Jacob Shipp

From Waste to Resource:
An investigation into London's embryonic architectural recycling network.

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Abstract
Mining the Metropolis.

This thesis examines the complex landscape of material re-use in London's built environment through: a comprehensive mapping of the city's re-use infrastructure; an analysis of current policy frameworks; and insights from practicing architects. Material re-use, refers to the practice of salvaging, recycling, and re-purposing materials from existing buildings to be reintegrated into new architectural projects. By means of mapping the material re-use and recycling landscape, this study reveals both strategic and physical opportunities and constraints within embryonic architectural recycling network of London. In combination with the perspectives of industry professionals, These findings highlight the challenges and opportunities in transforming London's built environment into a functioning material mine of valuable resources.

London's built environment represents challenges and opportunities for rethinking how we can re-use materials. Challenges such as London's high land values and limited space are some examples that increase the economic pressures typically favouring demolition over adaptive re-use. The city's mixture of historical buildings, dense development, and growing environmental pressures makes it a perfect setting to investigate the current approaches of architects and Planning authorities and identify the challenges to material re-use. Although modern architectural practices often follow a linear 'take-make-waste' model, this study proposes a more nuanced understanding of value in London's architectural landscape, by examining not just physical materials but also the intangible heritage ingrained in the urban fabric.

Similarly to an organ transplant, the re-use of architectural materials reintegrates materials, having already lived a first life, into a new context. Thereby extending their functional and aesthetic lifespan. By doing this, the traditional notions of 'waste' are challenged, encouraging an alternative perspective for discarded materials. This thesis investigates how redefining 'waste' can transform architectural practice to recognise re-claimed materials as dynamic and valuable resources.

From Georgian terraces and Victorian industrial buildings to post-war developments, London's diverse architectural catalogue emerges as a unique and valuable material mine. Providing a means to develop transferable material re-use strategies addressing the complex environmental and conservation challenges of today.

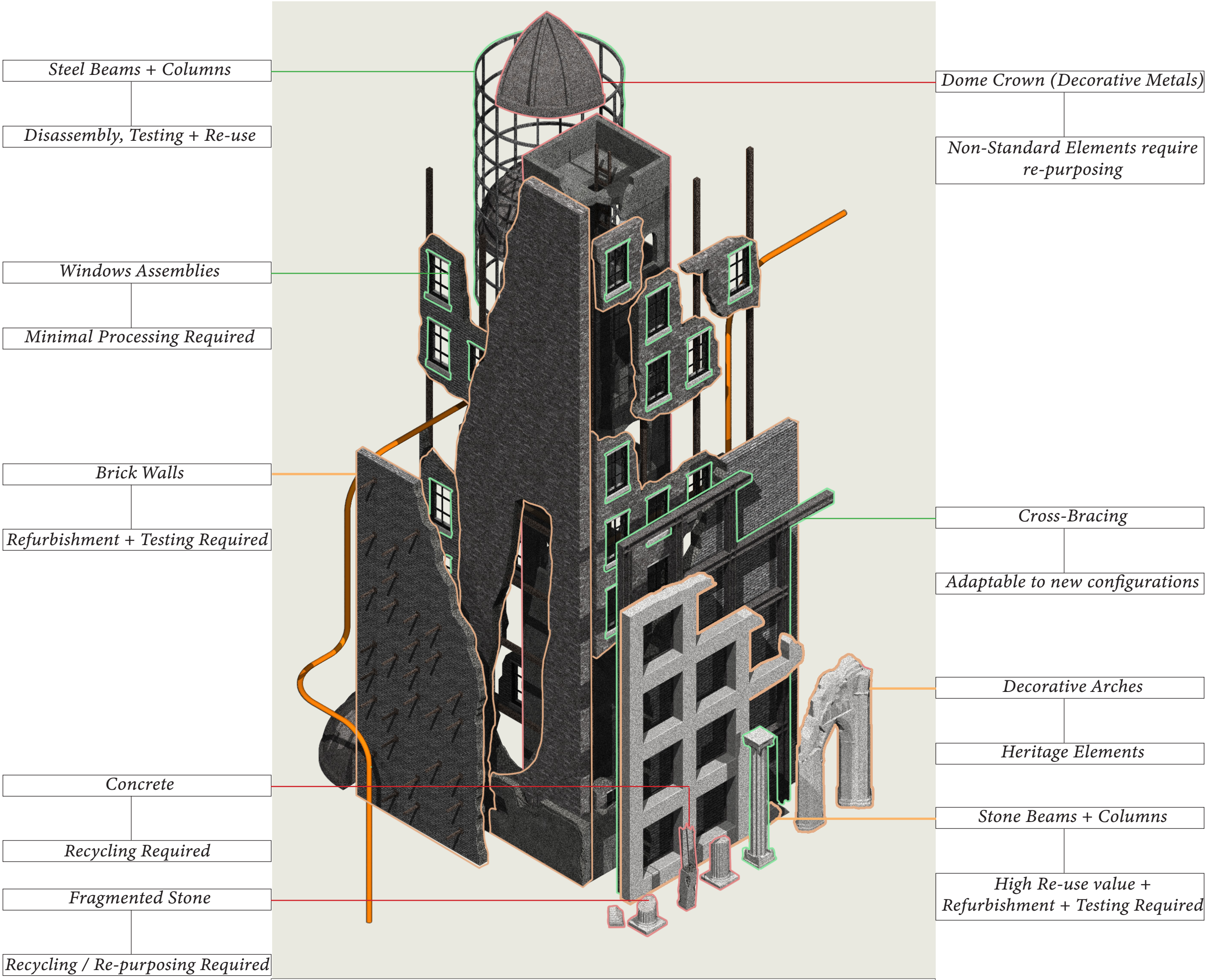


Fig . 1
Harvesting the material mine.

Legend

- *- Directly Re-usable Materials (best option)*
- *- Materials Requiring Refurbishment*
- *- Salvageable yet re-purposing required (Least best option)*

This illustration re-frames the urban landscape as a material library rather than structures awaiting demolition. The drawing brings together a library of salvageable components, demonstrating how existing buildings serve as rich material banks ready for careful harvesting. The colour-coding system indicates the level of intervention required for re-use: green represents directly reusable materials requiring minimal processing, orange indicates materials needing refurbishment before re-use, and red shows materials that require significant re-purposing for their next application.

Figure 1. Urban Mining: Harvesting the material mine (Shipp, 2024)

Introduction

Thesis Context.

The theory behind the Anthropocene states that human economic growth becomes mankind a significant geological and geo-biological force on Earth (Crutzen, 2002). Our present 'geological age' is defined by the major impact of human activities on the environment and climate of the Earth. Having modified 16% of the Earth's surface, humanities impact on the planet becomes most evident in the built environment (Kennedy, et al. 2019).

With almost half of its emissions coming from material manufacturing, the built environment is a significant contributor to environmental damage; annual CO2 emissions in the UK alone are almost 50 million tonnes (Government Commercial Function, 2022). Although material re-use and circular economy practices offer a potential to drastically reduce this figure, the built environment is still rooted in linear 'take-make-waste' practices. Challenges persist in transitioning away from this model to embrace circualr economy principles, driven by economic limitations, institutional habits, and a tendency to undervalue existing materials and re-use efforts.

Viewing cities as material banks reveals an unrealised potential in the built environment, this perspective is essential in tackling its environmental impact. From stone columns and metal frameworks to salvageable bricks and architectural details, the built environment is a catalgoue of materials ready for extraction, much as mining extracts materials from the ground. Figure 1, encapsulates the perspective of buildings as catalogues of materials, with elements identified, catalogued, and re-purposed. Whilst some materials, like bricks and concrete, require refurbishment and reprocessing (orange and red), others, like steel and stone, can be utilised almost directly (green). This approach redefines demolition as an opportunity for material recovery, turning cities into resource-rich material mines.

This thesis addresses to the urgent challenges of material re-use by examining London's architectural practices through interconnected investigations. The study begins by building a theoretical framework of the circular economy and its application to architecture. Following this is a case study on Holbein Gardens, which investigates the useful application of these ideas with an emphasis on steel due to its durability, structural integrity, and potential to offset carbon emissions when re-used instead of being newly fabricated.

The study broadens to consider how we value our built stock, exploring evolving perspectives on preservation and material recovery over time. The limitations of current preservation frameworks, such as the listed building system, which overlooks newer structures are also addressed. The theoretical foundation concludes with an analysis of value attribution, examining how economic and environmental considerations shape decisions regarding material re-use in architectural practice.

1. *Circular economy principles focus on minimising waste and making the most of resources by promoting re-use, recycling, and the regeneration of materials. This creates a closed-loop system where products and materials are continuously re-used.*

Introduction
Thesis Context.

The research scope then narrows in on London, examining how the characteristics and policies of the city influence material re-use practices. Through an analysis of local policies and the embryonic architectural recycling network, this study explores the existing infrastructure, identifying the challenges and opportunities to a better implementation of material re-use. The understanding of London's barriers to a greater implementation of re-use is then accentuated by the knowledge of professional architects, whose experiences point to practical challenges and solutions to enhance material re-use in London.

This primary objectives guide this thesis:

1 . To evaluate the current material re-use in frameworks, practices and infrastructure of London.

2 . To identify and examine the barriers that prevent the further implementation of material re-use strategies.

3 . To propose practical solutions to that enable London's architecture profession to embrace circular economy principles.

By means of this methodical research, the thesis contributes to the ongoing dialogue on sustainable architectural practice and proposes solutions to improve the adoption of material re-use within London's built environment.

The glossary defining key terms within this thesis, along with the three main thesis objectives, can be located in appendix A.

Please turn over for Chapter one: Theoretical Framework.

01

Theoretical Framework

Part One
Circular economy principles.

The current linear model of thinking, a 'take-make-waste' society, continues to shape how we consume everything from everyday products to architecture, producing significant consequences and disruption to the Earth's ecosystems. At this pace, access to natural resources and materials will soon become unviable. The circular economy and circular construction aim to ensure that resources remain viable by rethinking consumption and re-use. With over 16% of the surface of the Earth greatly changed by human activity (Grey, 2023), the built environment itself becomes a resource capable of both consuming and providing its own resources. Having reached a level of extensive development, cities should be designed to re-use and re-imagine the materials within them, creating a self-sustaining cycle of resource use.

The term 'circular economy' started to gain traction during the 2010s. Influential advocates for the circular economy, The Ellen MacArthur Foundation, offered a simple yet effective definition for the term, addressing environmental challenges, economic instability and resource scarcity:

"The circular economy is based on three principles, driven by design: Eliminate waste and pollution, Circulate products and materials (at highest value) and Regenerate Nature" (Ellen MacArthur Foundation,2022).

The concept of "eliminating waste" demands a fundamental shift in how we perceive and handle materials. It's about making sure their potential isn't lost in bad design, ineffective use, or premature disposal, not just about avoiding waste Whilst the concept of the circular economy has been central to global sustainability discussions since the early 2010s, its integration within the construction industry remains limited.

Professor of practice Mitchell Joachim of New York University and co-founder of none-profit think tank "Terreform ONE" has written extensively on sustainable and ecological design (Joachim, n.d.), advocating for a way of building that encourages people to co-exist with the Earth - living with it, not just on it. Joachim argues that future cities should ensure "all necessities are provided from inside [their] physical borders" (Joachim, 2014). Envisioning a city where "no distinction [exists] between waste and supply." Eleven years on, the urgency of such strategies has only grown. If we persist with a linear take-make-waste model, raw materials will become ecologically and economically unsustainable. Simply put, as resources dwindle, cities must function as material mines, both consuming and supplying the resources needed for survival.

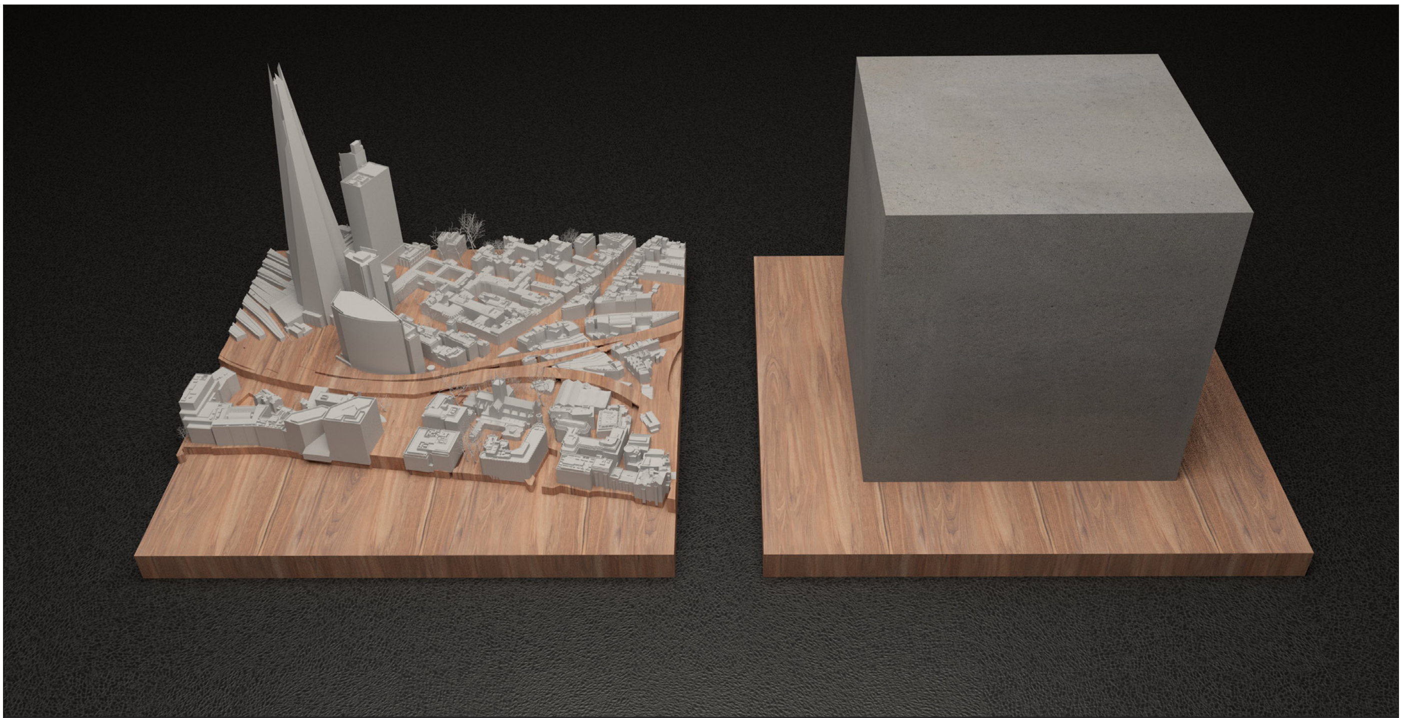


Fig . 2
The Shard Vs Annual UK Construction Waste (As a solid concrete cube).

This image illustrates the scale of the UK's annual construction waste by converting it into a physical form, a concrete cube. A small visual task for this is converting it into a physical object. To give some perspective, at 2.3 tonnes per cubic metre, 63 million tonnes equates to 27.4 million cubic metres. Pouring that concrete into a giant cube would require a cube with a length of 302 meters on each side, almost equalling the height of The Shard in all dimensions. This cube represents the same mass as the annual waste generated in the UK annually.

Figure 2. The Shard Vs Annual UK Construction Waste (as a solid concrete cube):81 Shards in Volume (Shipp, 2025).

Part One

Circular economy principles.

Particularly in European construction, President of the European Commission Ursula von der Leyen started actively supporting the circular economy in 2020. von der Leyen underlined the environmental influence of the industry by means of initiatives such as the EU Green Deal[1] and the Circular Economy Action Plan[2]. Underlining in her 2020 state of the union address the need for reform, she notes that over a third of the EU's solid waste and half of its raw material extraction comes from construction (Von Der Leyen, 2020). Her message is clear: the construction industry must make better use of the available resources, reducing waste and the demand for raw materials.

This is when material re-use comes into play. Addressing the enormous amount of waste produced annually is crucial; the UK alone produced 63 million tonnes of construction waste in 2022 (latest figure)(DEFRA, 2022). At 2.3 tonnes per cubic metre (concrete), this translates to 27,400,000m^3, enough to form a cube measuring 302 metres on each side, just shy of The Shard's 311-metre height. In terms of volume, 81 Shards could fit into this concrete mass annually. This enormous level of waste highlights the urgent need for a paradigm shift in the construction industry to drive a significant reduction in waste.

The 2023 annual waste report by QFlow[3] stated that 87% of construction waste is diverted from landfill, with a target of 99% (QFlow, 2023). Whilst this is a positive approach, much of the material, including most stone and concrete, is down-cycled using high-energy processes - Most of it being crushed and used as aggregate. This reduces waste in line with the circular economy principles, but it does not significantly lower embodied carbon or help to mitigate pollution. For example, recycling concrete with 25% fly ash(the minimum required) cuts carbon emissions by just 20% (Sabau, 2021). Though improved over nothing, it is still inadequate.

1. *The European Green Deal, launched in 2019 by von der Leyen, is the EU's plan for sustainable growth, aiming to achieve climate neutrality by 2050 through various policy initiatives.*
2. *The Circular Economy Action Plan is a key initiative under the European Green Deal, introduced in 2020 to promote a transition to circular economy where resources are re-used, repaired, and recycled.*
3. *QFlow is a company that provides a digital platform for managing construction waste and sustainability. Their software helps construction firms track, manage, and reduce waste on-site.*

Part Two

The role of steel within the circular economy.

An ideal circular economy would suggest that steel be directly re-used with minimal processing. This method minimises energy consumption and material waste, with significant environmental benefits over traditional recycling processes. Steel beams are fabricated through one of two production routes, either the BOF route[1] or the EAF route[2] (worldsteel, 2012). Once fabricated, the steel is rolled or cast being ready for use - it then has a life span of 40-70 years. (worldsteel, 2012, p.14). This expansive life span allows steel to be re-used and re-purposed, doing so in its original form is becoming increasingly relevant as demand for sustainable practices grows in order to reduce a buildings embodied carbon. Although steel is always recyclable, the process is energy intensive. Direct re-use therefore emerges as the optimal procedure, aligning with the Ellen MacArthur Foundation's circular economy principles.

When tracking materials across multiple life-cycles, the circular economy principle present both challenges and opportunities. Take steel, for example as it highlights these challenges quite well. When steel is reused, the structural elements often need to be oversized or "over-engineered" to account for uncertainties about their strength and durability (Iacovidoul, E & Purnell, P. 2016). By maintaining the embodied energy of the steel and offsetting emissions from new manufacture, this offers major environmental benefits - even if it would raise material use and initial energy requirements.

Re-using structural elements saves energy, reduces waste and replaces the demand for new materials. However, a adaptive design approach is required. The design must work with what is already available, thereby shaping the structure depending on the sizes, lengths, profiles, and condition of salvaged components, instead of specifying materials from inception (Brütting, Desruelle, et al., 2019). This change of strategy creates some challenges. Firstly, the specifications and details of older materials are often lost in time. A steel beam fabricated 50 years ago were designed with specified qualities and tolerances, known to manufacturers like Tata Steel. This knowledge may become fragmented through time, requiring engineers to take additional precautions resulting in more conservative designs. Furthermore, physical wear and tear, such as stress fatigue or corrosion adds another level of uncertainty to the re-use initiative , which may undermine the steels structural performance.

Looking ahead, material passport systems - like Madaster, a registry designed to facilitate circular construction practices - are widely adopted but remain limited in scope; they focus on material documentation and assessing circularity potential but could evolve to do much more (Heinrich & Lang, 2019). Modern technological developments hold the possibility to produce a better, enhanced, 'structural material passport'. Including comprehensive performance data, load histories, stress patterns and maintenance records, this version could offer a more holistic perspective of the material life-cycle. Building on initiatives like 'BAMB'[3], which seek to close information gaps for material re-use, this approach could address further knowledge gaps in steel re-use. The EU's Level(s) framework[1] (2020) serves as a precedent of how material

1. Basic oxygen furnace, this route uses iron ore and coal as raw materials.
2. Electric arc furnace, this route uses electricity and mainly recycled steel.
3. Buildings as material banks

Part Two
The role of steel within the circular economy.

documentation can assist circular economies in construction; but, adding structural performance information would act as a catalyst in the re-use of load bearing components.

Although steel re-use offers significant environmental benefits, it also introduces inherent uncertainties that challenge conventional architectural practices. Every recovered steel component has its own history of stress, environmental exposure, and structural load background that typical assessment methods cannot fully capture. Due to these uncertainties and assumed economic costs, the construction industry tends to favour new materials over re-claimed ones. Emerging technologies such as USD[2] are, however, enhancing material traceability and increasing the feasibility of future re-use. Whilst these uncertainties require more flexible design approaches and closer engagement with salvage suppliers, they also present opportunities for innovative architectural solutions that embrace the unique characteristics of reclaimed materials (see Appendix B for detailed discussion of uncertainty in steel re-use).

1. *The EU Levels framework 2020 is a voluntary reporting tool that helps to assess and improve the sustainability and circularity of buildings throughout their entire life cycle.*
2. *Universal scene descriptor - A software which describes materials, physics and behaviour simulations of the real world.*

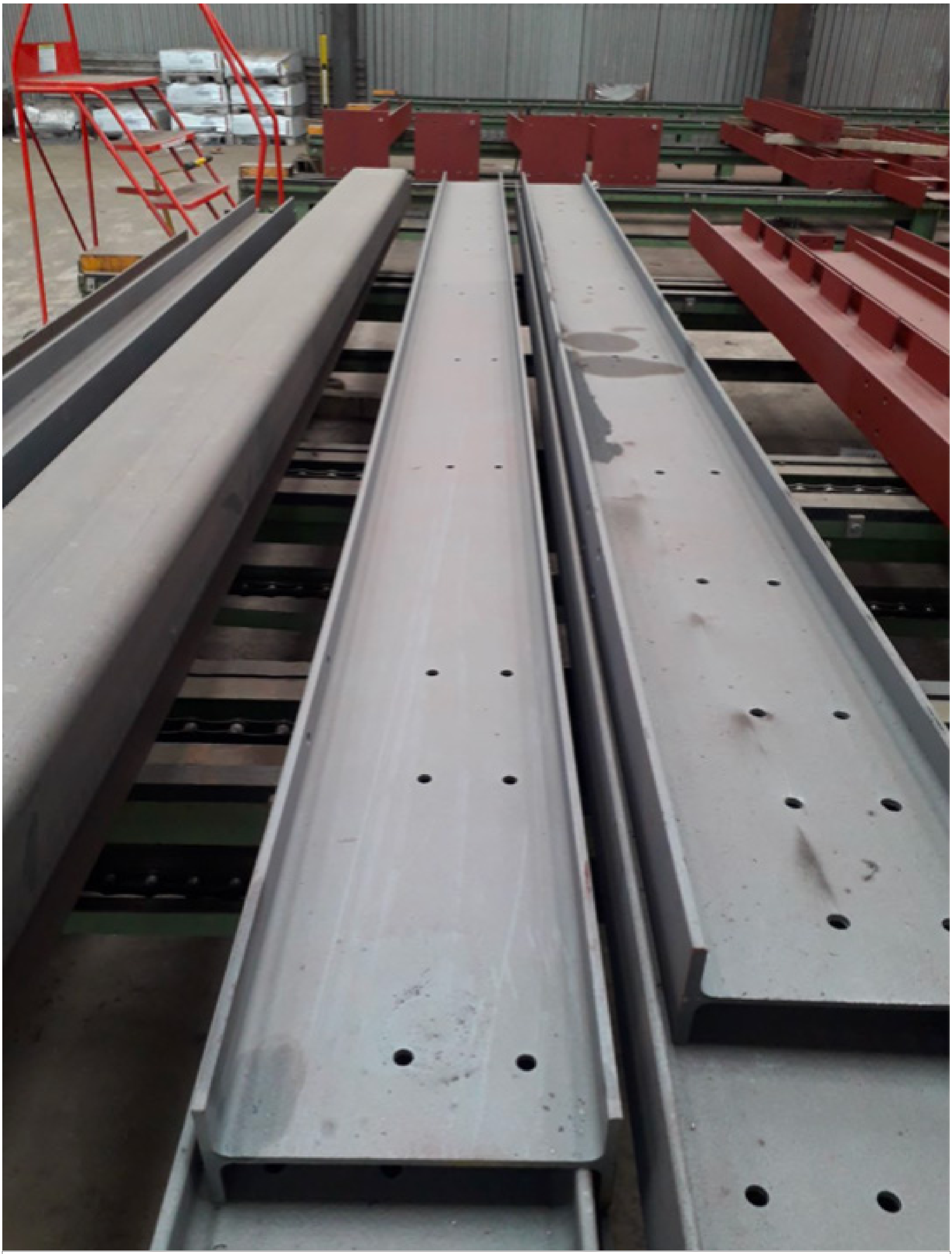


Fig . 3A
Spot-blasted steel beams.

This photograph shows the beams that have been salvaged from The Biscuit Factory. They have been spot-Blasted which tests the integrity and quality of steel surfaces. By blasting localised areas of the beam, it removes any paint, rust, or other coatings, exposing the underlying steel to assess its condition. This process helps identify any potential weaknesses, corrosion, or structural issues.

Figure 3A. Spot-Blasted Steel Beams (Castillo, 2023).

Case Study

Case Study : Holbein Gardens, London.

The Grosvenor estate, owned by the Dukes of Westminster, emphasises responsible property development. Their approach promotes sustainable urban growth, targeting a 90% emissions reduction by 2040 and aims for their 147 acres of public realm to be carbon positive by 2050 (Grosvenor, 2024). This reflects Grosvenors' commitment to exceeding baseline sustainability standards and achieving higher environmental standards, future-proofing assets whilst contributing to the city's environmental well-being.

Designed by Barr Gazetas, one of London's most sustainable office buildings by the Grosvenor estate, Holbein Gardens, showcases material re-use in a renovation of a 1980s office building. Completed in 2022, it is one of the first projects to directly re-use steel straight from a demolition site (O'Connell, 2022), justifying the expansion of the material re-use industry. Reflecting the dedication of the Grosvenor estate to openness and detailed project reporting, the development is extensively recorded.

Re-use of steel follows a set of guidelines described in P427[1] of the SCI Steel Protocol, addressing the acceptability of steel elements, initial data collecting, and stockholder requirements. For instance, steel fabricated before 1970 must be tested to destruction, since it pre-dates the Euro-code programme (Kanyilmaz et al., 2023), a set of guidelines controlling steel design and use launched in the 1970s. This means all steel fabricated after 1970 satisfies the criteria. For material re-use. This was a turning point, as from then on, steels characteristics became predictable and consistent, transforming the unknown properties into the known. Other standard tests also have to be carried out to validate re-use, including damage checks, fire exposure, and evidence of plasticity (D Brown et al., 2019).

Guidelines like these highlight challenges in re-using steel. For example, the restriction on reusing steel fabricated before 1970 shows how evolving standards can affect material re-use. This could also mean that future technological developments may bring new requirements that might limit re-use in the future. This is improbable, but cannot be ruled out. Furthermore, The current system for steel re-use relies more on guidelines and best practices rather than rigid legal restrictions. This allows space for future standards to be developed or reinforced to create clearer, enforceable guidelines for material re-use.

The re-used steel at Holbein Gardens was sourced from the demolition of two existing Grosvenor projects and the re-use stock of Cleveland Steel. Cleveland steel are a leader in the steel re-use market, they conducted a series of none destructive assessments on the salvaged materials in accordance with SCI P427[1] to confirm the surface condition (O'Connell, 2022). These assessments enabled the calculation of the steel's properties, such as tensile and yield strength, ensuring it met the necessary legislative requirements for re-use. Figure 3A shows the steel beams shot blasted before re-coating and figure 3B shows the refinished steel elements during construction. Overall, the re-use of steel reduced the extensions total embodied carbon by 60 tonnes (O'Connell, 2022). Beyond reducing carbon emissions, Holbein Gardens serves

1. *To summarise P427, the re-use of reclaimed steel is limited to applications where the reclaimed members were not subjected to fatigue, for example, steelwork from bridges (The Steel Construction Institute, 2019). A summary of P247 can be found in appendix C.*

Fig . 3B
The Biscuit Factory's steel beams in re-use.

This photograph, taken at Holbein Gardens, shows steel beams re-purposed from the Biscuit Factory in Bermondsey. Overlaid on the image is a proposed design for a "Biscuit Factory stamp," a concept that could acknowledge the beam's history and its journey from its original site.

Figure 3B. The Biscuit Factory's steel beams in re-use (Edwards, 2023).

Part Three

Case Study : Holbein Gardens, London.

as a precedent for scaling up the second-hand materials market in construction, demonstrating the viability of steel re-use at a commercial level.

Figure 3C shows the completed extension, Holbein Gardens serves as a precedent for material re-use being one of the first high-profile commercial projects to place salvaged steel at the core of its design - 24 tonnes of re-used steel, 9 of which from the Grosvenors' Biscuit Factory in Bermondsey. From their original use in the Biscuit Factory, these steel beams have been transformed into a component of an innovative and sustainable office development.

The Peek Frean Biscuit Factory, established in 1866, was a key part of Bermondsey's industrial landscape, earning the area the nickname "Biscuit Town." Producing biscuits like the "Bourbon" it was a major component of London's manufacturing sector before closing in 1989. Now, as the site's steel beams find new purpose at Holbein Gardens, they carry a tangible link to the city's industrial past, the history and legacy of the factory's long-standing presence in Bermondsey creates an aura that has been instilled within them. Beyond material conservation, their re-use preserves London's built environment, where historic buildings are not demolished, but re-imagined in new contexts offering historical narratives and unique design opportunities. As illustrated in figure 3B, tagging or stamping could be one approach to commemorate their re-use, marking their journey from the biscuit factory and ensuring their quality is evident in their new architectural setting.

This journey from industrial heritage to a precedent of material re-use and sustainability is exemplar of how material re-use can link different eras of construction whilst setting new benchmarks. Holbein Gardens represents a step forward in integrating salvaged steel into a larger, more complex redevelopment project. It sets a precedent for scaling up such practices in commercial construction. Each beam carries a rich history, contributing to a future where sustainable building practices are the expectation.

Fig . 3C
Completed holbein Gardens.

This photograph, taken at Holbein Gardens, shows the completed project. The development incorporates 24 tonnes of re-used steel, including 9 tonnes salvaged from the former Peek Frean Biscuit Factory in Bermondsey. By embedding reclaimed structural elements, the project not only reduces embodied carbon but also carries forward the material history of London's industrial past into a new architectural context.

Figure 3C. Completed Holbein Gardens (Gezetas, 2023)

Please turn over for 01.4: The value of preservation.

Part Four
The value of preservation.

"For once a building is gone, it is gone forever, and with it goes its history, culture, and material value." – Kathryn Rogers Merlino, *Building Re-use*.

Through this short and powerful statement, Merlino (2018, p.13) reminds us that demolishing a building destroys more than just a structure, but also the historical narratives, culture and valuable materials embedded within it. Particular attention is drawn to the loss of history, an inherent quality in re-used materials - one that new materials cannot possess. Signs of wear, weathering and previous fixtures embed these materials with a historical narrative that ties them to historical eras. These details provide character and a richness that new materials cannot replicate. Through the demolition of newer buildings we are putting a stop to this process, thereby losing the opportunity for these materials to develop their own narrative. To maintain and preserve this instilled value, these materials must remain in circulation.

Conventional methods of preservation have concentrated on protecting iconic and historically significant buildings, meaning that more ordinary structures are side-lined that - although less aesthetically appealing, these buildings still hold important value. For example, the listed building system[1] preserves many historic structures in the UK; but, the emphasis on age and architectural uniqueness leaves more contemporary or commonplace buildings unprotected even if they reflect social and cultural significance. This approach runs the danger of assigning a sense these more ordinary buildings a sense of 'disposability', despite contributions to local identity. Aside from their character, their social and environmental values are just as important; these structures become ingrained in the daily lives and rituals their communities. Though simple in design, a local community hall or bar may serve as a hub for social gatherings or events, becoming essential to the daily life of the community, having significance beyond their architectural merit.

Adaptive re-use[2] and retrofit can allow these structures to evolve whilst maintaining their cultural value, instead of demolishing and rebuilding. Listing a building as "protected", however, usually prevents alterations, preserving its original state but limits adaptability. This emphasises the need of extending preservation strategies to protect the social and communal value of newer, less historically significant buildings, ensuring they are re-purposed and re-used rather than demolished. Introducing adaptive re-use guidelines would offer a balanced approach to protecting newer buildings, allowing modifications respect the buildings social and cultural value whilst maintaining their functionality. This method would reduce waste to a minimum whilst retaining the structure's key characteristic, offering a sustainable alternative to demolition. This is not meant to replace the listed building system but to serve as a new branch, protecting more ordinary buildings.

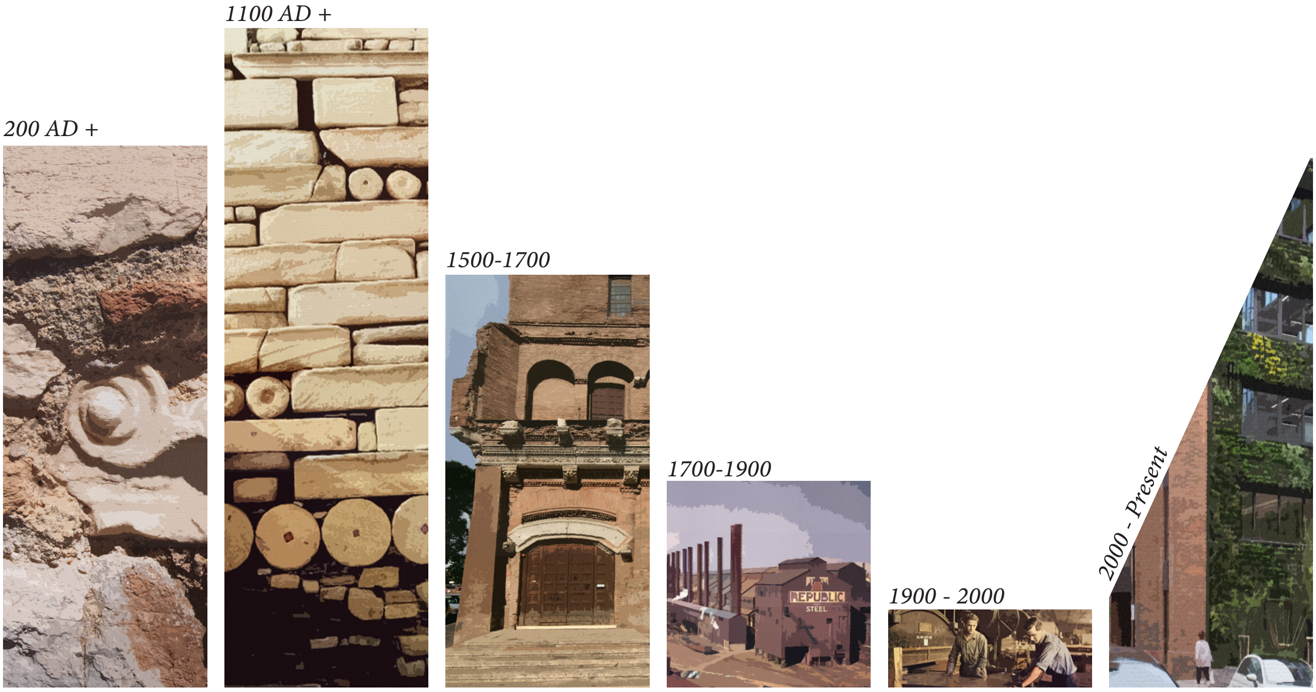
1. A listed building is a building, object or structure that has been judged to be of national historic or architectural interest (Islington Council, n.d.). It protects them by restricting alterations, demolition, and unauthorised changes to preserve their value.
2. Adaptive re-use is the process of re-purposing buildings for new functions whilst retaining their original structure and character.

Part Four
The value of preservation.

As ideas around a circular economy and circular construction grow, people are beginning to rethink the value of all buildings, not just the buildings that hold architectural merit. Adaptive re-use, a strategy that breathes new life into existing structures, is gaining traction and allows the preservation of both cultural heritage and the physical resources within the buildings themselves. This approach shifts the view of older buildings from disposable to valuable resources, offering new purposes whilst honouring their past.

Merlino (2018, p.36) states that "the greenest building is the one that is already built", although there may be some implications such as the efficiency of the façade that have to be considered. These buildings are likely to result in fewer adverse impacts in the environment that a typical 'green' new build. Adaptive re-use builds on what already exists, cutting waste and maximising environmental benefits by reusing materials and spaces. This approach also redefines what we consider as a building's "value," looking beyond age or historical status to appreciate the materials, spaces, and embedded cultural stories. The adaptive re-use of buildings and materials opens the idea of the city itself as a resource, echoing Joachim's idea discussed in 01.1, that cities should both provide and consume their own materials.

Despite these environmental and cultural benefits of adaptive re-use, it hasn't yet been fully embraced. A lack of incentives and concerns about working with older buildings slow its broader adoption. Changing how we think about value in preservation could be key to making adaptive re-use a go-to strategy for sustainable city-building. When paired with material re-use, adaptive re-use exemplifies the city as a resource, a material mine, and it holds the key to unlocking the sustainable cities of the future, rich with material re-use.



Time-line.

Roman Times *Re-use Level: High*	*Middle Ages* *Re-use Level: Very High*	*Pre-Industrial Era* *Re-use Level: Moderate*	*Industrial Revolution* *Re-use Level: Low*	*Mid-20th Century* *Re-use Level: Very Low*	*Modern Age* *Re-use Level: High + Climbing*
"Spolia" - the practical re-use of building materials and components, often forcefully taken from existing structures. This reflects an early perspective of treating buildings as material banks to be carefully harvested and re-purposed, driven by necessity.	*Material re-use during the Middle Ages was viewed as a practical, creative, and symbolic act. Ancient materials and structures were not only scavenged, but actively integrated into the fabric of mediaeval life, taking on renewed purpose, meaning, and significance.*	*Material re-use was seen as routine behaviour before the eighteenth century. Re-purposing building components and other materials was a regular part of daily living, not a 'specialised' task given the scarce resources and a need to avoid waste.*	*The Industrial Revolution introduced new manufacturing capabilities and abundant material resources This change in availability and production resulted in a drop in material re-use since the construction industry gave mass production's low cost and efficiency top priority.*	*Methods of mass production and high consumption grew into to 20th century. As a result, Speed and scale became priority, whilst re-use was often seen as 'backwards' and linked to social marginality.*	*Material re-use has gained traction in recent years, as environmental concerns have risen.* *Material passports and other strategies are redefining buildings as material banks, therefore enabling the re-purposing of components.*
Image Location: Church of St. Peter Kalyvia Thorikou Greece	Image Location: Kastro Wall Paros Greece	Image Location: Casa Dei Crenscenzi Rome Italy			Image Location: Holbein Gardens London UK

Figure 4. A time-line of material re-use throughout history (Shipp, 2025).

Part Five
Perspectives on Material Recovery through time.

Re-use has long been a common practice, often seen as a practical solution rather than a deliberate action, particularly in societies with limited resources. In pre-industrial economies, waste was avoided, and reusing materials was integral to daily life. Art historian Dale Kinney, specialising in ancient and mediaeval Roman buildings and objects, has written extensively on this. Re-use is described by Kinney (2011, p.18) as a standard practice during these periods, essential for preserving identity in communities with limited resources. Re-use is not viewed as a notable act for Kinney; instead, it was simply a part of life. However, Kinney's writing clarifies how re-use also permeating cultural realms and societal practices, extending beyond physical objects.

Figure 4 shows the varying importance of material re-use over several historical eras. It maps the degree of material re-use from the practices of 'spolia'[1] during the Roman times, through the heights of re-use during the Middle Ages, then into a gradual decline during industrialisation. The modern age shows a marked resurgence in re-use practices, indicated by the rising slope, driven by environmental consciousness and the imperative need to apply circular economy principles within designs. The heights of each graphic represent relative levels of material re-use intensity during each period, demonstrating how modern construction is returning to historical principles of material conservation and re-purposing.

A prominent term in architectural discourse is 'spolia,' which refers to materials seized and re-used, often from one space to another. Greenhalgh's (2008, p. 77) applies this term to Roman relief's (300 AD), where materials, like marble inscriptions, were re-purposed for their practicality rather than their meaning. For example, the salvaged column cap in figure 4 has been used in the construction of a wall. Driven by scarcity and necessity rather than environmental concerns, This practical approach to material re-use offers early proof of viewing buildings as material banks. Whilst environmental motivations weren't at play, this historical practice mirrors modern sustainability initiatives, where cities are envisioned as material mines, with nothing wasted.

After the Roman Ages, the Middle Ages (twelfth and thirteenth century) understood re-use to be both practical and symbolic. The practice of re-use gave new purpose and significance to scavenged materials by embedding them into mediaeval life. As Esch (2011, p.37) states, "The re-use of Antiquity in the Middle Ages is not 'perpetua notte[2]'; it is not death but rather new life, new agency, a new adventure". This captures how mediaeval cultures re-interpreted scavenged items and spaces by blending cultural reinterpretation with resource conservation. These acts of re-use gave materials renewed purpose.

1. *'Spolia' is an ambiguous term originating from 'spoliation', which is defined as "the seizure of goods or property by violent means" (Oxford English Dictionary, 2024)*
2. *In this context, "perpetua notte" (meaning "eternal night") is used by Esch metaphorically to convey death, contrasting with the idea that mediaeval re-use was about giving materials a fresh life and purpose rather than conserving them in a lifeless state.*

Part Five

Perspectives on Material Recovery through time.

Up until the Industrial Revolution (1760–1840), Kinney (2011, p.18) describes re-use to have been firmly ingrained into society, as pre-industrial economies, which produced little excess, could not afford waste. There was a cyclical approach to construction and resource use where materials were continuously re-purposed. However, this relationship was fundamentally changed by industrialisation. Technological advancements gave priority to the new production of materials, emphasising speed and scale of production. Consequently, this lowered the reliance on re-use and rendered it to seem unnecessary.

This adoption of high speed mass production habits grew into the twentieth century, strengthening the preference on new materials. As Kinney (2011, p.19) points out, "In the context of the prolific production and consumption of commodities in mid-twentieth-century America, the re-use of consumer products was negatively charged with implications of backwardness and social marginality." The rise of industrial processes, such as the Bessemer process[1] for steel production (World Steel, 2012), greatly reduced labour requirements and costs, reinforcing the belief that re-use was inefficient. Unlike historic traditions such as 'spolia,' where material re-use was a cultural and symbolic act, the industrial revolution prioritised speed, uniformity, and low-cost manufacturing over re-purposing existing resources.

The contemporary embrace of material re-use represents a shift in architectural practice, this time driven not by material scarcity but by urgent environmental concerns. Although re-use out of necessity still drives informal settlements in developing countries (Gorgolewski, 2018), the larger construction sector is increasing the adoption of re-use as a sustainability strategy. This change is, in part, a response to the environmental impact of the sector, with the UK construction industry generating approximately 63 million tonnes of waste annually (DEFRA, 2022). Promoted by the Ellen MacArthur Foundation, circular economy principles have become popular, inspiring architects and developers to see buildings as material banks. Joachim's vision of a city where there is "no distinction between waste and supply" (2014, p. 21), encapsulates this. Emerging approaches which reflect this perspective include material passports[2] and BIM[3], which improve the tracking and re-use of building components.

The perception on material re-use has evolved full circle, once an economic necessity, then devalued by industrialisation, and now re-framed as a core principle of sustainable architecture. Including embodied carbon savings, circularity, and the preservation of cultural heritage, this resurgence for re-use challenges the narrow industrial-era perceptions of re-use. As the severe impact of the construction industry becomes recognised, existing materials are being re-discovered as valuable resources embedded within our cities - redefining 'waste' not as an endpoint but as an opportunity.

1. *The Bessemer process is a method converting iron into steel by blowing air through molten iron, removing impurities and making it stronger and more durable.*
2. *A material passport is a digital record that provides information about the materials within a structure, This helps to facilitate circular economy principles by providing opportunities for material re-use.*
3. *BIM (Building Information Modelling) provides detailed data on existing materials, enabling efficient identification, tracking, and re-use of resources.*

Please turn over for 01.6: The implications of ethical, economic and environmental value attribution.

Part Six

The implications of economic and environmental value attribution.

The concept of value is inherently fluid, it is shaped by social, economic, and cultural contexts that essentially define different understandings of worth. In architecture, this fluidity becomes evident when assessing how value is assigned to building components, especially those intended for re-use. Usually, material valuation gives newness, uniformity, and consistency top priority. However, this approach sometimes ignored the unique potential and value that re-used materials can provide. Part 01.6 explores how value is currently assigned to materials, questioning whether existing regulations and building standards adequately reflect the worth of re-used materials, and considering whether this framework should be re-evaluated.

Economic Value attribution

Value in architectural preservation and resource recovery is inherently complex and transcends simple monetary assessment. Traditionally, the highest value has been placed on a material's condition and standardised performance - primarily to avoid unknown or variable properties. Today, points of view now question this perspective and instead, value is now seen as multi-dimensional, including environmental and cultural significance. For instance, a steel beam is now a source of embodied energy, a fragment of history with future possibilities, rather than a structural element.

Economic value in material re-use extends beyond cost savings. Whilst the financial benefits remain complex, studies indicate that re-used materials generate additional value. For example, Nuβholz et al. (2019) found that reclaimed materials can increase in worth through broader impacts like carbon reduction and job creation, even though their evaluation showed "material re-use gave no indication of superior financial benefits" (Nuβholz et al., 2019).

Developers and investors also mentioned non-financial advantages of material re-use, such as the "opportunity to innovate, gain competitive advantage and align with societal trends or future legislation" (Nuβholz et al., 2019). These factors can increase marketability and contribute to a company's strategic vision (e.g., SDGs1) (Nuβholz et al., 2019), potentially offering economic advantages in return. This highlights the complex economic value of material re-use, which extends beyond immediate financial considerations, although significant challenges still exist.

Architectural discourse on the economic value of material re-use remains mixed. The construction industry remains sceptical, with many anticipating higher costs for re-using materials. One study, for example, argues that doubts about the economic viability of circular approaches come from factors including: the lack of a holistic supply chain, short-term thinking, and the low value of construction products at the end of life (Riuttala et al., 2024). This unpredictability makes it challenging for material recovery practices to be embraced. Some research, nevertheless, casts doubt on this assumption. For example, Mollaei et al. (2023) found that policy tools promoting resource recovery can reduce waste and carbon

1. SDGs is an acronym for sustainable development goals.

Part Six

The implications of economic and environmental value attribution.

emissions whilst also generating positive financial returns, challenging the notion that sustainable practices inherently incur financial costs. The economic value of re-used materials is therefore broader than immediate financial considerations, encompassing employment benefits, marketability, carbon savings, and improved long-term resource efficiency.

Environmental Value Attribution

Whilst economic concerns usually dictate the discussions on material re-use, environmental value is becoming increasingly important. Environmental value, however, is more difficult to evaluate than economic value, since it included less quantifiable measures such as ecological benefits, as well as quantitative benefits such as carbon savings. Embodied carbon savings are the most straightforward approach to evaluating environmental value, being more easily quantified than the offset of broader ecological impacts like biodiversity loss. Material re-use nearly eliminates the carbon emissions from manufacturing. Sometimes this could lead to a net carbon benefit, as the emissions avoided from new manufacturing may outweigh the low carbon cost of salvaging and processing reclaimed materials.

A key aspect of environmental value in material re-use is reducing embodied carbon. Architectural discourse places strong emphasis on carbon metrics, as they are easily tracked and directly linked to climate change goals. Industry standards and assessment tools reflect this focus, often prioritising carbon reduction. However, London's 2022 Circular Economy Statement guidance[1] calls for a broader assessment, stating "where an achievement is not adequately captured by quantitative metrics, the applicant should highlight the achievement within the Circular Economy Statement written report... (Including) any other benefits... These may be qualitative or quantitative but will need to be backed up by evidence" (Greater London Authority, 2022). Although reducing embodied carbon remains crucial due to its immediate climate impact, the limited attention paid in SDG[2]s risks overlooking the wider ecological benefits of material re-use.

As the significance of environmental value in material re-use becomes recognised, a key issue emerges: this value is often reduced to simple measurements of embodied carbon. A study looking at obstacles to a circular economy in the built environment revealed this issue: the environmental benefit of material re-use has not been thoroughly investigated. The study stated, "The environmental case for material re-use is still largely under-explored and it lacks rigorous case studies that could validate value creation of re-use strategies" (Hart et al, 2019). This lack of thorough analysis and supporting data often leads to a limited emphasis on embodied carbon, instead of a holistic understanding of the broader, long-term benefits of material re-use. This implies that the present valuation systems undervalue long-term environmental benefits. More comprehensive frameworks that consider the full range of ecological, social, and economic impacts of material re-use are clearly needed to solve this, enabling accurate calculation of the actual environmental value in re-use.

1. London's Circular Economy Statement Guidance (2022) outlines requirements for developers to integrate circular economy principles, prioritising retention and re-use of materials over demolition.
2. SDGs is an acronym for sustainable development goals.

Part Six

The implications of economic and environmental value attribution.

These findings on the environmental value in material re-use reveal a disconnect between awareness and quantification. Although material re-use has obvious advantages beyond just carbon reduction, the current valuation methods and objectives remain centred on a quantifiable criteria. This underscores the current constraint in the valuation perspectives: even though the wider ecological benefits are understood, they risk being undervalued. Policies such as London's Circular Economy Statement encourage consideration of both qualitative and quantitative benefits, thereby provide an opportunity to develop thorough approaches of assessing environmental value.

Balancing Economic and Environmental Value

The tension between the environmental and economic value of material re-use mirrors the broader challenges facing London's built environment. Although these ideas have been explored separately, their interaction has pointed to opportunities and constraints in adapting from the 'take-make-waste' model towards a circular economy. Architectural discourse and current frameworks indicate the struggle to strike a balance between these values, with economic considerations directing decisions on material re-use. Although material re-use demonstrated no immediate financial benefits, as Nuβholz et al. (2019) points out, it generated additional value through broader impacts such as carbon reduction and positive employment effects. This shows that environmental benefits such as the long-term ecological effects are often overlooked in conventional cost benefit analysis, although vital for urban sustainability.

Please turn over for Chapter two: The context of London.

02

The Context of London

Part One

Evaluating London's Circular Economy Policy Framework.

The London Plan 2021 introduces policy SI 7[1], intended to demonstrate how developers are prioritising re-use and recycling, demonstrating an assigned value to these objectives. However, while not directly addressing how material value is perceived, it does advocate for innovation to "keep products and materials at their highest value for as long as possible" (Greater London Authority, 2021). However, the enforcement and urgency of these goals are undermined through language use. For instance, "Encourage waste minimisation through the re-use of materials" (Greater London Authority, 2021), weakens the enforceability and urgency. Policy SI 2[2], which recommends significant development proposals to include a detailed energy strategy (Greater London Authority, 2021), clearly shows this as well. Such ambiguous phrasing reduces the policy's influence on architectural practice, especially in contrast to the urgency of material re-use in the construction industry. Studies have confirmed the need for better policies. A study by Mollaei et al. (2023), proposed that policy tools can promote waste reductions and carbon savings "whilst also generating positive financial returns", emphasising the possibility for clearer, enforceable regulations to alter how value is allocated to re-used materials.

The policy's requirement for circular economy statements, which aims to demonstrate how developers give re-use and recycling top priority, is a key feature of the policy. Whilst the policy supports innovation to "keep products and materials at their highest value for as long as possible" (Greater London Authority, 2021), it does not specifically address how this value is evaluated. This statement can be open to interpretation in the context of value assignment and raises a question: Who is deciding what makes something valuable? The phrase is suggesting that materials have a hierarchy for their usefulness, but raises questions for the value means, is the 'highest value' an economic value, environmental value or something different?. Although the policy emphasises materials to be resources rather than a disposable, it implies that value is flexible and context-dependent; possibly changing depending on how materials are re-interpreted. Though it would be beneficial if the policy gave environmental value explicit priority.

By showing a clear prioritisation for environmental sustainability as the primary measure of value in re-used materials, future iterations of *The London Plan* could provide more clear guidance for both developers and architects. As a result, the legislation could direct the practice of re-use towards a significant and tangible change.

Building on *The London Plan* analysis, looking at borough-specific supplementary planning documents exposes varying approaches of valuing material re-use. One particularly forward-thinking Environmental Design Guide from 2012 is Islington's.. Unlike the London Plan's tentative phrasing, Islington sets precise, quantifiable goals, including requiring "a minimum of 10% of the total value of materials used to derive from recycled and re-used content" (Islington Council, 2012). This unambiguous guidance contrasts with the unclear terminology of the London Plan.

1. Policy SI 7: Reducing waste and supporting the circular economy. Please see appendix A for more details.
2. Policy SI 2: Minimising greenhouse gas emissions.

Fig . 5A
The Angel Building, Islington, during works.

The exposed concrete frame reveals the original structure being retained and re-purposed, demonstrating how buildings can be re-imagined whilst preserving their embodied carbon.

Figure 5A. The angel building's re-used concrete frame (Allford Hall Monaghan Morris, 2011) .

Part One

Evaluating London's Circular Economy Policy Framework.

The Islington SPD[1] further exemplifies the importance of designing for material re-use. Encouraging re-use and recycling at the end of a building's life, the SPD underlines that buildings should be planned with re-use in mind. "Tall building designers need to pay particular attention to minimising environmental impacts, flexibility for future adaptation, and facilitating re-use and recycling at the end of a building's life," states Islington council (2012). This preserves material value by encouraging disassembly rather than demolition. It supports the notion that materials retain their value beyond the building's life cycle and serve future purposes. Drawing upon the Angel Building refurbishment (London, 2011), where re-using the in-situ concrete frame resulted in significant embodied carbon reductions, the SPD[1] also illustrates the value of re-use (Islington Council, 2012). Figures 5A and 5B show the building's re-use, with the structural frame retained due to the generous floor-to-ceiling heights, whilst cladding and services were replaced.

Although Islington's policies show promise, other boroughs have less robust frameworks for material re-use. For example, the Haringey SPD[1] on Sustainable Design and Construction provides minimal guidance on material re-use, merely suggesting it should be considered early in the design process (Haringey Council, 2013). This vague recommendation contrasts with the clearer guidance in Islington's policies. Instead, the Haringey SPD[1] emphasises using low-impact building materials, stating that "building materials should be selected based on sustainable supply and minimal energy consumption in their manufacture" (Haringey Council, 2013). Whilst this approach is valuable, it lacks the specificity and actionable targets seen in the other boroughs' policies, particularly regarding material re-use. Figure 6 summarises the approach of each document in a comparative format.

These differences highlight that material valuation varies across London Boroughs. Whilst some boroughs, like Haringey, have a less comprehensive approach, boroughs like Islington are specific and proactive. This difference emphasises the need for a more consistent methodology for material valuation across London's SPD[1]s. Effective policies, like Islington's, which mandate at least 10% of materials to be re-used, combine measurable targets with a greater awareness of material value that transcends economic concerns.

Although environmental advantages are gaining recognition, the London's 2022 Circular Economy Statement Guidance suggests that the construction illustrates that the construction industry still needs a methodical approach to balance and quantify these alongside economic value. Consequently, economic value still rules most decision-making, often discouraging material re-use. This gap emphasises the need to change the guidance on implementing re-use, alongside material value assessments, thereby moving beyond traditional economic measures to a more comprehensive understanding that revolutionise material re-use and urban regeneration.

Please turn over for figures 5B and 6.

1. Supplementary planning document.

Fig . 5B
The completed Angel Building atrium.

This photograph shows the completed refurbishment of The Angel Building. The preserved and exposed structural elements are integrated with the new interventions, showcasing how material re-use can contribute to both environmental sustainability and architectural character.

Figure 5B. The angel building complete (Allford Hall Monaghan Morris, 2011).

Policy Aspect	London Plan 2021 (GLA)	Islington SPD (2012)	Harringey SPD (2013)
Overall Approach	Broad framework emphasising circular economy principles over re-use specifically	Specific, target-driven approach with measurable outcomes	General sustainability focus with limited material re-use specifics
Language Style	Typically Non-binding ("encourage," "should")	Directive, measurable requirements	Suggestive, general guidance
Material Re-use Targets	95% re-use and recycling of construction/demolition waste	Minimum 10% of total material value from recycled/re-used content	No specific targets mentioned
Design Requirements	General guidance on circular economy principles	Detailed requirements for designing with future re-use in mind, especially for tall buildings	Focus on sustainable material selection rather than re-use
Implementation Examples	Circular Economy Statements required	Angel Building case study provided as practical example	Limited practical examples
End-of-Life Considerations	Broad statements about waste reduction	Specific guidance on deconstruction and material preservation	Focus on initial material selection
Value Attribution	Ambiguous definition of material value	Clear framework for assessing material worth through multiple life-cycles	Emphasis on initial environmental impact
Monitoring/Enforcement	Limited enforcement mechanisms	More structured approach with measurable targets	Minimal enforcement structure

Fig . 6

Approach comparison of different governing bodies.

Legend

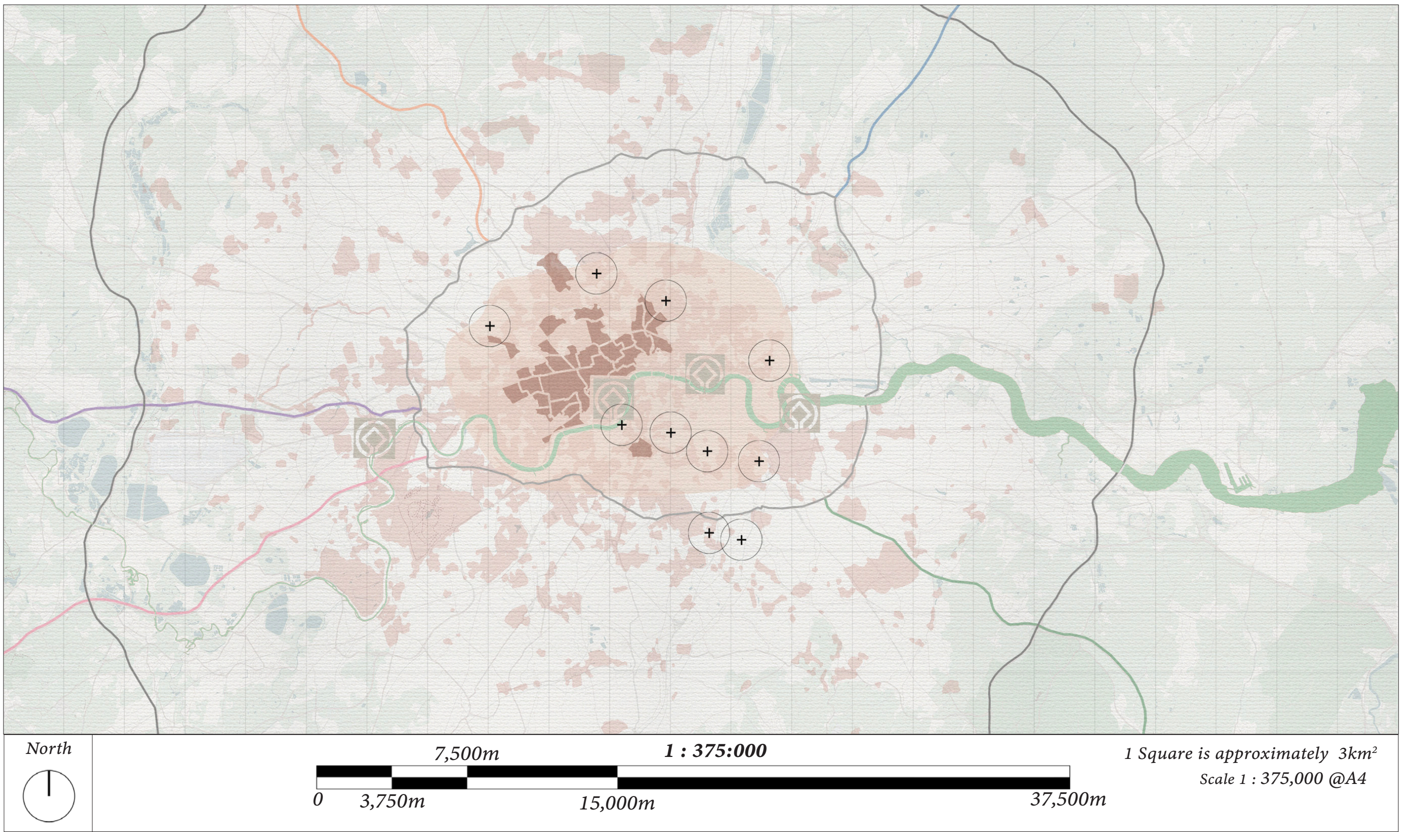
Limited/Insufficient - Minimal or non-specific guidance with no clear requirements

Moderate/Developing - General guidance provided but lacking specificity or enforcement

Strong/Comprehensive - Clear, measurable requirements with specific targets and enforcement mechanisms.

Figure 6 evaluates key policy aspects across three London authorities using a traffic light system: Green indicates strong, measurable requirements with clear enforcement; Amber shows moderate guidance lacking full specificity; and Red highlights limited or insufficient policy measures. This assessment reveals Islington's SPD (2012) as having the most robust framework for material re-use, while the London Plan 2021 shows mixed effectiveness, and Harringey's SPD (2013) demonstrates significant room for improvement in most areas.

Figure 6. Approach comparison of different governing bodies (Shipp, 2025).



London's Circular Economy Landscape Map 1:
The map of London's architectural salvage yards.

Figure 7 shows the spatial distribution of architectural salvage yards across London, overlaid with heritage-rich areas and planning designations. The salvage yards (indicated by cross-hair icons) are predominantly clustered within London's Zone 2 (shaded in orange). Their distribution closely aligns with areas of high heritage value, shown by the dark terracotta shading indicating areas with over 100 listed buildings per square kilometre. The light brown patches represent conservation areas, whilst larger icons denote UNESCO World Heritage Sites. The map reveals a clear correlation between the location of salvage yards and areas of significant architectural heritage.

Legend.

Icons

- *Architectutral Salvage Yards*
- *UNESCO World Heritage Sites*

Road Network

- *M25*
- *M4*
- *A10*
- *M40 into A40*
- *M1*
- *M11*
- *A13*
- *M20 into A20*

Boundaries

- *Greater London Boundary*

Areas

- *Conservation Areas*
- *Zone 2 Area*

Figure 7. Architectural Salvage yards Map (Shipp, 2025).

Part Two
The London Resource Recovery Landscape.

Centuries of redevelopment have embedded significant 'stores' of building materials into London's fabric, ready to be salvaged. The city's rich mix of historical and modern structures offers both opportunities and constraints for material re-use. With the UK construction sector generating approximately 50 million tonnes of CO2 annually (Government Commercial Function, 2022), London's architectural stock serves as an expansive material mine which would allow this figure to drastically decrease. Utilising these resources, however, requires the navigation of a series of regulations, logistical challenges and re-use facilities that shape the hard practicality of material re-use.

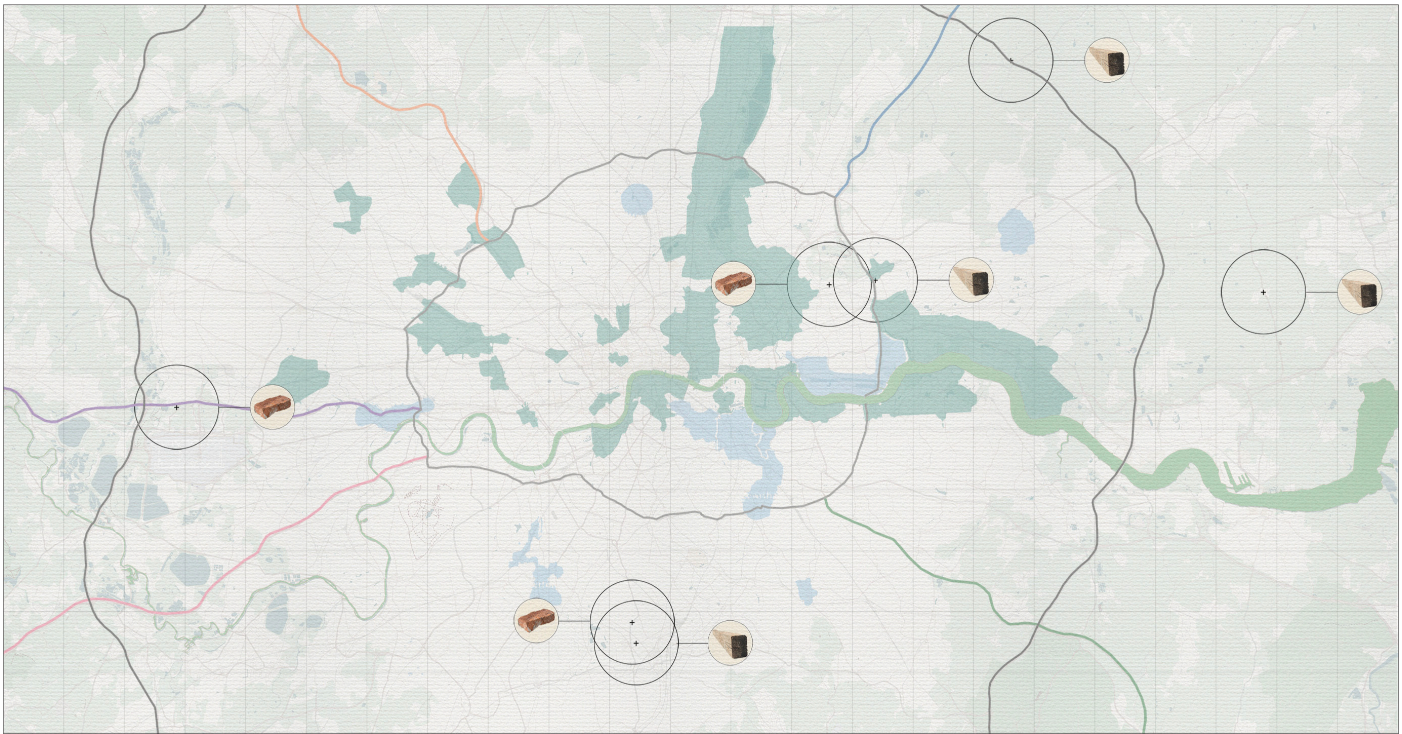
The landscape of material use, within London, can be characterised by a fragmented network re-use facilities, as shown in Figure 11. These resources are unevenly distributed throughout London, creating challenges for material re-use projects. The facilities can be broadly categorised into architectural salvage yards, material re-use facilities, and construction waste processing sites.

Architectural Salvage Yards

Architectural salvage yards store and sell salvaged building components for re-use, typically at a smaller scale to a re-use materials yard. Some of which, specialise in different types of salvage, for example, LASSCO[1] in Brunswick House and Retrovius in Kensal Green, focus on preserving and selling on high value architectural elements. These materials often command premium prices, with items such as salvaged Victorian signage exceeding the £12,000 mark (see appendix F for further details), reflecting the historic and aesthetic value that has been instilled within them. Their locations, within the inner London Boroughs, aligns with their emphasis on heritage materials and clientele - mainly of architects and designers rather than contractors. For projects on the outskirts of London and further, this concentration in TFL[2] zones 1 and 2 can present challenges. This has accessibility implications for outer London projects, due to increased transportation costs and the logistical difficulties in moving large materials across London potentially having a disproportionate impact on projects with rigid time-lines and budgets.

For figure 11, please refer to pages 46-47 or the printed map, this is a combination the series of maps within this section.

1. *LASSCO (London Architectural Salvage and Supply Company) is a renowned dealer of reclaimed architectural materials, known for its wide range of high-quality, historically significant items and its commitment to preservation.*
2. *Transport for London*



North

7,500m 1 : 375:000

0 3,750m 15,000m 37,500m

1 Square is approximately $3km^2$
Scale 1 : 375,000 @A4

London's Circular Economy Landscape Map 2:
The map of London's material re-use facilities.

Figure 8 illustrates the spatial distribution of building material re-use facilities across London. The facilities (marked by cross-hair icons with accompanying material storage icons) are predominantly located in outer London, with good access to major road networks (shown by coloured lines). The map overlays London's Opportunity Areas(OA) (shown in teal) and emerging Opportunity Areas(EOA) (shown in blue), highlighting areas designated for major development and opportunities for the development of new material re-use facilities. Notably, none of the facilities specialise in steel and metals, and their fringed locations contrast with the more centrally located architectural salvage yards shown in Figure 7.

Legend.

Icons

- Timber Reclamation Facility
- Masonry Reclamation Facility

Road Network

- M25
- M4
- A10
- M40 into A40
- M1
- M11
- A13
- M20 into A20

Boundaries

- Greater London Boundary

Areas

- Opportunity Areas
- Emerging Opportunity Areas

Figure 8. Construction Material Re-use Facilities (Shipp, 2025).

Part Two

The London Resource Recovery Landscape.

Construction Material Re-use facilities

Re-use facilities play a crucial role in extracting value from London's material reserves. They specialise in storing and redistributing salvaged building materials, such as steel, timber, and masonry. Figure 8 highlights facilities like Ashwells Timber in Essex and London Reclaimed Brick Merchants in Harmondsworth: small-scale reclamation yards located just outside London, where space allows for more extensive storage.

Figure 8 illustrates the lack of re-use centres, in London, for steel. Whilst London's material reserves contain substantial quantities of potentially reusable steel, there are few suppliers specialising in reclaimed steel for construction in the UK. Most businesses in this sector focus on recycling steel, rather than recovering it for re-use. Based just outside of York (192 miles), Cleveland Steel & Tubes is the closest significant source of recovered steel; alongside Ainscough Metals in West Lancashire(183 miles)(Figure 9). This illustrates a clear gap in the market, possibly due to London's high land value and density, which makes the necessary space for large-scale reclamation yards economically infeasible. Outer locations like Yorkshire and Lancashire offer the space needed for such operations.

Furthermore, Figure 8 shows that these facilities are often located far from the OAs[1] and EOAs[2], which are designated for major development. This is significant, as these areas are expected to experience substantial construction activity in the coming years, potentially creating both supply and demand for re-used materials. However, the current capacity and specialisation of existing facilities may not be enough to fully meet the needs of these areas.

As a result, the distance between large-capacity facilities and areas of high demand creates several challenges:

1. Transportation costs and carbon emissions increase significantly when moving materials between outer storage facilities and inner-city construction sites.

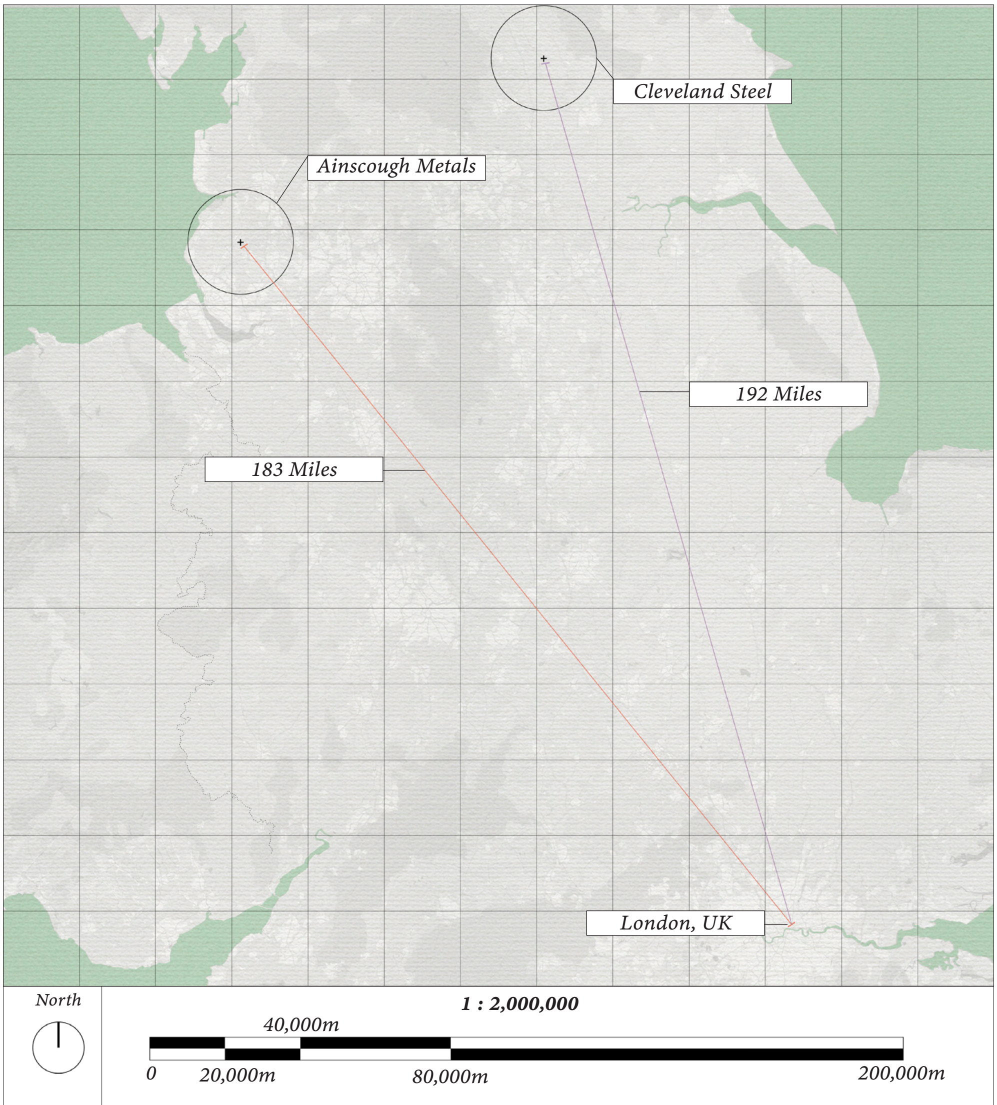
2. The cost of transporting materials from peripheral locations can offset the potential savings and likelihood of material re-use.

3. The lack of intermediate storage facilities in central London creates a missing link in the re-use chain.

4. Even though London has a lot of reusable materials in its buildings, the lack of storage and processing facilities makes it hard to efficiently 'mine' these urban resources.

For figure 9, please see next page.

1. Opportunity Areas - large-scale, strategic locations identified for significant housing, commercial, and infrastructure development Greater London Authority, 2021).
2. Emerging Opportunity Areas are similar to opportunity areas, however they have a greater focus on business and employment rather than housing.



London's Circular Economy Landscape Map 3 :
The location of the nearest steel re-use facilities.

Figure 9 depicts the absence of steel re-use facilities within London, with the nearest major facilities located at significant distances from the city. The map illustrates straight-line distances to the two closest substantial steel re-use operations, highlighting the considerable logistical challenges for steel re-use in London-based projects. The most notable facility, Cleveland Steel and Tubes, is situated 192 miles from central London (shown in red).

Scale 1 : 275,000 @A3 | + *- Steel Re-use Facility* | *1 Square is approximately 20km²*

Figure 9. Location of nearest steel re-use facilities (Shipp, 2025).

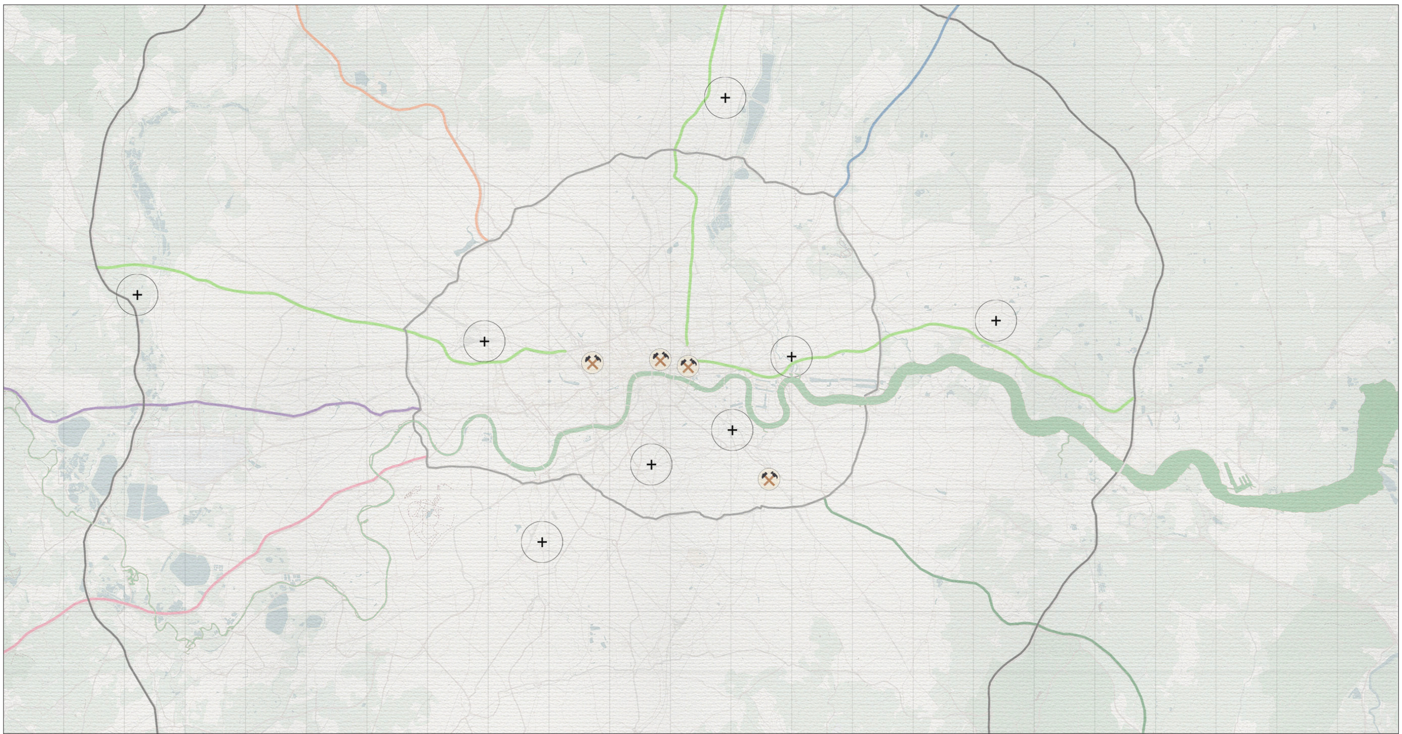
Part Two

The London Resource Recovery Landscape.

This distribution highlights how London's urban fabric influences practical possibilities for material re-use. However, several interventions might be able to bridge the gap between the outer London storage with the needs of the inner city. As discussed in 02.1, some policy measures, particularly in particular areas such as Haringey, do not strongly support material re-use. Improvements in this, such as subsidised land allocation for material reuse yards, in strategic locations of the city, could create a more evenly distributed network of reclamation facilities.

Additionally, the Greater London authority, in their London Plan, have specific policies such as policy E5 "SILs[1] should be managed pro-actively through a plan-led process to sustain them..." (Greater London Authority, 2021), that protect industrial land, including SIL[1]s and LSIS[2]s for industrial purposes. Designating zones for material banking could increase the likelihood of materials being salvaged, potentially reducing transportation costs and emissions, making material reuse and recovery more economically viable for inner London projects. This would help address the tension between economic and environmental value which was discussed in 01.06. Whilst these sorts of interventions would require public investments and policy support, they may be able to transform London's fragmented material re-use infrastructure.

1. Strategic Industrial Locations
2. Locally Significant Industrial Locations



North

7,500m   **1 : 375:000**

0   3,750m   15,000m   37,500m

1 Square is approximately 3km²

Scale 1 : 375,000 @A4

London's Circular Economy Landscape Map 4:
The map of London's construction waste recycling facilities.

Figure 10 illustrates the distribution of construction waste recycling facilities across London (indicated by cross-hairs) in relation to major transport infrastructure. The facilities are positioned along well-connected routes such as the A10, A40, and A13, which facilitates efficient movement of materials. The crossed hammers symbols indicate locations with approved major demolition permissions, representing significant opportunities for future material re-use and circular economy practices. This mapping highlights potential areas where early intervention could maximise material recovery and re-use.

Legend.

Icons

- *Recycling Centres*
- *Demolition Permission Granted*

Road Network

- *M25*
- *M4*
- *A10*
- *M40 into A40*
- *M1*
- *M11*
- *A13*
- *M20 into A20*

Boundaries

- *Greater London Boundary*

Figure 10. Map of construction waste recycling Facilities (Shipp, 2025).

Part Two
The London Resource Recovery Landscape.

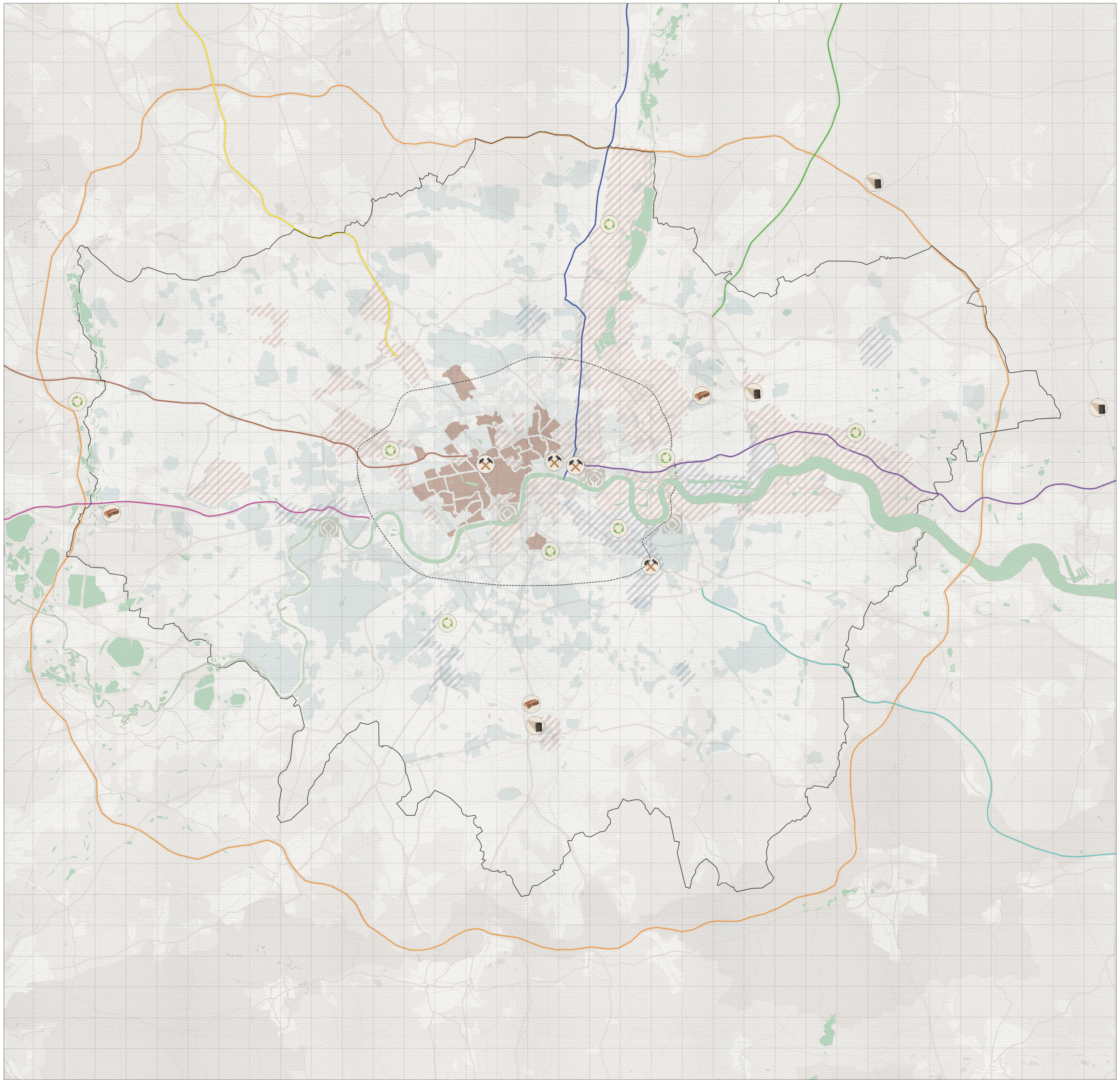
Material Re-use Centres

Despite the growing material re-use initiative, many materials continue to flow through traditional waste processing routes, even though London holds significant potential as a material mine. Facilities like Powerday in Old Oak Common, along with several other London locations (Figure 10), primarily focus on recycling and waste management rather than re-use. Whilst this is environmentally beneficial and preferable to landfill, the process still requires significant energy and often leads to a downgrading of material value. For example, a steel beam might be turned into scrap metal, and architectural stone could become aggregate. This represents a missed opportunity to maximise the value of these components through re-use.

The presence of these large-scale sites along major London transport routes, such as the A40, A10, and A13, as illustrated in Figure 10, reflects the contemporary emphasis on recycling rather than reusing. However, their strategic positioning and established networks could provide an opportunity to shift towards re-use practices. This shift would be especially effective if policies were to prioritise re-use over recycling, though not without challenges.

The London Resource Recovery Map Concluding thoughts

The spatial distribution of London's material re-use infrastructure has revealed both opportunities and constraints for the city's circular economy practices. Architectural salvage yards are concentrated in central, heritage-rich areas, whilst larger re-use operations are found on the periphery, often along major transportation routes. This fragmentation, along with the absence of facilities dedicated to steel re-use in the city, indicates both a challenge and an opportunity for targeted intervention. Given the presence of significant central London demolition approvals (figure 10), such as the demolition of St Helen's Tower in, standing at 122 metres tall in the City of London, which point to substantial future material flows and activity, there is potential to develop a more integrated network of re-use facilities. Such a network could enable London to function more effectively as a material mine. However, any such development would require careful consideration of supportive policies and spatial constraints to bridge the gap between future material activity and the current infrastructure available to support material re-use.



North

1 : 275:000

5,500 m

0 2,750m 11,000 m 27,500 m

Scale 1 : 275,000 @A3

1 Square is approximately equal to 2km^2

Figure 11. London's embryonic architectural recycling network (Shipp, 2025). To view this map at a larger scale, please see the supplementary map (Physical).

London's embryonic architectural recycling network
A Map of Infrastructure and Opportunity.

This map combines London's complete circular economy infrastructure, overlaying architectural salvage yards, building material re-use facilities, and waste processing centres against the key urban context. Heritage-rich areas and conservation zones are shown alongside opportunity areas and approved demolition sites, highlighting the complex spatial relationship between material sources and re-use facilities. Major transport routes highlight the logistical networks connecting these sites, whilst the contrasting locations of different facility types reveals both challenges and opportunities in London's circular economy ambitions. The map demonstrates the current fragmentation of re-use infrastructure and identifies potential areas for strategic intervention to better serve London's potential as a rich material mine.

Legend.

Icons.

- Recycling Centres
- Brick Material Re-use Centres
- Timber Material Re-use Centres
- Demolition Permission Granted
- UNESCO World Heritage Site

Areas.

- Conservation Areas
- Opportunity Areas
- Emerging Opportunity Areas
- 100+ Listed Buildings per Square Kilometre

Road Network

- M25
- M1
- M4
- M11
- M40 into A40
- M20 into A20
- A10
- A13

Boundaries

- Greater London Boundary
- Zone 2 Boundary

Data Sources:

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Part Three

An insight into professionals' perspectives on material re-use.

Assessing Re-use Potential

A focused survey of London-based architects from practices such as Assemble Studio and Buckley Gray Yeoman offered insights into material re-use. The survey found that the assessment of material re-use potential is heavily reliant on specialist consultants. The importance of sustainability trackers and material audits at early stages in the project were both emphasised, although noting that these are "costly and upfront" expenses that require client investment. This reveals that material re-use is not yet embedded in mainstream architectural work-flows but viewed as an outsourced service, increasing costs. This financial burden falls on the clients, making re-use an upfront investment rather than a standard part of the process. In London, where project budgets are tightly controlled due to higher land values, this additional cost deters developers from prioritising re-use and sustainable approaches.

Economic and Logistical Barriers

A common theme within the responses was the economic challenge of implementing material re-use strategies. An associate architect said "its literally cheaper to throw things away, end of story," exemplifying the fundamental challenge to wider adoption. The economic burden is compounded by "time implications to the scheme", with suggestions that assessments be integrated early in the project, particularly "during (RIBA) stage 1 when feasibility studies and very initial ideas are being formulated". This reflects a broader issue within London's material re-use landscape, where cost tends to take priority. While material re-use can lower material costs and embodied carbon, the financial benefits are not always immediate, making it harder to justify on tight-budget projects. With London's development process prioritising speed and cost, reclaiming and reintegrating materials is frequently seen as a time-consuming challenge, rather than an opportunity. Without financial incentives or stronger policy interventions, cost may remain a major barrier, limiting the potential of material re-use.

A senior architect noted that, in commercial projects, "their is a real drive to achieve the 'sustainability badges" (e.g., BREEAM[1], LEED[2]), but material re-use depends on client and letting agent priorities. Whilst sustainability is often emphasised, its implementation is entirely client-driven; some value its relevance and others see no benefit. Certifications like BREEAM[1] or LEED[2] can improve a building's marketability and encourage re-use for commercial appeal. However, without additional regulatory interventions or financial incentives, sustainability remains choice rather than a mandatory requirement, preventing the widespread adoption of material re-use.

For survey transcript, please see appendix B.

1. *Building Research Establishment Environmental Assessment Method*
2. *Leadership in Energy and Environmental Design*

Part Three

An insight into professionals' perspectives on material re-use.

Successful Projects

Despite these barriers, some London projects have successfully implemented re-use strategies, albeit for internal fittings and finishes rather than architectural elements. One architect noted that retaining existing lighting and carpets in a commercial office fit-out was cheaper than buying new, whilst another described re-purposing marble panels into terrazzo, rather than being discarded. These examples demonstrate that re-use is often preferred when it corresponds with cost efficiency. Furthermore, they emphasise the value of re-using materials with minimal processing, as extensive refurbishment can diminish both the financial and environmental benefits.

Knowledge Gaps and Industry Needs

Survey responses highlighted another fundamental challenge to material re-use in London: the lack of accessible information, industry contacts and clarity on possible re-use strategies. One architect said they would "re-use more if I(they) had the contacts". This highlights the challenge not to be a lack of willingness, but rather a lack of clear pathways and accessibility to material re-use, most likely due to the absence of a centralised database or supplier network.

According to respondents, there is a lack of cost data available to quantity surveyors, making it difficult to compare the financial viability of reclaimed materials against new ones. Clients are often discouraged from investing in material re-use, since there are no clear pricing structures or case studies demonstrating cost savings. Greater transparency in financial data may help to change client perceptions and make material re-use a more justifiable investment.

A senior architect noted that the main obstacle for architects is the lack of industry connections. As noted in section 02.2, this issue is particularly evident in London's fragmented supply chain for reclaimed materials, particularly steel. Whilst facilities like Ashwell's Timber and London Reclaimed Brick Merchants store and redistribute salvaged materials, there is a significant gap in reclaimed steel suppliers, with the nearest major suppliers located 183-192 miles outside London. This distance, combined with high land values, makes large-scale facilities infeasible in central areas.

There are several solutions that could be implemented to address this. For instance, the creation of a centralised digital marketplace for reclaimed materials, the establishment of a professional network connecting architects, suppliers, and specialists possibly managed by RIBA, and the development of a knowledge-sharing framework with standardised material assessments and case studies. Additionally, policy support, such as established material re-use co-ordinators within local planning authorities or design teams could create an accessible system for specifying material re-use.

Part Three

An insight into professionals' perspectives on material re-use.

The Future of Material Re-use in London

The survey responses show a rising awareness of material re-use, with expectations of increased implementation other the next 5-10 years. Although, significant barriers exist, particularly related to policy and infrastructure. A senior architect stated that material re-use is rarely prioritised in most projects due to a lack of regulatory enforcement, noting "as it currently is not regulation, it isn't a consideration for most projects".

Key recommendations include standardised tested details and the integration of material re-use into building regulations. Whilst these changes could encourage wider adoption, one respondent highlighted a competing challenge: "the changes to building regulations around fire safety under the BSA[1]" mean that there are "much larger constraints at play for clients and design teams, so unfortunately material re-use becomes secondary". This exemplifies a wider industry reality: sustainability is important, but safety will always be priority. Ultimately, whilst awareness and momentum for material re-use are rising, regulatory and infrastructural adjustments are required for its full potential to be fulfilled.

Response Summary

The survey responses indicate both the growing awareness of material re-use in London's architecture scene and the ongoing challenges limiting its wider adoption. Whilst the environmental benefits are increasingly recognised, significant barriers remain, including high upfront costs, logistical difficulties, limited industry connections, and regulatory constraints. Clients often view material re-use an optional sustainability check-box with added cost rather than an integral part of the building design process. This perspective is largely due to a lack of standardised processes, fragmented supplier network and insufficient regulatory support.

Moving forward, addressing these barriers requires a coordinated approach that includes regulatory intervention, improved infrastructure and industry-wide engagement. Only through these approaches can material re-use become an inherent and routine part of the design process. Whilst there is optimism for wider adoption, meaningful progress depends on addressing these key challenges.

1. *The Building Safety Act (BSA) that is likely being referenced in this response is the Building Safety Act 2022 in the UK. It was introduced following the Grenfell Tower fire in 2017 to improve building safety, particularly in relation to fire safety and to address issues around the safety of high-rise buildings.*

Please turn over for Chapter three: Concluding Thoughts.

03

Concluding Thoughts.

Conclusion

A new perspective for architecture.

Summary

This thesis has investigated how the built environment represents more than a collection of buildings, it is a vast material mine ready to be harvested. This study represents an investigation of material re-use within the circular economy, highlighting the challenges and misconceptions surrounding its value.

Architectural discourse remains divided on the economic viability of material re-use. Whilst Nuβholz et al. (2019) found no immediate financial benefits despite environmental advantages, Hart et al. (2019) reported industry scepticism. The survey of London architects reflected this scepticism; one architect noting, “it’s literally cheaper to throw things away”. The survey found that material re-use is typically seen as an optional sustainability criteria, rather than a necessary practice mostly due to high upfront costs and need for specialist consultants.

This reluctance is further reinforced by doubts regarding circular approaches providing actual economic value, owing to the lack of a holistic supply chain, short-term thinking, and the low value of many construction products at the end of life. As a result, the industry’s current prioritisation of quick financial returns compromises the greater environmental and cultural value of reclaimed materials.

The fragmented material recovery network of London demonstrates both the potential and limitations to material mining. The mapping study revealed a disconnect between supply and material storage; recycling facilities are located on the city’s outskirts and the nearest steel re-use yard is 183 miles away. Despite London’s immense inventory of steel, the absence of dedicated re-use facilities and material yards highlights the significant gap in its circular economy infrastructure. This, combined with the limited aims and material re-use emphasis of the borough-level policies, shows how London’s fragmented network is not yet optimised for material re-use, despite the city's abundant resources.

Regarding the distance of the steel re-use facilities, local food suppliers allow one to draw a parallel from farmers' markets, where proximity is given priority to reduce impact. Material re-use can be approached in the same manner. A steel re-use facility should ideally be be no more than 75 miles away, therefore lowering transport emissions and costs and ensuring efficient redistribution and processing within the city. However, such a restriction would add a higher degree of uncertainty, forcing architects to adapt to the available materials, therefore encouraging a more opportunistic design approach, where constraints inspire creative and innovative architectural solutions.

Conclusion

A new perspective for architecture.

Proposition

This thesis has underscored that implementing material re-use requires a shift in how design and construction are approached by architects, planners, policy makers and clients. The survey highlighted the need for material re-use assessments to be incorporated "during RIBA stage1[1] when feasibility studies and very initial ideas are being formulated." However, respondents noted that specialist consultants and sustainability trackers are "costly and upfront" expenses requiring significant client buy-in. This makes it difficult to implement into the early design stages, often discouraging clients from material re-use.

Despite these barriers, successful implementation is achievable through a re-conceptualisation of the design process. Re-use must be embedded from the project's inception, not seen as an add-on, therefore requiring early engagement with salvage yards and re-use facilities by architects, engineers, and contractors. This approach reverses the conventional design process: the design must adapt to the available resources and accommodate varying material properties rather than specifying materials to fit a design.

This approach will require greater flexibility in design development. When working with re-used steel, for instance, designs must accommodate varying material properties until specific materials are secured. This necessitates additional tolerance in structural calculations, flexible design solutions, early engagement with salvage suppliers, and time for material sourcing and testing. Whilst there may be initial cost implications, particularly in extending project time-lines and certifying materials, these costs will be offset by lower raw material costs, environmental benefits, and the added historical value. Successful implementation depends on early planning, to manage expectations, simplify processes and maximise material re-use as well as close coordination with suppliers, engineers, and clients.

Mapping London's material recovery network revealed areas for development of the city's circular economy. Designated opportunity areas, identified by the GLA[2] for major development, could house new material banks, bridging the gap between material storage and construction needs. Given London's lack of a dedicated facility, existing waste processing sites along roads like the A40 and A13 could prioritise re-use over down-cycling, especially for steel. Furthermore, varying strategies and re-use guidelines between boroughs also show how urgently a more cohesive policy framework is needed.

To address this, London could establish a more integrated re-use network by implementing policies and legislation to mandate material re-use and leverage the GLA[2]'s opportunity areas for material banking. Such initiatives could transform London's fragmented infrastructure into a functional material mine. This would position London as a leader in material mining, but requires coordination between local councils, the GLA, and industry stakeholders.

1. *RIBA Stage 1 is the Preparation and Brief stage, where the project's initial requirements are defined. This includes understanding the client's needs, setting project objectives, and developing a project brief that outlines the scope, budget, and time-line.*
2. *Greater London Authority.*

Conclusion

A new perspective for architecture.

Practice

As a young architect entering the profession, this research reshapes my view of sustainable architectural practices. The findings imply that material re-use is not just an optional sustainability measure, but an ethical necessity for the next generation of architects. Today's architects have the ethical responsibility to establish re-use as routine practice, allowing cities to sustain themselves from within. This approach will reduces dependency on raw materials and foster a more sustainable future.

To achieve this, the effects on design work-flows are significant. Firstly, material availability and uncertainty will shape decisions, fostering a more iterative design approach. This requires an alternative perspective and a more holistic attitude: giving material surveys priority before concept design; conducting material sourcing time-lines from the start; and using adaptable designs that can adapt to material variations. Whilst this introduces constraints, it also creates opportunities for the unexpected, adding a unique aura to materials as they carry their histories between projects. These shifts represent a fundamental redirection in thinking. Young architects have both the responsibility and opportunity to drive this transformation, viewing cities as material mines rich with resources. As a result, there will be challenges such as material uncertainties and extended project, but the environmental benefits far outweigh them: reducing embodied carbon and minimising construction waste.

From a design standpoint, re-used materials also bring layers of embedded history and character to architecture: worn surfaces, markings and textures, revealing their passage through time. This points towards a more sustainable future, creating architecture that not only serves a function but also embodies a narrative through its materials. From the documented 18th-century floorboards (Figure 12) to the 19th-century wrought iron fire screen salvaged from the manor of Sir Robert Lorimer and valued at £2,200 (Figure 13), this richness is reflected at architectural salvage yards like LASSCO, where each item tells a story. These historical narratives translate into both cultural and economic value.

The future of architectural practice lies not in the continual consumption of new materials, but in the careful re-use and re-imagining of existing resources, no longer viewed as construction waste. By means of material re-use, architecture can be designed that acknowledges its position within the greater context, with each component embodying its own narrative and so shaping a more sustainable future.

For figure 12 and 13, please see next page. For additional photos taken at LASSCO, please see appendix F.

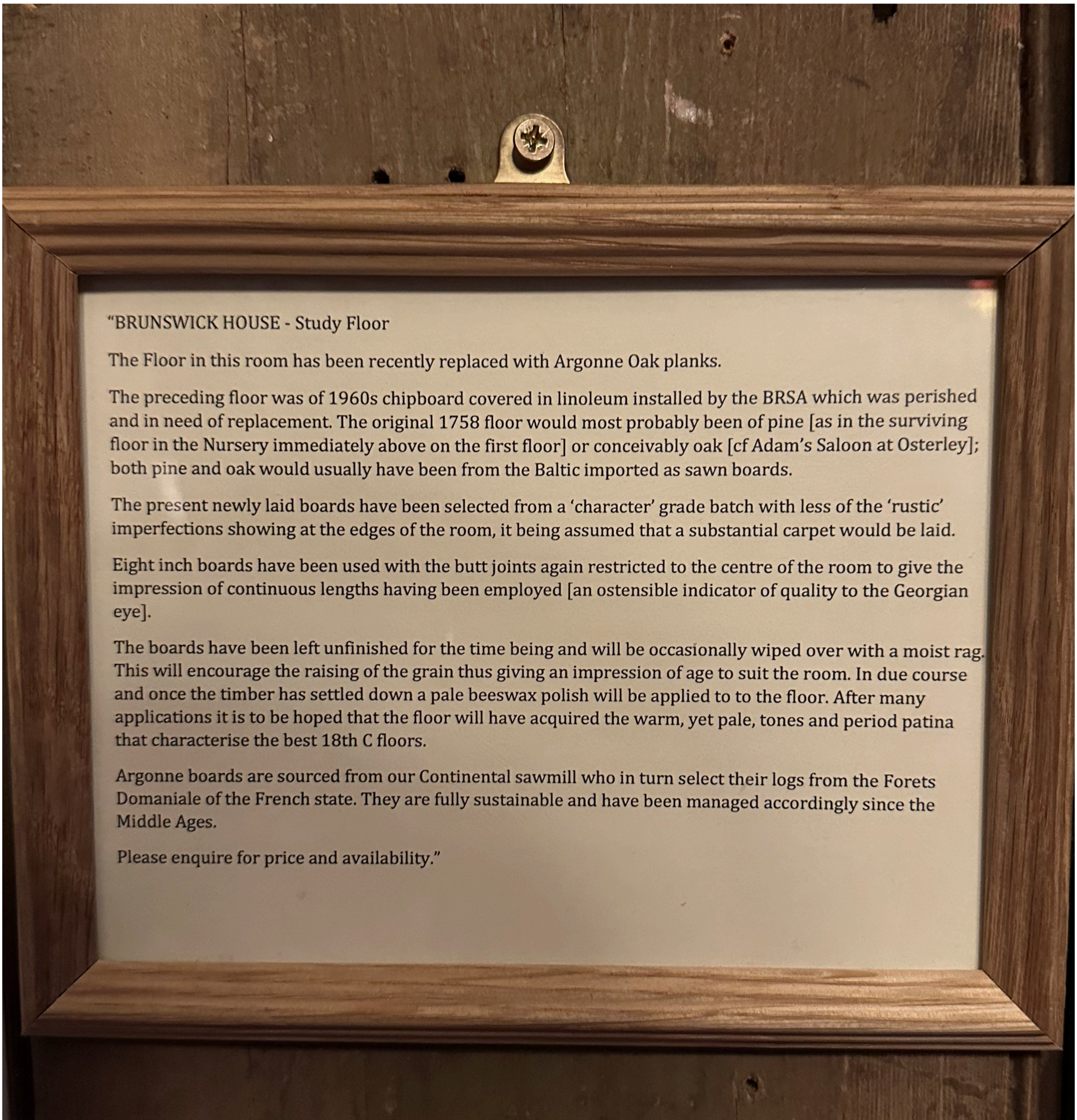

Fig . 12
Burnswick House Study Floor boards.

This photograph was taken during a visit to LASSCO at Burnswick House. It is of a description of the recently replaced study room floor boards which are now for sale. The description accompanying the boards tells a rich story of their history, exemplifying the embedded narratives that are infused into re-used materials.

Figure 12. Burnswick house study Floorboards (Shipp, 2025).

Fig . 13

Fine and intricately worked wrought iron firescreen at LASSCO.

This photograph was taken during a visit to LASSCO at Burnswick House. It shows a 19th-century wrought iron fireplace screen, salvaged from the manor of Sir Robert Lorimer. The item's rich historical background not only adds cultural value but also contributes to the economic worth of re-used materials, demonstrating how their stories enhance the materials' significance.

Figure 13. Fine and intricately worked wrought iron firescreen at LASSCO, Burnswick House (Shipp, 2025)

Please turn over for References and Appendices.

04

References and Appendices.

Appendix
A

00.2 Glossary

Glossary

Four key terms underpin this research: waste, value, preservation and re-use.

The term ***waste*** (from Old French ***weste***, meaning Uninhabited or Deserted) (Oxford English Dictionary, 2020) was historically tied to destruction and ruins. Now, its meaning has adapted to refer to discarded items. Within the context of this thesis, ***waste*** is used to describe a redundant resource that is not to be discarded, one that holds potential to become an element of innovative sustainable design. ***Waste*** describes an unrealised potential within the built environment, more than just discarded materials. A fabric woven of underutilised resources with intrinsic value, going beyond their material worth. ***Waste*** is a chance for innovative design to mitigate the environmental impacts of the construction industry.

The concept of ***value*** (from Latin ***valere***, meaning to be strong or worth something) (Oxford English Dictionary, 2020), was historically tied to physical strength, adapting to define monetary worth. More recently, the term has strayed away from 'economic worth' gaining a moral and cultural meaning. The term is a socially and politically ambiguous term, which may be used in a variety of contexts. In this research, the term extends beyond monetary worth, encompassing the sustainable impact of material re-use, as well as the cultural and historical significance embodied in existing structures and building components. Ordinary construction materials, like a steel beam, have inherent worth since they provide architectural practice with opportunities for re-use and innovation; they offer not just a high environmental value, but also social value too.

Preservation (from Latin ***praeservare***, meaning to protect) (Oxford English Dictionary, 2020) was historically tied to physical protection, however it has now grown to include the protecting of cultural and historical value. 21^{st} century architectural interpretations of the term now embrace adaptive re-use, an act of transformation whilst retaining valuable characteristics of the original structure. ***Preservation*** is not used 100% literally but in a way that transcends the literal retention of spaces and materials. Although building components and materials may not always be re-used in their original role-for example, steel beams may be re-purposed for their aesthetic function rather than their structural function – the materials can still be reinterpreted in creative ways that honour their inherent value. This perspective facilitates sustainability by allowing historical and cultural relevance to be protected within modern architectural contexts, conserving value. The preservation of resources is far better than allowing them to be wasted, hence a lost potential.

Appendix
A

00.2 Glossary

Glossary
Four key terms underpin this research: waste, value, preservation and re-use.

The term ***re-use*** originates from the prefix ***re***, meaning 'again' or 'back' and the verb ***use*** which comes from the old French ***user*** ("to employ, make use of") and the Latin ***uti*** ("to use, employ, enjoy"). Within this thesis, ***re-use*** is used to describe the process of recovering and re-purposing building components or materials from existing structures for use in new construction projects, maintaining their original form and function where possible. Unlike recycling, which involves breaking down materials for reprocessing, re-use preserves the embedded carbon, cultural and historical value of materials while minimising waste.

Appendix
B

01.2 Navigating uncertainty in steel re-use

Part Two
Navigating uncertainty in steel re-use.

Re-using materials, particularly steel, presents a challenge due to the uncertainty regarding their material properties. Every recovered piece has a unique structural loads, environmental exposure, and stress history that traditional evaluation methods cannot that cannot be fully identified through standard assessment methods. Conventional architectural methods are thus challenged since they usually depend on materials with consistent and predictable properties. When steels are salvaged there are placed into groups, these groups depended on size and original function. However, the properties of each individual steel in those groups may still drastically differ (Ferrao, 2023). This makes material behaviour more difficult to predict, therefore challenging engineers and architects. However, this presents a chance to investigate the adaptive potential of both the material and building design. Materials therefore change from being standardised, interchangeable components to unique elements with their own histories; this uncertainty thereby presents both a challenge and an opportunity. Whilst re-use introduces complexity and requires new approaches, it also opens up the possibility for more innovative, sustainable, and contextually rich architectural solutions.

As a result, when designing with re-used components, architects must account for a significant tolerance for variability. This accountability require a more flexible design to be taken in the early stages of design, accommodating variations in the material properties, possibly right up until procurement. As a result, designers must accommodate for a variety of possibilities, as opposed to predefined specifications. Additionally, they must have early and close engagement with reclaimed material providers, as this will be essential in order to anticipate the available resources. At the same time, BIM[1] work-flows must be adjusted to account for the variability in material properties to accommodate different scenarios, based on evolving material data. Construction sequencing also becomes more adaptive, with final design decisions made as material properties are confirmed.

Unfortunately, new materials are often favoured over reclaimed ones. This is largely due to the perception that reclaimed materials are less reliable as for their variable properties, as well as the presumed financial costs for clients, who could be concerned about the extra work necessary. This mindset makes it harder to integrate salvaged materials into projects, as architects and engineers may be hesitant, and local planning authorities may be reluctant to approve plans that include re-used materials. This suggests a widespread assumption that new materials are inherently more valuable and reliable than salvaged ones (Kanyilmaz et al., 2023).

1. BIM (Building Information Modelling) provides detailed data on existing materials, enabling efficient identification, tracking, and re-use of resources.

Appendix
B

01.2 Navigating uncertainty in steel re-use

Part Two
Navigating uncertainty in steel re-use.

This viewpoint overlooks the broader value of reclaimed materials. Beyond their structural potential, these materials offer significant benefits, including reduced carbon footprints, the preservation of cultural heritage, and a challenge to wasteful consumption patterns. By redefining the value seen in re-used materials, they can be seen not only as physical components but also as integral elements of a sustainable and innovative design approach.

Over time, this process may become easier, as the traceability of steel has improved significantly with the advent of software such as USD[1]. However, this remains a challenge today because many buildings being considered for re-use were constructed before such technologies were widely adopted. As a result, the traceability of materials in older structures remains less clear. But with the increasing use of tools like USD, the properties of materials that would have previously been unknown in buildings constructed today will be fully documented, allowing us to re-use these materials more effectively in the future.

1. USD is an acronym for Universal Scene Description, it enables the creation of an audit trail for structural steel used in buildings, facilitating the recovery and re-use of materials.

Appendix
C

01.3 P247 of the SCI Protocol

P247 SCI Steel Protocol
(The Steel Construction Institute, 2019)

"This document has been prepared to help facilitate the reuse of structural steel sections reclaimed from existing building structures. The principal focus of this protocol is the reclamation and reuse of individual members within a new structure, rather than the reuse of an entire building structure in a new location.

The protocol proposes a system of investigation and testing to establish material characteristics, with advice for designers completing member verifications of reclaimed steelwork. The protocol places important responsibilities on the holder of reclaimed steelwork including identification, assessment, control procedures and declarations of conformity.

The protocol is founded on the principle that given appropriate determination of material characteristics and tolerances, re-fabricated reclaimed steelwork can be fabricated and CE marked in accordance with BS EN 1090[1]. BS EN 1090 is a European standard that sets requirements for safety of steel and aluminum construction products."
(The Steel Construction Institute, 2019)

Appendix
D

02.1 Evaluating London's Circular Economy Policy Framework

Policy SI 7
(The Greater London Authority, 2021):

A "Waste planning authorities, the mayor of London, and the industry will practise the following: Resource conservation, waste reduction, increases in material re-use and recycling, and reductions in waste going for disposal, workin in collaboration to:

- Promote a more circular economy that improves resource efficiency and innovation to keep
- Products and materials at their highest use for as long as possible
- Encourage waste minimisation and waste prevention through the reuse of materials and
- using fewer resources in the production and distribution of products
- Ensure that there is zero biodegradable or recyclable waste to landfill by 2026
- Meet or exceed the municipal waste recycling target of 65 per cent by 2030163
- Meet or exceed the targets for each of the following waste and material streams:
    a) construction and demolition – 95 per cent reuse/recycling/recovery
    b) excavation – 95 per cent beneficial use164
- Design developments with adequate, flexible, and easily accessible storage space and collection systems that support, as a minimum, the separate collection of dry recyclables (at least card, paper, mixed plastics, metals, glass) and food.

B Referable applications should promote circular economy outcomes and aim to be net zero-waste. A Circular Economy Statement should be submitted, to demonstrate:

- How all materials arising from demolition and remediation works will be re-used and/or recycled
- How the proposal's design and construction will reduce material demands and enable building materials, components and products to be disassembled and re-used at the end of their useful life
- Opportunities for managing as much waste as possible on site
- Adequate and easily accessible storage space and collection systems to support recycling and re-use
- How much waste the proposal is expected to generate, and how and where the waste will be managed in accordance with the waste hierarchy
- How performance will be monitored and reported.

C Development Plans that apply circular economy principles and set local lower thresholds for the application of Circular Economy Statements for development proposals are supported." (The Greater London Authority, 2021).

Appendix
E

02.3 Survey Transcripts

Can you walk me through your process of assessing the potential re-use value of materials or building elements in a project? Is there a specific criteria that you use?

"Ask a specialist consultant"

"Sustainability tracker and sustainability reviews early in the project, organising a site audit of materials - this is all costly and upfront stuff that the client would need to pay for."

"We usually work alongside a material cataloging consultant who the client appoints to survey the existing building before any demo works commence. The report will then highlight any materials which can be re-used elsewhere or stored/recycled/sold on."

What are the key barriers you see within the industry that prevent greater adoption of material re-use strategies?

"Architects are tied to their desks and less scope to explore buildings in detail. Material re-use is identified too late in the process to be meaningful to creative design input. Clients aren't interested in sustainability. Need convincing that material re-use is justifiable."

"Its literally cheaper to throw things away end of story. There isn't enough money around to allow for 'indulgences' such as sustainability for some, it also often adds time implications to the scheme as assessments take time and then need to be fed in. Its best done during stage 1 when feasibility studies and very initial ideas are being formulated. It also needs to be accurately costed."

"Commercial viability - the amount of material available and cost of refurbishing it if reusing. In some instances it would need to be fire tested which is a long process and expensive - Client and agents, in commercial projects their is a real drive to achieve the 'sustainability badges' which is fully dependent on the type of client and letting agents who either value its relevance or don't see a benefit."

Appendix
E

02.3 Survey Transcripts

Could you describe a specific project where you successfully implemented material re-use? What were the key factors that made it successful, and what Responses: 2 ***would you do differently next time?***

“Cat B office commercial fit out - re-used existing lighting and carpet. The client drove the process as it was cheaper to keep these and it also saved cash on services engineers as we didn’t need to design a new lighting arrangement. Saved a lot and was sustainable.”

“We have specified re-use of existing marble panels in lobby areas to be sued as aggregate base in work surfaces throughout the building. Using a company called British Terrazzo who take existing materials and re-use.”

What skills or knowledge gaps need to be addressed to increase the capacity for material re-use within the construction industry?

“The types of re-use possible, companies to contact about this, timescales involved, are there specialists that can come in and see designers about their projects and assist with this like another consultant. Better cost information available to quantity surveyors. I would re-use more if I had the contacts.”

“Material cataloging to become part of the strip-out/enabling works contract. Regulations.”

If any, which regulations do you find most challenging when implementing material re-use strategies, and what specific changes would make material re- Responses: 2 ***use more feasible?***

“Its a complex question. Fire regs will be the biggest problem, due to the need to have tested arrangements with specific materials and arrangement in some scenarios. When renovating existing commercial buildings, theres often a problem with an existing finish hense stripping it out, perhaps its too slippy a floor tile or whatever. Standards have moved on but some existing finishes no longer meet those standards. Its a fine balancing act.”

“Part B + Part L” (Building regulations)

Appendix
E

02.3 Survey Transcripts

Based on your experience, what specific changes do you expect to see in material re-use practices over the next 5-10 years? What developments would** Responses: 3 **have the biggest impact?

“I expect the changes to increase. I had never heard of material re-use as a ‘thing’ prior to working at BGY.”

“Answer to question 5 is basically the same. In terms of developments - standard tested details, other arrangement details and also recycled materials being an option to select, so for example can companies have direct lines to manufacturers who configure glazed partitions for example? You need to be able to select recycled parts as an option when procuring/specifying product. Existing materials in a building itself are more complex to re-use, its makes more sense to have companies who process materials for re-use and sell them on to bigger manufacturers who want to offer such things as part of their product offering. It is more efficient on time cost and quality.”

“This feels like a London based trend currently, that may be just my experience to date but as it currently isn’t regulation, it isn’t a consideration for most projects. Changes to regulation would generate the biggest impact but honestly with the changes to building regulations around fire safety under the Building safety act there are much larger constraints at play for clients and design teams so unfortunately material re-use becomes secondary.”

When sourcing materials for re-use, what do you consider the main logistical challenges in accessing reclaimed materials in London?

“The amount of companies actually stripping out the material/cataloging and storing. Where do you store the materials? These guys are a good example - https://excessmaterialsexchange.com”

Appendix
F

03.1 LASSCO Photographs

Two Late Victorian Parcel-gilt Wrought Iron Signs - "Saloon Bar Lounge"

These refurbished Victorian saloon signs provide us with an insight into a historical era, one of quality and craftsmanship. They have been polished in a beautiful mid-Burnwick green gloss (LASSCO, n.d.), Priced at £12,500 apiece, they have cultural and aesthetic significance as historical aura and high quality craftsmanship.

Appendix
F

03.1 LASSCO Photographs

A Pair of Antique Carrara Marble Pedestal Columns.

This pair of nineteenth-century Carrara marble columns, with turned socle and square plinth base, reflect the craftsmanship of the era. Their design and quality give them both historical and visual appeal. Priced at £8,750 for the pair, these columns hold a sense of magnificence and a direct connection to the craftsmanship and architectural traditions of the past.

Appendix
F

03.1 LASSCO Photographs

A Pair of Rosso Levanto Marble Columns.

These twentieth-century columns are crafted from Rosso Levanto marble, featuring a turned socle on a plinth base made of Rojo Alicante marble.

Appendix
F

03.1 LASSCO Photographs

An English Cast Plaster Relief Panel - From Dominico Brucciani £545

Domenico Brucciani (1815-1880) was born in Lucca, Italy, moved to London as a young man, by at least 1837, and soon became a revered formatore – plaster-caster. His business built up special links with both the British Museum and the South Kensington Museum (later re-named The Victoria & Albert Museum) (LASSCO, n.d.). These castings direct replicas of iconic Renaissance work hold historic value. A layer of value is added that transcends the material itself.

Appendix
F

03.1 LASSCO Photographs

A Selection of Similar Castings - From Dominico Brucciani

A selection of castings created from Renaissance moulds by Domenico Brucciani. These pieces carry historical significance and a connection to artwork of the Renaissance, embedding them with an aura and an intrinsic value.

Appendix
F

03.1 LASSCO Photographs

A Selection of Similar Castings - From Dominico Brucciani

A selection of castings created from Renaissance moulds by Domenico Brucciani. These pieces carry historical significance and a connection to artwork of the Renaissance, embedding them with an aura and an intrinsic value.

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List of Figures

List of Figures

After investigating the history of re-use, a narrative emerged that shows how once a necessary component of daily life, re-use faded into the background over time. However, as we face significant environmental challenges, re-use has now re-emerged as a critical solution for a sustainable future. Recognising its significance, it was important to illustrate this resurgence graphically by charting its evolution from the Roman times forward till now using a dynamic time line.

List of Figures