# Closing the circle

## Making London the circular construction capital of the world

macegroup.com

mace

# CONTENTS

Click on the page number to jump to a section

# FOREWORD

**The built environment continues to be a crucial component of global efforts to mitigate climate change. The construction industry globally still accounts for 40% of carbon emissions and over 50% of material waste.**

Wasteful and carbon intensive consumption undermines international Net Zero commitments. Moreover, it disrupts the construction industry's ability to build – with increasingly stringent environmental requirements on developments and investors demanding more sustainable design and construction practices.

This issue is most urgent in our cities. Research from the World Green Building Council in 2023 revealed that despite covering 2% of the world's surface, cities contributed to half of all resource consumption and a staggering 70% of $CO_2$ emissions.[i] As new and existing urban areas continue to expand, we must prioritise the solutions and innovations that minimise, and eventually eliminate embodied carbon in these heavily developed megacities.

There is a huge opportunity for the industry to make meaningful reductions in its use of virgin materials. By making more effective use of materials released from either demolitions or waste from construction projects, we can drastically reduce embodied carbon throughout the lifecycle of buildings and eliminate unnecessary waste.

To do this, the construction industry must move away from an extremely wasteful linear way of working. The culture of the industry is that buildings are built, are used for a period of time and are often demolished at the end of their life. This is where the role of circularity comes into play.

Circularity, also described as the circular economy, is defined as 'a system where materials never become waste and nature is regenerated'.[ii] Within construction, this means that materials and components should be directly reused or recycled, in order to conserve virgin resource and reduce embodied carbon.

At Mace, we are passionate about pursuing a more sustainable world and contributing to global carbon reduction, not just for ourselves but our clients and partners globally. That is why we are committed to delivering 10 million tonnes of carbon savings for our clients by 2026. We believe that the transition to a circular economy is among the most important innovations for the built environment to deliver on embodied carbon targets and that now is the time for the industry to agree a roadmap to a circular future.

**James Low**
Global Head of Responsible Business, Mace

# ABOUT THIS REPORT
# WHY CIRCULARITY?

## Our industry has an outsized role to play in addressing the climate emergency.

The embodied carbon generated by the built environment has a huge number of sources – from the energy required to power construction machinery on site, to the water and natural resources used in the manufacture of materials and the fuel used to move those materials around the world.

Circularity – or the creation of a circular economy – is a necessary part of how our industry must respond to that challenge. Through the principles of 'reduce, reuse and recycle', the construction and development industries must address our use of virgin construction materials.

As an industry, we know that we need to move quickly on all those fronts – finding innovative solutions to make our use of energy and natural resources more sustainable, to re-use and retrofit existing buildings to avoid unnecessary waste; and – as detailed in this report – find more effective ways to re-use the waste we do generate. Those efforts must cross the entire life cycle of the built environment – from scoping to design, to construction and through to demolition or re-use and retrofit.

As a global consultancy and construction company, Mace works across the property and infrastructure life cycle, and is working with clients around the world on every stage of the 'reduce, reuse and recycle' model. In this report, we've specifically focussed on 'reuse and recycle', presenting a model for managing construction waste and reducing the use of virgin materials through direct reuse or recycling within the industry.

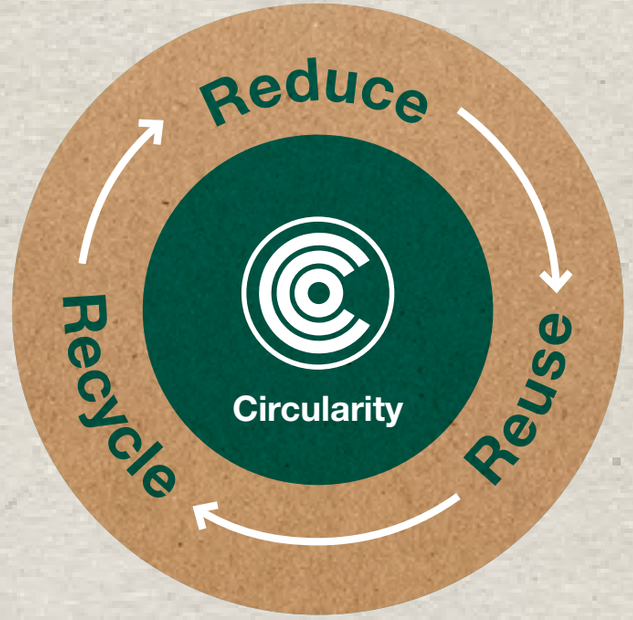
By doing so, we believe we can evidence that circularity approaches can make a meaningful and necessary contribution to reducing the embodied carbon of buildings – a vital step towards reducing our industry's emissions and ensuring our clients can meet their ambitious ESG goals when investing in development projects.

Elsewhere Mace has explored the challenges of reducing waste through retrofit within the commercial and public sector; and we plan to do further work around reduction strategies in the design and development stages of a new build project, particularly around the use of construction to production and modern methods of construction techniques.

## Circularity

/ ***sur-kyuh-lar-i-tee*** / **noun** sustainably delivering and operating the built environment in a way that minimises the consumption of resources.

**The circular economy in the built environment relies on three core principles:**




### Reduce

Reducing resource use in construction through the design of projects, avoiding new build and the use of innovation construction approaches.

Examples: MMC, design for production and manufacture

### Reuse

Directly re-using construction products and materials so they don't become waste.

Examples: Retrofit, materials passports, urban mining, re-using steel frames

### Recycle

Taking construction waste materials and recycling them back into the industry, reducing the use of virgin materials.

Examples: Redirecting flooring materials or concrete waste into new products

# ABOUT THIS REPORT
# WHY LONDON?

**Global cities offer the greatest opportunity to have a material impact on the built environment's carbon emissions.**

**Their sheer density and scale - and the progressive construction and development industries they support - provide a foundation for circularity principles to take root and help us to transform the embodied carbon of new build construction.**

## The global picture – why cities, and why focus on London?

Our ambition should not stop at cities – but they are a vital first step towards a more sustainable future. For now, the application of a circular economy within the construction industry remains a relatively niche endeavour. Changing this requires an understanding of the barriers inherent within the current industry model, to rethink the way we use resources and embrace new business models.

To do so, in this report, we have focussed on one of those cities to build a replicable model that demonstrates the scale of opportunity and the right conditions for a solution to be delivered. We then broaden our approach to explore the potential for other global cities to expand their use of circularity principles in the delivery of construction – stepping towards a truly global approach.

We believe that London offers an ideal place to build the world's first true circular construction economy for a number of reasons. The UK capital has a construction market of highly innovative firms that are familiar with tackling complex construction projects, an occupier base that places value on becoming more sustainable, and planning authorities keen to promote circularity practices.

As such, this report will examine in depth the barriers and opportunities that arise from a fully realised circular economy for London's construction industry, as a feasibility study for other major global cities.

# EXECUTIVE SUMMARY

**Currently, 90.2% of waste from demolition and construction from both the City of London, and London more broadly is recovered for some form of reuse or recycling.**

## The value of circularity

Much of this waste once reconstituted does not end up back in the construction sector, flowing to other sectors or even overseas. This leaves the construction sector bringing in much more virgin material than these impressive recycling rates would suggest, a problem which dramatically increases the degrees of embodied carbon in our new buildings.

A closed materials loop would dramatically cut the lifecycle emissions of future redevelopment projects, as well as cutting down on their costs. As both demands on the quantity and quality of commercial property in the City increase over the coming decade, such measures may become an absolute necessity for redevelopment projects.

By adopting more circular approaches over the next decade, we could see over 900k tonnes of material remaining within the City of London's construction supply chain, rather than leaking elsewhere – a huge contribution to future redevelopment projects.

Expanding to London as a whole, circularity will keep 13.8 million tonnes of materials within the construction supply chain over the coming decade. If produced new, these materials would generate 11.8 million tonnes of $CO_2$, around 3.6% of the UK's total emissions.

## Barriers and opportunities to circular construction

The following points were made in interviews with circular construction experts, when asked about the barriers and opportunities in implementing circular construction:

- **The construction industry continues to be dominated by non-circular working practices.** Finite raw materials were extracted to build buildings that have been designed with little thought given to adaptation or disassembly. Time and resources must be expended today to understand how a building was put together years ago. Additionally, deeper understanding of circularity is not yet widespread among developers and building occupants. There is a limited pool of industry knowledge and capability around circular practices. Compounding both are cost and speed-to-market disincentives to adopting circularity.
- **Materials and components need to be designed for reuse from the outset.** Many suppliers are working hard to offer products made from reused material and beyond this products that are designed for even further reuse. However, there needs to be a scaling up of manufacturers creating these products for the market so that in future, the majority of materials and components incorporate circular design.
- **In the future there needs to be established circularity structures.** More standardised building elements, easier adaptation, or substitute elements should be included in building design to future-proof them. Significant collaboration between industry, academia and civil society to speak with a united voice to policymakers is necessary. Investment in circularity infrastructure – such as materials stores and recycling plants – will support a growing market for circular construction.

This understanding will enable the construction industry to extract value from circular construction, and contribute to Net Zero in the process.

# EXECUTIVE SUMMARY

## Possible solutions

There are significant barriers to overcome if circular construction is to replace the construction industry's linear model. There is no pretence that this will be straightforward – changing decades worth of working practices never can be – but policymakers and the construction industry should consider the following ideas to support the move to circular construction.

### Information

- **Incentivise standardising of 'Materials Passports' to be best practice in construction projects.** This is a digital statement that details the materials that have been used in buildings (and how they have been used). London's industry should collaborate to create a standardised model.
- **Industry should encourage a market for circularity.** Industry representative bodies should explore the viability of setting up Circularity Hubs where companies can share data on available circular materials and provide resources to aid circularity.

### Infrastructure

- **Identify how Circularity Material Banks can be created to serve the London construction market.** Tier 1 suppliers should work with the construction industry to understand what space requirements are needed for different types of circularity material, with the aim of establishing 'Materials Banks' for projects.

### Incentives

- **Explore how to regulate to encourage circularity.** This could be via legislative mandate, such as the circulatory requirements in the London Plan. There are successful examples from overseas that could inform London's future policy.
- **Provide a financial incentive to pursue circularity.** Dedicating existing public subsidy for apprenticeships in construction specifically towards apprenticeships in circularity. Or reducing Section 106 requirements if circular practices are adopted in construction.
- **Introducing a credible circularity accreditation scheme.** The industry already has measurement such as BREEAM for responsible procurement. We could also look to incorporate circularity into this, to allow for transparent sourcing of circular materials.

# 1. Setting the scene

## The what, why and how of circular construction in London

# SETTING THE SCENE

## The UK construction industry has a linear way of working.

It is primarily on environmental grounds that the construction industry needs to urgently move away from the wasteful linear model. On one level this move needs to happen so the construction industry can become Net Zero. On a more fundamental level, the move needs to happen because policymakers know that reducing emissions from the built environment is a critical route to achieving Net Zero by 2050. More stringent environmental regulations and requirements will be placed on future developments.

Indeed, this is already happening. A recent decision to reject planning permission to Marks and Spencer to demolish and rebuild flagship buildings on London's Oxford Street gave embodied carbon as a contributing factor.[iii] There is also increasing pressure from investors and financial institutions that their money is not used to harm the environment. An estimated $41 trillion is currently held in ESG assets which is predicted to potentially rise to $50 trillion by 2025 according to Bloomberg Intelligence.

Beyond the environment, there are also practical reasons for the construction industry to move away from the linear model. Moving towards circular construction will likely be more resource efficient and resilient against external shocks, such as supply chain disruptions or unanticipated price spikes for materials, further reducing costs.[iv]

This report is about moving away from the linear construction model and establishing London as a global leader in circular construction processes.

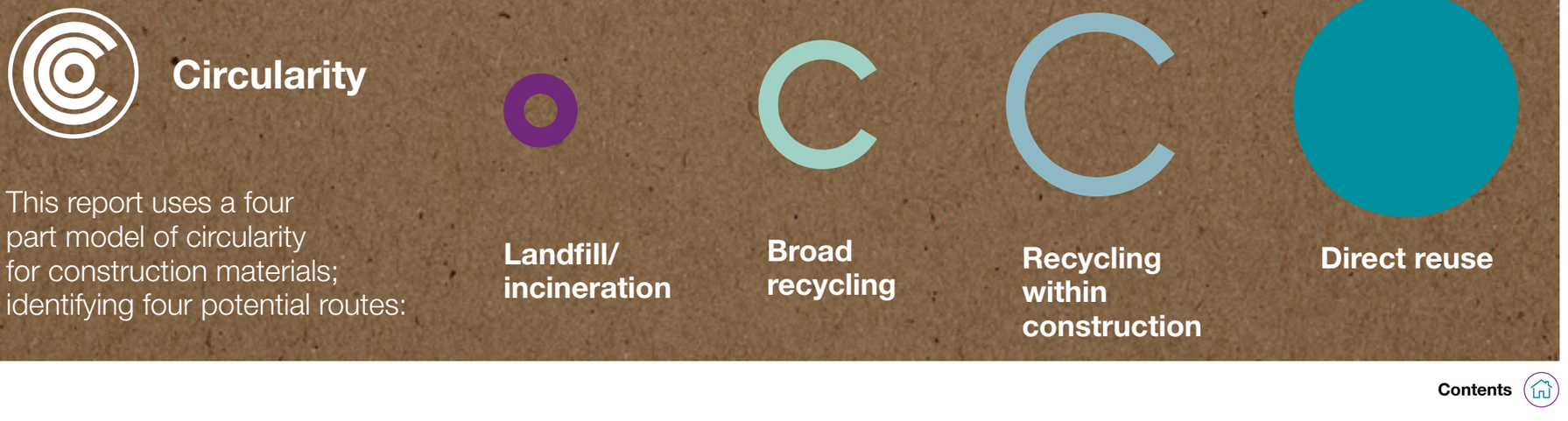
### What is circular construction?

The circular economy is defined as 'a system where materials never become waste and nature is regenerated'. Within construction, this means that recycling or reusing materials and components is essential. The idea is that the steel, concrete, timber, masonry, façades, fit-out materials and MEP/HVAC that are used within buildings are not sent to landfill after single-use. Instead, they are used over and over again, extracting value from them over a longer period of time.

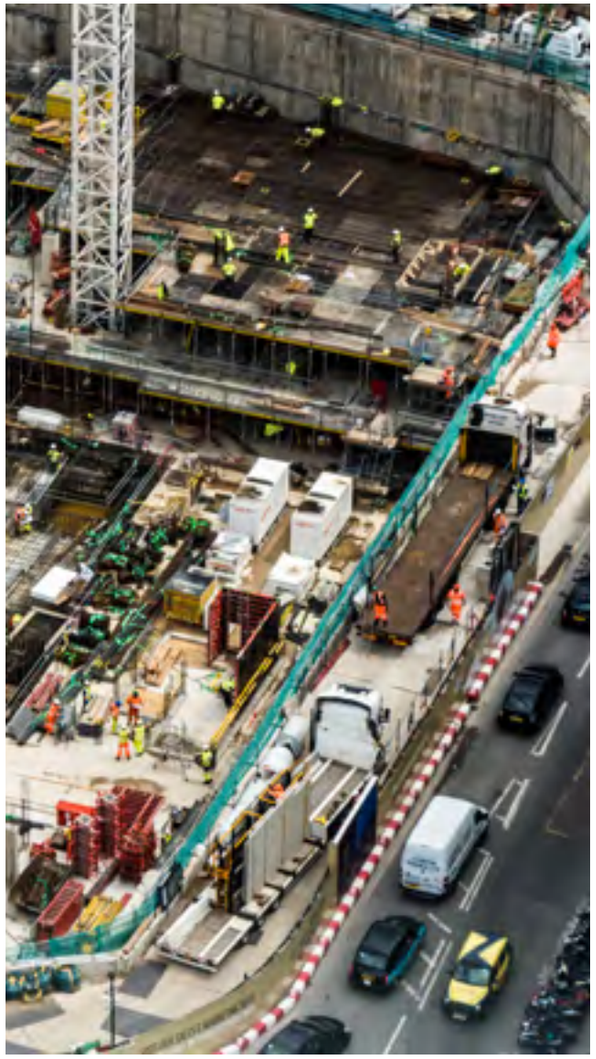
The circularity model is targeted at reducing 'embodied carbon' of a building – the emissions before, during and after a building's construction. However, it is also about the conservation of vital materials. This begins with the extraction, transportation and manufacture of raw materials, the construction of the building, then by its maintenance, repair and refurbishment, and finally by demolition, waste processing and disposal.[v]

We cannot expect to achieve a fully circular economy in the next few years, with barriers to reducing virgin material use, including issues relating to quality, cost and technology.[vi] Nor will the mining of raw materials be drastically reduced. The growth of our towns and cities can use reused and recycled materials, but growth will still need new resources, and it will sometimes be more sustainable to build a new – and more efficient building – rather than repurpose an old one.

Nevertheless, circularity promises a much more sustainable construction industry in the future, but only if the action to promote circular practices are taken seriously today, with the right information, infrastructure and incentives put in place.



# SETTING THE SCENE



## Why London?

London is widely regarded as the best candidate to meet the need for urgency and shift the dial on moving to a circular construction model. The capital has:

- **The right construction market.** With a wealth of highly innovative firms that are used to tackling difficult construction projects, and that can influence supply chains. Equally, London has a huge amount of construction activity taking place in a relatively small geographic area.
- **The right occupier base.** Some of those procuring construction projects have the resources to - and are willing to - pay a premium in order to enhance the environmental credentials of the project.
- **The right approach from planning authorities.** Circularity has been incorporated into the London Plan, with its associated guidance stating that building materials need to be treated as resources rather than waste, and existing structures should be prioritised over demolition.[vii]

Of course, London is not the only place that is making moves towards circularity in construction. Several countries across Europe are thinking about – and implementing – policies around it too (usually as part of broader circular economy packages). This means that there is also an economic opportunity behind embedding circular construction practices. Nurturing circularity expertise in the UK means that it could become a centre of global expertise that could be sold across the world.

## How is circularity being implemented now?

There is a growing number of case studies to demonstrate a growing prominence of thinking about circularity in the construction. Different parts of the industry are producing guidance on how to embed circularity in processes; academics are working on how to reduce $CO_2$ emissions within certain materials;[viii] construction firms are embedding circularity practices. There is also a growing stock of case studies to demonstrate circularity in practice – see the Mace project of Panorama St Paul's as just one of many examples.

But the application of a circular economy within construction remains a relatively niche endeavour. It is not the default approach of many architects, contractors, developers and materials suppliers within the construction value chain. To become widespread, it requires a whole system change to better maintain, prolong, share, reuse, redistribute, refurbish and recycle buildings and their materials.[ix]

Doing this comes with complexity and barriers. There is simply no developed market for circular construction, acting as a brake on its development.

It should also be noted that moving towards a more circular construction model to support the move to Net Zero needs to work in tandem with other changes in working practices in the construction industry. Retrofitting buildings to make them more efficient and less carbon-emitting is one example of this and comes with its own set of policy asks. These asks include certainty around energy efficiency regulations, introducing a consideration to retrofit in every major planning application, and introducing awareness raising campaigns.[x]

## The rest of this report

The rest of this report makes the case for developing a better market for circularity:

- **Chapter two** looks at our current understanding of the barriers to delivering circularity in construction.
- **Chapter three** looks at the value that the construction industry can gain from growing circularity practices in London.
- **Chapter four** sets out recommendations to promote the widespread adoption of circularity practices in London and beyond.

The report's content will be of interest to anyone interested in the future of the construction industry, the move towards a circular economy and the path to Net Zero.

# 2.

# Barriers and opportunities to circular construction

**There are numerous barriers to transforming the construction industry's linear model into a circular model. Understanding these barriers requires an understanding of how buildings were built in the past, where the circularity model stands in the construction industry today and what needs to happen in the future for the circularity model to be commonplace.**

**This chapter summarises the understanding there is of these topics in London, based upon the interview contributions of leading circularity experts.**

**If these barriers can be overcome, then it offers a huge opportunity to the construction industry in London – worth over £1bn, with millions of tonnes of material and components prevented from going to waste.**

# BARRIERS AND OPPORTUNITIES TO CIRCULAR CONSTRUCTION

## The present – an immature circularity market

- **Linear cultures are firmly established.** The construction industry's methods have become entrenched over the course of many years. Finite raw materials have been extracted to build buildings that have been designed with little thought given to the possibility of adaptation to other uses, or how disassembly may work. Today, it requires time and resource to understand how a building was constructed, and what materials were used when doing so. Only once this audit has been completed is it possible to develop a plan to recycle and reuse materials.
- **A full understanding of circularity among property and infrastructure developers and end-users of buildings is not widespread.** Often those procuring construction services do not fully understand the pros, cons or methods associated with circularity. This can mean clients making demands around circularity that cannot easily be fulfilled (such as focus on reusing fixtures and fittings, when the embodied carbon benefits to doing so are unclear and there is no market for the components). Equally, some clients harbour concerns that recycled or reused materials will not look as aesthetically pleasing as new materials and are sceptical that these materials can deliver the 'box-fresh and shiny' new buildings that they want.
- **A limited pool of industry knowledge and capability on circularity.** At present, the whole construction value chain – particularly SMEs in the supply chain – are still learning about how to deliver circularity. For instance, on one recent Mace project it was estimated before the project began that roughly 65% of stone could be reused; at the end of the project, it was calculated that over 90% of the stone was reused. It is expected that as circularity practice becomes more widespread, skills needs, knowledge, capability gaps – and how to fill them – will become more evident.
- **Cost and time disincentives to adopting circularity.** While not always the case, the recycling and reuse of materials can be more expensive than using new materials. Although, the cost profile of circularity is changing all the time. For instance, the cost of landfill from construction and demolition waste has reached €150 per tonne in the European Union.[xi] Equally, applying circular practices may be much slower than demolition and creating a new building, which may not be appealing to clients (and could also harm London's international competitiveness if it is mandated to pursue lengthier construction processes).[xii]

# BARRIERS AND OPPORTUNITIES TO CIRCULAR CONSTRUCTION

## The future – established circularity structures

- **Future-proofing circularity.** A building being built in London today will not easily support circularity processes when that building ends its current use in 20-30 years' time. The practice of recording information on what materials are in a building and how they have been fitted is not widespread. The advocacy group, New London Architecture argue that future-proofing today's buildings for circularity is key. The more standardised building elements that can be incorporated into design, and the more that the durability of different materials in a building's substructure is understood, the easier they should be to adapt, or it should be to substitute elements.[xiii]
- **Industry collaboration on circularity.** Circularity will only be accelerated as a practice if there is significant collaboration between industry, government, academia and civil society.[xiv] Industry has to speak with a united voice on the issue to policymakers and has to come up with joint solutions to overcome the barriers to circularity that are currently in train. This could be achieved through industry working groups and alliances.
- **Investment in circularity infrastructure.** Space is needed to store the large amount of material that is waiting to be reused. London is short of space and land is costly to use. While looking for space in London to store material for London construction is preferable, other parts of the country are likely to play an instrumental role in enabling circularity to happen in London, where the majority of UK construction takes place. Other infrastructure is needed, such as investment in recycling plants (where a certain amount of circularity has to happen to make the investment case to develop them), and investment in data infrastructure that will allow more and better information on buildings to be collected.

Conveyor belt on plant designed to reuse concrete from demolished buildings on the London 2012 Aquatics Centre site.

# 3.

# The value of circularity

This chapter presents an analysis of the potential benefits of circularity in the City of London, then extrapolating to London more broadly.

The analysis first looks at the materials which are currently being made available by the demolition and construction activities within this square mile area and what the current fates of these materials are. It then goes on to project the volumes of material that could be reused, first within the City and then London more widely over the coming decade. From these material volumes, we provide the resultant reduction in carbon emissions.

# THE VALUE OF CIRCULARITY

**The square mile of the City of London is unique in London's built landscape. While only being officially the home of only 8,600 people,[xv] 575,000 go there for work each day[xvi] – by far the highest ratio of workers to residents of any part of London.**

## Construction and waste in the City of London

The buildings of the square mile reflect this, with a ratio between residential and commercial buildings of 2 to 1, compared to 13 to 1 across London as a whole.[xvii] Floorspace is also, of course, much denser in the City than elsewhere, with it home to a major share of the tallest buildings in London, including 22 Bishopsgate and The Leadenhall building.

The square mile is set to become yet more densely built over the coming years. With the continued growth of the UK's services sector and the Elizabeth Line (previously known as Crossrail) at Liverpool Street Station, providing much easier access into the City, its workforce is set to grow by 37,000 between 2021 and 2031.[xviii] These workers will no doubt need desks, thus putting upward pressure on already densely packed floorspace. The City of London Corporation expects that by 2042, the City will need up to 20 million square feet of extra office space, up from around 50 million square feet today.[xix]

Further pressure is being added to the mix by demands for commercial buildings to offer greater energy efficiency standards, as well as better quality environments for occupants. Tightening EPC regulations will create pressure on the quantity, quality and efficiency of commercial premises. These regulations will see many offices requiring serious retrofits to keep up with efficiency standards. Where this is not possible, we will see demolitions and redevelopment. For redevelopment to be allowed to go ahead, strong cases must be made for the sustainability of the project relative to retrofitting, especially as government eyes turn toward the issue of embodied carbon. Even the shift to low carbon new materials, such as concrete, is not without mitigating factors. Low carbon concrete contains PFA, a by-product of coal burning power stations. As the UK has almost eliminated coal from its energy mix, we are forced to import our PFA from markets such as China. This means that even low carbon building solutions are hampered by the emissions brought by global sourcing of virgin material.

Circular construction provides an answer to the redevelopment problem, cutting down virgin material usage and thus the carbon embodied in new structures. Keeping a greater share of the construction and demolition waste generated within the square mile inside its construction supply chain, as opposed to leaking to landfill and incineration or reuse within other sectors may prove a key component in keeping the City's built environment up to scratch over the next decade.

The question arises then as to how much virgin material usage could be cut by the improved processing of the materials made available via demolitions and construction activity within the square mile. For this, we will first look at a profile of the materials made available over the past decade, before going on to present a model showing what the potential of circularity could be in cutting raw material usage over the coming decade.

**Between 2021–2031, London's square mile workforce is set to grow by...**

**▲ 37,000**

# THE VALUE OF CIRCULARITY

## An overview of construction and demolition waste

Construction and demolition waste data is collected by Department for Environment Food & Rural Affairs (DEFRA) from waste processing facilities across the UK. The data contains information on the material categories, the tonnage of the waste, the local authority from which it was received and the waste's final fate e.g. recovery or landfill.

Given current data recording conventions, it is not possible to distinguish between materials which stem from the demolition of structures or those which come out as waste in construction projects. It is possible to identify the likely residues from dredging and excavation activities. Of the remaining construction and demolition material, some estimate that demolition wastes make up to 70% of the total. Beneath the broad category of construction and demolition waste sit eight material sub-chapters, including gypsum-based material, insulation materials and metals.

# THE VALUE OF CIRCULARITY

**In the decade running up to 2021, the most recent year for which data is available, construction and demolition activities in the City of London generated 1.54 million tonnes of identifiable waste.[xx] That's equivalent to 2.7 tonnes per worker in the square mile.**

The major waste categories making up this volume were concrete, bricks, wood, iron and steel, gypsum, aluminium and copper.

The lion's share of these materials is currently being recycled or reused either in construction or the wider economy. We see some of the highest rates of recovery for metals, with almost 100% of the iron and steel from City building sites recovered and 95% for aluminium and copper. The share is significantly lower, however, among concrete (71%) and bricks (49%). The materials left after initial recovery, ending up in landfill, incineration or further treatment total at 458,000 tonnes – the equivalent of 0.8 tonnes per worker in the City.

Most recovered material is recycled, for example, with concrete broken down and reused as aggregate, often in road building. It should be noted here that while a large portion of this material is recycled, only a fraction of that recycled material will make its way back into the urban construction sector. What we see here could be characterised more as a 'cascading' economy, rather than a closed-loop circular economy.

Under some circumstances, recycling materials for use in further removed sectors could be deemed a success for circularity, but as discussed above, construction within the City faces a number of pressures all of which increase the impetus for keeping materials within its construction supply chain. Closing the loop on materials waste within the City will provide a core piece of the puzzle in ensuring the environmental and economic development of property within the square mile.

### Identifiable waste volumes from the City of London, 2011-2021[xxi]

| Classification | Tonnes | % |
|---|---|---|
| Concrete | 870,428 | 56.7 |
| Brick | 327,903 | 21.3 |
| Wood | 120,454 | 7.8 |
| Iron/steel | 77,077 | 5.0 |
| Gypsum | 55,483 | 3.6 |
| Aluminium and copper | 46,953 | 3.1 |
| Bitumen | 35,978 | 2.3 |
| Glass | 1,779 | 0.1 |
| Mortar/plaster | 234 | <0.1 |
| Plastics | 144 | <0.1 |

# THE VALUE OF CIRCULARITY

## Concrete

At present, concrete sees relatively high rates of recycling, with much of it turned to aggregate to be used in road building. There is, however, significant scope for a greater share of concrete waste aggregate to be used within urban construction projects. A huge share of the embodied carbon in buildings is generated by concrete, which typically generates around 900 kg of $CO_2$ per tonne in its production.[xxiii] With this in mind, further closing the loop of concrete production can dramatically cut emissions and embodied carbon and in turn improve the environmental and regulatory viability of redevelopment projects.

There are also a number of direct reuse cases for concrete, including retaining and reusing existing concrete frames and floors. It is also possible to take individual elements such as precast concrete floor planks and cladding.

## Bricks

The recycling processes for bricks can be relatively problematic – the burning processes of bricks are not reversible, meaning the raw material cannot be directly reintroduced into brick manufacturing. That said, prior to the development of cement-based mortar, bricks were in regular reuse. Recent experiments undertaken by the Meridian Water project have shown that it is possible to separate and clean even bricks held together by cement. There is scope, however, for the use of bricks in concrete and other aggregates and the aluminium-oxides and silicates may be extracted for the cement industry.[xxiv]

## Timber

Timber can be challenging to recycle 'circularly.' That is, while much of the wood salvaged from construction sites is recyclable, it often leaves the loop of the construction sector, with common end uses being in e.g. MDF and chipboard. There are research projects into new recycling methods for timber which may leave it more suitable for reuse within construction, including the production of cross-laminated secondary timber, a potential route to timber reuse as a structural component in buildings, something which could dramatically cut its leakage from the construction system.[xxv]

## Iron and steel

Iron and steel components are already almost entirely recycled, but given that a large proportion of that scrap is exported and demand for the used scrap both within other sectors and other countries, the odds of any given unit of iron or steel scrap making its way back to the construction sector are relatively slim. However, steel in particular has very high reuse potential, with the steel frames from a number of more modern buildings being directly reusable. Work by the Alliance for Sustainable Building Products has suggested that as much as 45% of structural steel from building demolition could be reused in 2050.[xxvi]

## Glass

It is possible to directly reuse windows, so long as they are not damaged in the process of removal, which is admittedly easier said than done. Given this glass can be somewhat problematic for direct re-use, with it being nearly impossible to cut toughened glass. At present melting down and repurposing is the most viable solution to its reuse/recycling problem. Glass aggregate can be useful in the production of concrete, replacing sand or gravel, as well as being processed for use in the production of insulation.

# THE VALUE OF CIRCULARITY

## What is possible for circular construction in the City?

To answer this important question, we have modelled the likely waste flows that will appear from the City of London over the next decade and run them through two scenarios showing what their final fates will be.

These scenarios are:

- **The business as usual scenario:** Materials are treated as they are currently, without the application of circular economy principles.
- **The short term circular scenario:** The increased avenues for circularity based on today's infrastructure and circular potential.
- **The long term ideal circular scenario:** A projection towards 2050 that factors in the highest realistic rates of reusability for materials, including the application of the recommendations in this report.

Moving from the business-as-usual scenario to the short term circular scenario sees significant increases in the volumes of certain material types towards either direct reuse or recycling for use within construction. The volumes of waste allocated to each process under each scenario have been informed by results from academia and the publicly available data on the possible ranges of circularity achievable in construction – for more detail see appendix 1.

While the scope for increasing rates of circularity is significant and valuable, it does have its limits. The figures reflect the limits of what may be possible using today's building stock. The true potential of circularity into the future is captured by the long term circular scenario which we have constructed based on an idealistic 2050 scenario which includes recommendations within this report being widely adopted.

**Within each scenario, there are four potential fates for each material:**

### 1. Direct reuse:

Where materials are gathered, cleaned up and quality assured before being directly reused in new structures. Examples may include the reuse of masonry and cladding or structural steel salvaged from construction and demolition sites.

### 2. Recycling within construction:

Where materials are broken down and reconstituted into either a use similar to their original application, or something new for use within the construction sector.

### 3. Broad recycling:

Same as 2. but the material is used outside of the construction sector once reconstituted.

### 4. Landfill/incineration:

Materials are disposed of as no reuse option for them can be found.

# THE VALUE OF CIRCULARITY

**Were construction in the City of London to move from business-as-usual to a more circular approach to its material usage, 256,000 more tonnes of materials would remain within its supply chain either through recycling or through direct reuse.**

## Results

The production of these volumes of materials new would generate in the vicinity of 300,000 tonnes of $CO_2$ – around the same as the yearly emissions of the Central African Republic.

This is around 50% of the identifiable waste volume[xxvii] projected to be produced within the City and equivalent to 15% of its total value at today's market prices, totalling around £21 million. This value share is low relative to the share of overall material volume given the relatively low value per tonne of dense materials like concrete and bricks.

These changes will also see materials saved overall. That is in addition to fewer materials being reused outside of construction's supply chain loop, fewer materials – at the volume of just under 20,000 tonnes – would be sent to landfill or incineration.

We see much of this material volume being generated by a 230,000 tonne increase in the volume of concrete being retained within the construction supply chain via e.g. greater shares of recycled concrete aggregate being used in buildings, rather than leaking towards roads or other civil engineering projects. While concrete's value per tonne is significantly lower than materials like copper or aluminium, it is one of the most carbon intensive to produce.

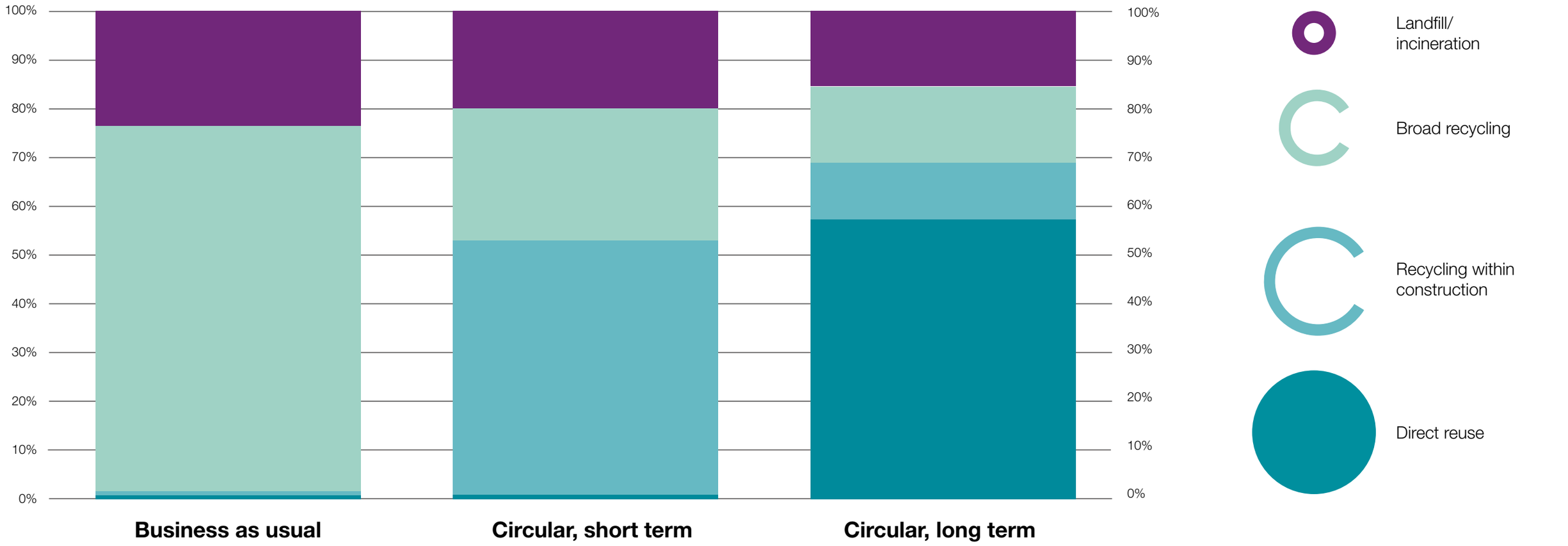
Work by Association for Sustainable Building Products suggests that by 2030 15% of structural steel may be directly reusable, the impact of which would allow 2,457 tonnes more ferrous material to be retained in the City's construction loop. We would also expect to see greater direct reuse of bricks as the treatment options for cement-based mortars improve, keeping another 75 tonnes of materials within the City's supply loop.

The infographic overleaf shows how the fates of different material wastes from the City are likely to change as we move from the business as usual to the circular scenario.

At our Mace 50 Finsbury Square project for GPE, 364 stone panels were used from the existing stone facade to produce 2,285 pieces to build the now formed reception feature wall, excellent work by Szerelmey.

# THE VALUE OF CIRCULARITY

## How building materials would be re-routed in a circular economy



# THE VALUE OF CIRCULARITY

**If we expand the model to take into account the entire capital, figures become much more dramatic. Shifting from business-as-usual to the circular scenario would see a total reduction in waste of 13.8 million tonnes worth £1.25bn.**

Looking to London's construction sector in particular, we could expect to see 13.8 million tonnes more materials, worth £1.25bn, kept within its supply loop than we do now – that's 1.55 tonnes per London resident over the next decade. Producing these materials new would emit over 11 million tons of $CO_2$ into the atmosphere, equivalent to more than 3.5% of the UK's yearly emissions.

**The value of the material gained for use just in London construction, total the equivalent of**

**1%**

**of UK construction's current yearly GVA.**

# THE VALUE OF CIRCULARITY

## Combatting urban material consumption is a global issue and applying these circular scenarios for London across the other international cities yields substantial results.


### The global opportunity

Across seven identified megacities, 77 million tonnes of materials would be retained in the construction supply loop over the next decade. That value of that material is an immense £10.6 billion, over ten years, all through the shift to a circular scenario.

# THE VALUE OF CIRCULARITY

The figure below further breaks down the potential gains in materials and their value by city, as well as the reductions in waste that would be made in the switch from business as usual to our circular+ scenario.

## NEW YORK

**Extra waste kept in the construction loop**

**30.6m** tonnes saved

**= £2,772m** saved

**Waste saved from landfill/ incineration**

**2m** tonnes saved

**= £68.1m**

## AMSTERDAM

**Extra waste kept in the construction loop**

**2.8m** tonnes saved

**= £257m** saved

**Waste saved from landfill/ incineration**

**0.2m** tonnes saved

**= £6.3m**

## MADRID

**Extra waste kept in the construction loop**

**1.9m** tonnes saved

**= £172.8m**

**Waste saved from landfill/ incineration**

**0.1m** tonnes saved

**= £4.2m**

# THE VALUE OF CIRCULARITY

The figure below further breaks down the potential gains in materials and their value by city, as well as the reductions in waste that would be made in the switch from business as usual to our circular+ scenario.

## ROME

**Extra waste kept in the construction loop**

**0.8m**
tonnes saved

**= £74.3m**

**Waste saved from landfill/ incineration**

**0.1m**
tonnes saved

**= £1.8m**

## BERLIN

**Extra waste kept in the construction loop**

**11.2m**
tonnes saved

**= £1,06.2m**
saved

**Waste saved from landfill/ incineration**

**0.7m**
tonnes saved

**= £25m**

## PARIS

**Extra waste kept in the construction loop**

**15.4m**
tonnes saved

**= £1,394m**

**Waste saved from landfill/ incineration**

**1m**
tonnes saved

**= £34.2m**

# 4.

# Recommendations – moving to a circular construction market in London

**The case for circularity in construction is compelling. It will mean that the UK makes greater strides towards its Net Zero 2050 targets by reducing the embodied carbon in the built environment. It will mean that the construction industry itself reduces its costs.**

**There are significant barriers to overcome if circular construction is to replace the industry's linear model. There is no pretence that this will be straightforward – changing decades worth of working practices never can be – but policymakers and the construction industry should consider the following ideas to support the move to circular construction.**

# RECOMMENDATIONS – MOVING TO A CIRCULAR CONSTRUCTION MARKET IN LONDON

**London should attempt to learn from other countries' approach to incentivising materials passports and test the viability of their adoption.**

## Information

- **Incentivise the standardising and delivery of 'materials passports' at scale.**
  This is a digital statement that details the materials that have been used in buildings (and how they have been used). Some innovative firms are already looking at how this can be done, including Mace, trialling the use of materials passports in the UK at 'Edenica' – an office and retail building in central London.[xxviii] The idea is also gaining traction among policymakers in other countries as they attempt to embed circular economy practices.[xxix] So far, policy has stopped short of fully mandating the use of Materials Passports. Instead, various incentives have been used.

  These include tax incentives for projects that incorporate materials passports, or scoring bids for public projects more highly if materials passports are part of the project delivery. London should attempt to learn from other countries' approach to incentivising materials passports and test the viability of their adoption. Any incentive should consider a leading role for Tier 1 contractors, as they typically have the resources and knowledge to ensure their supply chains can collate and present the necessary information.

- **Industry should encourage a market for circularity.**
  For a circularity market to work efficiently, buyers and sellers of recycled and reusable building materials need to be connected, and elements of data standardisation introduced. Industry representative bodies should explore setting up circularity hubs where companies can share information on available circular materials. For instance, projects looking for recycled steel would want to understand how much recyclable steel there is in the market. For example, HTS have developed their Stockmatcher tool for steel which allows buyers to look at available reclaimed steel elements and where they could be purchased as alternatives to newly fabricated steel.[xxx]

  These hubs could also provide resources to aid circularity, such as informatics solutions for the materials passports. This would provide a valuable resource for the construction sector trying to plan and execute circularity projects. Finally, this market could be supported by having a set of consistent metrics, benchmarks and indicators of circular practices, as suggested by the Green Building Council.[xxxi]

## Infrastructure

- **Identify how circularity material banks can be created to serve the London construction market.**
  London is short of space, and building materials that are waiting for reuse or recycling can take up a lot of space. Beginning with Tier 1 suppliers, who are the most well versed in storing and transporting large volumes of material, should work with the wider industry and policymakers to understand what space requirements are needed for different types of materials that can be used in circularity projects. Following this exercise, they should work together to establish spaces that can serve as Materials Banks for circularity construction projects in London.

  This could mean converting spaces that are already used for waste management, the yards of existing buildings merchants, or disused public land in London. The closer materials are to London the better in order to reduce the carbon footprint of transportation and reduce the time it takes for projects to receive these materials. But it may also be the case that in other parts of the country where there is more space and/or firms engaged in recycling materials this exercise will be beneficial too.

# RECOMMENDATIONS – MOVING TO A CIRCULAR CONSTRUCTION MARKET IN LONDON

**With the potential to reduce carbon, conserve virgin materials and inject value into the supply chain, it is clear that a mature circular construction economy could prove a far-reaching positive for players across the industry.**

## Incentives

- **Explore how to regulate to encourage circularity.**
  The quickest route to embed circularity is mandating it in legislation. This will catalyse innovation and interest in the area. Of course, any regulatory requirements should be designed with industry in mind to be proportionate and not counter-productive. London has already made strides in this area with the circulatory requirements in the London Plan (such as the requirement to submit a Circular Economy statement and the need for planning applicants to aim for at least 20 percent recycled or reused content, by value, for the whole building). There are some options from overseas as to what this regulation may look like. For instance, the previous example of the city of Zurich demanding that for newly constructed municipal buildings 50% of the aggregate used in concrete for construction has to be recycled aggregate.
- **Provide a financial incentive for circularity.**
  There have been some calls to attach tax incentives to circularity projects, such as reducing the VAT for retrofit to the same level as for new buildings. The principle is the right one, i.e. the cost of pursuing circularity can sometimes be prohibitive. Yet there are other options other than direct tax cuts that can be used to support circularity. Some of these options are: dedicating existing public subsidy for apprenticeships and other learning opportunities in construction specifically towards circularity skills development.
- **Introducing a credible circularity accreditation scheme.**
  The industry already has measurement such as BREEAM for responsible procurement. We could also look to incorporate circularity into this, to allow for transparent sourcing of circular materials or to reward projects that have utilised a certain level of circular economy principles.

Whilst there are many avenues to increasing the rate of circularity within London's construction sector, all roads lead to the need for collaboration and transparency on the lifecycle of materials used in our built environment. With the potential to reduce carbon, conserve virgin materials and inject value into the supply chain, it is clear that a mature circular construction economy could prove a far-reaching positive for players across the industry. The hope is that London can act as an example and a beacon for the rest of the world on how impactful the circular economy will be.

# APPENDIX 1: MODELLING METHODOLOGY

The model underlying our projections of the value of circular construction to the City of London is drawn from waste data received by DEFRA between 2011 and 2021.[xxxii] These figures provide an overview of the construction and demolition waste generated in the City of London and London more widely over the course of that decade, disaggregated by material type, origin waste processing authority and material fate (e.g. recovery, landfill etc.).

For the modelling, only waste categories with clearly identified materials were used, with e.g. 'mixed construction waste' and other similarly categorised waste types not factored into calculations. Waste largely made up of soil, stone and slurry were also discarded, as were the volumes of contaminated materials given that they have no chance of reuse or recycling.

From these figures, we made projections of the construction and demolition waste produced within the City, assuming that construction and demolition waste would grow at the same rate as the rate of growth of the City's commercial floorspace. It was assumed that the rate of commercial floorspace growth will continue at the rate seen post-2015, using figures from the Valuation Office Agency. To generate figures for London more widely, it was assumed that construction and demolition waste would grow in proportion to the city's population, with population projections taken from the Greater London Authority.[xxxiii]

Assumptions, under both the circular and business-as-usual scenarios around the rates of reuse, recycling (within and outside of the construction sector) and landfill/incineration were derived from the results of research undertaken at the University of Vienna.[xxxiv] These figures were supplemented by further data on the rates of recycling and recycled content of iron/steel and aluminium/copper drawn from industry data, as well as projections of the proportion of structural steel which can be put to direct reuse in construction, provided by the Association for Sustainable Building Products.[xxxv]

These assumed recycling rates were combined with projected waste flows, broken down by waste type, to produce forecasts of the final fates of the materials produced in the City and London more widely over the coming decade. These volumes are valued at the current prices of the commodities in question, with figures drawn from commodity exchanges. These should not be taken as a forward projection of what the volumes of these commodities will be worth in 10 years, with commodity price swings being largely impossible to predict that far in the future.

Projections of the value and volume of waste types for other global cities have been produced based on relative population sizes.

Complex sort machine on the London 2012 Velo Park. This machine cleans large waste materials from soil as part of the wider aim of bio-remediation and re-use of all the soil within the Olympic Park.

# APPENDIX 2: REFERENCES


i. WGBC – The Circular Built Environment Playbook. https://worldgbc.org/article/circular-built-environment-playbook/

ii. Ellen MacArthur Foundation, What is a Circular Economy? https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

iii. DLUHC, July 2023, Called-in Decision 456-472 Oxford Street, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1172463/23-07-20_DL_+_IR_456-472_OXFORD_STREET_LONDON_W1_-_3301508.pdf

iv. Ibid

v. The RIBA Journal, January 2023, How to calculate embodied carbon for the 2030 Climate Challenge, https://www.ribaj.com/intelligence/how-to-calculate-embodied-carbon-for-riba-2030-climate-challenge

vi. Purchase, Al Zulayq et all, January 2022, Circular Economy Construction and Demolition Waste: A literature review on lessons, challenges and benefits, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8745857/

vii. GLA website, Circular Economy Statement Guidance, https://www.london.gov.uk/programmes-strategies/planning/implementing-london-plan/london-plan-guidance/circular-economy-statement-guidance

viii. Examples are provided in the document produced by the New London Architecture in the document, “Circular London: Building a Renewable City”, https://nla.london/insights/circular-london-building-a-renewable-city

ix. Ellen Macarthur Foundation, The Circular Economy Butterfly Diagram, https://ellenmacarthurfoundation.org/circular-economy-diagram

x. Mace, June 2023, Transform & Renew, https://www.macegroup.com/media-centre/call-to-action-from-mace-to-ramp-up-efforts-to-retrofit-uk-commercial-and-public-building-stock

xi. World Economic Forum, July 2023, Emerging Insights for Achieving Circularity in the Built Environment, https://www3.weforum.org/docs/WEF_Emerging_Insights_for_Achieving_Circularity_in_the_Built_Environment_2023.pdf?utm_medium=DSMN8&utm_source=LinkedIn&utm_user=14419234594387765

xii. New London Architecture, “Circular London: Building a Renewable City”, https://nla.london/insights/circular-london-building-a-renewable-city

xiii. New London Architecture, “Circular London: Building a Renewable City”, https://nla.london/insights/circular-london-building-a-renewable-city

xiv. Local Governments for Sustainability, June 2023, Our shared understanding: a circular economy in the built environment, https://circulars.iclei.org/resource/our-shared-understanding-a-circular-economy-in-the-built-environment/

xv. Census 2021

xvi. GLA (2022): ‘Long-Term Labour Market Projections.’

xvii. UCL London Building Stock Model

xviii. GLA (2022): ‘Long-Term Labour Market Projections.’

xix. City of London Corporation (2023): ‘Future of Office Use.’

xx. Excluded from this figure are undifferentiated construction wastes, dredge and spoil, soil and stones.

xxi. DEFRA (2021): Waste data explorer

xxii. ‘Other fates’ may include being sent for further treatment or waste options like surface impoundment.

xxiii. Fayomi, Gbenga & Mini, Simphiwe & Fayomi, Ojo Sunday Isaac & Ayoola, Ayodeji. (2019). Perspectives on environmental CO2 emission and energy factor in Cement Industry. IOP Conference Series: Earth and Environmental Science. 331. 012035. 10.1088/1755-1315/331/1/012035.

xxiv. NLA (2023): ‘Circular London.’

xxv. Rose, CM; Bergsagel, D; Dufresne, T; Unubreme, E; Lyu, T; Duffour, P; Stegemann, JA; (2018) Cross-laminated secondary timber: Experimental testing and modelling the effect of defects and reduced feedstock properties. Sustainability , 10 (11) , Article 4118.

xxvi. Alliance for Sustainable Building Products (2023): ‘DISRUPT - Steel Reuse Toolkit.’

xxvii. This does not include figures on soil, stones and dredging waste, nor on those materials which are not specifically identified by DEFRA.

xxviii. Mace, January 2023, Mace appointed as contractor on Edenica at 100 Fetter Lane, https://www.macegroup.com/media-centre/mace-appointed-as-contractor-on-edenica-at-100-fetter-lane

xxix. Circular Construction Economy Transition Agenda, 2018, Circular Construction Economy, https://hollandcircularhotspot.nl/wp-content/uploads/2019/09/Circular-Construction-Economy.pdf

xxx. HTS StockMatcher, https://stockmatcher.co.uk/

xxxi. Green Building Council, https://ukgbc.org/resources/system-enablers-for-a-circular-economy/

xxxii. DEFRA (2021): ‘Waste Data Interrogator.’

xxxiii. Greater London Authority (2020): ‘Population projection explorer.’

xxxiv. Keemann et al (2018): ‘urban mining – potentials and limitations for a circular economy in the building sector.’

xxxv. Association for Sustainable Building Products (2023): ‘DISRUPT (Delivering Innovative Steel ReUse Project).

# Closing the circle

macegroup.com