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## Session 2

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## Ann-Marie Fallon

Co-Director Passivhaus Trust, Mentor Architype,  
BE-ST Board Member, Coaction Trainer

## Reuse, Circularity and Innovation at Entopia

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Re-Use Circularity & Innovation at Entopia

Ann-Marie Fallon



Passivhaus Trust

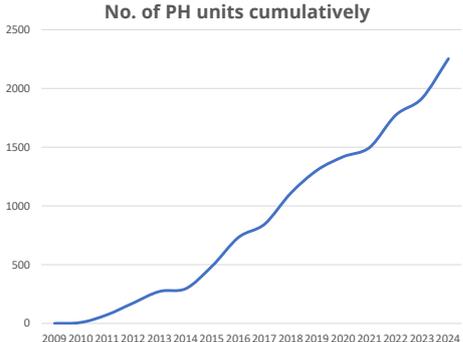
BE-ST board member





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## Passivhaus Trust – Certified projects update



No. of PH units cumulatively

2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024

- > 470

GB CERTIFIED PROJECTS
- > 2200

GB CERTIFIED DWELLINGS
- 370,600 m<sup>2</sup>

TFA CERTIFIED
- > 8000

UNITS IN DEVELOPMENT



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T1

# 40 years of sustainable design and data – evidence led

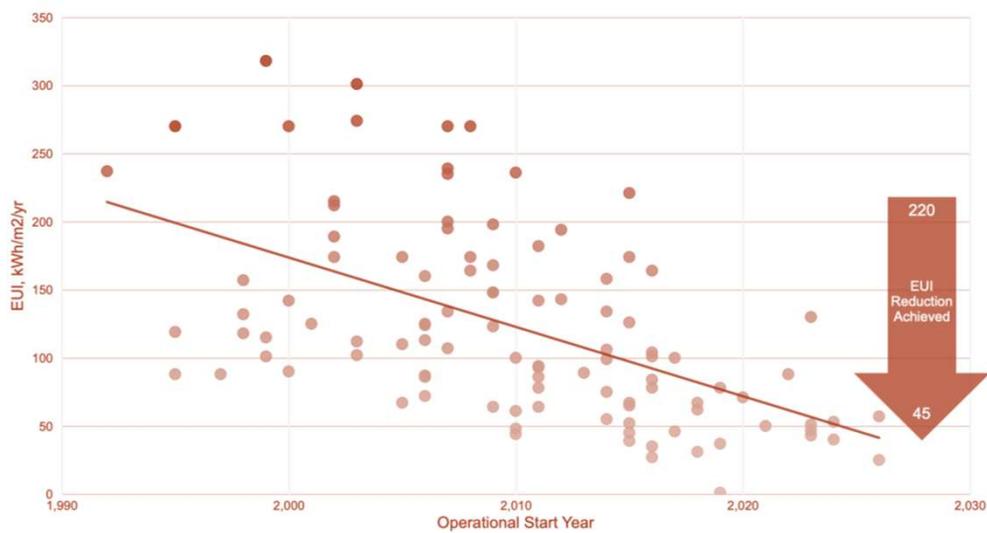
Diversity of scale and sector new build Passivhaus over 15 years



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# 40 years of sustainable design and data – evidence led



Archetype EUI reduction – 162 buildings over 40 years

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**JT1** 'I would prefer if this said something like 40 years of sustainable design', in particular we are best known for Passivhaus, which we know through 15 years of research to be the most effective method to reach net zero - i.e bring it back to their theme no yours

Jessica Taylor, 2024-10-17T09:13:00.191

# Why Entopia is important

- Exemplar large scale retrofit blueprint
- Successfully demonstrates an approach that can be used on existing buildings including heritage
- Open knowledge sharing



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“... an impact-led institute within the University of Cambridge that activates leadership globally to transform economies for people, nature and climate.”



# UNIVERSITY OF CAMBRIDGE

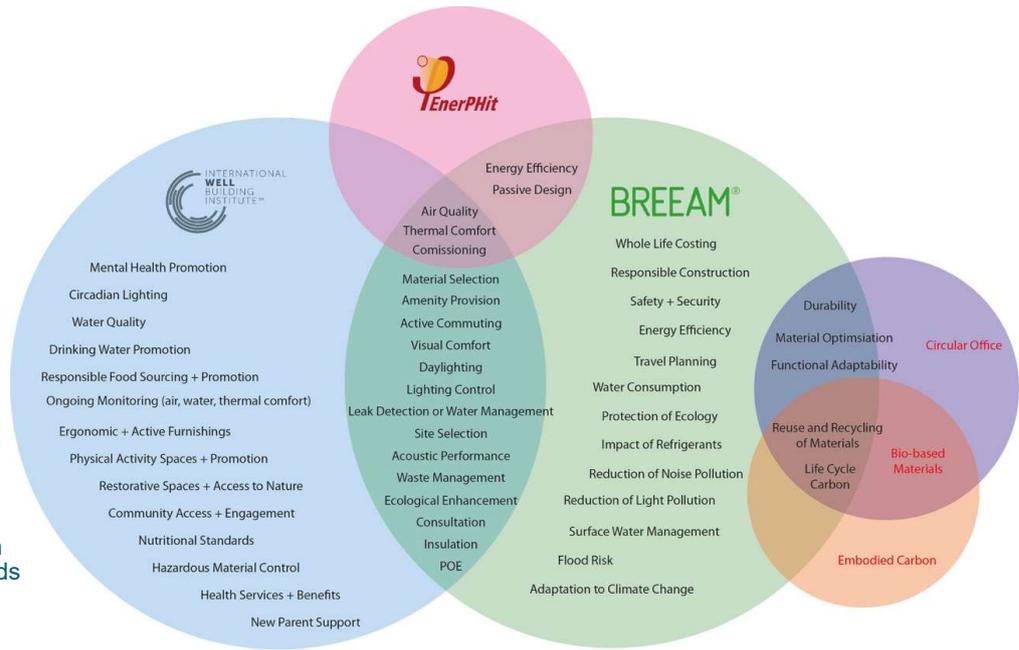
INSTITUTE FOR  
SUSTAINABILITY LEADERSHIP



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# Brief

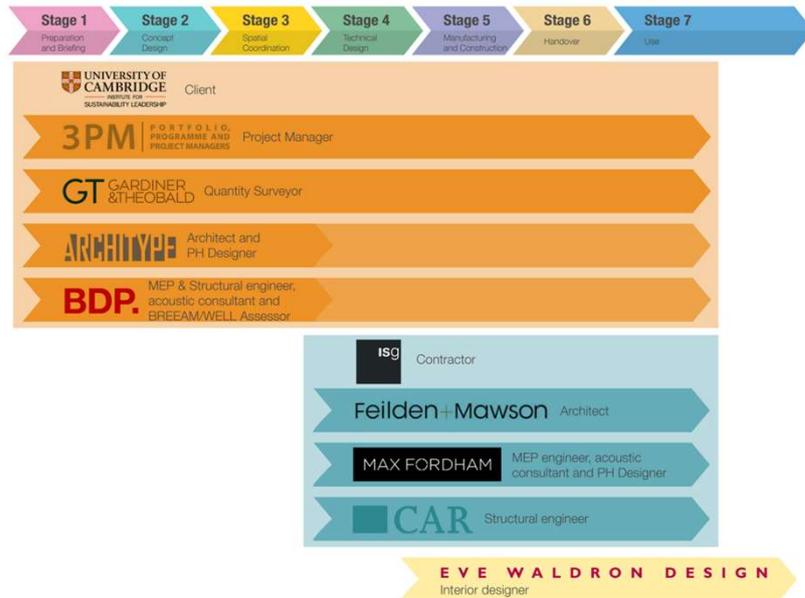
- Ambitious and challenging brief
- Overlap between different standards
- Consistent client commitment and advocacy



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# Design team

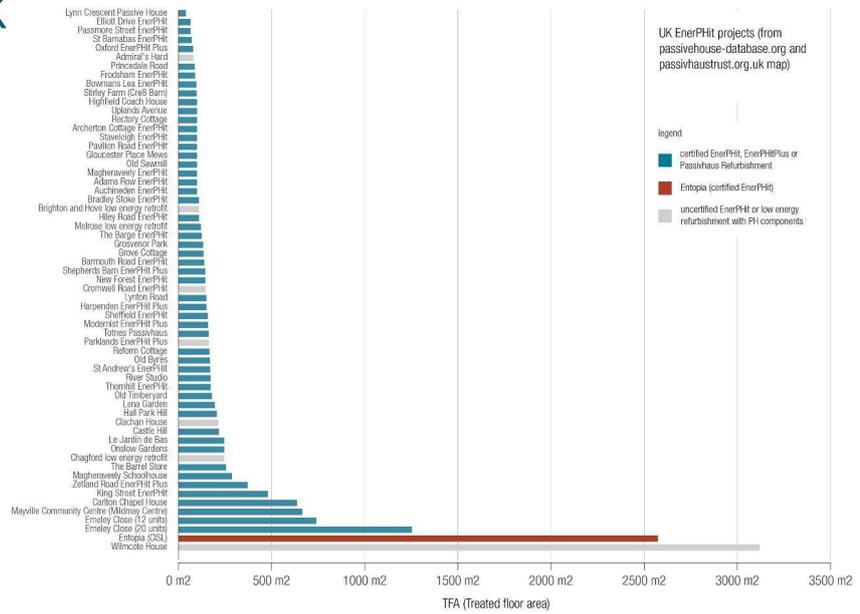
- Initial design team developed scheme to Stage 3, including planning permission, and retained client-side
- ISG-lead design team developed design through to practical completion
- Mead Consulting – Passivhaus Certifier



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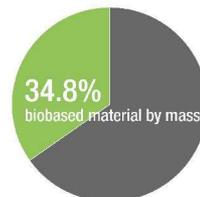
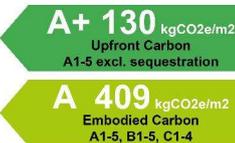
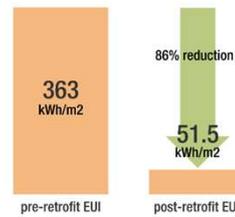
# EnerPHit in the UK

- Mainly domestic-scale at present
- Entopia is the largest certified EnerPHit in UK
- The lowest embodied carbon EnerPHit in the UK



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## Results



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## Before

- Originally built in 1939 as a telephone exchange
- Photo from BT Archives of a Cambridge telephone exchange – may not be 1 Regent Street, but gives sense of original use



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## Before

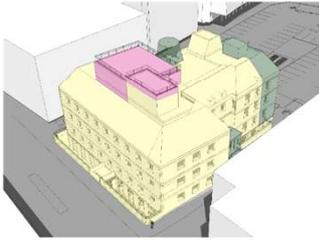
- Most recent use before CISL acquired the building was as offices for Cambridge Assessment
- Previous refurbishment in 1998
- Dark interior due to windows being partially covered by dropped ceiling



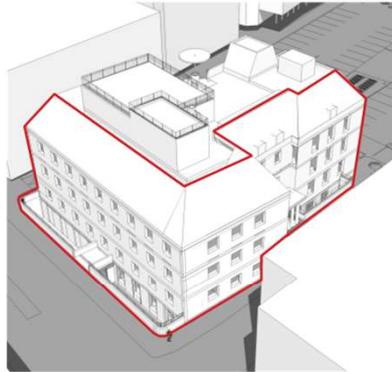
221

# Before

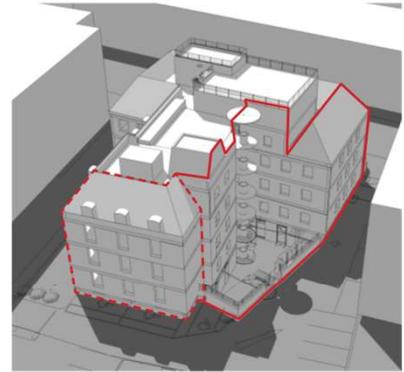
- Owned by the University
- Refurbished in 1998 as an office
- Mostly solid brick walls, with single glazed sash windows with some secondary glazing



- 1939
- Possibly 1965
- 1998

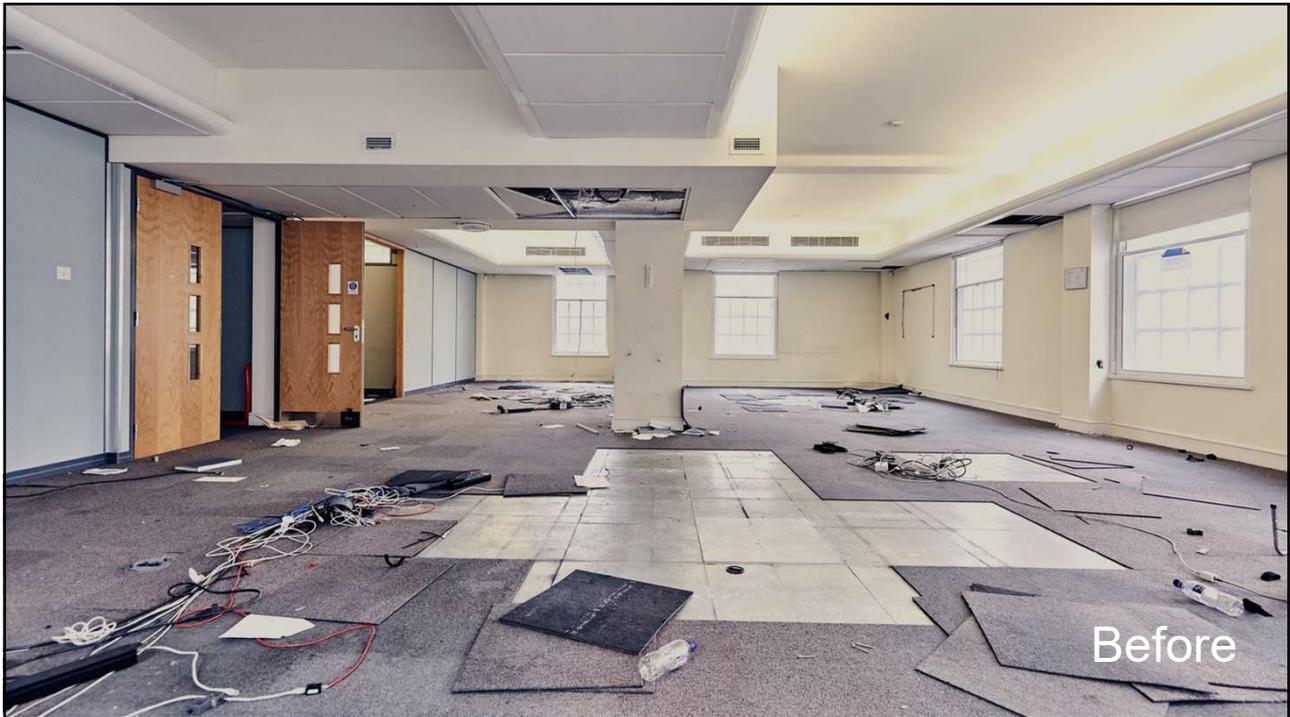


Higher heritage value:  
- Addressing the street  
- West / South facing



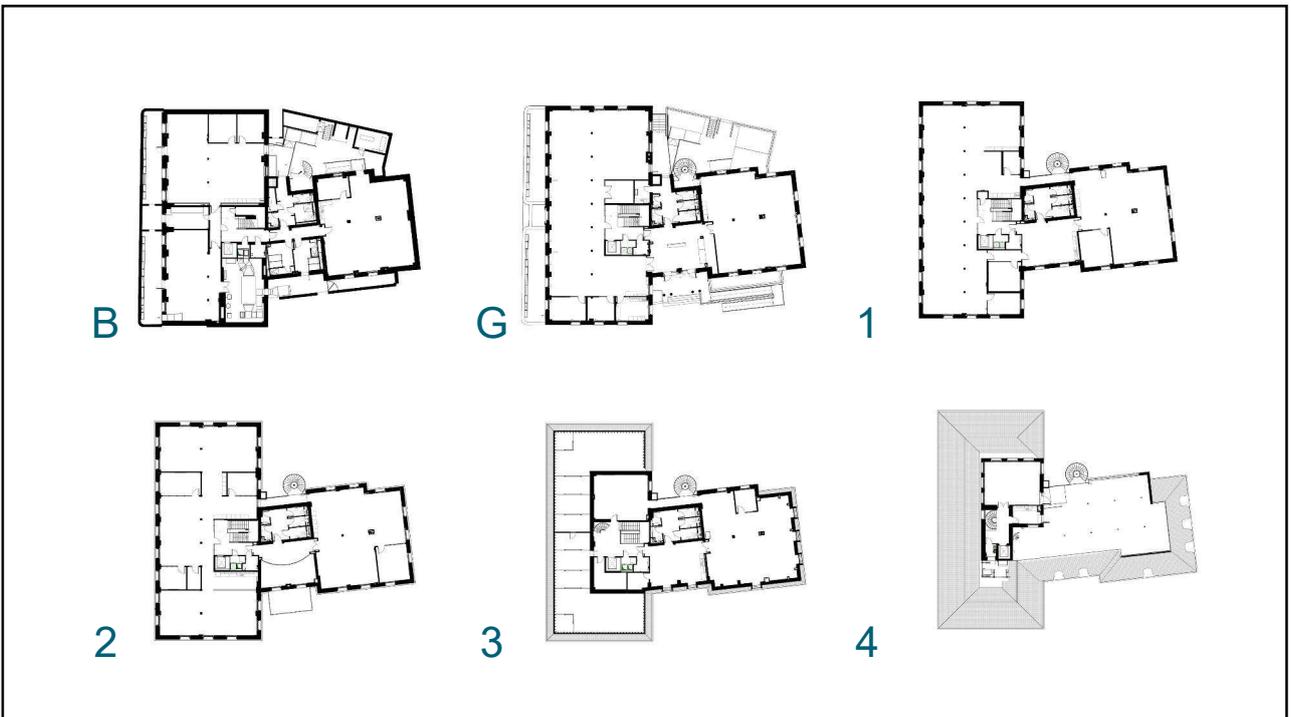
Lower heritage value:

- Servicing zone
- Addressing back of neighbouring building
- East / North facing
- Value of 1998 West extension debatable



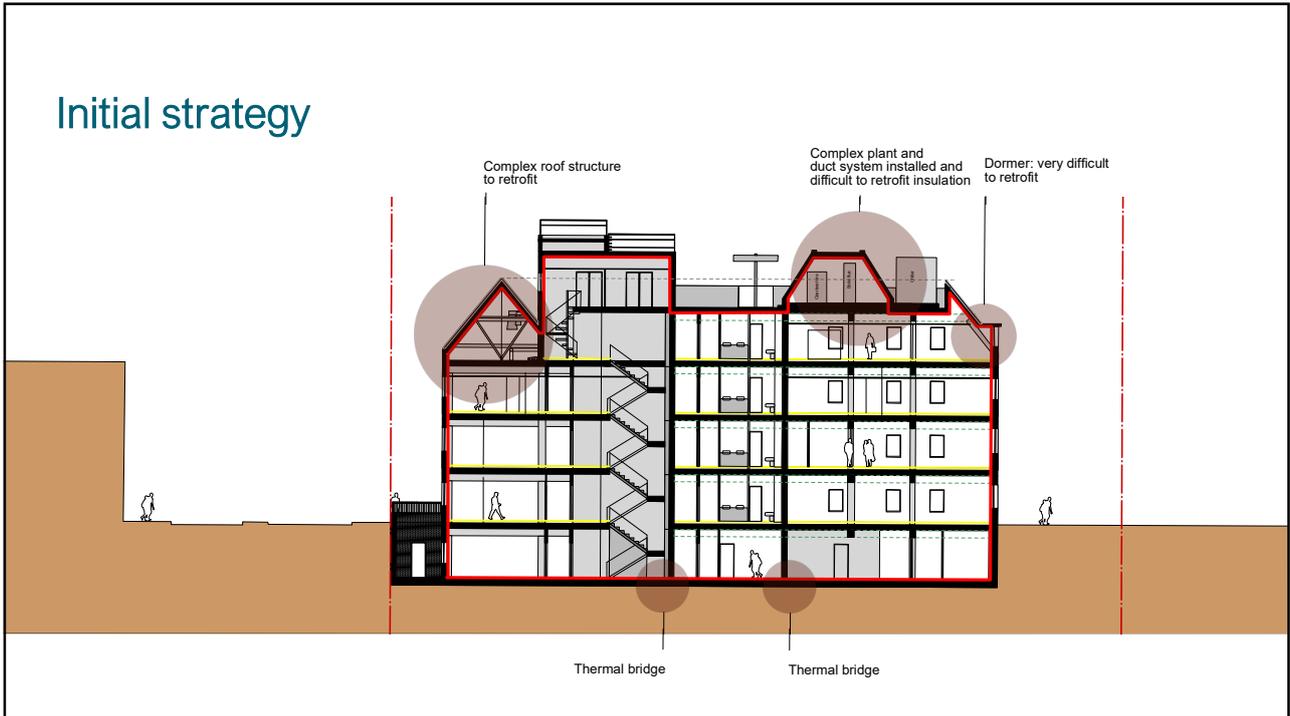


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## Initial strategy



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## Developed strategy

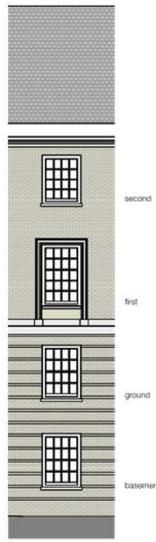


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# Windows



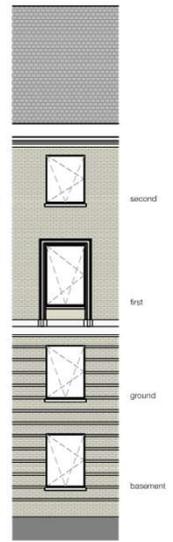
3D View - Existing Window Bay



Elevation - Existing Window Bay  
1:100

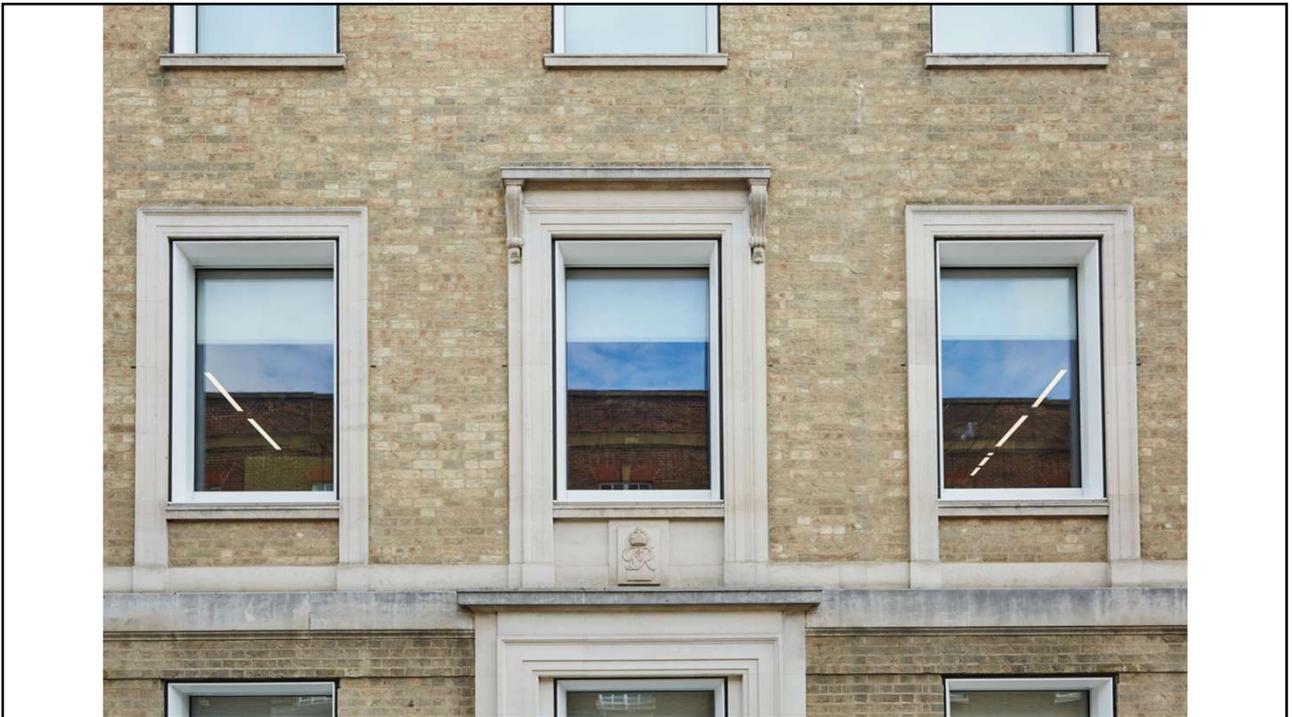


3D View - Proposed Window Bay



Elevation - Proposed Window Bay  
1:100

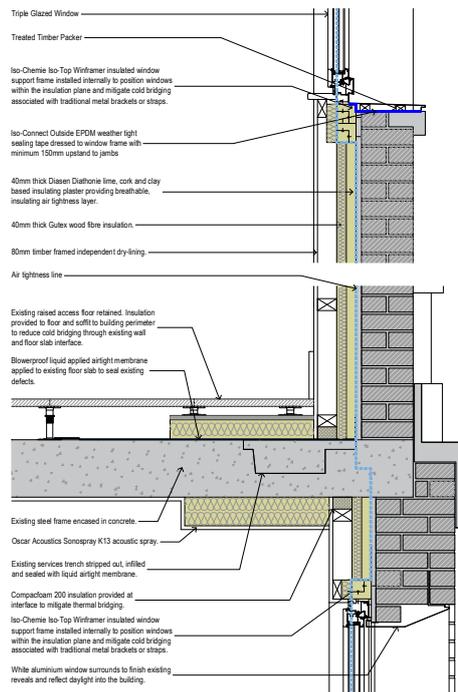
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## Detail development

- Detailed modelling of thermal bridges and moisture risks
- Development of detail to include 40mm Diathonite insulating render and 40mm Gutex woodfibre board to minimise embodied carbon and manage moisture



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### Tricky junctions – Steel frame



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©SOLK Photography

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## EnerPHit certification



- ISG team achieved impressively low air leakage rate - 1.33 m3/(h.m2)@50Pa or 0.605 ach@50Pa

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**Certificate**  
Certified retrofit  
'EnerPHit Classic'  
(Climate zone: Cool-temperate)

Meat:  
Energy &  
Architectural  
Design Ltd.

Authorised  
by:

Passive House  
Institute  
Dr. Wolfgang Feist  
64283 Darmstadt  
Germany

**The Entopia Building**  
1 Regent Street, CB2 1GG Cambridge, United Kingdom/ Britain

Certified  
Retrofit  
Passive House Institute

classic | plus | premium

Client	University of Cambridge Greenwich House, Madingley Road		
Architect	Archtype / Felidan and Mawson		
Building Services	Max Fordham LLP / BDP Ltd		
Energy Consultant	Max Fordham LLP		
Main Contractor	ISG Ltd		

Building retrofitted to the EnerPHit Standard offer excellent thermal comfort and very good air quality all year round. Due to their high energy efficiency, energy costs as well as greenhouse gas emissions are extremely low.

The design of the above-mentioned building meets the criteria defined by the Passive House Institute for modernization to the 'EnerPHit Classic' standard:

Building quality		This building	Criteria	Alternative criteria
Heating	Heating demand [kWh/(m²a)]	24	≤ 25	-
	Cooling + dehumidification demand [kWh/(m²a)]	0	≤ 15	-
Cooling	Frequency of overheating (> 25 °C) [%]	-	≤ 10	-
	Particulate matter (PM10) [µg/m³]	0.6	≤ 1.0	-
Airtightness	Pressurization test result [h/m³]	1.33	≤ 2	≤ 2
	Renewable primary energy (RPE) [kWh/(m²a)]	65	≤ 25	75
Component quality	Generation (reference to ground area) [kWh/(m²a)]	17	≤ -	-
	Building envelope to ambient air (U-value) [W/(m²K)]	0.20	≤ -	-
	Building envelope to ground (heat loss load) [kWh/(m²a)]	0.54	≤ -	-
	Windows/door doors (U-value) [W/(m²K)]	0.83	≤ -	-
	Glasst (g-value) [-]	0.57	≤ -	-
Glasst (solar load) [kWh/(m²a)]	100	≤ -	-	
Ventilation (effect: heat recovery efficiency) [%]	83	≥ -	-	

The associated certification booklet contains more characteristic values for this building.

London  
11.07.2022
Certifier: Kym Mead, MEAD Ltd

www.passivehouse.com
35486-35511\_MEAD\_EP\_20220714\_KM



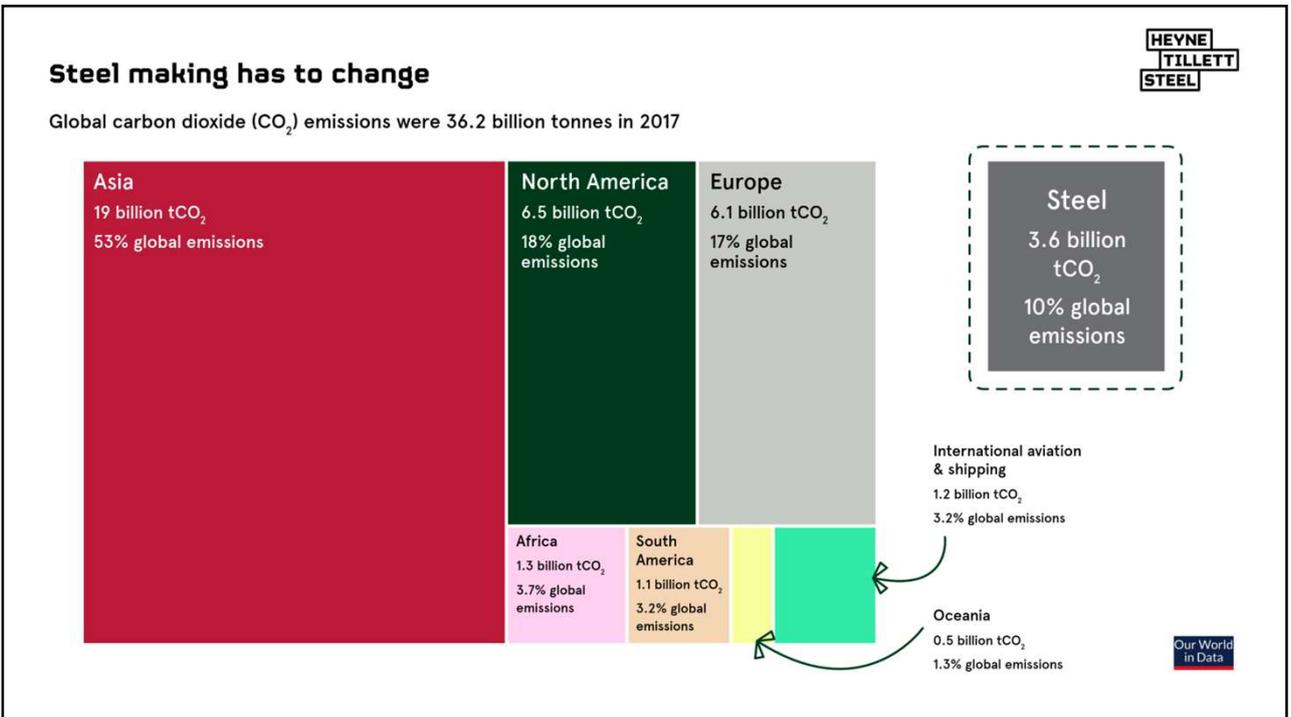
236



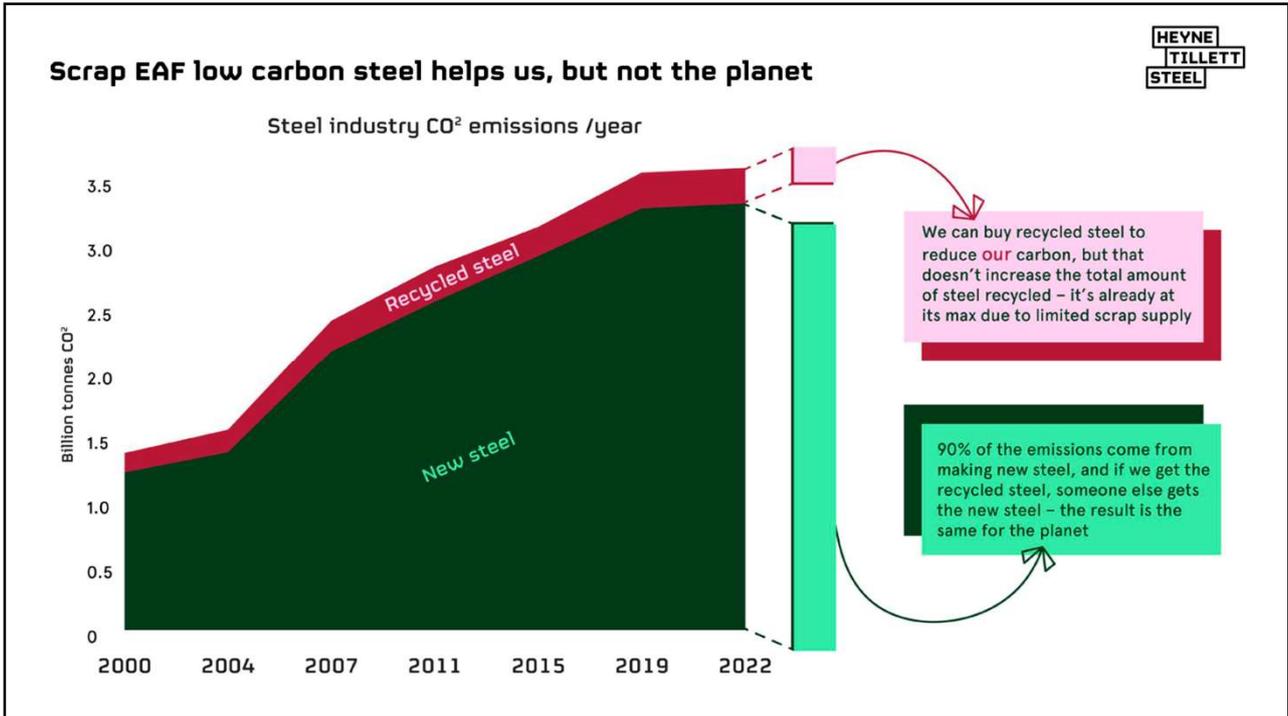
237



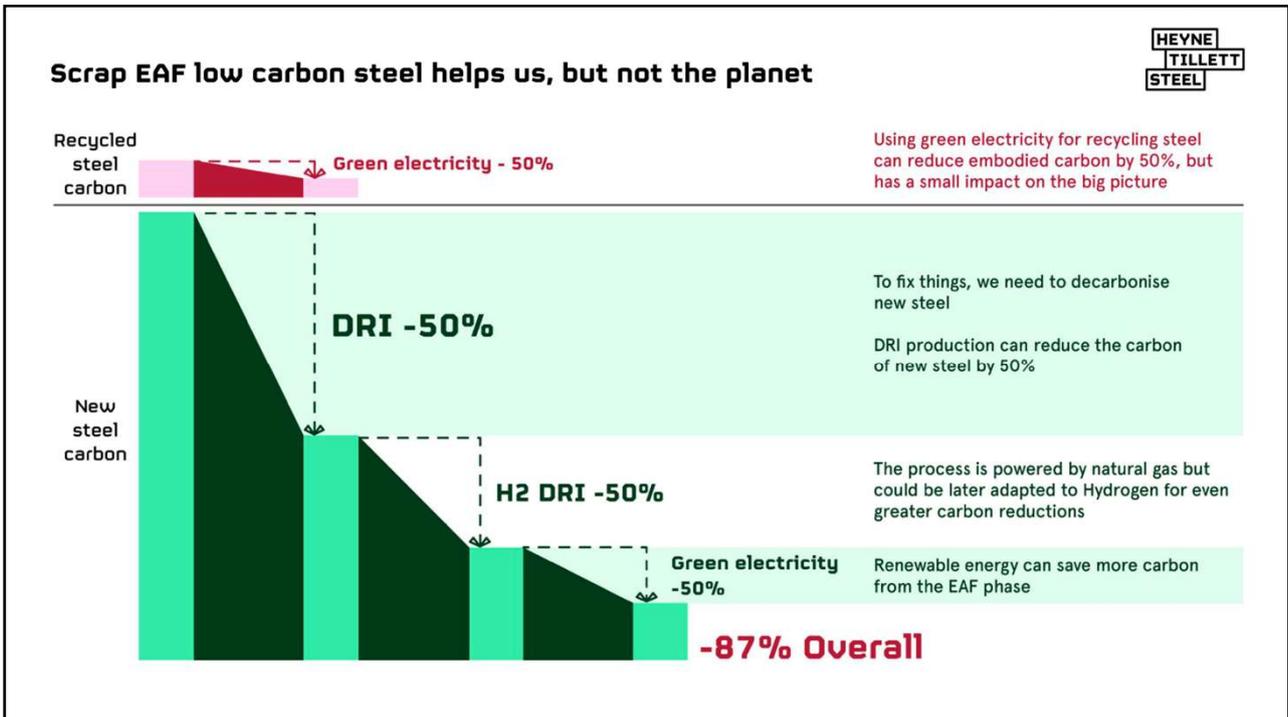
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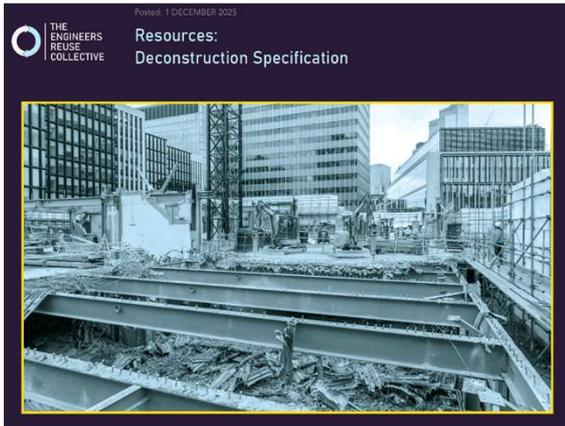


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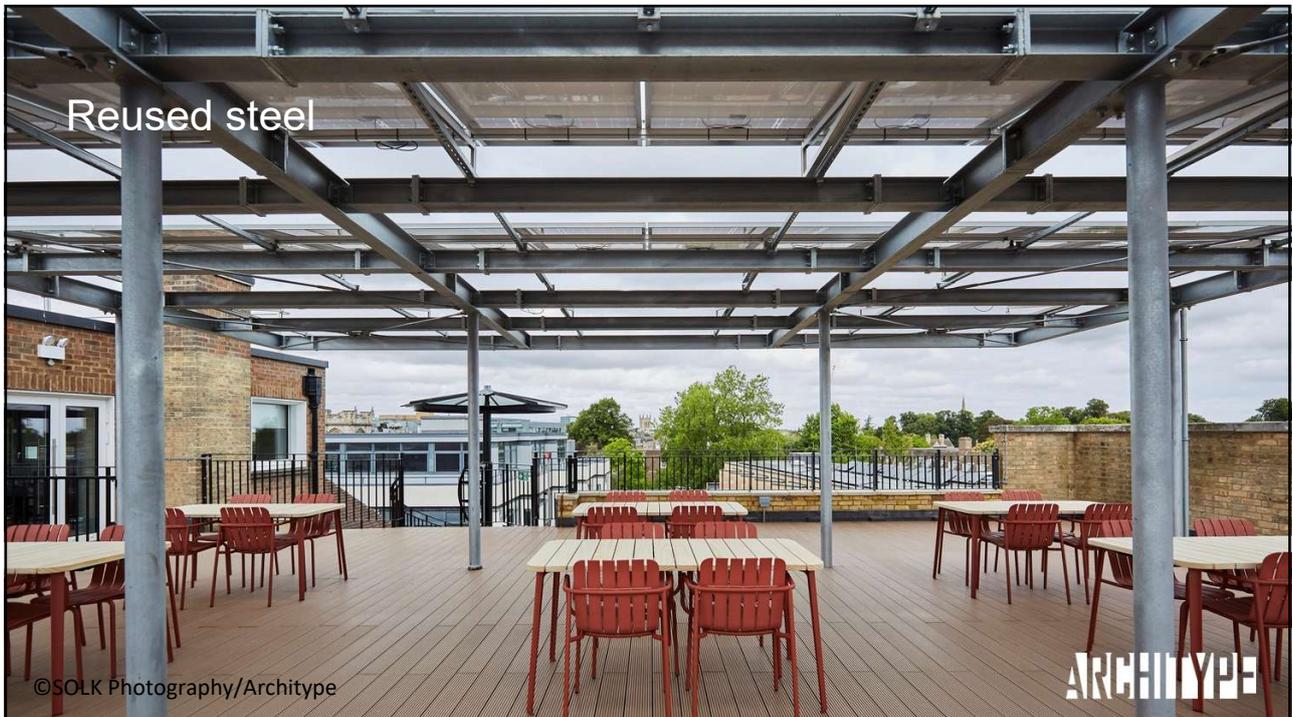


## The case for steel re-use

- Re-fabrication guidance
- Develop a design process to facilitate re-use
- 7000 tonnes available via Cleveland Steel end of 2025



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## Reused steel

- ISG procured secondhand steel section from Cleveland Steel, who acquired the sections from a Marvel film set
- Original documentation made reuse straightforward
- 3.79 tonnes reused, saving an estimated 2,000 kgCO<sub>2</sub>e



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## Reused steel



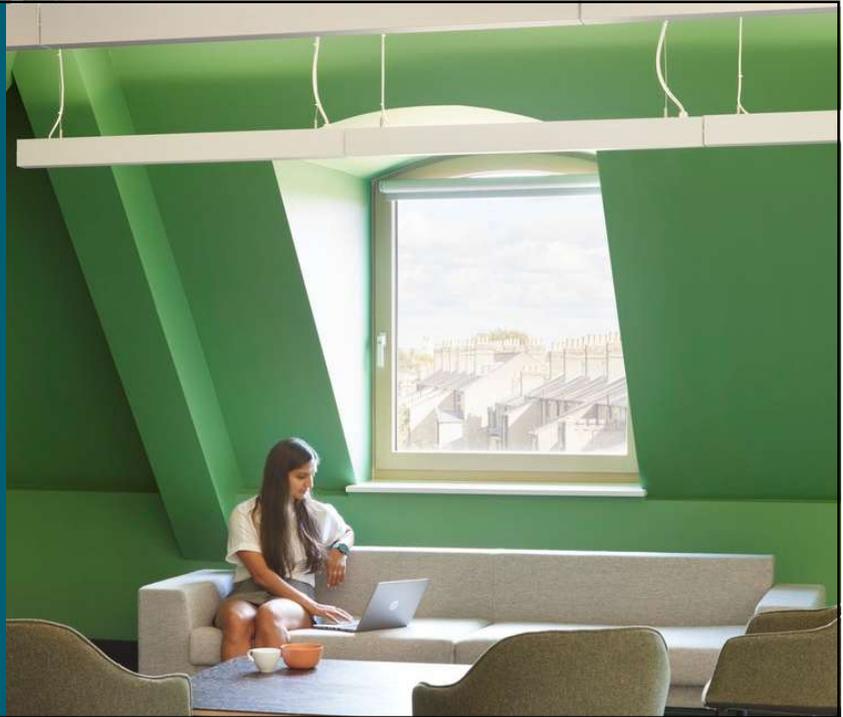
## Key insights

- Key role of contractor and stockholder
- Early engagement
- Lower cost for reused steel
- Smaller sections, greater flexibility with sequencing and installation
- Original test certificates were obtained, & no warranty impacts

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## Reused lights

- ISG sourced 350 light fittings from CAT A fit out in London, and persuaded the original manufacturer to test and honour the remaining warranty period
- Lights adapted to be hung suspended, with additional LED strip for uplight



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## Finishes

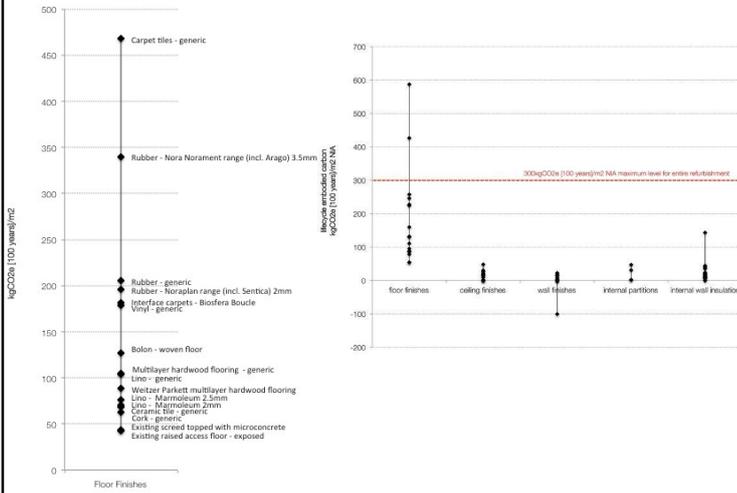
- 25% of wall paint was made of 35% recycled paint: 10% lower embodied carbon compared to standard
- Raised access floor re-used and carpet tiles re-used
- Sonaspray cellulose acoustic insulation used instead of additive solutions like panels



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## Floor finishes – carbon & cost benefit



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## Reused reception desk

- Sourced by ISG from the Copyright Building, London
- Removed in 2021 and taken back to original manufacturer's workshop to be stored and adjusted
- Lower wheelchair accessible added and linear bench seats created from excess desk length



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## Kintsugi Repair

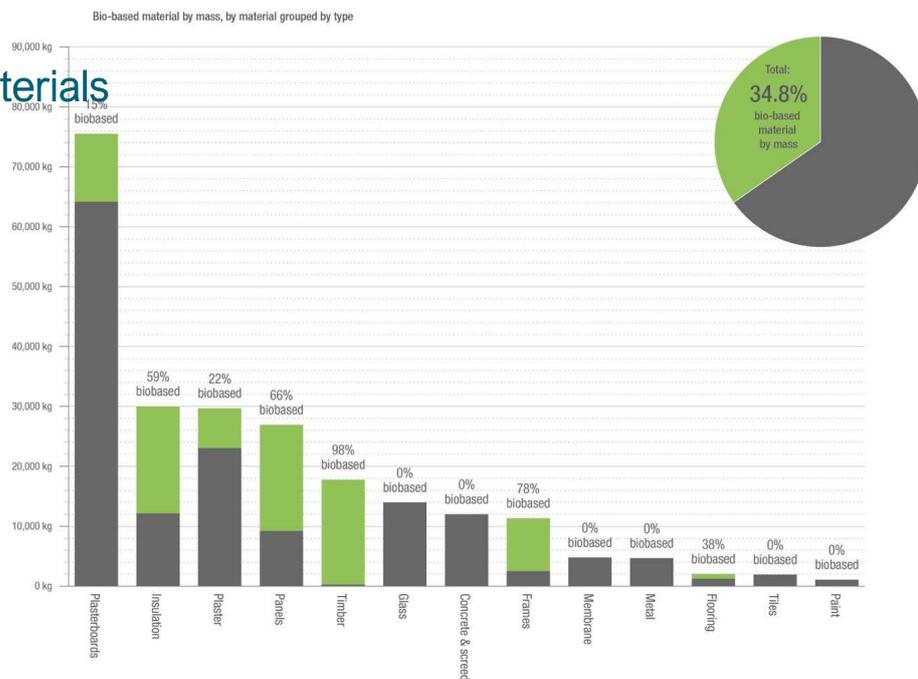
- Travertine stone top cracked during removal and repaired in the spirit of the Japanese Kintsugi technique
- Breakage and repair treated as part of the history of the object - to be celebrated rather than hidden
- Manufacturer now designing for disassembly



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## Bio-based materials

- 35% bio based materials
- Cellulose acoustic insulation, gutex wood fibre, diathonite hemp fibre Warmcel and linoleum



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## Minimising Waste

▪ Finishes and furniture not used from previous fit out were passed to community via CollectEco.



KEY RESULTS



£100,225

Value Donated To The Community

21,119kg

CO2e Avoided

21,648kg

Diverted From Landfill

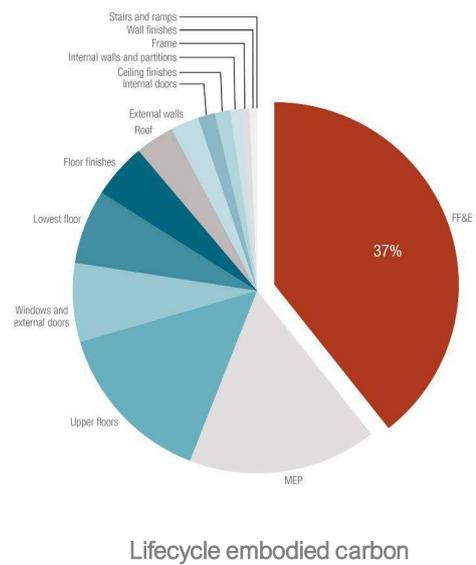
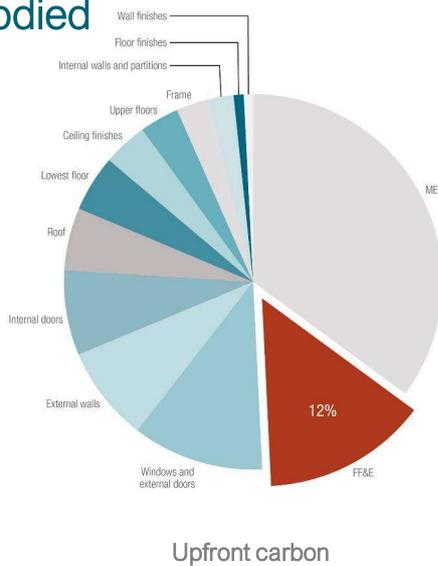
©SOLK Photography

### CISL REUSABLES ON SITE

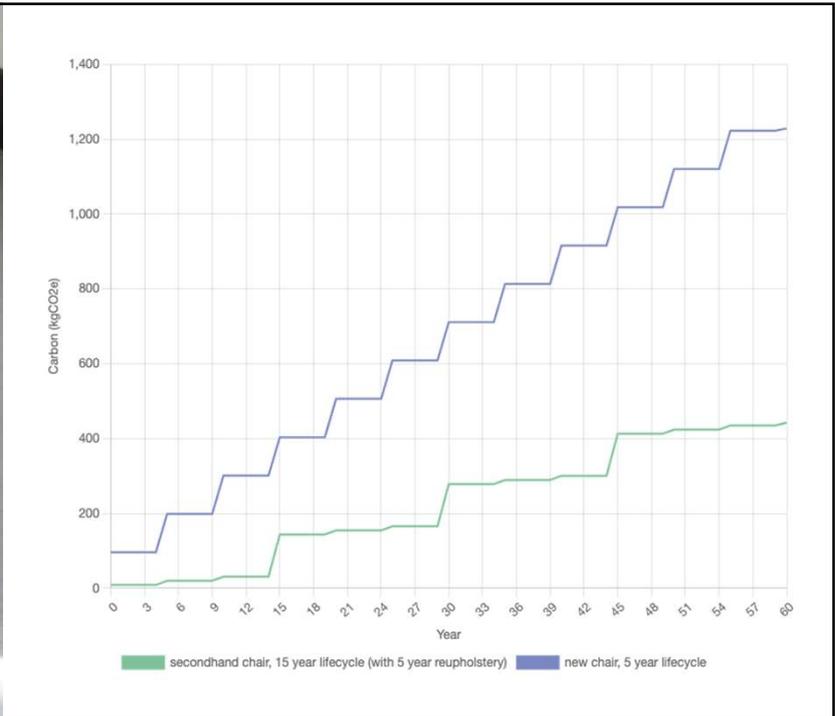
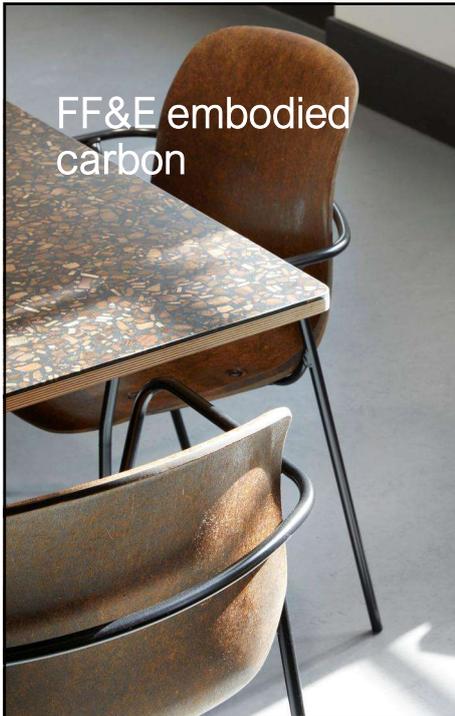
Basement				
Description	Approx. Quantity	Approx. Weight	Location on plans	
Sash window panels – frames will not come out in reusable condition	7	186	Various	
Secondary glazing and frames	5	171	Various	
Internal doors (single/double). Complete with hinges, closers, handles, kick/push plates and other hardware	34	1258	Various	
Toilet cubicles (not backboards or casing behind toilet pans)	2	700	Toilets	
Toilet pans, cistems and associated	3	78	Toilets	
Toilet sinks, taps, waste, etc (happy for these to stay on the plinth if easier)	3	36	Toilets	
Mirrors in toilets	3	23	Toilets	
Hot water boilers in toilets	3	25.5	Toilets	
Toilet roll holders, paper towel holders and associated	Various	10	Toilets	
Hand dryers in toilets	3	13.5	Toilets	

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## FF&E embodied carbon



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### Furniture

Total: 31.3% reused material by mass

Total: 55.9% bio-based material by mass

- Furniture also followed same brief, although a separate contract.

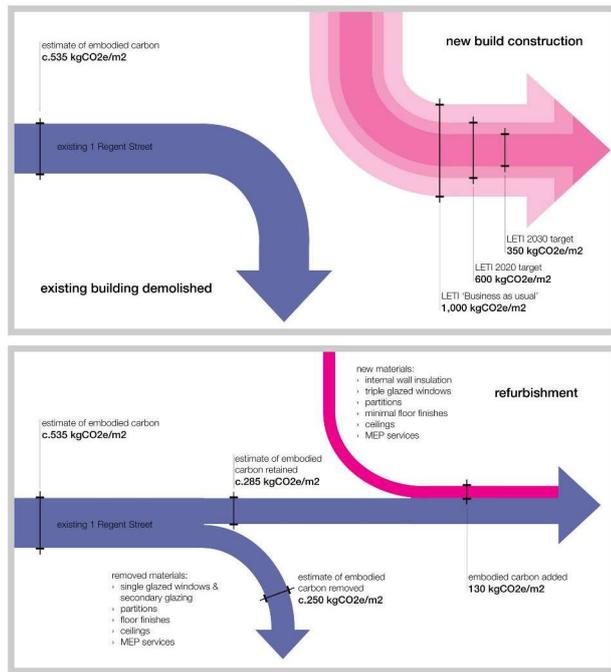
© Jack Hobhouse/Architype

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# Embodied carbon

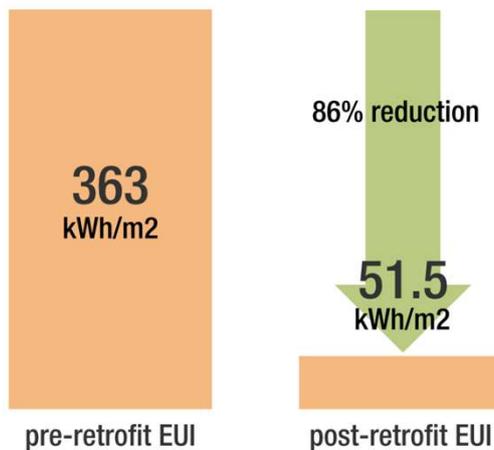
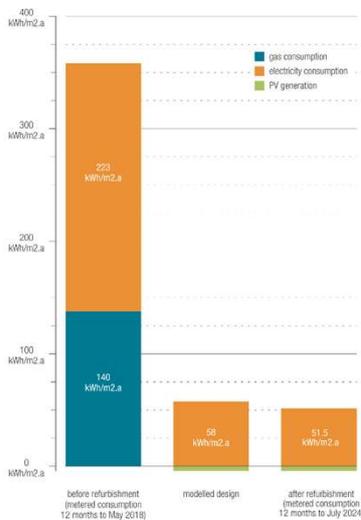
- Comparison between a 'demolish and build new' scenario, and the retrofit of Entopia
- Embodied carbon of retrofit is significantly lower



Note: Embodied carbon figures are for building life cycle Stages A1-A5. Figures for 1 Regent Street and LETI targets include substructure, superstructure, internal finishes and MEP. Figures for 1 Regent Street are from Stage 5 design (May 22 update).

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# Entopia In-use performance – saving £100,000 a year in costs



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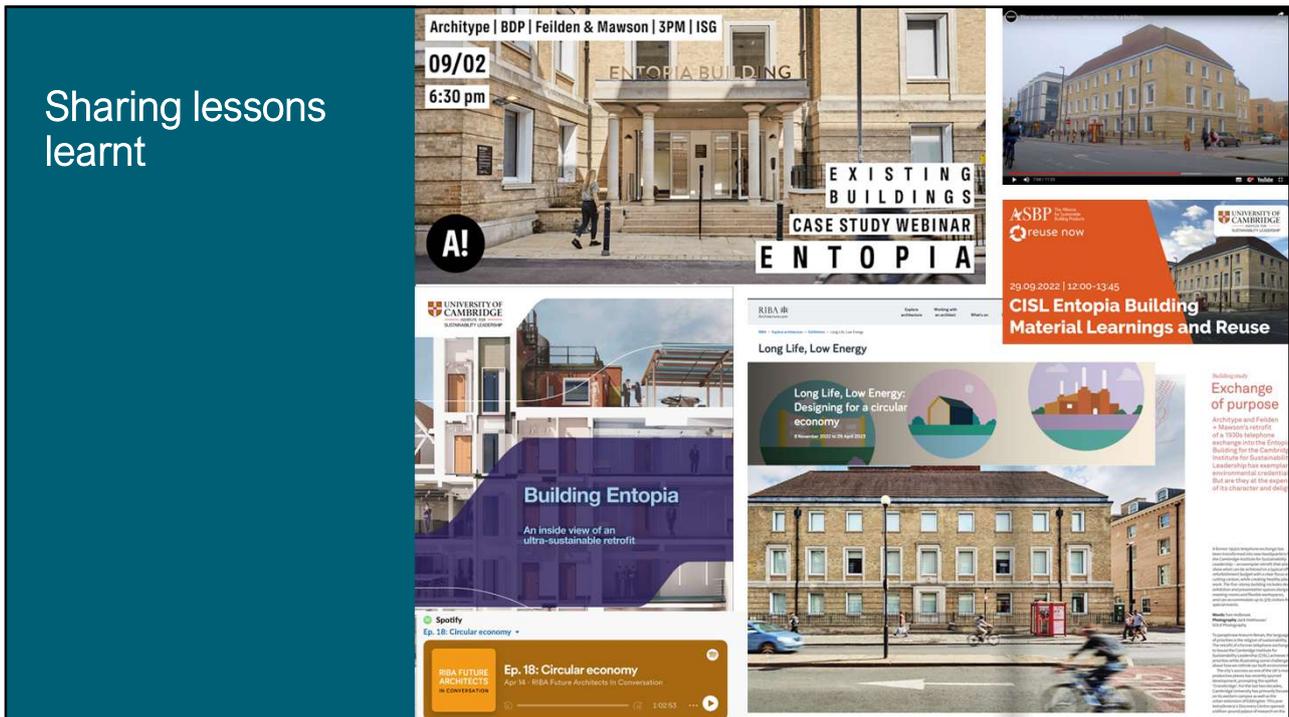
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## Sharing lessons learnt

- Early collaborative involvement of contractor
- Opening up – always do as much as is feasible
- Whole life carbon lack of data around FFE and MEP
- Conservation / heritage tensions and policies based on science-based energy targets – need the right outcome
- Client leadership in setting an ambitious brief – need not cost more, challenge and be persistent
- Costs - RIBA stage 1 suggested 25% overall additional cost. Overall project estimated 8% and within the RICS upper benchmarking values for refurbishment

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## Sharing lessons learnt



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## Resources

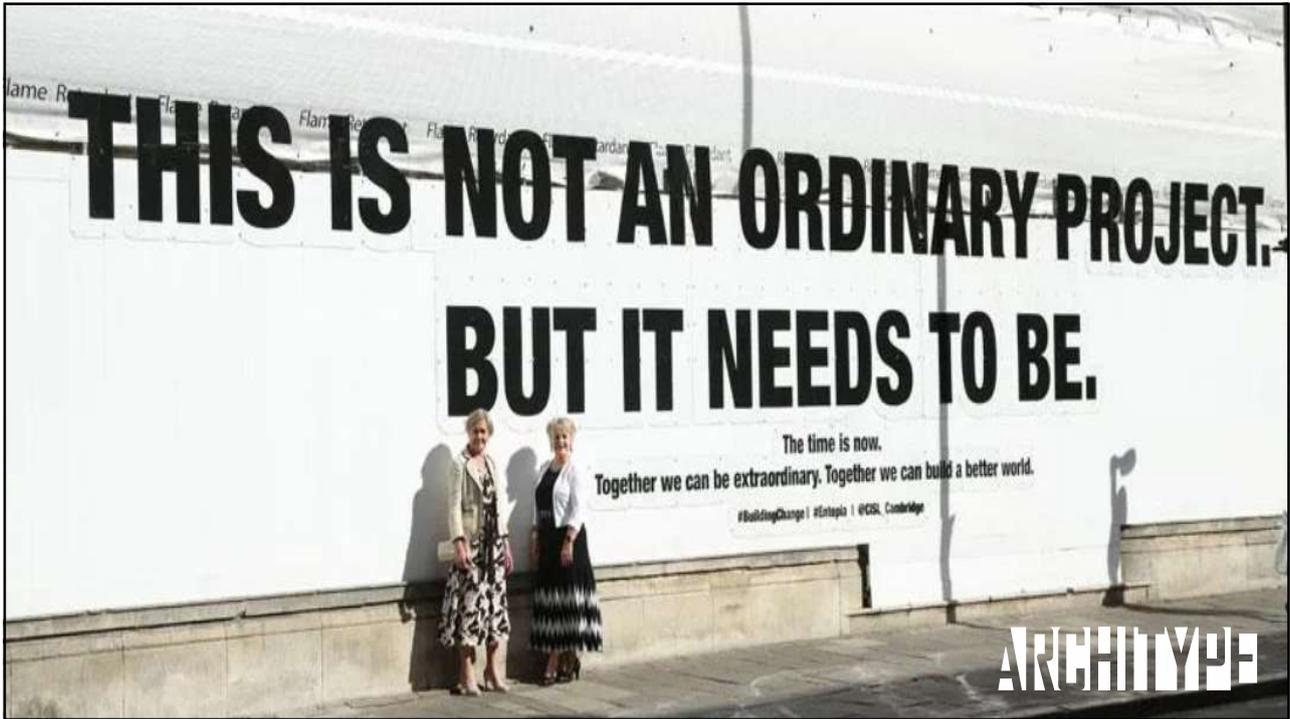
- CISL's summary case study (2022):  
[https://www.cisl.cam.ac.uk/files/cisl\\_entopia\\_report\\_short\\_version.pdf](https://www.cisl.cam.ac.uk/files/cisl_entopia_report_short_version.pdf)
- CISL's full case study (2022):  
[https://www.cisl.cam.ac.uk/files/entopia\\_case\\_study.pdf](https://www.cisl.cam.ac.uk/files/entopia_case_study.pdf)
- RIBA Journal PoW Stages (2021-22):  
<https://www.ribaj.com/intelligence/sustainable-retrofit-cambridge-institute-for-sustainability-leadership-riba-plan-of-work>
- UKGBC 'How Circular Economy Principles can impact carbon and value' (2022):  
<https://www.ukgbc.org/ukgbc-work/how-circular-economy-principles-can-impact-carbon-and-value/>



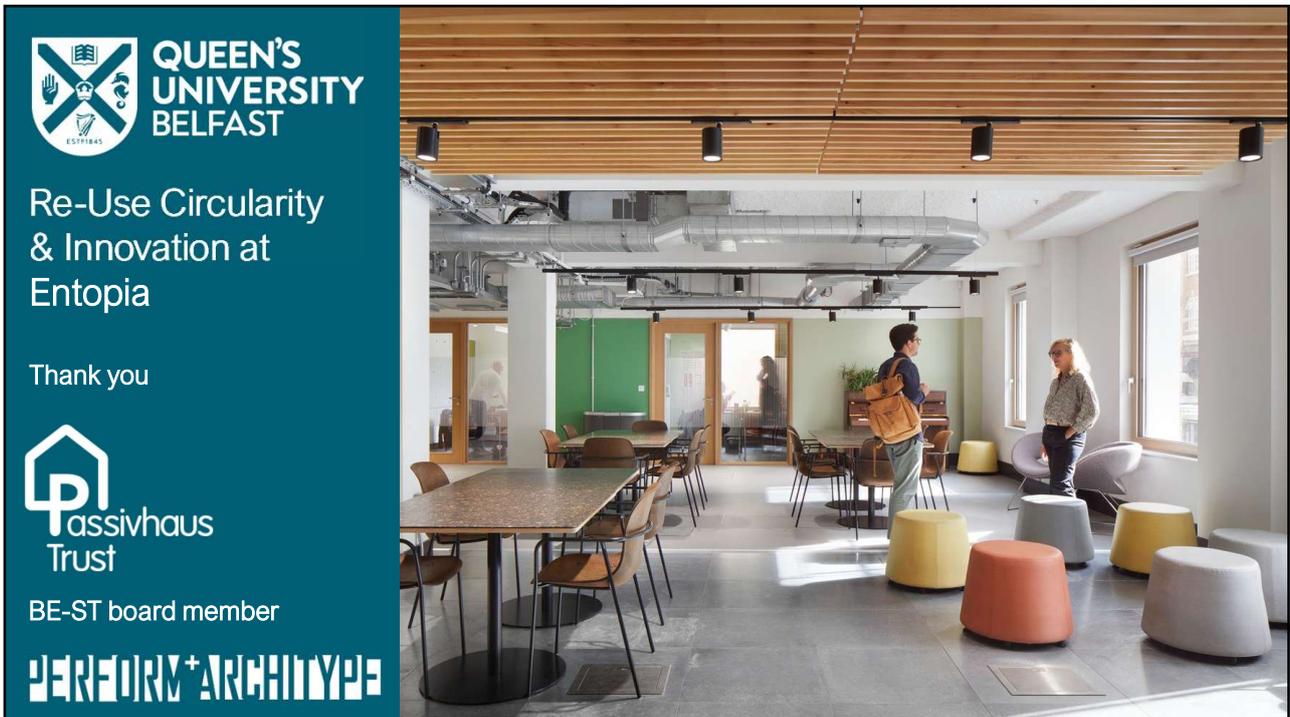
© Cambridge Institute for Sustainability Leadership (CISL)

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Thank You

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**Dr Fragkoulis Kanavaris**

Global Lead, Concrete Materials and Decarbonisation, ARUP

**Can Concrete Decarbonise?**

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## Introduction

A global firm with global influence

We are a global collective of designers, engineers and technical experts. We use imagination, technology and rigour to shape a more sustainable world.

- ~20,000 staff
- 94 offices in 34 countries
- Diverse portfolio
- Buildings, bridges, road and metro tunnels, nuclear, maritime, energy, policy, strategic leadership, community engagement



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## Introduction & background

**Fragkoulis Kanavaris** - [LinkedIn](#)

**Global Lead - Concrete Materials and Decarbonisation** at ARUP, London, UK

Contributed to 400+ projects since then (buildings, bridges, tunnels, nuclear, maritime, offshore, energy, research).

**MEng in Civil & Structural Engineering; PhD in 2017** Concrete Tech

Focus on: Lower carbon concrete materials and structures, durability, structural optimisation concrete technology and others.

Initiated and managed several innovations in the concrete materials sector

2022 Engineer of the Year (Royal Academy of Eng.) and Fellow of IoMMM

2024 Sir Henry Royce Medal from IET

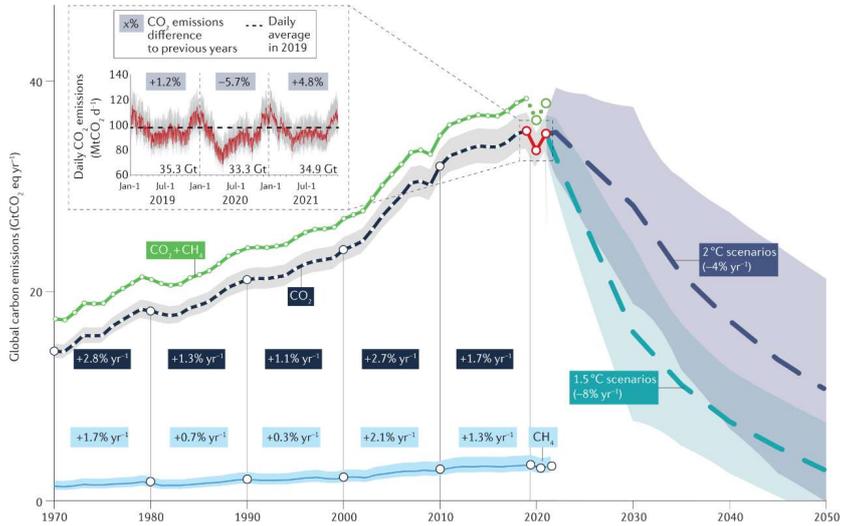
2025 Gustavo Colonnetti Medal from RILEM



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# First – some facts

## The global warming issue



Liu et al. 2022. Nature Reviews Earth & Environment 3, 217-219

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# Concrete – “bad” news

### Climate change: The massive CO2 emitter you may not know about

© 17 December 2018



Cement and concrete industry's emissions 'have doubled in 20 years'

### Concrete needs to lose its colossal carbon footprint

Concrete will be crucial for much-needed climate-resilient construction. But the cement industry must set out its plan for decarbonization.

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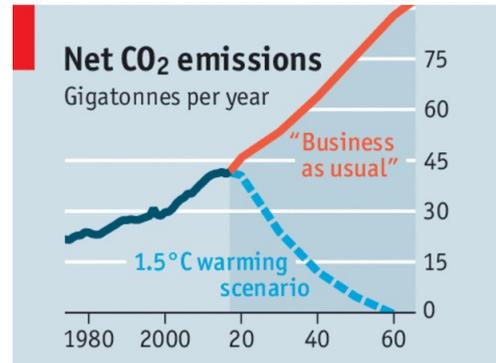
# Concrete – the “problem” material

## CO<sub>2</sub> emissions associated with cement

- Cementitious materials account for **8% of global emissions** (more than India!)
- ~60% of emissions come from the chemical breakdown of limestone to CO<sub>2</sub>



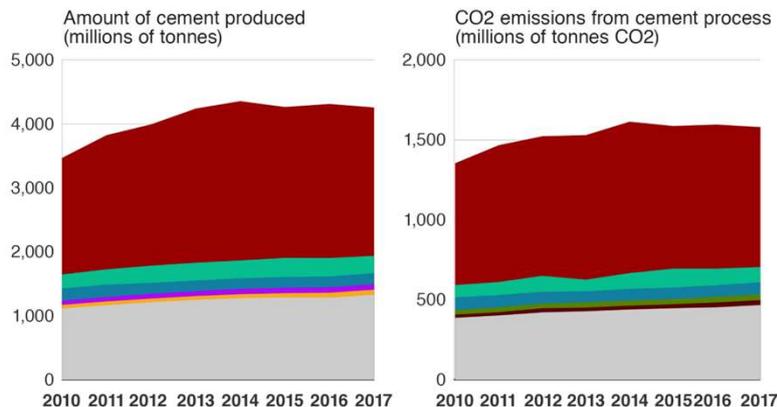
- Demand for concrete is set to **increase in next decade...**
- To keep to 1.5°C warming, **the economy needs to be carbon neutral by 2050**



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# Global cement production

- China
- India
- EU
- US
- Vietnam
- Turkey
- Egypt
- Other countries



Source: PBL Netherlands Environmental Assessment Agency

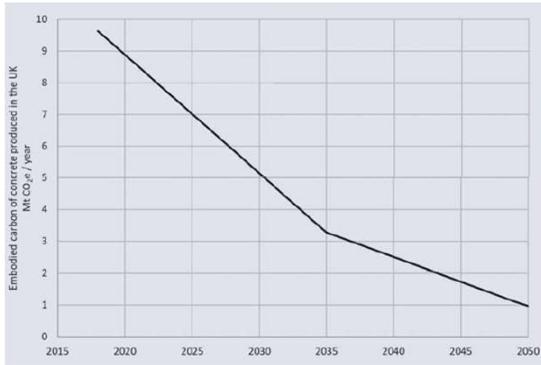
BBC

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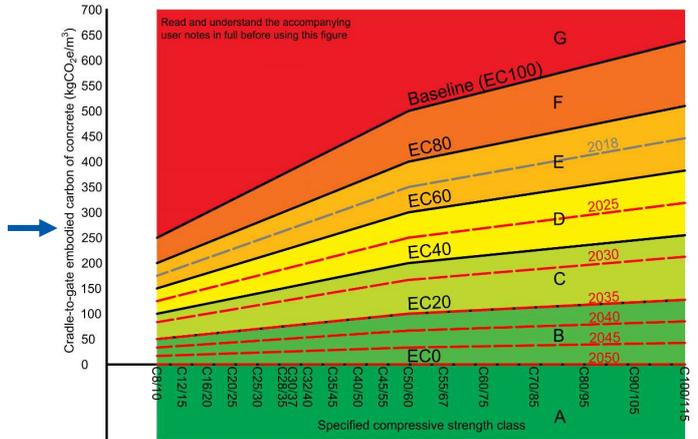
# A localised view

UK concrete & industrial decarbonisation

HM Government Industrial Decarbonisation Pathway



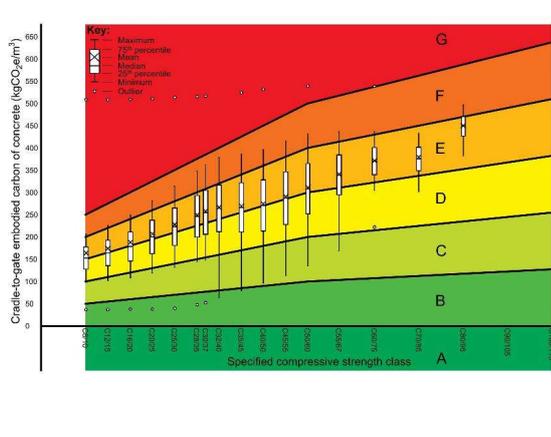
Kanavaris & Martin, Concrete, 2025



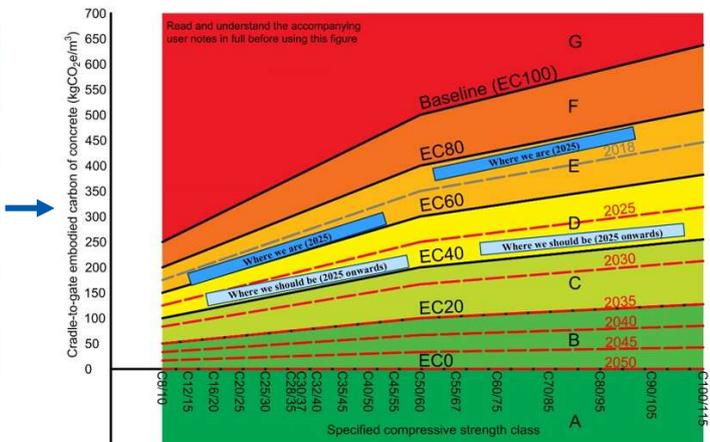
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# UK concrete decarbonisation progress

UK concrete & industrial decarbonisation



Kanavaris, Concrete, 2026



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# Approaches & Opportunities

## Reducing the embodied carbon of concrete

- **Partial replacement and reduction of Portland cement**
  - *Supplementary cementitious materials*
  - *Performance improvers – e.g., graphene?*
- **Total replacement of Portland cement**
  - *Alkali-activated materials*
  - *Use of alternative cements, e.g., Magnesium based*
- **Use carbon sequestering technologies**
  - *Carbon negative “binders”-cements*
  - *Carbon negative aggregates; biochar*

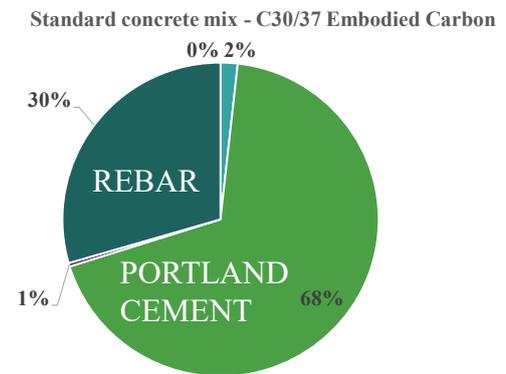
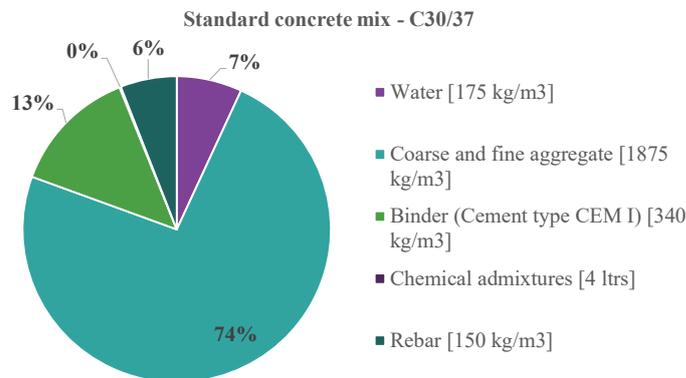


*Even more special technologies exist - all cannot be covered*

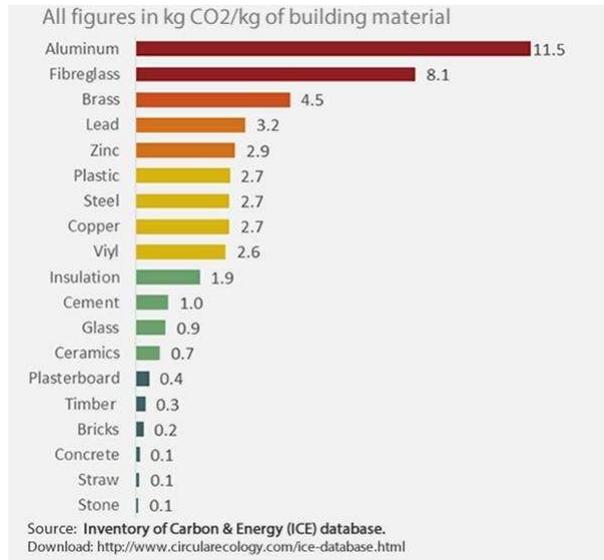
*Around ~150 startups on cement/concrete technology... 10% will survive*

# CO<sub>2</sub> emissions related to concrete

## Concrete carbon dioxide emissions breakdown

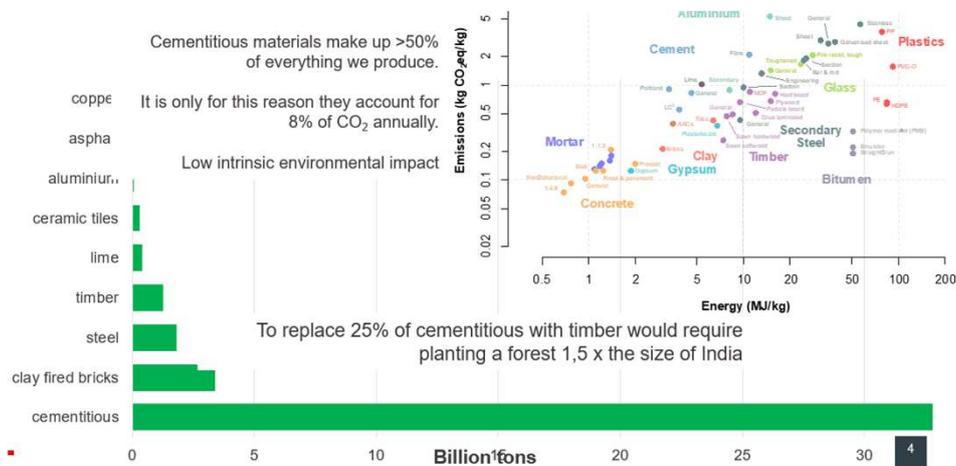


# Embodied carbon of construction materials



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# Total consumption of materials



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# Availability of SCMs

**Diminishing availability of traditionally used SCMs**

**The efficient use of GGBS in reducing global emissions**

An appraisal of the global availability of ground granulated blast furnace slag

Draft for presentation to ConcreteZero members

Material	Used in cement	Reserve
Clays (with potential for calcination)	~4500	~4500
Rice husk ash	~100	~100
Silica fume	~100	~100
Burnt shale	~100	~100
Natural pozzolana	~100	~100
Blast furnace slag	~200	~200
Fly ash	~500	~1000
Cement	~3800	~3800
Limestone	~4500	~4500

Figures from ~2013

Legend: ■ Used in cement, ■ Reserve

Note: Fly ash: significant volumes with low performance

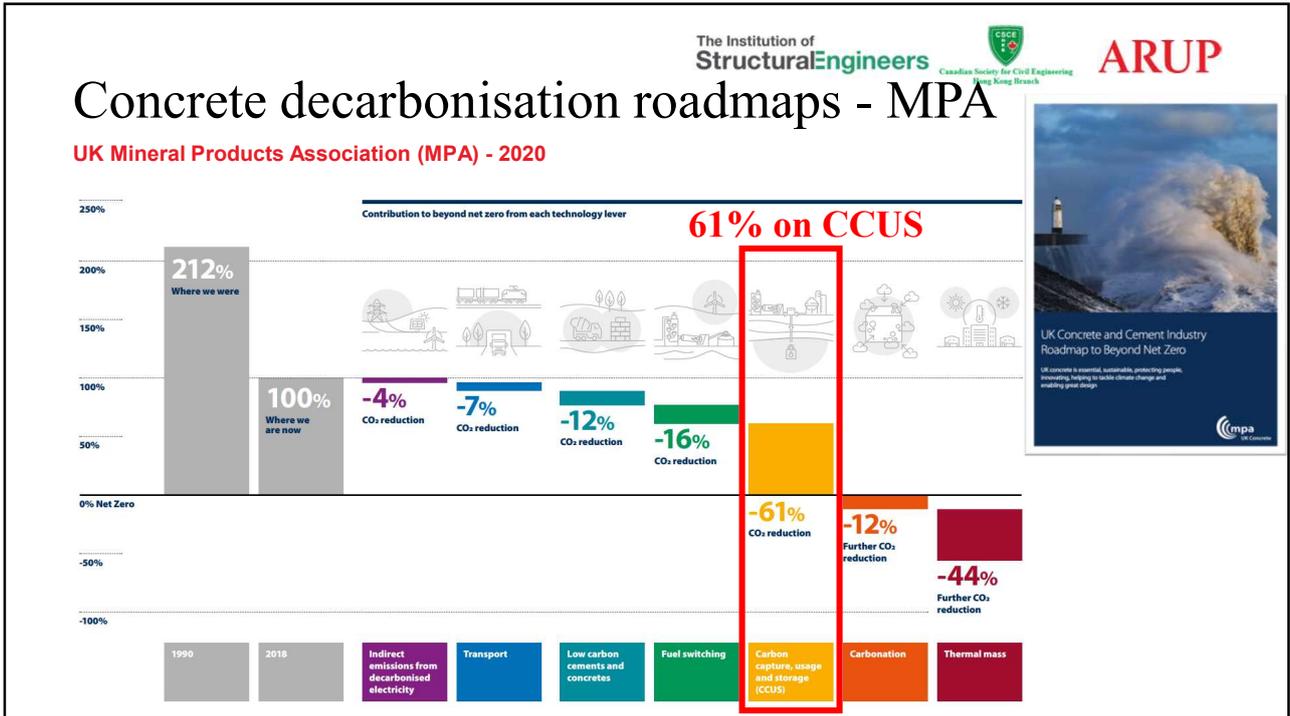
Source: Scrivener et al. Calcined clay limestone cements (LC3), CCR, Volume 114, December 2018, Pages 49-56

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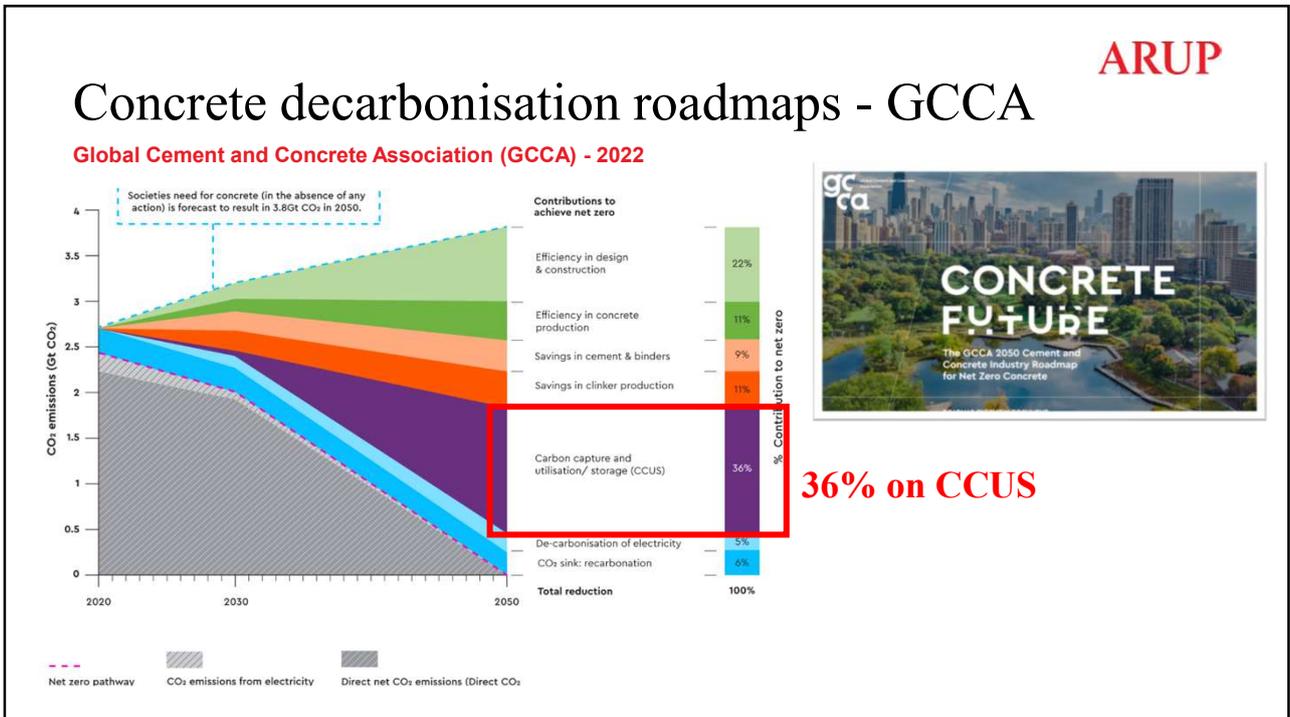
# Leading calcined clay innovation

**Using calcined clay from waste clay in the UK**

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# Concrete decarbonisation roadmaps - CEMBUREAU

**European Cement Association -**

Year	Emissions (kg CO <sub>2</sub> /t of cement)	Key Contributions
1990	783	2017 emissions: -116
2050	0	CCS/CCU: -290 (36% on CCUS)

## Cementing the European Green Deal

REACHING CLIMATE NEUTRALITY ALONG THE CEMENT AND CONCRETE VALUE CHAIN BY 2050

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# Carbon Capture (Utilisation) and Storage

Effective but expensive!

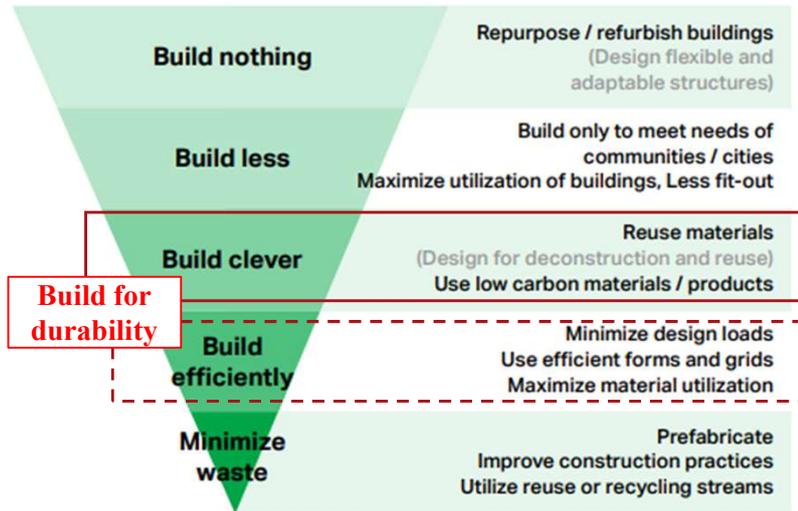
Brevik CCS Mechanical Complete

- More investments and plants will come online
- High CAPEX and OPEX
- Increase \$\$\$ of cement x3

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# Carbon hierarchy

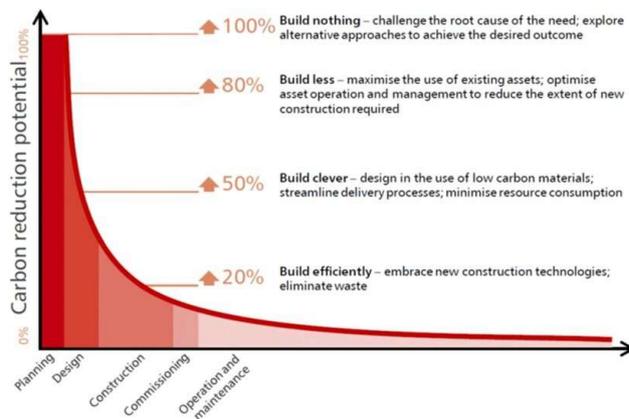
Build clever & efficiently



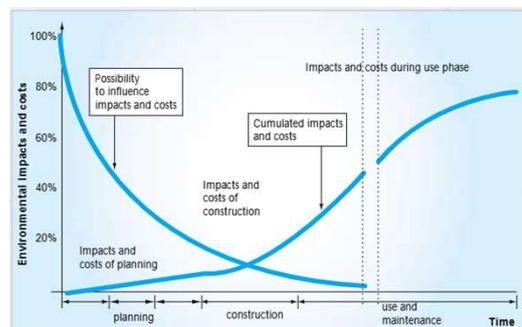
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# PAS2080

Carbon management in infrastructure

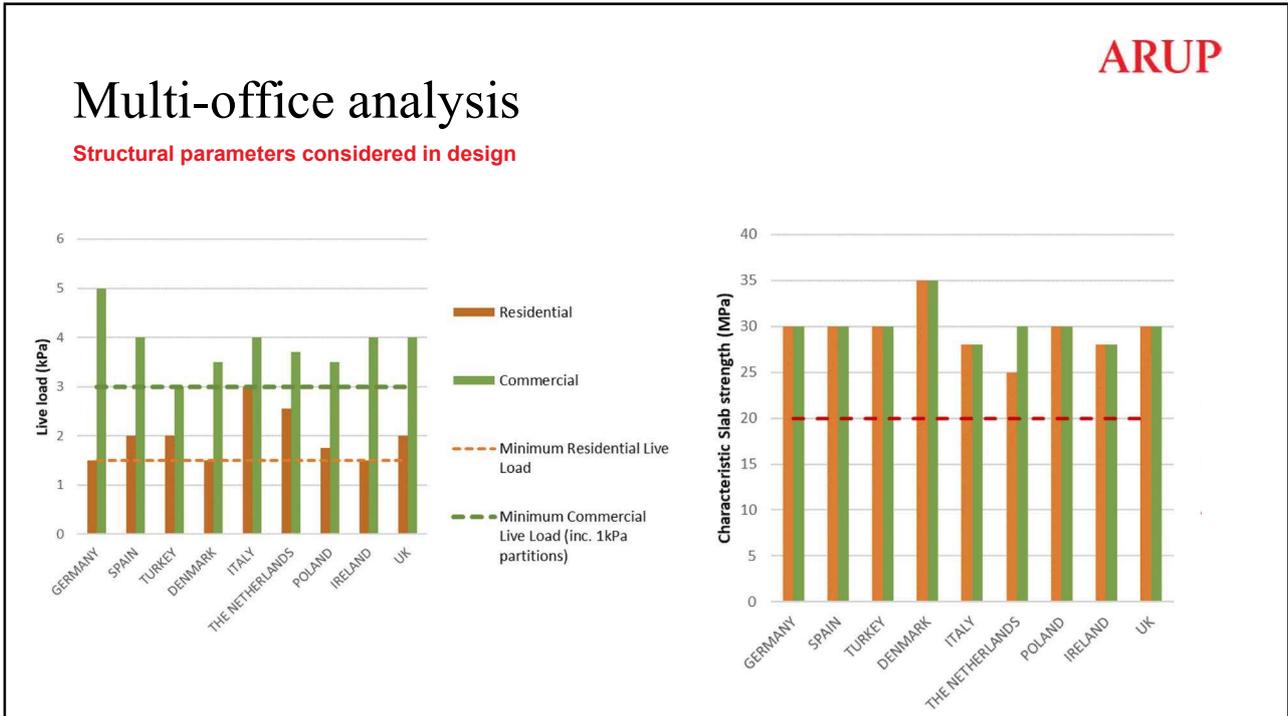


Infrastructure Carbon Review, HM Treasury 2013

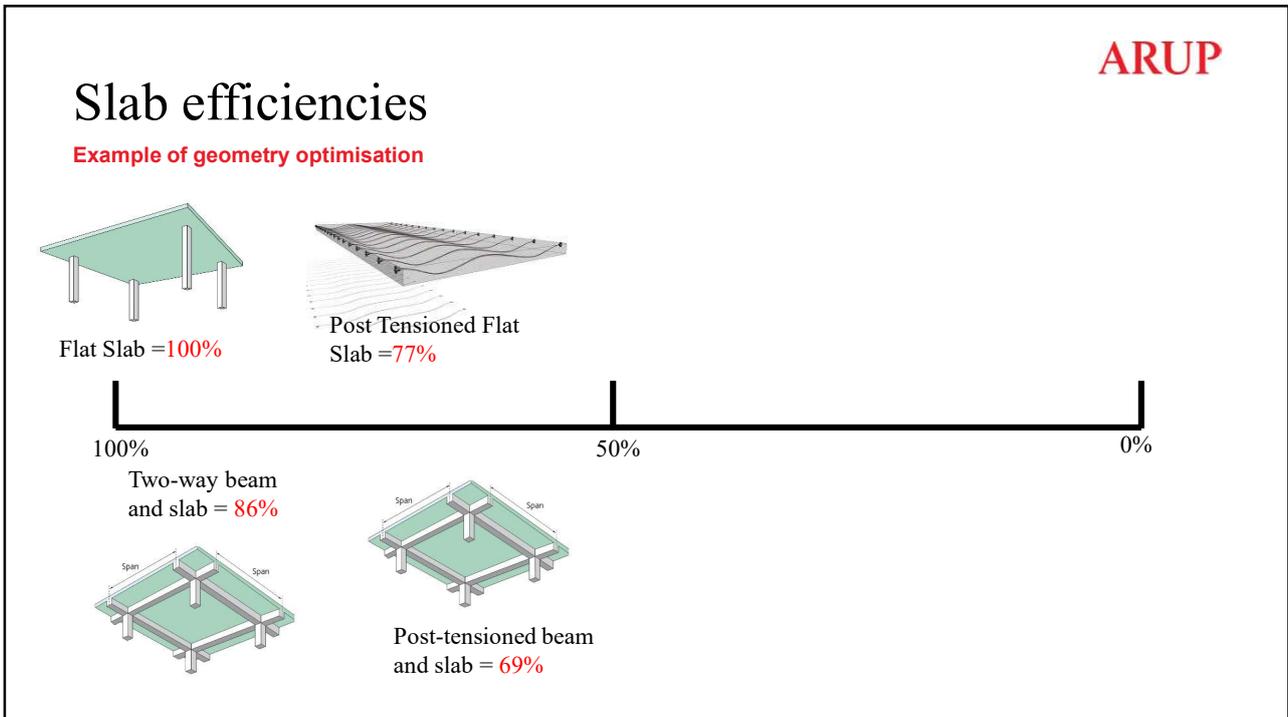


Life-cycle analysis of the built environment  
N Kohler, S Moffatt  
Industry and environment 26 (2), 17-21

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# Waffle slabs

Materials efficiency



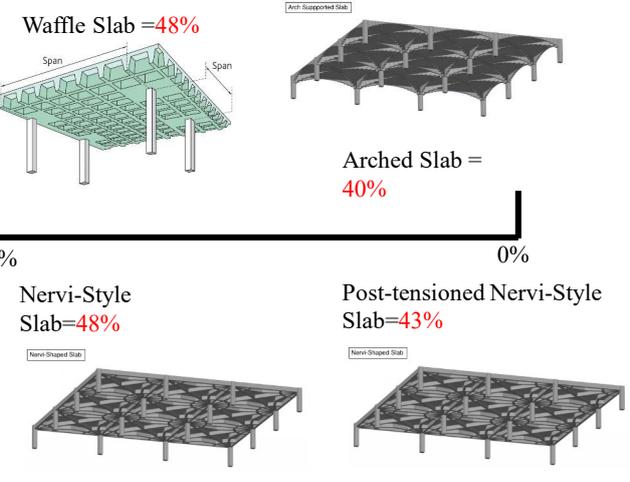
Advanced Materials for Sustainable Infrastructure Development  
Gordon Research Conference  
ARUP

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# Slab efficiencies

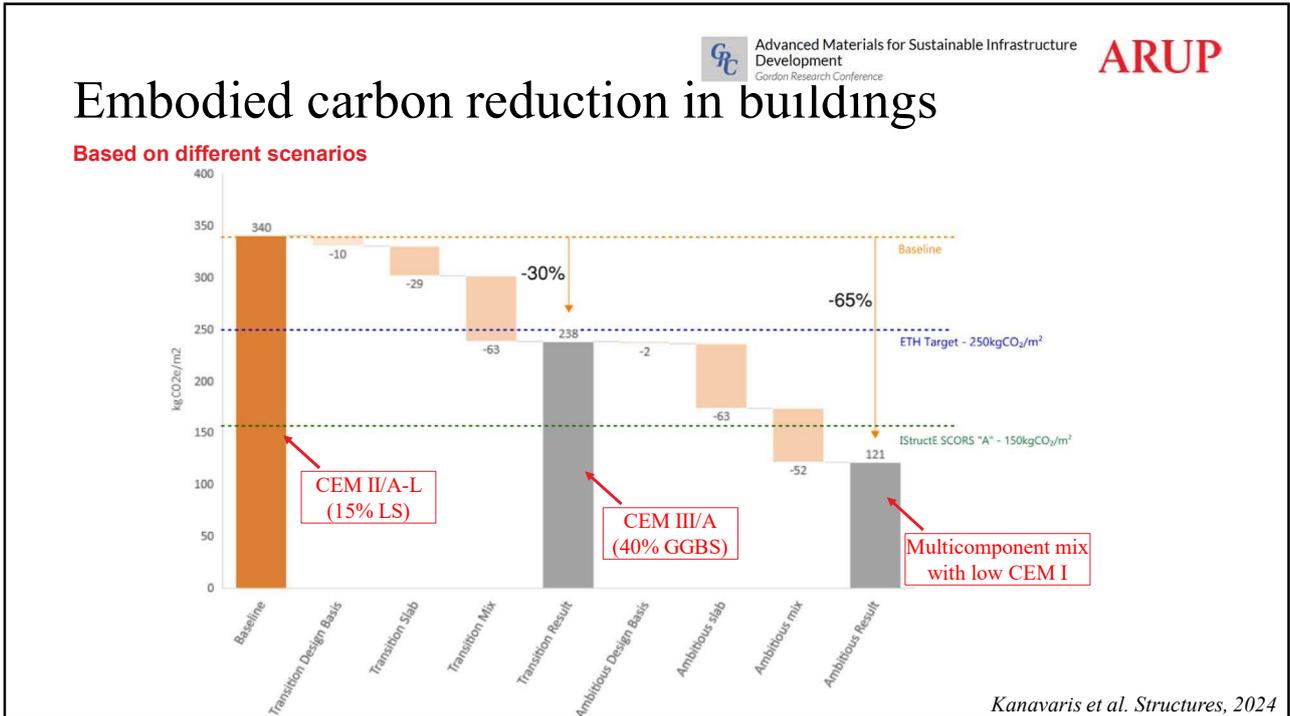
Example of geometry optimisation

CEMBUREAU The European Cement Association | The Institution of Structural Engineers | ARUP

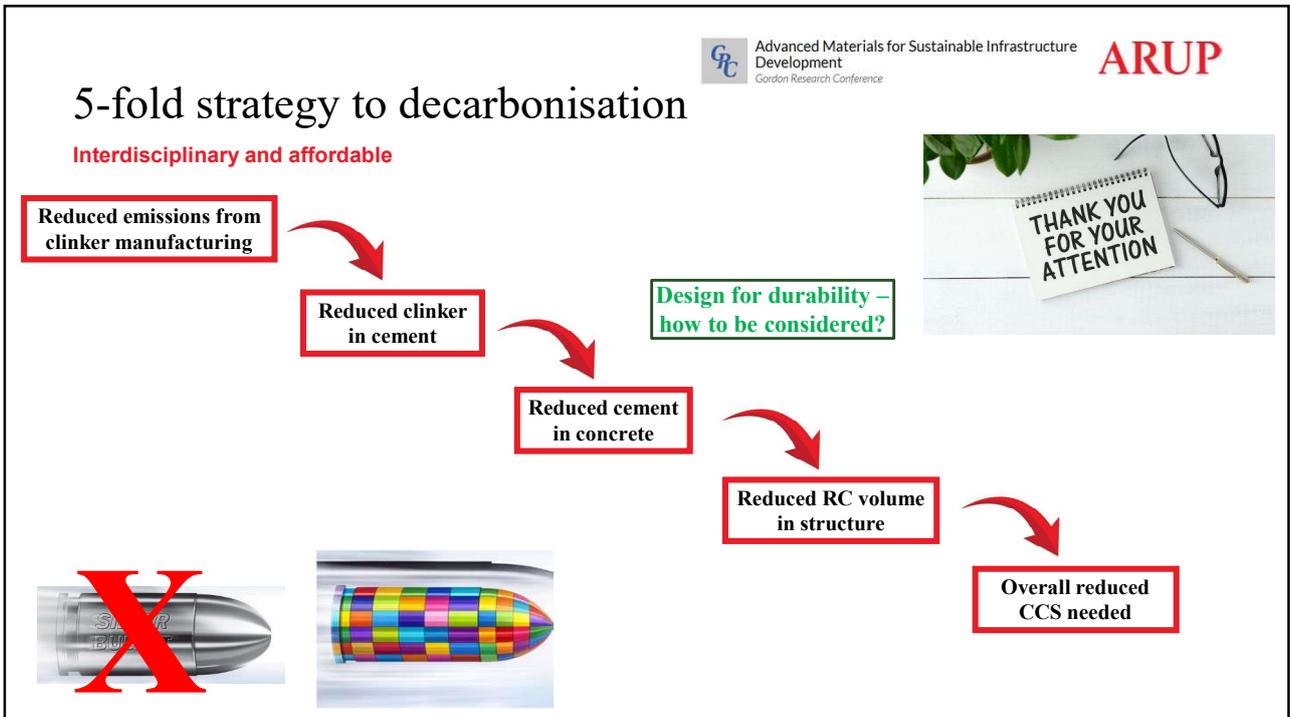


and slab = 69%

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