



Circular Economy Symposium – Towards a circular built environment: bridging the gap between research and practice

30th June 2023

Institution of Civil Engineers, 1 Great George Street, London, SW1P 3AA

09.30 – 10.00	Registration, tea, coffee & pastries
10.00 – 10.05	Welcome
10.05 – 10.25	Keynote: "The role of material stocks for a sustainable circular economy and climate change mitigation" <i>Dr Dominik Wiedenhofer, University of Natural Resources and Life Sciences, Vienna</i>
10.25 – 10.45	Keynote: Derisking Material Reuse: Material Passports in practice <i>Melanie Martin, ORMS Architects</i>
10.45 – 10.55	Discussion
10.55 – 11.25	Presentations: Urban Mines
11.25 – 12.30	Poster Session
12.30 – 13.15	Lunch
13.15 – 14.15	Presentations: Reuse
14.15 – 14.45	Presentations: Material Reprocessing
14.45 – 15.15	Break: Tea, Coffee & Biscuits
15.15 – 16.00	Presentations: CE Design Drivers
16.00 – 16.20	Keynote: Reflections from a bridge between industry and academia <i>Andrea Charlson, Useful Simple Trust</i>
16.20 – 16.50	Panel Discussion: Next Steps for CE Research & Practice <i>Andrea Charlson, Will Mihkelson, & Dr Maud Lanau</i>
16.50 – 17.00	Best Presentation & Poster & Close





Detailed Programme:

Keynote: *Dr Dominik Wiedenhofer, University of Natural Resources and Life Sciences, Vienna*

"The role of material stocks for a sustainable circular economy and climate change mitigation"

Material stocks of buildings, infrastructure and machinery constitute the biophysical basis of production and consumption. Due to the long lifetimes of already accumulated material stocks, they constitute a critical legacy for efforts aiming at a more sustainable circular economy and climate change mitigation, because material stocks lock-in current and future dynamics of resource use, waste and GHG emissions.

In this talk, I will discuss the latest findings about the role of stock-flow relations for a more sustainable circular economy in the UK and internationally, drawing on macro-level biophysical modelling of national economies, as well as high-resolution remote-sensing derived mapping of building and infrastructure stocks in the UK. I will finalize with reflections about future research needs regarding a better understanding of the systemic relations of material stocks and their legacies for climate change mitigation and sustainable circularity.

Keynote: *Melanie Martin, ORMS Architects*

Derisking Material Reuse: Material Passports in practice

Presentations: Urban Mines

Arta Bytyqi: "Archotyping for Urban Mining: A Comparative Analysis of Building Archetypes' Contribution to Material Stocks in Cities"

The EU's strategy for the circular economy has projected urban mining as a crucial measure to improve resource efficiency- pressuring the construction industry to turn its eyes toward mining the "urban ore". Furthermore, the reuse of construction materials contributes to waste reduction and helps to mitigate the environmental impact of the construction processes. While aiming for optimal reuse of building materials in new constructions there are still many challenges in practice. Most of the existing studies use archotyping approaches to the model building stock. But different building archetypes contribute differently to the total material stocks in cities and face different challenges when aiming to join circular construction cycles. In order to facilitate the urban mining process and gain optimal benefits from reusing materials, this study compares different archotyping methods as well as the contribution of different building archetypes in the city's material stocks for urban mining purposes. Analysis is based on indicators like material types that become available, the amounts of these materials, demolition processes, ownership, lifespan, and their location in the city. Results will show which building archetypes are more 'mining friendly' and the characteristics that contribute to such adaptability. Such results will enable the prioritisation of certain archetypes of buildings when it comes





to demolition processes and will provide insights that could be used in future buildings in order to facilitate urban mining.

Ben Cartwright: “Making use of existing buildings and material stocks: lessons learned from recent pre-redevelopment audits, pre-demolition audits and practical research”

Recently, UK built environment industries have seen an uptick in interest around circular economy, and an apparently increasing number of projects are being undertaken using circular approaches thanks in part to the introduction of new policies as well as a general move towards sustainable business activity. However, despite recent interest and progress, many buildings that could still deliver social and economic value are being demolished to make way for more profitable new construction projects, whilst the rate at which end-of-use components and materials are recirculated through reuse and high-value recycling is negligible. Two tools that are increasingly being made use of to support the recovery of value are (a) the pre-redevelopment audit, a methodology for exploring options for an existing building to be retained and determining their feasibility, and (b) the pre-demolition audit, a methodology to identify reusable and components and recyclable materials within an existing building, and provide recommendations on optimising reuse and high-value recycling. Drawing on recent experience with pre-redevelopment audits and pre-demolition audits, as well as related research projects, Reusefully Ltd. will present their perspective on how policy and practice may be improved to reduce material consumption and waste by making use of the value inherent in the existing built environment.

Presentations: Reuse

Ling Min Tan: “Mapping Storage Infrastructure for a CE”

More than 60% of UK waste comes from construction, demolition, and excavation (CD&E), according to UKGBC. The majority of the recovered CD&E waste is downcycled into products of lower value such as recycled aggregates, and some ends up in landfill. Increasing reuse of waste recovered from CD&E can help to reduce primary material demand and the associated embodied carbon emissions from the extraction, manufacturing, storage, and transport of materials. However, a key barrier to reuse of these materials is the lack of infrastructure to store the bulky and heavy building materials that could be reclaimed from CD&E before they have a chance to be reused when the supply and demand are matched. Hence, this project aims to explore how the utilisation of storage facilities can improve the uptake of reusable materials from the demolition of buildings. In this pilot study we work with major infrastructure providers to identify the type, size, and location of potential storage facilities. This information is used to produce a GIS-map of storage facilities which is then overlaid with the national transport network to compute the shortest distance between the storage sites by roads and rails. As a proof-of-concept study, this work demonstrates how a network analysis method can be applied to analyse the storage capacity of existing infrastructure in terms of nodal centrality and clustering of the storage sites across the UK. Going forward, collaborations between organisations will aid standardisation and enhance network efficiency for effective resource exchange in the future.





Elham Maghsoudi Nia: "Investigation Of The Reuse Rate Of Materials And Elements In The Construction Sector"

In North-West European countries only 1% of building elements are reused following their first application. Although a large number of elements are technically reusable they end up being recycled by crushing or melting or being disposed of. The result is a high environmental impact and a net loss of economic value. As part of the project entitled "Facilitating the Circulation of Reclaimed Building Elements (FCRBE)" we studied material reuse in buildings. The research question of our study is twofold: (1) What method can be developed to set, measure and report on rates of material reuse in construction and renovation projects? and (2) What material reuse per building type and building layer is feasible? The study has analysed 30 new construction and renovation projects that have successfully reused building materials and elements. These projects are analysed according to the developed methodology including the inflow and outflow of materials. The results provide an overview of the reuse rates that can be achieved in different contexts and for different applications within the built environment. This method is aimed at project owners, public authorities, and any organisation that needs to set, measure, and report on rates of material reuse in construction and renovation projects.

Laura Batty: "HTS Reused Steel Stockmatcher"

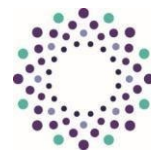
Heyne Tillett Steel Structural & Civil Engineers (London) has built a tool to facilitate using reclaimed steel in new building projects. The HTS Reused Steel Stockmatcher is an innovative tool for fast and accurate stock matching of reused steel in new structures. The system is based in Excel with Python-based functions to carry out the evaluation. It compares steel stock lists from reused stockholders with a design list to automatically find ideal pairings- where the section properties and the lengths are close matches. It has extra features to maximise efficiency: as stock beams are assigned- their offcuts are fed back into the stockpile and to be matched with other beams. It also optimises the process by repeating the exercise through automatically shuffled design lists and selects the cycle with the best overall material efficiency. The HTS Stockmatcher requires only Excel to run. It quickly solves the current problem of how to best use reclaimed steel in buildings- maximising the efficient use of this low carbon material. The interface is simple- the inputs are flexible- and the results can be easily interrogated. The HTS Stockmatcher will be released for free to the industry in June 2023.

Thomas Howarth: "Steel Reuse in Action"

This case study shares the key lessons learnt during the large-scale steel reclamation at an ongoing central London deconstruction. The case study gives an excellent perspective on circular economy principles in practice. The scope of the project covers the whole process of steel re-use- including:

- The recovery of sections from the ongoing deconstruction of the 'donor' building





- The process of testing- de/refabrication and certification for re-use
- The integration of re-used steel into the design of a new structure.

The presentation aims to share the main insights which have arisen from the recovery phase- with questions and discussion around the future encouraged. The presentation covers the key challenges encountered during the recovery and how the circular economy potential has been maximised by:

- Minimising and preventing damage to steel sections
- Maximising lengths of steels being recovered
- Efficiently integrating steel recovery into the deconstruction programme
- Tracking recovery progress and feeding back lessons as the project progresses
- Inventory creation and tracking throughout the process.

Furthermore, exciting opportunities for the use of material passports on this project are being explored! By sharing this case study at Circular Economy Symposium we can raise awareness of the opportunities for circular economy in practice and encourage responsible steel re-use on future projects.

Presentations: Material Reprocessing

Miguel Castro Diaz: Improving plasterboard waste gypsum recyclability through a novel acid leaching purification process

The standard recycling process for construction, refurbishment, and demolition plasterboard waste involves several mechanical steps that include manual segregation, grinding, sieving, and ferrous and non-ferrous magnetic separation. However, one of the main challenges to obtaining suitable recycled gypsum from refurbishment and demolition (post-consumer) plasterboard waste comes from the difficulty of achieving consistent purity levels via current mechanical recycling technologies. In addition, post-consumer plasterboard waste contains water-soluble impurities that affect paper-gypsum bonding during plasterboard production. As a result, most post-consumer plasterboard waste is not recycled and ends up in landfills, decomposing and releasing toxic hydrogen sulphide, or used in low-grade applications such as agriculture or as an additive in cement production. A modified mechanical process and a novel acid leaching purification process were developed and combined to obtain a recycled gypsum product from post-consumer plasterboard waste with consistent purity values above 96 wt% and fulfilling all the requirements from plasterboard manufacturers. The wastewater from the acid leaching purification process was treated to recover the soluble impurities and water separately. The soluble impurities were precipitated as a magnesium-rich gypsum, which could be commercialised as soil fertiliser. The treated water was reused in the acid leaching purification process for six cycles without impacting its efficiency. Current work is focusing on the upscaling of the acid leaching purification process to purify 20 tonnes of refurbishment and demolition plasterboard waste and manufacture new plasterboards with 35 wt% recycled gypsum content, in contrast to the average 10 wt% recycled gypsum content in actual plasterboards.





Colin Rose & Andy McFadden: "Grave-to-cradle: Using wood from demolition in mass timber products"

The construction industry creates vast quantities of waste. To unlock the environmental, social, and economic opportunities that this represents there is an urgent need for new practices and processes that tackle particular waste streams and recertify the resulting products to meet industry requirements. We present a solution for timber: its reuse in mass timber products. UK demolition creates 1 Mtpa of waste wood- much of which has residual quality and value that dissipates in conventional waste management. Recycled timber products like chipboard are relatively short-lived and represent the final material use before incineration or disposal. Reclaimed whole members tend towards shorter usable lengths and smaller effective cross-sections and are sold without warranties- which restricts demand in mainstream construction. Improving the supply of secondary timber from demolition/deconstruction back into the industry could mitigate risks such as rising prices and rising price volatility. These trends are likely to continue: supply is affected by wildfires, tree diseases, insect attack and supply chain problems, and faces increasing competition over the use of land; while the World Bank has predicted demand for wood products will rise by 4% annually for the next 30-40 years. We present findings from two case studies: experimental testing of CLT and glulam- both made from secondary timber. These structural applications are low-carbon- circular alternatives to concrete and steel. They achieve long-term carbon capture and storage beyond timber's first use. Furthermore, they can be designed for future adaptability, deconstruction, and reuse.

Presentations: Design

Scott Kent: "Implementing 'front end' Circular Economy design principles - applying lessons from temporary buildings to permanent structures"

CE principles are gaining ground in the built environment, but often with a focus on waste minimisation at the back end of the construction process, rather than the front end. Front-end CE principles are more difficult to define, measure, and implement. DfD, design for flexibility, reconfigurability and design for adaptability, as well as being able to relocate and accommodate further incorporation of digital innovation systems are more challenging to embed into the design process. Front-end CE is also more challenging due to the lack of readily available reused materials and bespoke solutions required for the use of salvaged materials on projects. There is also uncertainty about the performance and safety of these materials. Front-end CE could also be challenging due to lack of support in project planning- budget set up and options that are provided to clients to fulfil their objectives in CE approach. Temporary buildings, where the design is done in-house by the contractor and ownership of the building materials is retained, can provide valuable lessons to implementing CE principles in permanent buildings- i.e. the continuous re-use and refurbishment of standardised material components, ease of assembly and disassembly, ability to separate material streams and a guarantee of product performance. We shall give examples from our joint work, illustrate how these





principles are increasingly manifesting in permanent buildings, and speculate on the future of CE in buildings.

Isuru Nanayakkara & Pascal Ally: "Towards a Human-Environment-Oriented Construction Industry"

Every project in the current construction industry purports to be simultaneously socially valuable and beneficial to its own client. Conversely- every such project is likely to cause some damage to the environment and the society- given that currently there are no mass producible carbon neutral building materials. Morally speaking- as an engineer tasked with the design of such a project- you should implement it only after you have determined that its expected benefits significantly offset the foreseeable costs. How would you figure out if this is the case? This work argues that the currently dominant 'client-oriented' approach is inadequate because of its bias towards the needs and the requirements of the client of the project. As a result- it develops an alternative model—'the human-environment-oriented model'—and shows how this model has the resources to guide engineers in working out the overall impact of the project. This new model treats client requirements as one kind of important consideration bearing on the choice-worthiness of the project. One way of implementing this model is by comparing the estimated loss of lives due to anthropogenic climate change on the one hand- and the potential lives saved (due to the benefits of the project) on the other. A project having a higher number of lives saved than of lives lost has a net benefit to the society. Results of some hypothetical project scenarios suggest the significance of the 'build' decision and hence the necessity of circular economy solutions for human and environmental welfare.

Charles Gillott: "Circular economy policy and practice: the international context and potential future directions."

An increase in policy aimed at accelerating transition to a circular economy in the built environment is being seen around the globe. This is enacted in a number of different ways (e.g. through planning policy and building regulations) and promotes a range of different circular economy strategies (e.g. design for adaptability or increased recycling and reuse), as well as being implemented at various governance levels (i.e. sub-, inter- or nationally) and project stages (e.g. pre-, post- or during construction).

The proposed presentation will include a summary of an ongoing international research project characterising the policy landscape in different countries and the influence this has upon construction sector practice. As well as an overview of current policies, their intended aims and success in achieving these, comparisons between different national policies will be made in consideration of the international context in which they are applied. From this work, the proposed presentation will make initial recommendations for future circular economy policy in the UK context and beyond.





Keynote: *Andrea Charlson, Useful Simple Trust*

Reflections from the bridge between industry and academia

Panel Discussion: Next Steps for CE Research & Practice

Andrea Charlson, Will Mihkelson, & Dr Maud Lanau

Keynote Bios:

Dominik Wiedenhofer, University of Natural Resources and Life Sciences, Vienna

Dominik Wiedenhofer is an internationally recognized scholar from the interdisciplinary field of Industrial Ecology, who is working on the potentials of and barriers for integrated supply- and demand-side strategies to mitigate resource use and greenhouse gas emissions in two areas. He assesses how societal resource use and the socio-economic material stocks of buildings, infrastructure, machinery and all products jointly provide functions and services to society, which also results in waste and emissions. He investigates how resource use, waste and emissions occur along global supply chains supporting final demand to assess the role of affluence, inequality, socio-demographic drivers, as well as the mitigation potentials of lifestyle change, consumption options, and infrastructural measures.

Dominik has pioneered the dynamic, inflow-driven modelling of stock-flow relations for economy-wide material flow accounting, which is globally used to account for resource use of nations. Based on this work, he contributes to developing novel approaches to assess the circularity of national economies and investigates the potentials and limits of a circular economy to contribute to mitigating resource use and emissions.





Melanie Martin - Associate Director, ORMS Architects

As Associate Director, Melanie leads a team committed to a range of sectors and scales. Among her current projects are a number of refurbishment schemes for The Crown Estate, 10 Spring Gardens and 20 Air Street and a prominent new retail facade on Oxford Street for M&G Investors. She oversaw the development of the Orms sustainability research programme, and is an active member of our in-house sustainability group. Her projects with The Crown Estates have set pioneering sustainability, and specifically reuse ambitions, which are being delivered with the assistance of material passports.





Andrea Charlson - Associate Director, Useful Simple Trust

Andrea is a Chartered Environmentalist and Engineer specialising in the sustainability of the built environment, with particular expertise in the circular economy and how this applies to materials, structures and buildings. Her work has covered both increasing the use of reclaimed materials and designing to facilitate future reuse. She has vast experience working in both the public and private sector, in an advisory, client and research capacity, and all scales from industry-wide initiatives, to focussing on cities, projects, organisations and products. Her current interest is in exploring how we can build truly regenerative places - places that form the basis for continued life; supporting plants, animals and healthier humans, now and in the future.

