea Leaf Market of Zhuguanlong ©SUP Atelier

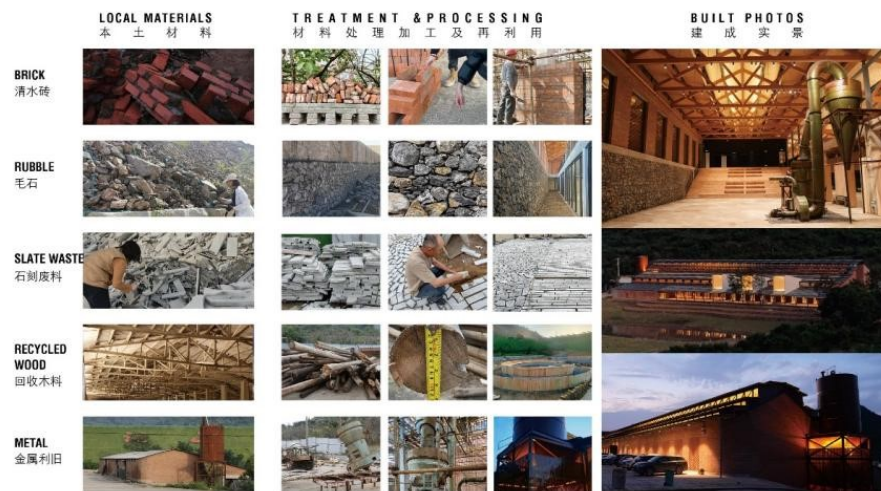


Figure3 Reuse strategies in Taoli - Zhaoshan Village Center © SUP Atelier

In addition to utilizing demolition materials for architectural "decoration" and "beautification" in landscaped sites, façade articulation, installation works, and interior design, it is imperative to investigate alternative reuse methodologies for diverse building demolition materials and components while expanding their application scope across distinct architectural parts.

Post-evaluation, well-performing demolition materials and components may be redeployed in alternative building contexts. Steel structures demonstrating optimal integrity may be disassembled and repurposed as structural elements in new constructions. Steel staircases sustaining minimal damage through systematic dismantling can maintain their vertical circulation functionality in new buildings. Recycled photovoltaic panels may

be integrated to supply renewable energy for new buildings. Recovered thermal insulation materials can be effectively implemented within building envelope systems. Salvaged windows of varied typologies may constitute distinctive façade expressions, while recycled metal cladding panels serve as exterior surfacing materials.[27]

Reclaimed solid timber, after removal of mechanical fasteners and ancillary components, may be processed into higher-performance glued laminated timber for deployment in timber façades.[28]

Recycled steel and timber materials exhibit structural applicability. Through structural and nodal optimization, recycled paper tubes with verified load-bearing capacity can be repurposed as load-bearing structures when assembled in combination.[29][30]

The reuse of demolition materials in new architectural design constitutes a material-characteristic-guided reverse design methodology. The inherent complexity of demolition material typologies and technical characteristics dictates the diversity of their application modalities. Consequently, this approach necessitates ongoing experimentation within design practice to develop expanded material reuse strategies.

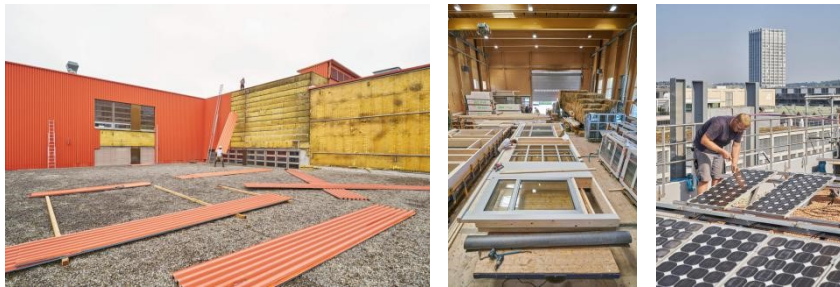


Figure4 Reuse strategies in K118 ©Martin Zeller



Figure5 Reuse strategies in Elys Culture and Commercial Building ©Martin Zeller

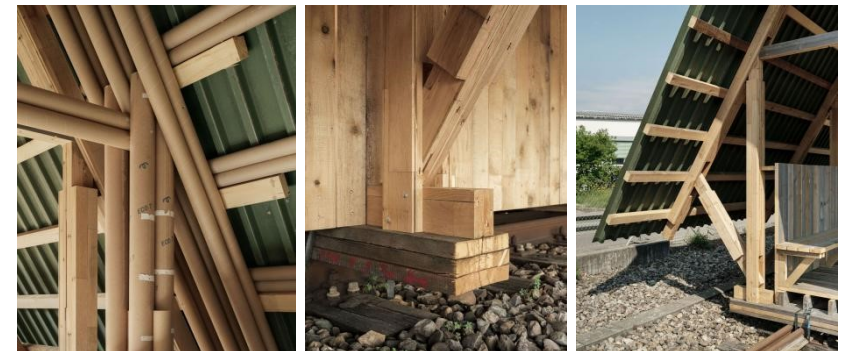
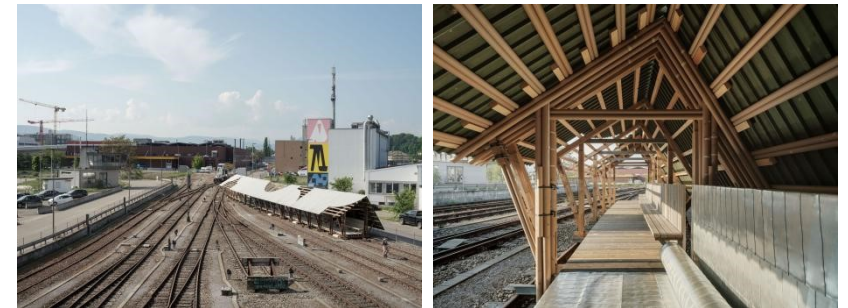


Figure6 Reuse strategies and nodal design in Basel Pavilion 2022 ©Luis Díaz Díaz

1.3.2 Recycled Products Produced from Resource Utilization

In addition to the direct reuse of demolition materials for design applications, the waste-derived material fraction undergoes downcycled applications through resource recovery processes to produce recycled products. For instance, waste concrete and masonry are processed into graded aggregates (Table 1) for deployment in bedding courses, subgrade stabilization, and structural reinforcement, while simultaneously serving as raw materials for recycled products including recycled bricks.[18] Constrained by technological and economic factors, the majority of aggregates and recycled products derived from C&DW recycling exhibit diminished performance characteristics relative to natural aggregates and their derivative products, constituting a form of material downcycling.[31]

As C&DW recycling transitions from downcycling to higher-grade recovery approaches coupled with advancements in production technologies, high-performance recycled aggregates and products have progressively attained technical specifications enabling their substitution for natural aggregates and conventional products. This evolution signifies a paradigm shift from "downcycling material recovery" to "equivalent-grade recycling".[18]

Downcycling can actually increase contamination of the biosphere.[24] Both "downcycling" and "equivalent-grade recycling" constitute resource-depleting processes that generate environmental impacts by adding substances to raw materials to enhance performance and through waste discharge. From a life-cycle assessment perspective, direct landfilling of C&DW demonstrates the most significant environmental burdens. Comparatively, downcycling and conventional recycling processes can

mitigate approximately one-third of these environmental impacts. When implementing selective demolition protocols prior to recycling operations, environmental impact mitigation exceeds 50% reduction thresholds.[31]

Therefore, adopting appropriate building demolition methodologies and ratios, improving the direct reuse potential of demolition materials, and minimizing waste generation requiring recycling and reprocessing constitute an environmentally sustainable recycling strategy. Architects must persistently explore practical methods for integrating diverse demolition materials into design applications through continuous experimentation.

1.3.3 Design Interventions

The utilization efficiency of building demolition materials can be optimized through design-driven strategies. This operational framework can be systematically structured as follows: During the pre-design phase, collect comprehensive data regarding demolition material sources. These materials may originate from the project site, adjacent demolition projects, or secondary material markets. Strategically assess their applicability within the new project's design parameters. Implement controlled demolition protocols and material inventory management. Catalog and evaluate material categories, quantities, and technical specifications. Develop material-design compatibility matrices, or alternatively employ reverse design methodologies by adapting designs to material availability. Select appropriate construction detailing and installation sequences. Ensure future material recovery through planned disassembly methods that minimize degradation, thereby facilitating material reuse at the building's end-of-life phase.

Material circularity in demolition contexts remains an evolving practice requiring empirical refinement. Each successful reuse methodology effectively converts a demolition waste stream into valuable resources, establishing more direct, efficient, and sustainable material lifecycle loops.

2. SWISS EXPERIENCE IN CIRCULAR CONSTRUCTION

2.1 Circular Construction Strategies

2.1.1 Circular Economy

As opposed to a linear economy, a circular economy enables products and raw materials to be used and reused efficiently and for as long as possible. Thus, it can help to protect the environment by reducing resource consumption and waste emissions. The circular economy is an integrated approach and covers all stages of the cycle, including raw material preparation, product design and manufacture, distribution and transportation, consumption and use, as well as reuse or recycling as secondary raw materials.[32]

In Switzerland, building and relevant construction accounts for the largest share of the waste, which is over 80%. And a fifth of the total waste is from demolition of buildings, roads and railways. Circular economy helps improve the recyclability of building materials and components, realize circular construction and further reduce the environmental impact of construction sector.[33]

- Introduce policies and standards relevant to recyclability of building components and materials
- Limit the simple disposal of recyclable waste
- Introduce material passports
- Improve the image of recycled materials
- Promote the use of local and renewable building materials
- Include recyclability and sustainability factors in public procurement criteria

- Raise awareness of reuse and recycling among participants in all stages, including producers, contractors and architects
-[34]



Figure7 Circular Economy ©FOEN

Circular Economy Strategies[33]

(1) Minimizing material flows

- Economical use of materials and energy
- Resource-saving use models

(2) Slowing down the material cycle

- Extending product life cycles on the supply side
- Increasing the useful life of products

(3) Closing material cycles

- Designing products to be recyclable
- Recycling or reusing raw materials

(4) Utilizing renewable energy and materials

2.1.2 Circular Construction

Circular construction entails extending the service lifecycle of building components to maximize their functional utilization. This approach can be conceptualized through three distinct pathways: Recycling, Reuse, and Preservation. The reuse cycle specifically involves disassembly, recycling, and rehabilitation from architectural design perspectives, followed by reintegration into new projects. This cyclical process systematically incorporates five operational phases: disassembly, transport, refurbishment, transport, and reintegration.[27]

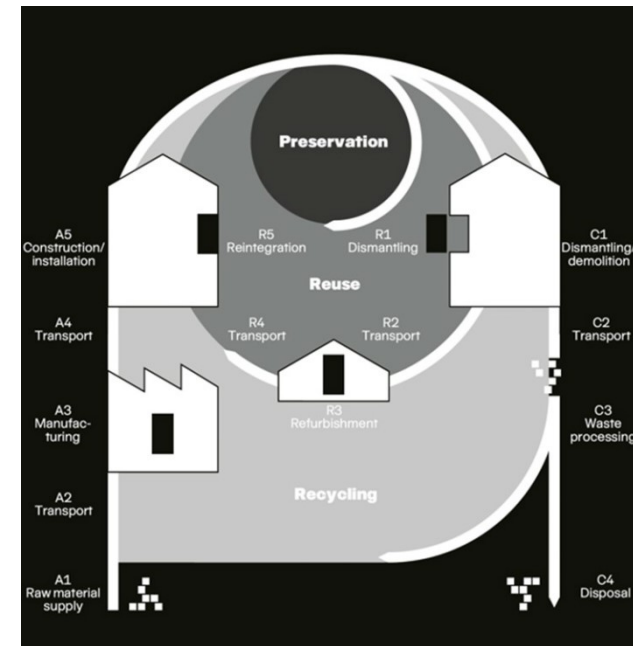


Figure8 Circular Construction ©ZHAW

The reuse process can be categorized into three stages based on the combined separation relationship between the building and the demolished materials. This report will examine strategies to improve the reuse of building demolition materials from three aspects of Swiss practice in the field of circular construction:

- (1) Demolition phase: separation of building and materials
- (2) Transition phase: material treatment and information transfer
- (3) Design Phase: reorganization of materials and building

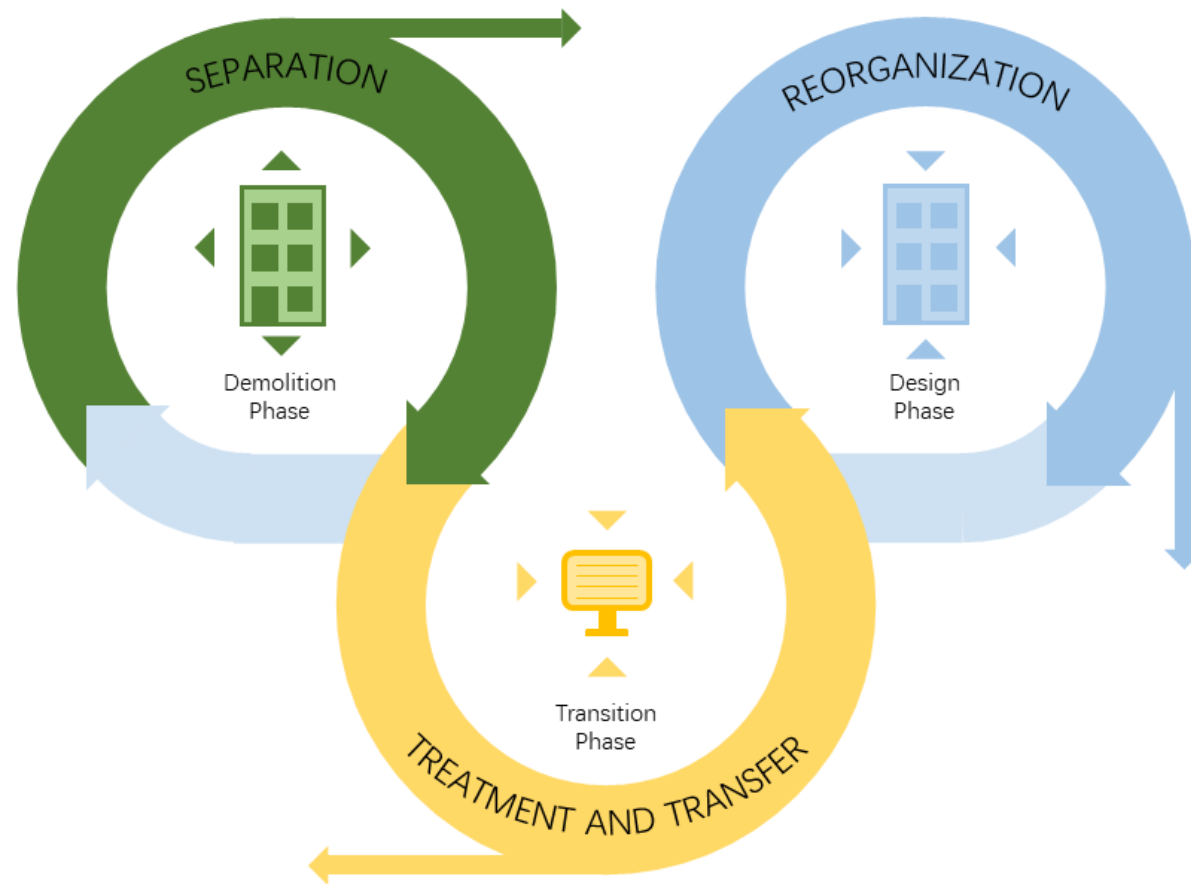


Figure9 Three Stages in the Reuse Process ©SUP Atelier

2.2 Swiss Circular Construction Practices

2.2.1 Demolition Phase

The integration of materials into reuse cycles commences with their physical separation from buildings during demolition processes. Selecting optimal dismantling methodologies facilitates the reduction of material damage during extraction, maximizes property retention, and enhances the recyclability potential of recycled materials.

Material separation techniques generally bifurcate into two categories: Conventional Demolition (CD) employing high-impact methods with significant material degradation risks, and Selective Demolition (SD) implementing precision disassembly based on material properties and connection typologies.[35] CD predominantly utilizes mechanical demolition equipment, generating substantial non-reusable waste streams that necessitate recycling processing. Conversely, SD prioritizes manual disassembly techniques, preserving material integrity for reuse applications despite requiring increased temporal and labor investments.

Design for Disassembly (DfD) emerges as a strategic framework to optimize post-demolition material integrity. This approach operationalizes principles enhancing the separability and detachability of building systems, incorporating some critical design considerations, such as future dismantling accessibility, operational safety, and process efficiency. By improving the reuse potential of non-deprecated components and minimizing waste generation, DfD establishes material circularity through reversible construction systems contrasting with irreversible demolition processes.[36]

Section three subsequently in this chapter analyzes DfD principles including system separability, detachable connections, and modular component configurations through case study evaluations. The demolition phase analysis examines methodology selection, operational management protocols, and material valuation criteria - specifically assessing low-damage separation techniques and reuse potential quantification metrics.

Demolition Process and Reuse of Materials: Huber Pavilions[37]

The deconstruction and material reuse of Huber Pavilions establishes practical precedents for sustainable architectural practice and education space design, demonstrating effective implementation strategies for SD and material circularity.

Originally constructed in 1989 as temporary architectural studios on ETH Zurich's campus, Huber Pavilions comprised three lightweight timber structures featuring simplified joint configurations. Their modular construction and disassembly-friendly design enabled complete deconstruction in 2022, with reused materials directly supporting new academic space development on campus.

This case study underscores the critical importance of precision deconstruction methodology. By prioritizing material preservation over conventional destructive demolition, the process required meticulous material identification, classification, and quantity documentation. Deconstruction techniques were strategically selected based on material properties, structural positioning, and connection types. Post-deconstruction

analysis revealed approximately 30% material suitability for direct reuse in new construction projects, with residual materials entering recycling streams. While refined deconstruction enhances direct reuse potential, practical constraints including time limitations, technical complexity, and cost considerations frequently restrict its full implementation.

Strategic deconstruction methodology preserves material value, while systematic documentation enables optimized post-demolition management. Categorizing and managing material information links the demolition and reuse processes. During Huber Pavilions' on - site demolition, architects implemented comprehensive material auditing through Excel-based tracking systems, cataloging reusable components from primary structures, building envelopes, and auxiliary elements.

Subsequent material management phases - encompassing temporary storage, transportation logistics, and redistribution - critically influence material integrity and environmental impact. During project demolition, reusable components were temporarily housed in an 8×20-meter outdoor space, covered with plastic sheeting for protection before being transported via optimized vehicle configurations matching material specifications. The useagain.ch website facilitated efficient redistribution, with 30 recipients acquiring materials within two weeks. Final allocations distributed 8 tons across 20 ETH internal projects, with 25 tons transferred to private sector users.

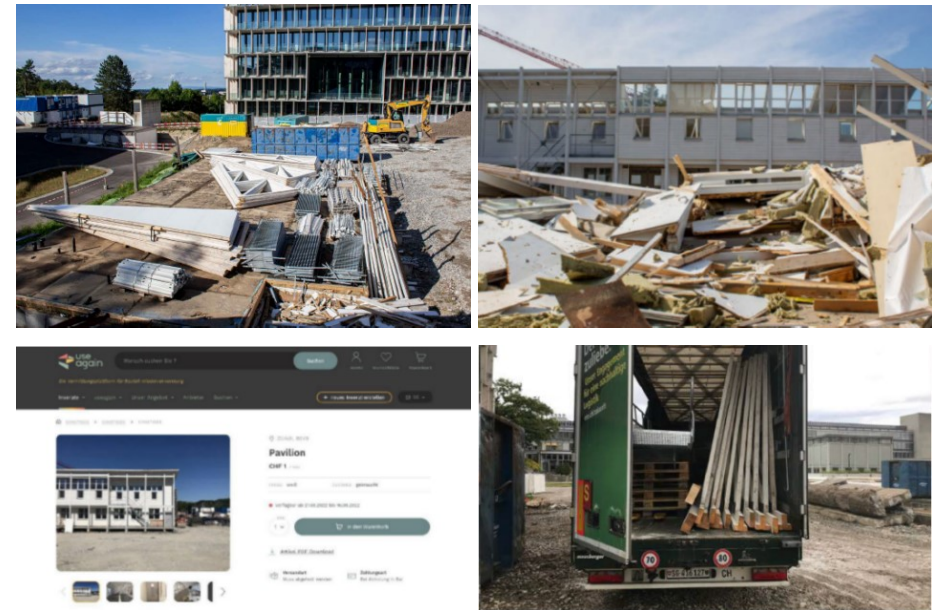


Figure10 Deconstruction process and materials of Huber Pavilions ©Elias Knecht

The Huber Pavilions project systematizes the complete material lifecycle management process, encompassing precision deconstruction protocols, digital material profiling, destination tracking, and reuse implementation. This case study validates that methodical deconstruction strategies effectively mitigate C&DW generation while optimizing material reuse rates. Critical success factors include systematic material stewardship (categorization, documentation, storage) coupled with targeted information dissemination during deconstruction phases, collectively maximizing material value retention and waste reduction.

Furthermore, this initiative embeds education practice within practical operations by transforming material circularity processes into applied learning modules. Students engage with full lifecycle building operations, gaining hands-on experience in valuable material identification and preservation techniques, material data management systems, and practical application of reclaimed components through design-build curricula. This pedagogy-practice integration advances sustainable design comprehension through material reuse perspectives while establishing an implementation blueprint for architectural education reform.

Assessment of Demolition Materials: Theory and Practice

Projects adhering DfD principles demonstrate superior component removability compared to conventional construction. Materials reclaimed from such projects exhibit enhanced integrity and reuse potential relative to standard demolition outputs. The evaluation of demolition materials employs a dedicated framework based on the DfD assessment quantifying key parameters: physical properties, durability, current condition, and crucially, disassemblability - measured through structural connection types, disassembly-induced damage levels, and component accessibility/independence.[38]

In practice, reused demolition materials typically underperform new equivalents in quality metrics. Without professional evaluation, ensuring performance and safety necessitates conservative approaches, like performance downgrading or structural redundancy.[3] This context has precipitated the emergence of Component Hunters - specialists dedicated

to sourcing and technically evaluating demolition materials.

The initial phase of the K118 project's design and construction involves sourcing and gathering available dismantled materials from various project sites and markets, effectively transforming "the city as mine"¹ of reused materials. Critical success factors include material identification and quality assessment and optimized disassembly-transport-storage logistics. Component Hunters execute field surveys, stakeholder consultations, and technical documentation to build material databases with performance specifications. They evaluate various performance metrics to create a database for designers' reference. Once the dismantled materials to be used in the design are identified, the next step is to organize the dismantling of the target materials, each assigned a specific code and Component Passport. After proper removal from the project site, the materials' performance must be re-evaluated to ensure they meet the design requirements.[27]

The evaluation of materials serves dual objectives: selecting suitable dismantled materials for the design to facilitate circular design integration, and ensuring material performance and safety, which is essential for subsequent repairs, refurbishment, and reinstallation. On one hand, it involves analyzing different materials based on their characteristics, screening indicators affecting their reusability, and establishing a theoretical evaluation framework for demolition materials with quantified indicators to provide a criterion for assessing reusability. On the other hand, unlike new materials with uniform standards from specialized production, the use history and demolition methods of the materials complicate the assessment

¹ Reference [27] P35

of their suitability for reuse. This complexity necessitates the involvement of experienced experts like Component Hunters for individual screening and evaluation, making the assessment process specialized and giving rise to a new industry in the demolition materials reuse market, thereby offering a new guarantee for circular construction.

2.2.2 Transition Phase

The transition phase constitutes the interim process between material removal from source buildings and their reintegration into new construction cycles. During this critical interval, materials exist outside circular frameworks. Both physical material processing and corresponding digital data management, along with their operational interconnections, directly influence the material's successful reuse within circular systems.

The transition phase is intrinsically linked to the demolition phase. Commencing at the demolition onset, an information file is established for materials to document all relevant details, thereby facilitating material integration and management. Recycled materials undergo processes such as treatment, transportation, and storage, during which their associated information evolves dynamically. The timely updating and transmission of material information enable designers to access current data promptly. Through effective material information transmission, materials can be more efficiently matched to design requirements, thereby enhancing the application of recycled materials in the design phase and improving overall material reuse rates.

Reuse Platform: Material Reuse and Information Dissemination

The reuse platform facilitates circular reuse of demolition materials through integrated lifecycle management: material documentation, refurbishment, storage logistics, information dissemination, transportation, and sales. This operational framework extends material service life, promotes resource efficiency, and mitigates environmental impacts.[39] Some furniture enterprises offer value-added services including maintenance, redesign, and customization for obsolete furnishings, transforming discarded items into upgraded products.[40]

Established in the 1990s, Bauteilboerse-basel has evolved into Switzerland's premier marketplace for reclaimed building components.[3] It has since evolved into a professional and comprehensive platform for obtaining and trading information on second-hand building components and materials. Clients submit material removal requests digitally. The platform evaluates, dismantles, and collects components on-site. Recoverable materials within their lifecycle undergo cleaning, repair, and quality certification before reintegrated into marketplace through both online and offline sales channels. Materials and components that have reached the end of their useful life are recycled, and the waste generated is disposed of appropriately. The platform maintains a detailed catalog of components based on building parts and material types, including all types of building materials, wall and floor coverings, windows and doors, household appliances, kitchen and bathroom equipment, lighting, and more, to facilitate quick access to information on reuse materials.[39]

Useagain, the online trading platform of Bauteilboerse-basel, supports the collection and sale of dismantled components and materials at the end of a

building's life cycle. This unified platform connects all stakeholders involved in the recycling process of building components and materials. Users can search for building components and materials via the online platform, and each product is linked to a webpage with detailed information and a downloadable product information file containing essential details such as name, number, characteristics, price, payment method, shipping method, and store address.[41]

Girsberger offers refurbishment and upcycling services for old furniture. This not only reduces the cost of acquiring new furniture and promotes furniture recycling but also creates new added value for obsolete furniture through aesthetic refurbishment. Girsberger's furniture upcycling services begin with customer requirements and involve processes such as design, prototyping, and product testing to create customized furniture that meets specific client needs.[40]

Cirkla, originally established as Bauteilnetz,[3] is an initiative-driven association committed to promoting the reuse of building materials and components within the construction industry. Its primary objective is to unite Swiss stakeholders in the realm of building material reuse into a collaborative network, fostering the exchange of ideas and best practices among related professions and raising public awareness of the value of building material reuse. Cirkla aims to enhance construction processes, advance building technologies, and emphasize the improvement of existing structures. The association also explores the historical and artistic potential of reused materials, striving to increase the reuse rate of dismantled building components and materials. Furthermore, Cirkla advocates for cultural,

technological, and legal changes that support circular construction, with the goal of reducing resource consumption, waste generation, and carbon emissions, thereby advancing sustainable development.[42]

Cirkla actively disseminates its design philosophy and sustainable vision for material reuse by publishing design projects that utilize recycled building components and materials. The association also organizes various communication activities to demonstrate the reuse value of these materials to the public. Some documents produced as part of the project "Reuse of Components: Legal Framework," co-financed by Innosuisse in collaboration with Zirkular GmbH/baubüro in situ and the Zurich University of Applied Sciences (ZHAW) School of Management and Law, have been made publicly available on Cirkla. The project provides a manual for component reuse[43] along with relevant legal documents under the framework[44].¹

Material Passports (MPs): Link between Materials and Information

Establishing digital connections between demolition materials and their information profiles simplifies transitional management and assists architects in optimizing material-design compatibility, thereby increasing reuse rates. In the K.118 Project, Component Hunter implemented unique identification codes for each design-matched material and created component passports to facilitate post-disassembly inventory generation and performance evaluation.

MPs compile comprehensive data about materials, products, and

¹ Innosuisse supports innovation projects for companies and research institutions at both national and international levels. <https://www.innosuisse.admin.ch>

components, including physical, chemical, and biological properties, process histories, and health/safety information.[45] Accessible through online platforms and physical labels, these passports enable full lifecycle tracking from production through use, reuse, and disposal. They standardize and make material information transparent, promoting reuse and recycling, reducing resource waste, and advancing circular economy practices and sustainable development.[46]

Take Madaster as an example. Its online MPs platform, using specific databases and evaluation methods, analyzes and calculates the basic information of imported building materials. It offers quantitative data on carbon emissions and other environmental impacts in the MPs, assesses separability and reusability, and gives optimization strategies to choose lower-carbon materials and less carbon footprint building design solutions for stakeholders like owners, designers, and construction teams. The MPs information can be incorporated into relevant databases for building design and subsequent information updating and tracking.[47] Madaster developed a Circularity Indicator (CI) to evaluate each building's circularity degree. The CI assesses building sustainability through three weighted phases: construction, operational use, and end-of-life management, with composite scores calculated through weighted evaluation.[48]

The MPs supports the project throughout the design and construction process. In the design stage, designers, referring to the MP, prioritize materials that meet the design requirements and are low-carbon, removable, and highly reusable, reducing the building's environmental impact from the initial design. In the construction stage, the construction team can refer to

the MPs to arrange material procurement, transportation, and installation, ensuring the materials meet the project's requirements and choosing a construction program with less environmental impact. In the final demolition phase, the team devises a suitable plan based on the MPs, maximizing recyclable material reuse and minimizing C&DW generation. Changes during demolition are updated into the MPs data, which follows the recycled materials back into the database.

Online passport systems aggregate material data from multiple projects and regions through unified platforms, managing storage, analysis, tracking, and updates. This digital approach improves the efficiency and convenience of material data acquisition and management. As a new carrier of building material information, the MPs stores detailed data on each material, turning the building into a collection of MPs. After a building is renewed or demolished, the information of these materials is more easily accessible. The online MPs database offers an interface for subsequent material tracking and updating, ensuring the timeliness and accuracy of MPs information, and promoting the reuse and recycling of demolition materials and circular construction in the building industry.

MPs information can also be efficiently accessed through physical encoding methods such as QR codes applied to material surfaces. These digital markers store comprehensive material datasets through integrated platforms while maintaining precise physical-digital correspondence, ensuring accurate information-material pairing. This approach surpasses standalone digital platform access in operational convenience. Effective lifecycle data management necessitates centralized digital systems capable of continuous

information updates and analytical processing.[49]

The Circular Engineering for Architecture (CEA) research group at ETH Zurich's Institute of Construction and Infrastructure Management conducted empirical studies on QR code applications as MPs identifiers in small-scale construction projects.[49] Three prototype structures were examined: Dome1 utilized laser-engraved QR codes directly etched into wooden components; Dome1.2 represented a reconstructed iteration of Dome1 using its original disassembled materials; and Dome2 employed plastic adhesive tags bearing printed QR codes affixed to wood surfaces.

Implementation of physical tag-based material passport systems involves three sequential operational phases: initial establishment of digital-physical tag linkages, development of supporting database and digital platforms, and ongoing material information updates to facilitate reuse processes. They should be chosen based on material characteristics, project scale, and reading mode to select suitable information carriers and attachment methods.

Dome1's laser-engraved QR code offers moderate durability, but surface wear from wood abrasion and paint coatings can make information reading difficult. Dome2's plastic labels for QR codes enhance label production ease, increase replacement flexibility, and facilitate QR code information updates. While less prone to damage than engraved tags, plastic tags pose risks of loss and additional production and installation costs.

Besides QR codes, radio frequency identification (RFID) is another link

information to physical tagging technology for creating MPs. RFID identifies target objects' frequency emission signals contactlessly. Similar to QR code tags, RFID systems contain tags storing information about the identified object. A reader quickly receives signals from multiple tags within the identification distance and obtains object information for material localization and tracking.[50]

Database development forms the foundation for complex material information management. Effective systems must accommodate multi-format data ingestion, implement standardized processing protocols, and establish hierarchical management frameworks with lifecycle tracking capabilities. Choose or design a suitable user interface based on the database to support data uploading, querying, downloading, management, and updating, ensuring material information's accessibility, manageability, and effectiveness.

Dome1's digital platform uses a static webpage to store material data, relying on manual modification for updates. This method has poor update, management, and query capabilities but offers low costs and relatively high efficiency, suitable for small-scale projects or in early stage of the project. Dome2's MPs is managed by a MERN stack database, enabling real-time data updates and improving the accuracy and timeliness of the MPs. However, this database requires a professional development and maintenance team, with high development and operation costs.

The Dome1.2 reconstruction project provided critical insights into practical implementation challenges. As a rebuild using original Dome1 components,

QR code tracking theoretically spanned the complete material lifecycle from initial construction through disassembly to reconstruction. Dome1.2's construction process is similar to Dome1's, with the QR code providing quick access to material installation location and order. However, operational realities revealed material loss due to transportation, label degradation impairing readability, and component misinstallation issues. The construction process from Dome1 to Dome1.2 shows the application of QR codes as MPs in circular construction workflows while highlighting persistent limitations in label-data linkage stability and dynamic information management capabilities.

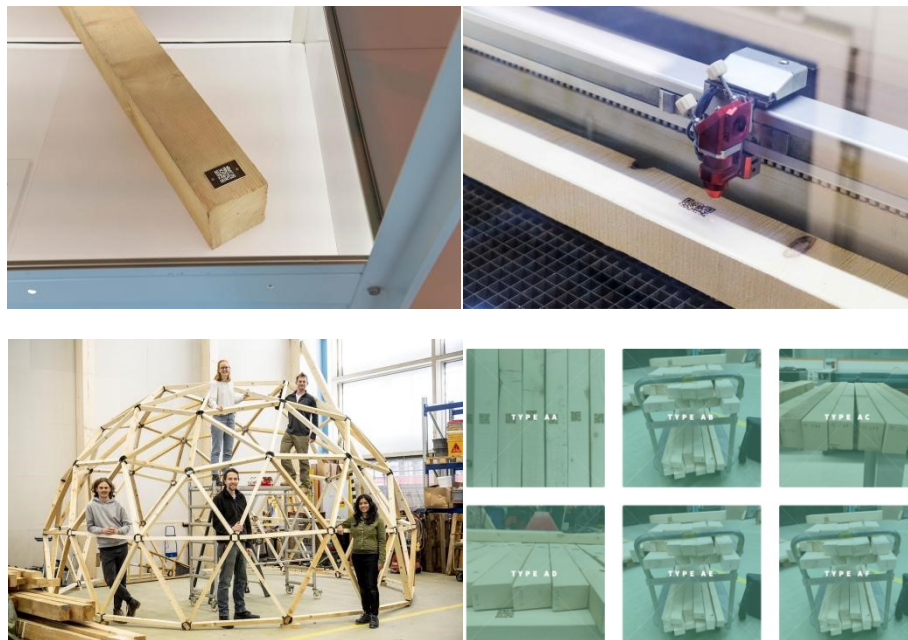


Figure11 QR Code MPs ©CEA ETH Zurich

Material passports systematically collect, store, and share material data,[51] transforming traditional resource management approaches and propelling circular construction practices in the building sector. Economically, these digital tools serve as design optimization instruments that assess material recycling and reuse potential.[52] Through comparative analysis with new material specifications, MPs enable selection of cost-efficient procurement and construction methodologies.[53]

However, the initial phase requires significant investment for data acquisition, database development, and system maintenance. Thus, assessing the value of MPs according to project characteristics and needs, choosing their intervention stage, and utilizing appropriate methods for creation is essential to enhance the overall economic benefits of material reuse.

Environmentally, MPs demonstrate measurable benefits by elevating material reuse rates. Compared to virgin material utilization, this approach reduces resource consumption and carbon emissions during production phases while decreasing C&DW volumes, thereby alleviating environmental pressures.

Implementation challenges persist across some primary dimensions. First, the reliability of identification and management technologies proves critical—system failures in data retrieval can disrupt material tracking and decision-making processes, potentially inflating timeframes, budgets, and ecological impacts. Second, successful adoption requires multi-stakeholder collaboration, yet inadequate recognition of system value frequently results in insufficient resource allocation for MPs development and utilization. Third, data inconsistencies between project participants create coordination

complexities that hinder both system establishment efficiency and operational effectiveness.[54]

2.2.3 Design Phase¹

Reserve Design

The material-centric design approach fundamentally differs from conventional architectural practice where functional and spatial determinations precede material selection. This reverse methodology strategically adapts building configurations to the inherent characteristics of reuse materials and components, leveraging precise material data including dimensions, quantities, and performance specifications. By prioritizing recycled material utilization, this approach increases the reuse rate of demolition materials, reduces material waste during design and construction, and maximizes the use of existing resources. Architectural innovation emerges through proactive material research and adaptive design strategies that unlock the expressive potential of reclaimed elements within new structural contexts.

The K.118 expansion project exemplifies successful implementation, incorporating regionally sourced components, including steel structures, facade materials, windows, flooring, and metal panels, which collectively reduced greenhouse gas emissions by 60% compared to conventional material procurement.[27] Structural steel repurposed from a logistics center in Basel dictated the building's primary load-bearing system and spatial organization. The salvaged stair platforms from office building in Zurich

established critical dimensional parameters for floor-to-ceiling heights. Distinctive cladding elements from a Winterthur's printing plant, notably oversized orange-red metal panels, were innovatively layered without cutting to preserve material integrity while achieving architectural articulation. Composite window assemblies blending varied dimensions address daylighting requirements while creating unique facade patterns with the exterior orange-red metal panels. Secondary elements including flooring and cabinetry underwent minimal modifications for functional adaptation, demonstrating how strategic material reuse influences both spatial functionality and aesthetic narrative.

This reverse design paradigm is an innovative approach to improving recycled material reuse rates. It emphasizes optimizing architectural space and form based on recycled material characteristics. At the project's early stage, architects must plan the building's shape and space according to recycled material information collected through research. In the K.118 project, Initial material intelligence gathering involves specialized component hunters systematically identifying, evaluating, and cataloging available resources to architects. This proactive research and information integration are fundamental to material reuse. During design, architects fully consider recycled material characteristics, using them as a key design basis. This assists in optimizing the building's spatial layout and form, enhancing the design potential of reclaimed material, and achieving the unique aesthetic expression of material reuse. Meanwhile, during reuse process, architects must collaborate with owners, suppliers, constructors, and other participants. It also requires cross-disciplinary work with engineers and scientists in relevant fields like structure, material, and environment to improve the

¹ Refer to Appendix A1 for case sources.

potential and efficiency of recycled material reuse.

Design for Disassembly (DfD)

DfD employs reversible methodologies that enhance material separability disassembly capabilities. This approach facilitates material replacement and refurbishment during building operation, minimizes end-of-lifecycle dismantling damage, and improves reuse potential for building elements.

Material selection during design prioritizes high-reuse candidates such as timber and steel. Timber, as a renewable low-carbon resource, serves dual roles in decorative and structural applications. Its circular reuse is achievable through optimized joint connections. Steel offers superior strength and durability with versatile sizing options, accommodating diverse spatial and functional requirements. Assembly via mechanical fasteners (e.g., bolts) permits controlled disassembly and post-processing reconfiguration for circular applications.

The Transa office renovation features three-layer partition walls combining recycled timber keels with cut panels. Screw-fixed assemblies enable non-destructive disassembly and reuse. In the EMPA Nest Sprint module, partition walls incorporate demolished timber from an office in Basel secured with screws following DfD protocols. The 2022 Basel Pavilion utilizes reclaimed timber, steel, and paper tubes assembled through bolted and strapped connections, creating distinctive public spaces while maintaining future disassembly capacity. The Manegg Kindergarten's outdoor sunshade shelves and part of the indoor steel structure are made from recycled steel components, fixed with removable bolted connections.



Figure12 Construction of Transa interior wall © baubüro in situ/ Martin Zeller



Figure13 Kindergarten Manegg outdoor sunshade steel frame
©Bischof Föhn Architekten/ Theodor Stalder

DfD-oriented material connections prioritize dry assembly methods over fluid-based bonding techniques,[55] such as welding or chemical adhesives. These irreversible connection types complicate deconstruction processes, cause material degradation, and diminish reuse viability. Conversely, mechanical fastening systems, including bolts, snap, and special connectors, streamline both installation and deconstruction processes. This approach

facilitates maintenance operations, preserves post-disassembly material integrity, and enhances material recovery potential.

Innovative joint engineering enables complex disassembly-compliant structures. The Digital Building Technologies (dbt) at ETH Zurich demonstrates this through bamboo-composite system development. Their Digital Bamboo Pavilion integrates 900+ bamboo components with steel cables and 3D-printed elements using 380 custom connectors. This temporary structure achieves geometric complexity while maintaining rapid disassembly capabilities.[56] Central stainless steel connectors, fabricated via metal laser sintering technology, provide critical structural reinforcement. Bamboo-specific snap-fit fasteners enable complete disassembly without material compromise.[57]



Figure14 Connection nodes in Digital Bamboo ©dbt/ Marirena Kladeftira

The principles of DfD extend beyond material connections to encompass holistic architectural planning. By conceptualizing buildings as layered systems with distinct service lifecycles per stratum, and organizing inter/intra-layer components for detachability, this methodology ensures segmental separability. Such systematic organization facilitates future

disassembly, component replacement, and maintenance operations while enhancing structural adaptability.

Integration with modular design strategies proves particularly effective—modular component organization improves manufacturing efficiency, reduces material waste during production and construction, and optimizes workflow processes.[58] The combined application of DfD and modular principles enables component maintenance during operational phases, improves end-of-life deconstruction efficiency, minimizes material damage, and elevates reuse potential.

The Zurich Wiedikon School project exemplifies this dual approach through wooden modular construction. Factory-prefabricated elements include structural members, wall panels, floor slabs, and spatial modules (sanitary facilities, staircases) for rapid on-site assembly. Detachable connection methods feature components with bolted joints, while concrete foundations employ sectional construction permitting dimensional disassembly. Selected sanitary fixtures and laboratory equipment incorporate reused components.

NEST, a modular research and innovation building by the Swiss Federal Laboratories for Materials Science and Technology (Empa) and the Swiss Federal Institute of Aquatic Science and Technology (Eawag), consists of a central backbone and three open platforms for the rapid installation of spatially modules (“units”) for experiments according to the “plug & play” principle. The building is designed for experimenting with new technologies and construction methods in a real-building environment. The rapid dismantling of the old units to provide space for experimentation with the

new ones once the research work is completed.[59] The Sprint units exemplify circular construction, maximizing recycled material integration according to the principle of DfD. Structural systems utilize reclaimed timber, while partition walls incorporate repurposed materials including wood panels, chalkboards, carpet tiles, publications, and bricks. All connections maintain disassembly capacity, including clay-bonded brick walls designed for post-use separation.



Figure15 Sprint Units ©Martin Zeller

DfD focuses on the separability and detachability of building components and materials. This approach not only simplifies maintenance and renovation

during building operation but also improves recycling and reuse efficiency of dismantled elements while reducing waste generation and environmental impact at end-of-life. Implementing DfD principles in architectural practice enables conceptualizing buildings as stratified systems with spatially segregated zones based on differential service lifecycles. Early-stage material selection should prioritize high-reuse candidates, employ mechanical connection methods where feasible, and develop innovative joint solutions to address complex structural disassembly challenges. Integrating DfD with modular strategies optimizes construction processes. Prefabricated standardized components enhance production efficiency, streamline onsite assembly/disassembly operations, and effectively promote circular reuse of building elements.

Case Colleciton (Appendix A1)

The appendix A1 compiles 20 exemplary Swiss architectural projects focused on demolition material reuse, geographically distributed across multiple cities with a temporal scope spanning nearly a decade. These cases encompass diverse building typologies including commercial, office, cultural, exhibition, educational, residential facilities and relevant teaching and research programs, demonstrating material reuse applications at varying architectural scales. Within the circular construction domain, extensively reused materials include timber (structural elements, panels, slats, flooring, etc.), steel (framing systems, staircases, etc.), other metals (plates, components, etc.), and masonry/stone. Adaptive reuse extends to building components such as windows, doors, sanitary fixtures, kitchen elements, lighting systems, and furnishings. These practical explorations test material adaptability while progressively expanding reuse boundaries in architectural

contexts.

From sustainability perspectives, material reuse undeniably reduces resource consumption and waste generation.

Aesthetically, designers must navigate historical preservation and contemporary functionality when integrating weathered materials. Critical considerations include dimensional compatibility between reclaimed elements and spatial requirements. Unlike standardized new materials, salvaged components exhibit dimensional variability that may challenge design intent. Adaptive strategies involve flexible design adjustments balancing old-new material relationships, optimizing aesthetic value of recycled materials while enhancing public acceptance of reuse practices.

Technical implementation requires rigorous performance assessments. Material degradation from prior use necessitates careful evaluation, particularly for structural and envelope applications. Downcycling strategies often apply to components with reduced performance capacity. For critical building elements, like structure and enclosure, pre-use testing and post-application monitoring inform safe reuse parameters. Such empirical data collection supports broader material reuse implementation across architectural systems.

3. ADAPTIVE OPTIMIZATION OF REUSE STRATEGIES FOR DEMOLITION MATERIALS

3.1 Multi-Dimensional Adaptability Analysis of Demolition Material Reuse

3.1.1 Design Practices

Research on reuse hierarchies in architectural design and the built environment originates from four industrial ecology scenarios: Reuse, Repair, Reconditioning, and Material Recycling. Fletcher, Popovic, and Plank consolidated the first three into the Product Level while classifying recycled materials under the Material Level, with additional System Level categorization representing adaptable building systems. Kibert and Chini's waste management hierarchy comprises Landfill, Burning, Composting, Recycling, Reuse, and Reduction, with Recycling subdivided into Downcycling, Recycling, and Upcycling, and Reuse categorized as Reuse of Materials versus Reuse of Components or Products.[60]

Current research in China demonstrates substantial progress in Material Level recycling (e.g., various recycled materials), while Product Level studies on direct material/component reuse remain limited and lack systematic frameworks.[61] From a design practice perspective, this gap presents architects with practical opportunities to explore demolition material reuse through real-world projects while establishing foundational research. Salvaged materials differ from new equivalents due to performance degradation and non-standard characteristics, like appearance alterations, dimensional inconsistencies, complicating reuse applications. Common

downcycling reuse requires expert verification and owner approval, facing multiple implementation constraints.[3]

This report systematically documents material reuse practices in Beijing's construction sector. The case collection (Appendix A2) analyzes 20 local projects spanning architecture, landscape design, interior spaces, and installations across multiple administrative districts. These cases demonstrate diverse material reuse applications through design practice perspectives, encompassing varied project typologies and salvaged material categories.

Analysis of Demolition Material Reuse Practices in Beijing¹

The examined projects demonstrate material circulation across recycling and reuse hierarchies. Within the recycling hierarchy, diverse waste streams are processed into standardized recycled products re-entering construction supply chains, including recycled concrete from demolition waste, polycarbonate tiles from plastic recycling, and furniture from repurposed textiles. The reuse hierarchy features extensive application of salvaged building components ranging from materials, such as concrete, steel, timber, masonry, to prefabricated elements, like windows, furniture, industrial equipment.

Predominantly employing downcycling strategies, these materials substitute new resources in built environments, reducing economic and environmental costs while leveraging aged materials' aesthetic value. Concrete, timber, and brick recycling are particularly widespread, illustrating their adaptability across contexts. crushed concrete serves in foundations and paving;

¹ Refer to Appendix A2

repurposed wood functions in façades and furniture; reused bricks primarily feature in paving with occasional structural applications.

Some projects have innovatively expanded reuse boundaries. For instance, reclaimed carport columns and steel reintegrate into new building structures, restoring their load-bearing functions. Discarded stone materials, after meticulous processing, enhance building interfaces with cultural textures. Old windows are creatively collaged into interior interfaces or reconfigured as external envelopes. Industrial equipment waste is transformed into installations, preserving industrial aesthetics.

From a functional perspective, reused demolition materials permeate multiple architectural design levels, from outdoor landscaping to structural components and façade aesthetics to interior decorations. Outdoor areas and interior decorations are the most utilized sectors. Outdoors, materials contribute to public space creation, including landscaping, paving, and facility construction. Indoors, they are used for wall decorations, flooring, and furniture, blending historical traces with sustainable ideologies.

Project typology analysis reveals diverse applications of demolition material reuse across landscape, commercial, office, cultural tourism, residential, facility, and installation designs, demonstrating broad functional adaptability.

Geographically, reuse practices extend from central urban commercial/office projects preserving regional identity to peripheral administrative districts' cultural/residential developments. Mountainous area facility projects further exemplify functional-aesthetic integration through material reuse.

Temporally, applications span three implementation models: temporary exhibition designs showcasing circular construction strategies, adaptive interior renovations enabling spatial optimization, and permanent buildings achieving material lifecycle extension. Each model maximizes reuse value within distinct temporal frameworks.

However, practical implementation faces systemic challenges. Material selection remains predominantly constrained to conventional construction materials including concrete, timber, masonry, and metals, with inherent quality variations necessitating conservative downcycling approaches. This operational caution, while ensuring safety, significantly limits design innovation potential. As for more special types of demolition materials and components, their reuse largely depends on designers' creative ideas and accumulated design experience. This leads to the lack of widely recognized reuse potential and economic value of these materials and components. Their market demand continues to decrease, and they are currently categorized as C&DW, used only as raw materials for material level recycling to enter circularity.

Even within sustainability-focused projects, material diversity remains disappointingly limited, typically featuring only 1-2 reused types with minimal supply chain development beyond local sources. This constrained implementation substantially diminishes anticipated environmental and economic benefits. In addition, the recycling sources of demolition materials are limited, mainly from the demolition site of the project itself or the surrounding area, which restricts the types and quantities of demolition

materials and may lead to the reduction or even abandonment of the reuse of materials due to the inability to obtain sufficient demolition materials to meet the design requirements, further limiting the practice of reusing demolition materials.

Performance-sensitive applications face additional technical barriers, particularly in load-bearing systems and building envelopes where material durability and strength require rigorous verification. Compared with new materials that have fixed standards, the performance evaluation of these old materials requires targeted professional appraisal. The reuse technology and methods are still immature, lacking extensive application cases and practical experience, which leads to greater barriers to their application in terms of economy risk and construction uncertainties.

From the three stages of demolition material reuse, Beijing's current practice is concentrated in the design phase, focusing on reusing different types of demolition materials in projects. Although some exhibitions and temporary projects like interiors have adopted modular or DfD approaches in the design process, considering the possibility of material recycling after project demolition, there is still a gap compared to Switzerland in terms of practice and research in the demolition and transition phases of materials. The lack of research on materials across different stages has led to a disconnect in the material reuse market between upstream and downstream industries, creating an information gap between material recycling and reuse, which limits the repeated use of reuse materials.

Analysis of Demolition Material Reuse Practices in Switzerland

Switzerland's demolition material reuse practices exhibit superior material diversity and methodological innovation compared to current Beijing implementations. Beyond conventional materials like concrete, timber, masonry, and metals, as well as complex components including thermal insulation systems, composite panels, staircases, lighting equipment and prefabricated kitchen/sanitary modules, unconventional materials such as shipping containers, railway sleepers, blackboards, carpets, paper products and industrial byproducts like high-voltage masts demonstrate expanded material recovery boundaries. This material inclusivity is matched by innovative reuse strategies that transcend basic downcycling and cycling. In terms of reuse methods, in addition to conventional downcycling or same-level recycling, Switzerland has explored innovative reuse approaches. For example, materials like panels, carpets, and paper are cut and stacked to form partitions, breaking conventional design and construction methods for material reuse. Additionally, in-depth exploration has been conducted on the sound insulation and comfort properties of these recycled materials. These diverse material reuse practices promote the in-depth exploration and innovative use of demolition materials, expanding the boundaries of reusable material types and their reuse potential.

The diversity and innovation of materials and reuse methods not only enrich sustainable design approaches for material reuse but also significantly increase the proportion of reused materials applied in new projects. Most cases emphasize the extensive reuse of recycled materials and components, and in some projects, demolition materials are deeply integrated as primary materials in the design and construction process. This approach effectively reduces the consumption of new materials, fully utilizes the environmental

benefits of reused materials, and achieves efficient resource utilization and environmental sustainability. For example, the K.118 renovation project, based on reused materials, reduced greenhouse gas emissions by 60% and saved 500 tons of primary materials;[27] Zurich Manegg kindergarten project reduced greenhouse gas emissions by approximately 30% through the reuse of recycled materials and components;[62] and the Uster temporary school project reduced carbon dioxide emissions by 488 tons through the reuse of components.[63]

The sources of recycled materials are not limited to demolished projects and surrounding sites. Waste generated from the production chains of construction and other industries, as well as by-products discarded during construction, can also serve as reused materials, as seen in projects in both Switzerland and Beijing. For instance, industrial processing waste is used as aggregate for terrazzo floors, stone factory scraps are polished and reused, and formwork used for concrete casting is repurposed after being discarded.

Switzerland's practices further expand material sources, broadening the vision for material reuse by treating the city as a mine. This approach fully explores and recovers reusable building materials and components within the urban environment. Additionally, through the circulation of reuse materials between different projects and the transportation of reuse materials across regions, Switzerland achieves integrated material management, improving the reuse rate of demolition materials. For example, in the H.141 office renovation project, reuse materials and components originated from the Winterthur storage area, which housed surplus materials and components from the K.118 renovation project. In the 2022 Basel

Pavilion, reuse materials and components came from renovation and demolition projects and were compiled into a component catalog as the basis for the exhibition pavilion design. The primary components reused in the Uster temporary school teaching spaces originated from a temporary school building in Winterthur.

Switzerland has studied the impact of refined and selective demolition on the reuse potential of demolition materials, established professional reuse material trading platforms, and developed dedicated research teams and emerging professions. This has formed a relatively complete reuse industry chain for demolition materials and a well-established market mechanism. Professional evaluation and stable supply chains ensure the quality of reuse materials to some extent, enabling them to meet higher building performance requirements and providing designers with more possibilities for reusing materials.

3.1.2 Technical Applications

Most projects in Beijing involving the reuse of demolition materials remain at the practical level and lack systematic design approaches and technical methods. This report analyzes the technical applications of demolition material reuse in China, focusing on theoretical research and technical pathways, primarily in the areas of material recycling and the reuse of intact components, corresponding to material level and product level reuse, respectively. However, research on the reuse of entire demolition components, often linked to DfD theory, is relatively limited.[61]

Compared to current technical research in China, Switzerland integrates digital technologies and artificial intelligence tools deeply into its research on building demolition and material reuse. By optimizing theoretical frameworks and technical methods based on practical design issues, Switzerland bridges the gap between theoretical research and practical application, connecting academia with construction practice and advancing the development of material reuse and circular construction.

Status Quo Analysis of

Demolition Material Reuse Technologies in China

Current research on building demolition materials in China has established a systematic and hierarchical framework, integrating global academic findings to prioritize material reuse strategies. The optimal way to recycle demolition materials and components is through direct reuse, followed by recycling them into raw materials.[61] A multidimensional development system for the reuse of demolition components and materials has been formed. The team from Tongji University has developed systematic building disassembly design and construction methods. They have studied the reuse of components and materials at different levels following building disassembly and established a theoretical framework for deconstruction engineering, aiming to reduce waste generation at the source and improve reuse rates.[64] The team from Harbin Institute of Technology has explored domestic and international masonry structure demolition techniques and proposed industrialized demolition and reuse methods for masonry structures, from wall cutting to reassembly.[65]

The evolution of DfD theory and prefabricated construction technology has transformed traditional building design and demolition practices. Using timber structures as an example, prefabricated timber structures exhibit significant disassembly characteristics. By selecting structural systems, standardizing component designs, and optimizing joints, the prefabrication level and future disassembly potential of timber structures can be enhanced, promoting the recycling and reuse of timber and its components at the end of a building's life cycle.[66]

Research on digital technology applications is driving the intelligent development of building demolition. Based on BIM, theoretical frameworks and technical methods have been established for the demolition management, information storage, and component reuse of steel[67] and concrete structures[68]. These advancements optimize the demolition process, assess component performance and reuse value, and enhance construction efficiency and component reuse potential. 3D scanning aids in reverse modeling of existing buildings, and when combined with mixed reality (MR) technology, it optimizes demolition plans and improves safety and efficiency.[69] Additionally, a computer-aided tool based on vector graphic statics (VGS tool), jointly developed by domestic teams and multiple foreign universities, supports computational and optimization processes for reused components, reducing material loss during component reuse.[70]

Regarding the management of building demolition materials, current domestic research primarily focuses on the macro-level management of construction waste. From a material flow perspective, studies analyze the generation and destination of C&DW, establishing a comprehensive

management framework to enhance its resource utilization and reuse.[71] BIM and GIS technologies are utilized for real-time monitoring of C&DW and the establishment of intelligent management platforms, achieving digital management of C&DW.[72] However, compared to international research, there is a gap in more micro-level management technologies for demolition materials and components, such as MPs.

Status Quo Analysis of

Demolition Material Reuse Technologies in Switzerland

In terms of technology application, Switzerland's exploration in building demolition and material reuse offers new ideas and technical pathways for future domestic research. A research team from ETH Zurich and the University of Waterloo systematically analyzed the information and technology gaps between academic research and industry practices in material reuse. They proposed a standardized framework for integrating information attributes, sources, and reuse, revealing the potential of digital technology in promoting material reuse and the challenges in practical applications. The team emphasized narrowing the research-practice gap through technological innovation, policy support, and standardization, providing theoretical and practical models for circular construction.[73]

Reality capture technologies such as photogrammetry and Lidar scanning, combined with BIM and computer vision, enable digital modeling of demolition sites and support planning for material demolition and reuse.[74] A BIM-GIS framework effectively analyzes and evaluates urban-scale building stock and material data, supporting the transition of urban development toward a circular economy.[75]

With the advancement of artificial intelligence (AI), research on building demolition and material reuse has gained more efficient analytical methods and technical pathways. Machine learning analyzes urban building stock using Google Street View imagery databases to identify façade materials and reusable components, aiding urban-scale material and component reuse.[76] Studies combining 360° imagery with machine learning enable efficient detection of reusable components, establishing automated identification methods and technical pathways for building component stock.[77] Machine learning also analyzes and calculates urban material stock, supporting dynamic predictions of city-level material resources.[78] During the demolition and reuse phase, ETH Zurich developed a multi-objective optimization algorithm for material matching, addressing the non-standard characteristics of demolition materials. By integrating dynamic construction demands and optimizing the matching rate between design and demolition components, this approach enhances material utilization and establishes theoretical and technical frameworks for efficient material use in circular construction.[79]

3.1.3 Policy and Standards

Current policy and standards in China regarding the reuse of demolition materials mainly focus on the management of C&DW and its resource utilization, with relatively limited support and regulations for the direct and intact reuse of demolition materials and components. Although relevant standards emphasize the detachability and replaceability of components during the design phase, the primary goal is to extend the lifespan of

buildings, rather than to regulate how to extend the lifespan of materials and components after demolition.

In contrast, the Swiss government provides comprehensive support for the reuse of demolition materials and components through policy and standards. In addition to the newly revised "SIA 430:2023 Avoidance and Disposal of Construction Waste," Switzerland has driven the research and application of multiple material reuse projects, gradually establishing a theoretical and application framework for the reuse of demolition materials that spans from interdisciplinary research to specific technical levels.

Status Quo Analysis of

Demolition Material Reuse Policies and Standards in Beijing

According to the policy analysis on building demolition and material reuse in China and Beijing presented in Chapter 1 of this report, current domestic policies in this field primarily focus on macro-level C&DW management and resource utilization of materials. There are relatively few regulations regarding the direct reuse of demolition materials and intact components. Similar to recycling policies for other products, such as waste batteries, home appliances, and automobiles, relevant policies aim to establish a robust social recycling and reuse system, explore new "Internet-enhanced recycling and reuse" models, and utilize digital technologies to integrate online and offline recycling and reuse pathways, thereby building an efficient reverse logistics system.[80]

Current national and industry standards in China related to the reuse of demolition materials are primarily concentrated in the field of C&DW

resource utilization, focusing on regenerative technologies for the waste, such as recycled aggregates, recycled concrete, and recycled bricks.[81] There is a lack of standards for the direct reuse of demolition materials. Some green building evaluation standards have established regulations for the use of recyclable and reusable materials,[58] emphasizing the need to enhance building adaptability in design to facilitate functional transformation and renovation. These standards also recommend combining components with different lifespans and adopting construction methods that are easy to disassemble.[82] While building adaptability and variability support systemic-level reuse, and the design of demountable components and equipment facilitates product-level reuse, there is currently no unified standard for reusing materials and components after demolition.

Status Quo Analysis of

Demolition Material Reuse Policies and Standards in Switzerland

The Swiss government has provided policy and financial support for the theoretical research and technological application in the reuse of demolition materials and components, enhancing their reuse rate and advancing circular construction in the construction industry.

The Federal Office for the Environment (FOEN) commissioned organizations like Salza.ch to study the reuse of components in Switzerland. Their report, "Reused Building – Current situation and prospects: The roadmap", analyzed the current status, challenges, and potential of reuse in the construction industry and proposed actions across multiple dimensions, including architectural design, reuse industry, construction education, public awareness, and policy support, providing a theoretical framework to

promote material and component reuse.[83] The "Reuse of Components: Legal Framework" project, funded by Innosuisse, offers a user guide and legal framework for the reuse of construction components.

The Swiss Federal Office of Energy (SFOE) supports the "Reuse-LCA" project, which combines material reuse strategies with low-carbon design methods. Using a hybrid approach of top-down Mass Flow Analysis (MFA) and bottom-up Life Cycle Assessment (LCA), it evaluates the environmental benefits of material reuse in new and renovated construction projects in Switzerland.[84][85] Also supported by the SFOE, the "FenSanReuse: Renovation and Reuse of Windows – Material Passport and Guidelines" project systematically explores the energy-saving renovation and reuse potential of windows. It develops standardized analysis methods and renovation processes for windows from a technical standpoint, assesses their environmental and economic benefits from a life cycle perspective, and establishes a policy framework for window material passports to improve window repairability and material recycling rates.[86][87]

3.2 Strategy Optimization of Demolition Material Reuse Based on Swiss Experience

3.2.1 Industry Synergy

Establishing Collaborative Industry Mechanisms

Promotes the integration of the construction demolition and material reuse industry chain, covering all stages from recycling to processing, storage, transportation, and reuse. A key focus is establishing specialized platforms for trading demolition materials and components, supported by government or private initiatives. These platforms offer comprehensive services, including demolition management, material assessment, processing, storage, and transportation. Integrating internet and information technologies, developing hybrid reuse models that combine online and offline approaches, aiming to enhance the circular use of demolition materials.

Launching Pilot Construction Projects

Demonstration projects, supported by the government and the construction industry, are crucial for advancing material reuse. These projects undergo special evaluations during design and construction, prioritizing the reuse of demolition materials. They serve as showcases for circular construction practices, highlighting design methods and technologies that facilitate material reuse.

Promoting Regional Collaborative Development

Regional collaboration is another important aspect. It is advised to establish management and transportation mechanisms for demolition material reuse with neighboring regions through industry synergy and hybrid online-offline

models. This approach optimizes resource allocation, boosts material reuse rates, and enhances the environmental and economic benefits of material reuse within the region.

3.2.2 Technological Innovation

Fostering Industry-Academia-Research Cooperation

It is recommended to establish industry-academia-research platforms and set up special scientific research funds to conduct theoretical research and technological development on the reuse of demolition materials from multiple parties, bridge the gap between academic research and practical applications, and accelerate the transformation of research results. Schools and industry training should be utilized to promote design practices for the reuse of demolition materials in the construction industry.

Advancing Digital Technology and AI Applications

Digital technology applications in building demolition and material reuse should be strengthened. Technologies such as BIM, GIS, reality capture, and MR can enable precise management of demolition sites and efficient reuse of materials. AI-assisted research paths and technical methods for multi-stage material reuse should also be explored, including prediction and assessment of demolition materials and design optimization algorithms for their reuse.

Strengthening Technological Exchange and Collaboration

Active engagement in domestic and international technology exchange and cooperation is essential for introducing advanced foreign technologies. These technologies must be adapted to China's policy direction, economic

development, social environment, and the specific circumstances of the construction sector and material reuse industries. Localizing international technologies and making adaptive improvements are crucial for ensuring their successful implementation and maximum effectiveness.

3.2.3 Policy and Standards

Funding Specialized Research Projects

Governments should establish specialized policies for the reuse of demolition materials and set up dedicated funds to support relevant technology development and demonstration projects, promoting the practical application of material reuse in architectural design. Policy guidance and financial support can address existing technological bottlenecks and market barriers in the field of material reuse, ensuring the sustainable development of material cycles.

Policy Support and Standard Enhancement

A comprehensive policy and standards system for the reuse of demolition materials should be developed to address regulatory gaps in the direct reuse of building materials and components at the product level. Establishing evaluation standards for non-standardized demolition materials and components can enhance the feasibility and scalability of material reuse in practical applications.

Strengthening Market Access and Regulation

The entire process of building demolition and material reuse should be subject to strict government supervision, covering all stages from project approval and construction oversight to the transportation, processing, and

reuse of demolition materials. Governments need to implement strict market access mechanisms and oversee enterprises across the industry chain. As non-new products, the quality management and regulation of demolition materials and components are essential for ensuring their safety and reliability during reuse.

4. CONCLUSION

This report examines China's current building demolition and material reuse practices in Chapter 1, Switzerland's circular construction strategies and practices in Chapter 2, and compares China and Switzerland's approaches to demolition material reuse in Chapter 3, focusing on design, technology, and policy standards. It also proposes context-appropriate recommendations for China.

In China, policy and research focus mainly on material-level recycling and C&DW resource utilization, with limited attention to direct reuse of building materials and components. No specialized market or industrial chain for demolition material reuse exists, hindering large-scale application in construction. Most reuse efforts rely on architects' initiatives, with limited reuse methods, technologies and material types. There is a gap between architectural practice and academic research. While systematic theoretical frameworks and diverse technical pathways have been established in research, there is a shortage of practical experience to support the implementation of these technologies.

Switzerland has accumulated extensive experience in the reuse of demolition materials through practical projects, exploring the boundaries of material types that can be reused. These range from structural components such as concrete, steel, and wood, to enclosure components like insulation, windows, and doors, to decorative materials such as panels, wood flooring, tiles, and carpets, and even to equipment modules for lighting, sanitation, and kitchens. A mature market for material circulation and component trading

platforms has been established, driving the emergence of related professions and industrial growth. Technologies for the reuse of demolition materials have evolved through in-depth research on theories such as DfD, reverse design, and MPs. Digital technologies and AI have been employed to optimize the design process of building demolition and material reuse. Additionally, targeted government support and specialized research have addressed challenges in implementing demolition material reuse, promoting the application of these technologies in real-world projects.

Drawing from Switzerland's experience and China's current status, promoting the reuse of demolition materials can begin with pilot construction projects. This approach can expand the application of demolition material markets and gradually form a complete industrial chain, combining online and offline reuse platforms. It is also essential to actively advance academic research and technology implementation in relevant fields, establish standards for demolition material reuse, and ensure efficiency, safety, and sustainability throughout the process.

A1 Case Collection——Switzerland

The case studies showcase some architectural practices in Switzerland on the reuse of building materials and components.

Num	Project Name	Location	Architect	Year
1	Kleine Freiheit Container Renovation	Zurich	baubüro in situ	2016
2	Binz Workshop	Zurich	baubüro in situ	2016
3	Im Lee Temporary Science Facility	Winterthur	baubüro in situ	2019
4	ImpactHUB Office	Basel	baubüro in situ	2019
5	Einfach Wohnen Office	Zurich	baubüro in situ, denkstatt sàrl	2020
6	K.118	Winterthur	baubüro in situ	2021
7	ELYS Culture & Commercial Center	Basel	baubüro in situ	2021
8	Four Artist Studio	Schlieren	baubüro in situ	2021
9	ETHZ Reuse Design Studio	Zurich	baubüro in situ, students (ETHZ)	2021、2022
10	NEST Sprint Units	Dübendorf	baubüro in situ	2022

11	Transa Office Renovation	Zurich	baubüro in situ	2022
12	H.141 Office Renovation	Winterthur	baubüro in situ	2022
13	Werkstadt Building A Renovation	Zurich	baubüro in situ	2022
14	Primeo Energie Science Center	Münchenstein	Rapp AG	2022
15	2022 Basel Pavilion	Basel	Isla Architects	2022
16	Manegg Kindergarten	Zurich	Bischof Föhn Architekten	2023
17	Hohlstrasse 418 Office Renovation	Zurich	baubüro in situ	2024
18	Wiedikon Temporary School	Zurich	baubüro in situ, pool Architekten	2024
19	Uster Temporary School	Uster	baubüro in situ	2024
20	Lysp8	Zurich	Loeliger Strub Architektur	Ongoing

Kleine Freiheit Container Renovation



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Project Information

Type	Commerce	Location	Zurich
Architect	baubüro in situ	Country	Switzerland
Year	2016	Area	40 m ²
Source	https://www.insitu.ch/projekte/195-kleine-freiheit		
Profile	This project transforms repurposed containers into a charming neighborhood dining space. Recycled wooden flooring is creatively reused as paving material, while reclaimed sliding doors and windows contrast beautifully with the bold red container façade, creating a striking visual identity. Even the outdoor garden furniture, crafted from reclaimed materials, seamlessly integrates functionality with sustainability, making the entire space a harmonious blend of innovation and eco-conscious design.		
Strategy	Material reuse		
Reuse Materials	Wooden flooring, sliding doors, windows, tables, chairs, etc.		

Binz Workshop



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Project Information

Type	Office	Location	Zurich
Architect	baubüro in situ	Country	Switzerland
Year	2016	Area	
Source	https://www.insitu.ch/projekte/200-werkhof-binz		
Profile	This project retains and expands the existing building, revising the entrance and adding an exterior staircase. New wooden modular units create 35 studios, offices, and workshops, complemented by shared kitchen and bathroom facilities, offering flexible spaces for users. The redesigned layout introduces a courtyard for meetings, outdoor work, and storage, while the visual contrast between old and new architecture creates a compelling dialogue with historical spaces. The integration of functionality and design results in a dynamic, sustainable environment that bridges past and present.		
Strategy	Material reuse, modular design		
Reuse Materials	Steel beams, wood, metal panels, timber, etc.		

Im Lee Temporary Science Facility



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Project Information

Type	Education	Location	Winterthur
Architect	baubüro in situ	Country	Switzerland
Year	2019	Area	1500 m ²
Source	https://www.insitu.ch/projekte/309-kantonsschule-im-lee-provisorium-naturwissenschaften		
Profile	This temporary science facility at Im Lee School's sports field was designed to accommodate classes during a three-year renovation period. The design team utilized shipping containers sourced from Uster, organizing the space in a modular layout. Special attention was given to the demountability and reusability of building materials and components, ensuring sustainable practices for both the temporary structure and future applications.		
Strategy	Modular design, material reuse, DfD.		
Reuse Materials	Shipping containers, wooden boxes, pallet boxes, lighting equipment, etc.		

ImpactHUB Office



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Project Information

Type	Office	Location	Basel
Architect	baubüro in situ	Country	Switzerland
Year	2019	Area	2500 m ²
Source	https://www.insitu.ch/projekte/298-impact-hub		
Profile	The ImpactHUB Basel association has leased the Christoph Merian Foundation as its new office space. The project transforms the existing building into a spacious workspace tailored for office needs, featuring event rooms and a café on the ground floor, both open to the public, as well as underground storage facilities. Designed with minimal intervention to preserve the existing space, the project prioritizes sustainability by reusing recycled building materials and components. Special emphasis is placed on ensuring that all installed elements are demountable and reusable, supporting the principles of circular design and long-term adaptability.		
Strategy	Material reuse, DfD		
Reuse Materials	Windows, steel staircases, catering kitchens, dining facilities (counters and furniture), wooden flooring, workshops, lighting fixtures, tables, chairs, exterior cladding, etc.		

Einfach Wohnen Office



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Project Information

Type	Office	Location	Zurich
Architect	baubüro in situ, denkstatt sàrl	Country	Switzerland
Year	2020	Area	250 m²
Source	https://www.insitu.ch/projekte/315-geschaeftsstelle-einfach-wohnen		
Profile	This project creates new office spaces for the Einfach Wohnen Foundation, designed with an open, flexible structure and movable furniture to adapt to various functional needs and ensure long-term usability with minimal renovation costs. The interior design emphasizes sustainability through the reuse of reclaimed building materials and components, while the furniture is crafted from upcycled materials, blending functionality with eco-conscious practices.		
Strategy	Materia reuse		
Reuse Materials	Asbestos cement boards and plywood used as templates, windows, sinks, templates, doors, dishwashers, etc.		

K.118



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Project Information

Type	Office	Location	Winterthur
Architect	baubüro in situ	Country	Switzerland
Year	2021	Area	1266 m ²
Source	https://zirkular.net/en/project/building-k-118/ https://www.insitu.ch/projekte/196-k118-kopfbau-halle-118 https://cirkla.ch/en/home/projektliste/projektdetails/?topic=91		
Profile	This project transforms the existing factory, a 19th-century brick building, into a office space. Employing a reverse design process, the project begins by sourcing reusable materials, which are then dismantled, assessed, treated, and reassembled for reuse in the renovation and expansion. This approach prioritizes sustainability and resource efficiency, seamlessly integrating historical architecture with modern functionality.		
Strategy	Material reuse, DfD		
Reuse Materials	Steel structures, steel staircases, doors and windows, insulation materials, exterior metal panels, wooden boards, flooring, photovoltaic panels, tiles, granite slabs, kitchen facilities, sanitary components, metal cabinets, etc.		

ELYS Culture & Commercial Center



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Project Information

Type	Culture & Commercial	Location	Basel
Architect	baubüro in situ	Country	Switzerland
Year	2021	Area	
Source	https://zirkular.net/en/project/culture-commercial-center-elys/ https://www.insitu.ch/projekte/229-umnutzung-elys-kultur-amp-gewerbehaus-lysbuechelareal https://cirkla.ch/en/home/projektliste/projektdetails/?topic=66		
Profile	The project utilizes 200 recycled windows, organized into a new façade using wooden frames to balance aesthetic appeal and natural lighting. The wooden frames, reclaimed from demolished buildings' glulam beams, meet structural requirements for exterior walls. These frames are filled with recycled insulation materials to ensure thermal performance. Additionally, green metal panels removed from the original roof are combined with recycled metal sheets to create the building's new façade, emphasizing sustainability and resource reuse		
Strategy	Material reuse		
Reuse Materials	Windows, laminated timber, insulation materials, metal sheets, etc.		

Four Artist Studio



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Project Information

Type	Office	Location	Schlieren
Architect	baubüro in situ	Country	Switzerland
Year	2021	Area	360 m ²
Source	https://www.insitu.ch/projekte/321-vier-kuenstlerateliers https://cirkla.ch/en/home/projektliste/projektdetails/?topic=2 https://prixignum.ch/0/279/projektarchiv/projektarchiv-prixignum/2376/kuenstlerateliers-turmstrasse-schlieren/		
Profile	This project transforms a late 19th-century gasworks building into a shared creative workspace for four artists. Reclaimed building components, sourced from demolition projects across various locations, are repurposed in the design. These components, bearing unique historical marks and stylistic features, add character to the space while emphasizing sustainability and resourcefulness.		
Strategy	Material reuse		
Reuse Materials	Wooden windows with handcrafted hinges, wooden boards from temporary railways, and wooden slats originally used as overpass railings.		

ETHZ Reuse Design Studio



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Project Information

Type	Teaching	Location	Zurich
Architect	baubüro in situ students (ETHZ)	Country	Switzerland
Year	2021、2022	Area	
Source	https://www.insitu.ch/projekte/380-ethz-studio-reuse-herbstsemester https://www.insitu.ch/projekte/379-ethz-studio-re-use-fruehlingssemester		
Profile	The ETH Zurich Reuse Studio is designed to teach students how to source and effectively utilize recycled components in design, giving them hands-on experience in architectural reuse. During the fall semester of 2021, students designed and built a 1:1 scale model using recycled components. In the spring semester of 2022, they constructed a reuse pavilion using these components, further emphasizing sustainable design practices and resourcefulness.		
Strategy	Material reuse		
Reuse Materials	Wooden structural components, steel structural components, doors and windows, wooden laths, floor tiles, metal components, etc.		

NEST Sprint Units



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Project Information

Type	Office	Location	Dübendorf
Architect	baubüro in situ	Country	Switzerland
Year	2022	Area	200 m ²
Source	https://zirkular.net/en/project/empa-sprint-unit/ https://www.insitu.ch/projekte/320-unit-sprint-im-nest-empa		
Profile	The project creates new office units on the second floor of the NEST building, designed and built using a modular approach with a focus on reuse materials. The space includes 12 individual offices, with interior partitions assembled using demountable materials to accommodate flexible space requirements. During its operational period, the unit serves as a real-world environment for testing room comfort, sound insulation, and other performance metrics. After use, the unit can be fully disassembled and recycled, emphasizing sustainability and adaptability in architectural design.		
Strategy	Material reuse, DfD, Modular design		
Reuse Materials	Wooden structures, wooden partitions, bricks, modular carpets, blackboards, books, magazines, etc.		

Transa Office Renovation

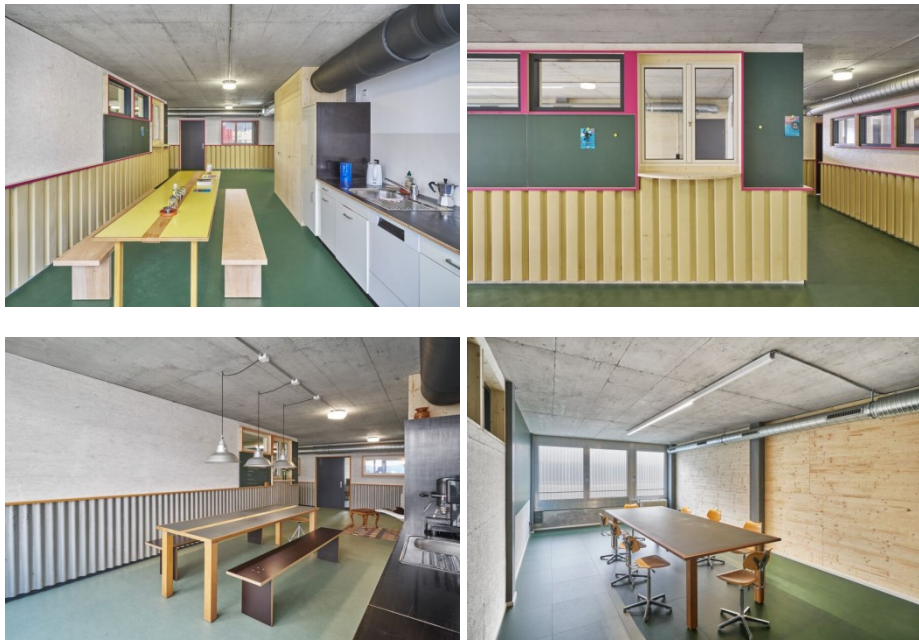


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Project Information

Type	Office	Location	Zurich
Architect	baubüro in situ	Country	Switzerland
Year	2022	Area	1500 m ²
Source	https://www.insitu.ch/projekte/328-zero-waste-umbau-transa https://cirkla.ch/en/home/projektliste/projektdetails/?topic=65		
Profile	The renovation of Transa Office adheres to a design principle centered on reusing recycled materials, with minimal intervention to the existing space. The original structure and material textures are preserved to free up interior space. Partitions and components are installed using DfD principles, ensuring materials can be easily disassembled and recycled at the end of their lifecycle. This approach balances sustainability with functionality while maintaining the building's historical character.		
Strategy	Material reuse, DfD		
Reuse Materials	LED light rails, pendant lighting components, wall lamps, and other lighting fixtures; acoustic ceiling plaster; wooden, metal, and glass doors and windows; flooring and carpets; various panels (wooden boards, wood fiber panels, perforated wood fiber panels, plywood, etc.); metal kitchen units, cabinets, and sinks; conference equipment; reinforced concrete cores, etc.		

H.141 Office Renovation

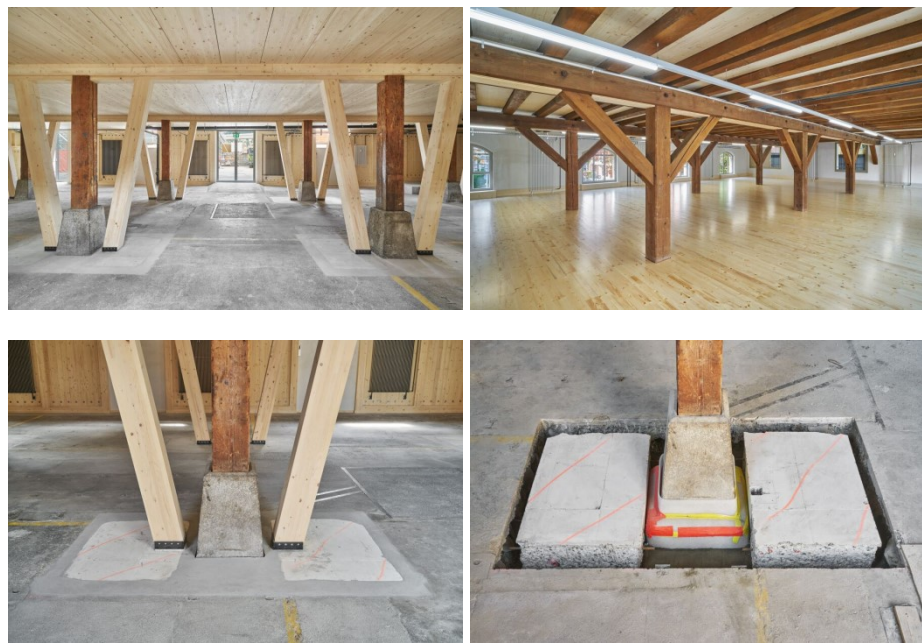


©baubüro in situ

Project Information

Type	Office	Location	Winterthur
Architect	baubüro in situ	Country	Switzerland
Year	2022	Area	290 m ²
Source	https://www.insitu.ch/projekte/336-bueroausbau-h141-lagerplatz		
Profile	The Abendrot Foundation has constructed a new building on the south side of Winterthur's storage area. The design team reimagined the existing space as smaller office units, using as many recycled materials as possible. The two-story office space includes five individual offices, one conference room, and a communal kitchen. Its flexible layout allows the structure to adapt to various user needs and scenarios.		
Strategy	Material reuse		
Reuse Materials	Wooden panels, Heraklith boards, wooden doors, metal sheets, blackboards, drawer cabinets, beech wood, etc.		

Werkstadt Building A Renovation



©baubüro in situ

Project Information

Type	Commercial	Location	Zurich
Architect	baubüro in situ	Country	Switzerland
Year	2022	Area	
Source	https://www.insitu.ch/projekte/339-gebaeude-a-werkstadt-areal-gesamtsanierung-2-etappe https://www.insitu.ch/projekte/285-werkstadt-areal		
Profile	The project, part of the industrial building renovation in the Werkstadt area, transforms existing spaces into commercial space, creating urban areas for future creative work and leisure. It adds high-performance wooden structures to preserve the historical building, using recycled concrete from demolition as the foundation. The design reduces the use of cement and plaster, and minimizes unnecessary technical treatments with a focus on simplicity and efficiency.		
Strategy	Material reuse		
Reuse Materials	Concrete, radiators, doors, sanitary ware, lighting fixtures, natural stone window sills, etc.		

Primeo Energie Science Center



©Rapp AG/ Beat Ernst

Project Information

Type	Culture	Location	Münchenstein
Architect	Rapp AG	Country	Switzerland
Year	2022	Area	
Source	https://cirkla.ch/en/home/projektliste/projektetails/?topic=104 https://www.primeo-energie.ch/en/ueber-uns/kosmos/science.html https://www.rapp.ch/de/referenzen/lernen-vom-energie-kosmos		
Profile	The project renovates an existing workshop into a science museum for Primeo Energie, following circular construction principles. The building is constructed entirely from wood, with the façade made from recycled materials sourced from other construction sites. The interior design maximizes the use of components from previous projects or the original building. Overall, 70% of the building components are made from reused, recycled, or renewable raw materials, highlighting its commitment to sustainability and resource efficiency.		
Strategy	Material reuse		
Reuse Materials	Wooden floor, sanitary facilities (sinks, partitions, and fittings), tiles, lighting fixtures, old high-voltage masts, railings, façade components, etc.		

2022 Basel Pavilion



© Luis Díaz Díaz

Project Information

Type	Exhibition	Location	Basel
Architect	Isla Architects	Country	Switzerland
Year	2022	Area	100 m ²
Source	https://zirkular.net/en/project/basel-pavillion-2022/ https://www.archdaily.com/982645/loggia-baseliana-pavilion-ista-architects https://baselpavillon.store		
Profile	The project explores circular construction and the reuse of building components. It involves researching and tracking reclaimed materials to compile a component catalog. Using materials from this catalog, architects designed five open modular units. These modules, arranged along railway tracks and extending over 50 meters, create an open, linear urban public space. The project emphasizes sustainability through its focus on resource reuse and modular design.		
Strategy	Material reuse, modular design		
Reuse Materials	Steel profiles, metal sheets, wooden laths, wooden panels, wooden planks, metal grilles, cardboard tubes, etc.		

Manegg Kindergarten



©Theodor Stalder

Project Information

Type	Education	Location	Zurich
Architect	Bischof Föhn Architekten	Country	Switzerland
Year	2023	Area	271 m ²
Source	https://zirkular.net/en/project/kindergarten-moeoeslistrasse/ https://www.espazium.ch/de/aktuelles/re-use-kindergarten-moeoesliweg-zuerich https://www.bf-architekten.ch/projects/kindergarten-manegg		
Profile	The project transforms former worker dormitories into a kindergarten, providing daycare services for Manegg Primary School. The design team preserved existing spatial elements and maximized the use of reusable components. By removing partitions from small rooms, the project creates a steel-structured open space that offers flexible options for multifunctional use. The interior features a vibrant color scheme, emphasizing the lively atmosphere suitable for a kindergarten.		
Strategy	Material reuse		
Reuse Materials	Steel structures, wooden structures, ceiling panels, exterior staircases, railings, planters, fireproof doors, acoustic components, and sanitary, kitchen equipment, etc.		

Hohlstrasse 418 Office Renovation



©baubüro in situ

Project Information

Type	Office	Location	Zurich
Architect	baubüro in situ	Country	Switzerland
Year	2024	Area	490 m ²
Source	https://www.insitu.ch/projekte/364-bueroausbau-hohlstrasse-418		
Profile	The Halle Q space has been transformed into office spaces for three subsidiaries: Denkstatt Sàrl, Zirkular, and baubüro in situ. The design team achieved this adaptive reuse through the strategic reuse of recycled materials, emphasizing both spatial flexibility and material sustainability. This approach not only revitalizes the building but also promotes circular resource management, aligning functionality with environmental responsibility.		
Strategy	Material reuse		
Reuse Materials	Glass partitions, cemsan boards, kitchen facilities, metal panels, beech wood panels, lighting fixtures, plywood, electrical tracks, etc.		

Wiedikon Temporary School



©baubüro in situ

Project Information

Type	Education	Location	Zurich
Architect	baubüro in situ, pool Architekten	Country	Switzerland
Year	2024	Area	8350 m ²
Source	https://www.insitu.ch/projekte/349-provisorium-kantonsschule-wiedikon https://www.poolarch.ch/projekte/2020/0423-hohlstrasse.html		
Profile	The project consists of temporary school facilities and a sports hall, designed for a 30-year lifespan. It employs prefabricated modular construction, with standardized components such as wooden beams, columns, walls, floors, ceilings, bathrooms, and staircases manufactured in a factory for rapid on-site assembly. The construction process follows DfD principles, ensuring components can be reused after disassembly. Additionally, some sanitary facilities and laboratory equipment incorporate recycled components, emphasizing sustainability and resource efficiency.		
Strategy	Modular design, DfD, material reuse		
Reuse Materials	sanitary facilities, laboratory equipment.		

Uster Temporary School



©Martin Zeller

Project Information

Type	Education	Location	Uster
Architect	baubüro in situ	Country	Switzerland
Year	2024	Area	1911.9 m ²
Source	https://zirkular.net/en/project/provisional-school/ https://www.espazium.ch/de/aktuelles/kantonsschule-uster-erweiterung-fassade-kreislauf https://www.insitu.ch/projekte/354-provisorium-kantonsschule-uster		
Profile	The project repurposes the temporary Im Lee school into two two-story buildings, featuring 13 classrooms and a teacher's office with a lounge. The design team transformed the existing schoolhouse through façade renovations, constructing outdoor buffer zones with recycled components, and retrofitting containers. The outdoor buffer zones, upgraded exterior walls with improved insulation, and sloped roof windows that enhance natural lighting and ventilation all contribute to regulating and improving the indoor climate.		
Strategy	Material reuse		
Reuse Materials	Doors and windows, fireproof doors, railings, colored metal sheets, roof panels, concrete slabs, glass, lighting fixtures, etc.		

Lysp8



© Loeliger Strub Architektur/ Martin Zeller

Project Information

Type	Residential	Location	Zurich
Architect	Loeliger Strub Architektur	Country	Switzerland
Year	Ongoing	Area	
Source	https://loeligerstrub.ch/nproject/lysp8-neubau-wohnhaus-mit-gewerbe/ https://zirkular.net/en/project/lysp8/		
Profile	The project creates a town-like public space atmosphere, with a three-dimensional wooden ventilated corridor connecting outdoor staircases and gardens, linking terraces and arcades, and organizing residential units across different floors. This design provides residents with social spaces for lingering and interaction, while flexible indoor-outdoor spaces meet diverse functional and temporal needs. Modular building components, open staircases and walkways, high-performance building envelopes, and well-designed shading devices fulfill the project's sustainable design requirements.		
Strategy	Material reuse, modular design		
Reuse Materials	Roof tiles, shutters, fiber cement boards, railings, wooden panels, awnings, landscape paving, kitchen components, radiators, etc.		

A2 Case Collection——Beijing

The case studies showcase some of Beijing's architectural practices in reusing building materials and components.

Num	Project Name	Locaiton	Designer	Year
1	CHI Restaurant	Dongcheng	odd	2013
2	Greenpeace Beijing Office	Dongcheng	Livil Architects	2015
3	The Treehouse	Miyun	Wee Studio	2016
4	Yingliang Stone Archive and Restaurant	Chaoyang	Atelier Alter	2016
5	Liangshuichi East Road – Shougang	Shijingshan	NICOLAS GODELET Architects & Engineers	2017
6	Concrete Vessel	Chaoyang	Atelier FCJZ	2018
7	Beijing Xidian FUNS iTown	Chaoyang	Change Landscape Studio	2019
8	The Beijing Yongxing River Greenway	Daxing	Turenscape	2019
9	Beijing Fashion Factory courtyard A	Chaoyang	AntiStatics Architecture	2020
10	Memory House 2020	Haidian	Yuan Ye Architects	2020
11	Youth Activity Center	Miyun	REDe Architects Moguang Studio	2020

12	ENKORE	Chaoyang	ATLAS	2021
13	Mixed House	Tongzhou	Arch Studio	2022
14	Gongchen ZEB Community Center	Fangshan	SUP Atelier THAD	2023
15	Langyuan Station	Chaoyang	Atelier KAI Architects, LAVA Structural Engineers	2023
16	ARC'TERYX Flagship Store (Sanlitun)	Chaoyang	STILL YOUNG	2023
17	SHASHA COFFEE	Dongcheng	WUE Studio	2023
18	%VOL Bar	Miyun	mint+ studio	2023
19	théATRE SHANJUCHAJING Concept Store	Chaoyang	kooo architects	2023
20	Nikon Beijing Flagship	Chaoyang	Lukstudio	2024

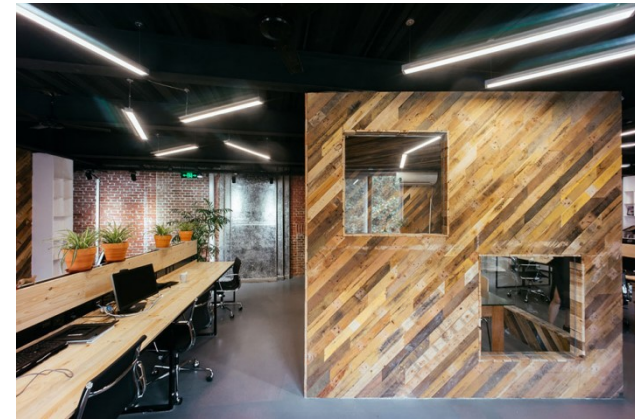
CHI Restaurant



© misae Hiromatsu/ Song Xianming

Type	Commercial	Location	Dongcheng, Beijing
Designer	odd	Country	China
Year	2013	Area	60 m ²
Source	https://www.gooood.cn/chi-restaurant-china-by-odd.htm		
Profile	This creative 60m ² restaurant in a hutong uses reclaimed window frames and aged wood to craft a unique dining atmosphere. Its open kitchen and movable wall design enhance spatial flexibility, offering diners a distinctive experience.		
Strategy	Material reuse		
Reuse Materials	Doors and windows, wood.		

Greenpeace Beijing Office



©Wang Hongyue/Lu Wenhui/Wu Wendi

Type	Office	Location	Dongcheng, Beijing
Designer	Livil Architects	Country	China
Year	2015	Area	1700 m ²
Source	https://www.gooood.cn/greenpeace-beijing-office.htm		
Profile	The project is located in a quiet courtyard off East Second Ring Road. It blends historical elements with modern design and uses reclaimed materials to create a unique office space that harmonizes old and new aesthetics.		
Strategy	Material reuse		
Reuse Materials	Reclaimed wood includes logistics pallets, various wooden furniture, outdoor wooden flooring, construction formwork, railroad ties, etc.		

The Treehouse



© Sun Haiting/RoadsideAlien Studio

Type	Lodge	Location	Miyun, Beijing
Designer	Wee Studio	Country	China
Year	2016	Area	8 m ²
Source	https://www.gooood.cn/the-treehouse-by-wee-studio.htm		
Profile	Nestled at the foot of Wuling Mountain in Miyun, Beijing, this project was crowdfunded online by a design team. It features a tea room and bathroom built with steel and reclaimed wood. Windows and skylights bring in natural views, creating a cozy, nature-connected space.		
Strategy	Material reuse		
Reuse Materials	Reclaimed wood panels are used to clad the exterior.		

Yingliang Stone Archive and Restaurant



© Atelier Alter

Type	Commercial	Location	Chaoyang, Beijing
Designer	Atelier Alter	Country	China
Year	2016	Area	472 m ²
Source	https://www.gooood.cn/yingliang-stone-archive-between-stonework-and-architecture-by-atelier-alter.htm		
Profile	The project transforms a factory into a stone gallery and restaurant, combining recycled stone and steel to highlight material authenticity and craftsmanship. It provides a space for interaction between designers and the public.		
Strategy	Material reuse		
Reuse Materials	Offcuts stone from the stone plant is processed and used for building surface.		

Liangshuichi East Road – Shougang



© NICOLAS GODELET Architects & Engineers

Type	Landscape	Location	Shijingshan, Beijing
Designer	NICOLAS GODELET Architects & Engineers	Country	China
Year	2017	Area	1800m
Source	https://www.gooood.cn/liangshuichi-east-road-shougang-beijing-by-nicolas-godelet-architects-engineers.htm		
Profile	The project integrates a pedestrian-friendly design with recycled materials and industrial elements, creating an innovative space that balances ecology, culture, and aesthetics.		
Strategy	Material reuse		
Reuse Materials	Recycled permeable materials are used for paving.		

Concrete Vessel – Pavilion no.1 in China House Vision



©Tian Fangfang

Type	Exhibition	Location	Chaoyang, Beijing
Designer	Atelier FCJZ	Country	China
Year	2018	Area	184 m ²
Source	https://www.gooood.cn/concrete-vessel-pavilion-1-in-china-house-vision-by-fcjz-haier.htm		
Profile	The project is an experimental housing inspired by Beijing's courtyard house. It features a central courtyard that brings natural light and greenery into the home. Constructed with recyclable materials, the design balances privacy with nature, offering a new model for sustainable living.		
Strategy	Regenerated material		
Reuse Materials	Glass Fiber Reinforced Concrete (GRC) made by C&DW.		

Beijing Xidian FUNS iTown



©Wang Ning

Type	Landscape	Location	Chaoyang, Beijing
Designer	Change Landscape Studio	Country	China
Year	2019	Area	3 ha
Source	https://www.gooood.cn/beijing-xidian-funs-itown-by-change-studio.htm		
Profile	The project transforms an old factory into a vibrant community hub, blending commercial, office, leisure, and creative spaces. It retains industrial textures and is designed around a central street, with modular paving and greenery enhancing the eco-friendly atmosphere.		
Strategy	Material reuse		
Reuse Materials	Irregular concrete blocks and crushed stones are combined to create landscape paving.		

The Beijing Yongxing River Greenway



©Turenscape

Type	Landscape	Location	Daxing, Beijing
Designer	Turenscape	Country	China
Year	2019	Area	150 ha
Source	https://www.gooood.cn/the-beijing-yongxing-river-greenway-china-by-turenscape.htm		
Profile	The project innovatively transforms an urban drainage channel into a green sponge. Through wetland construction and terrain reshaping, it provides integrated ecosystem services, including hydrological regulation, biodiversity support, and community vitality.		
Strategy	Material reuse		
Reuse Materials	Demolished concrete is used for the foundation of islands and terrain.		

Beijing Fashion Factory courtyard A



©Xia Zhi

Type	Office	Location	Chaoyang, Beijing
Designer	AntiStatics Architecture	Country	China
Year	2020	Area	18000 m ²
Source	https://www.gooood.cn/beijing-fashion-factory-courtyard-a-by-antistatics-architecture.htm		
Profile	The project transforms an industrial site into a fashion and creative workspace. It combines textile techniques and modern architectural elements to create a multifunctional creative hub for fashion and creative industries.		
Strategy	Material reuse		
Reuse Materials	Tanks are turned into public seating Pipes and valves are made into structural components and plant frames.		

Memory House 2020



©Lu Bo

Type	Installation	Location	Haidian, Beijing
Designer	Yuan Ye Architects	Country	China
Year	2020	Area	9 m ²
Source	https://www.gooood.cn/memory-house-2020-yuan-ye-architects.htm		
Profile	The project creates a 3m ³ installation with low-cost, lightweight modular construction, designed for quick assembly and disassembly. It offers flexibility and adaptability for various locations and functions.		
Strategy	Material reuse		
Reuse Materials	Reclaimed wooden pallets are used and all materials and components are reusable.		

Youth Activity Center – Renovated from Old Garment Plant



©Xia Zhi

Type	Education, Culture	Location	Miyun, Beijing
Designer	REDe Architects, Moguang Studio	Country	China
Year	2020	Area	6300 m ²
Source	https://www.gooood.cn/youth-activity-center-renovated-from-old-garment-plant-china-by-rede-architects-moguang-studio.htm		
Profile	The project transforms an factory into a multi-functional activity center, integrating a children's science museum, hotel, and parent-child education facilities. It combines old and new elements to create diverse spatial experiences.		
Strategy	Material reuse		
Reuse Materials	Bricks are used for paving and courtyard walls, steel from a carport are repurposed into the main entrance portico.		

ENKORE



©Boris Shiu

Type	Commerical	Location	Chaoyang, Beijing
Designer	ATLAS	Country	China
Year	2021	Area	370 m ²
Source	https://www.gooood.cn/enkore-a-space-return-to-nature-beijing-by-atlas.htm		
Profile	The project is a sustainable fashion space in Sanlitun Soho, Beijing, themed around "Seeds and Circularity." Using eco-friendly materials and artistic installations, it creates a multi-functional venue for exhibitions and retails.		
Strategy	Material reuse		
Reuse Materials	Waste shell is embedded in terrazzo flooring, reclaimed wood flooring is reused, and recycled fabric is pressed into display stands. Discarded fabric is used for changing room curtains, and old furniture is reused as cabinets.		

Mixed House



©Jin Weiqi

Type	Residential	Location	Tongzhou, Beijing
Designer	Arch Studio	Country	China
Year	2022	Area	373 m ²
Source	https://www.gooood.cn/mixed-house-china-by-archstudio.htm		
Profile	The project integrates new and old wooden houses into a rural village in Beijing's suburbs, using sustainable design and traditional structures to explore strategies for rural architecture renewal.		
Strategy	Material reuse		
Reuse Materials	Locally reclaimed red and green bricks are used to build new enclosure walls.		

Gongchen ZEB Community Center



©Xia Zhi

Type	Community	Location	Fangshan, Beijing
Designer	SUP Atelier of THAD	Country	China
Year	2023	Area	1500 m ²
Source	https://link.cnki.net/doi/10.19953/j.at.2024.08.003		
Profile	The project achieves health and energy goals through spatial optimization, photovoltaic integration, and low-carbon materials. It integrates sustainable design and building environments into community living.		
Strategy	Material reuse		
Reuse Materials	Reclaimed metal pipes from a nearby construction site are used to form the east façade.		

Langyuan Station



©Xing Rui

Type	Commercial	Location	Chaoyang, Beijing
Designer	Atelier KAI Architects, LAVA Structural Engineers	Country	China
Year	2023	Area	400 m ²
Source	https://www.gooood.cn/langyuan-station-by-atelier-kai-architects-and-lava-structural-engineers.htm		
Profile	The project transforms a 1960s and 70s textile warehouse into a unique commercial space. It retains old red brick walls and uses a column-free truss system. A serpentine layout creates a mysterious space, enhancing exploration and forming a distinctive commercial atmosphere.		
Strategy	Material reuse		
Reuse Materials	Reclaimed bricks from the site are used for masonry.		

ARC'TERYX Flagship Store (Sanlitun)



©Yuuuun Studio

Type	Commercial	Location	Chaoyang, Beijing
Designer	STILL YOUNG	Country	China
Year	2023	Area	885 m ²
Source	https://www.gooood.cn/arcteryx-flagship-store-in-beijing-by-still-young.htm		
Profile	The project, inspired by Vancouver's mountain forests, blends nature and art with sustainable materials to create an immersive space. It showcases outdoor spirit and brand culture, offering a unique consumer experience.		
Strategy	Material reuse		
Reuse Materials	Discarded rusted steel plates from the factory are used to create pinecone art installations, while waste wood slices are repurposed as decorative pillars.		

SHASHA COFFEE



©Fang Liming

Type	Commercial	Location	Dongcheng, Beijing
Designer	WUE Studio	Country	China
Year	2023 年	Area	115 m ²
Source	https://www.gooood.cn/shasha-coffee-by-wue-studio.htm		
Profile	The project features creative cold-brew coffee, creating a natural, rustic slow-living space through a "fishbone" layout and recycled materials. It retains the original structure while integrating modern functionality, offering a unique coffee experience.		
Strategy	Material reuse		
Reuse Materials	Reclaimed bricks and old elm wood panels are used as the main materials.		

%VOL Bar



©mint+studio

Type	Lodge	Location	Miyun, Beijing
Designer	mint+ studio	Country	China
Year	2023	Area	60 m ²
Source	https://www.gooood.cn/vol-bar-china-by-mint-studio.htm		
Profile	The project, located in a tea mountain area in the suburbs of Beijing, aims to create a mountain shelter for both tourists and local villagers through flexible design and sustainable materials, thereby helping to revitalize the local economy.		
Strategy	Material reuse, DfD, modular design		
Reuse Materials	Cypress and poplar branches form a three-tiered platform. Wood chips are reused for paving, and waste plastic is used for polycarbonate panels.		

théATRE SHANJUCHAJING Concept Store



©Horikoshi Keishin/ SS

Type	Commercial	Location	Chaoyang, Beijing
Designer	kooo architects	Country	China
Year	2023	Area	175 m ²
Source	https://www.gooood.cn/theatre-shanjuchajing-concept-store-by-kooo-architects.htm		
Profile	The project blends tea, dining, and art to create a tranquil "mountain retreat" for urban professionals, offering relief from city life. Using tea-soil bricks and a wooden lattice façade, it delivers an immersive tea-culture experience.		
Strategy	Material reuse		
Reuse Materials	Reclaimed terracotta bricks		

Nikon Beijing Flagship



©Wen Studio

Type	Commercial	Location	Chaoyang, Beijing
Designer	Lukstudio	Country	China
Year	2024	Area	377 m ²
Source	https://www.gooood.cn/nikon-beijing-flagship-by-lukstudio.htm		
Profile	The project combines camera aesthetics with natural and industrial elements, using eco-friendly materials and recycled structures to create a space with brand identity and regional culture.		
Strategy	Material reuse		
Reuse Materials	Reclaimed antique blue bricks from demolished old buildings in Beijing are used for paving.		

A3 Glossary

SDC

Swiss Agency for Development and Coordination

Mohurd

Ministry of Housing and Urban-Rural Development

SUP

SUP Atelier of THAD (The Architecture Design and Research
Institute of Tsinghua University Co., Ltd.)

C&DW

Construction and Demolition Waste

CD

Conventional Demolition

SD

Selective Demolition

DfD

Design for Disassembly

ETH Zurich

Swiss Federal Institute of Technology Zurich

ZHAW

Zurich University of Applied Sciences

MPs

Material Passports

CI

Circularity Indicator

QR code

Quick Response code

RFID

Radio Frequency Identification

Empa

Swiss Federal Laboratories for Materials Science and Technology

Eawag

Swiss Federal Institute of Aquatic Science and Technology

MR

Mixed Reality

VGS

Vector Graphic Statics

AI

Artificial Intelligence

FOEN

Federal Office for the Environment

SFOE

Swiss Federal Office of Energy

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