Absolute Zero: challenges and opportunities in construction

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London, March 2020

Outline

Emissions in context

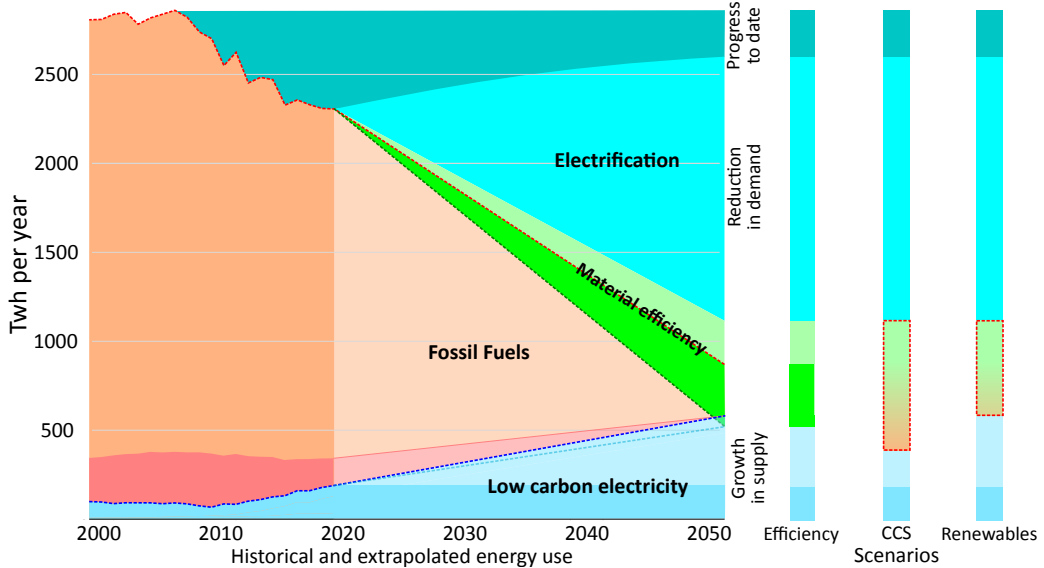
Material Utilisation in Construction

Role of the Layout

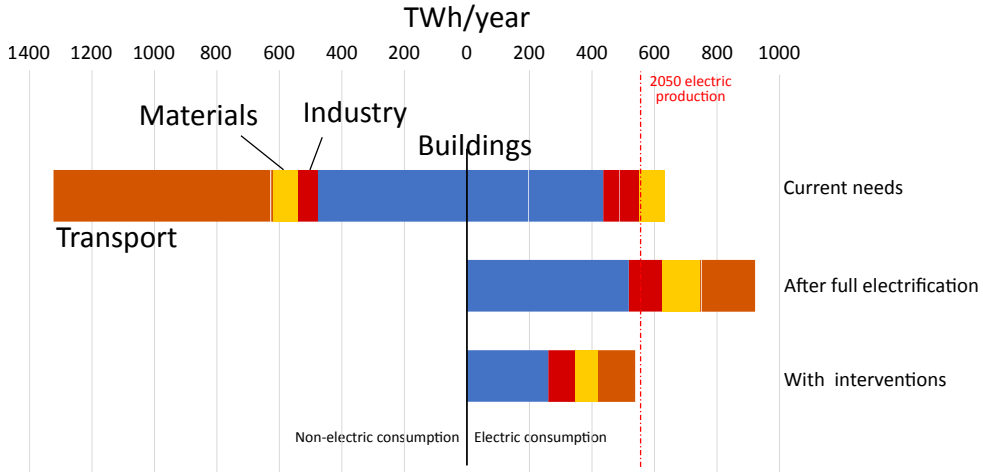
Better buildings design?

Emissions in context

The big picture



The energy budget



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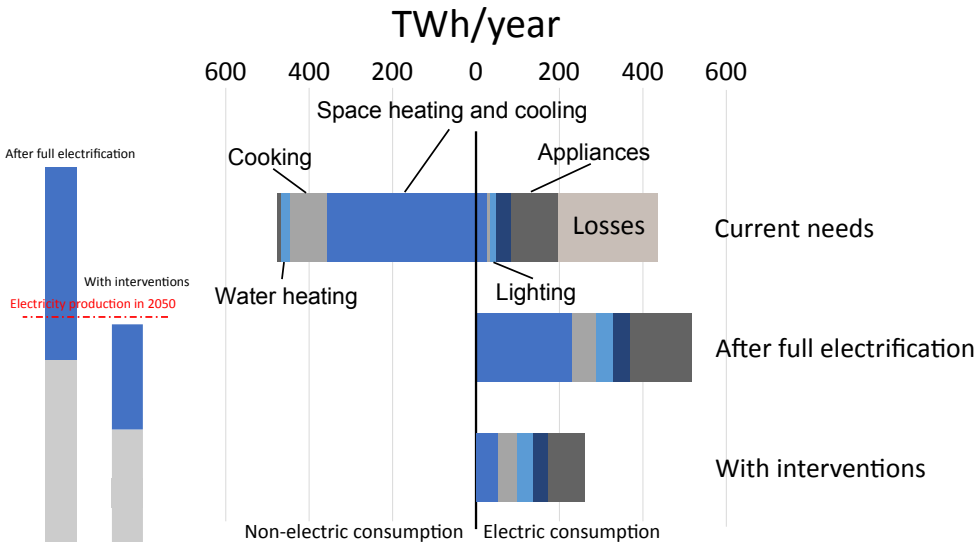
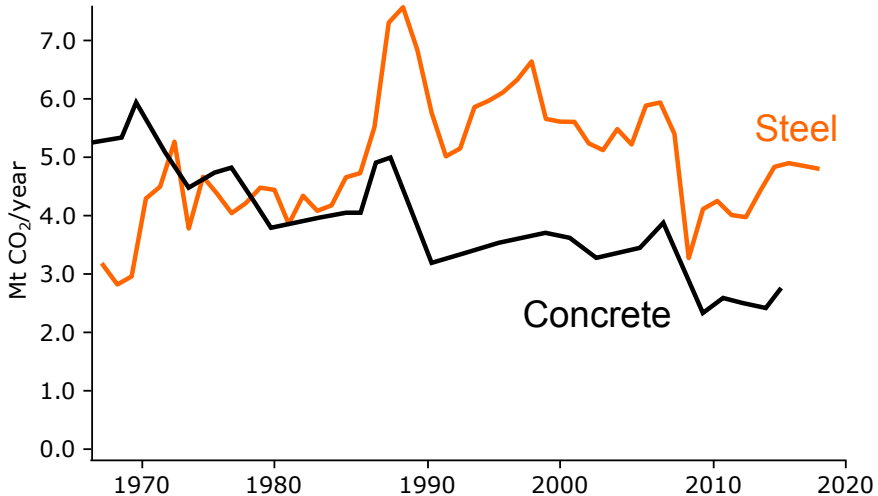
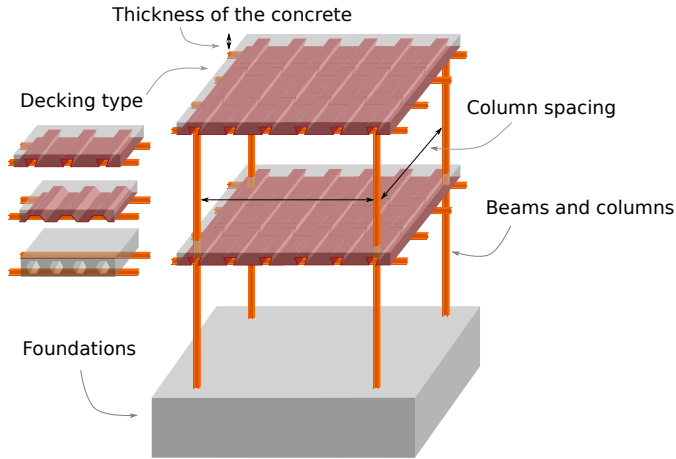


Process emissions — steel and cement scaled by CO_2



Decisions, decisions. . .

- Overall layout
- Grid spacing
- floor heights
- Serviceability
- Loads
- Type of frame
- Type of decking
- . . .

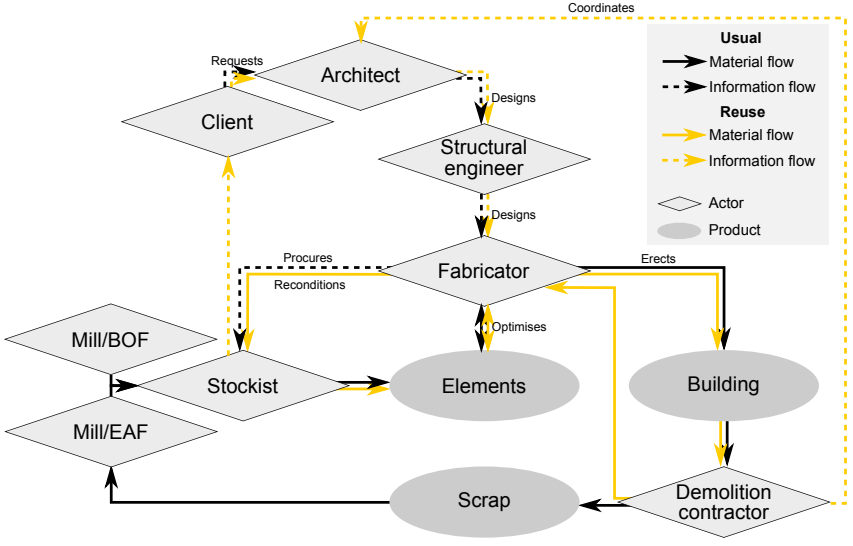


Value, Costs, Programmes

- Developers value flexible space
- Architects look at function and æstethics
- General contractors will take the project and coordinate actors
- Structural designers look at structural solutions and construction details
- Other contractors will finish the details and do the actual construction

As you go down that list, consideration of value gives place to consideration of costs

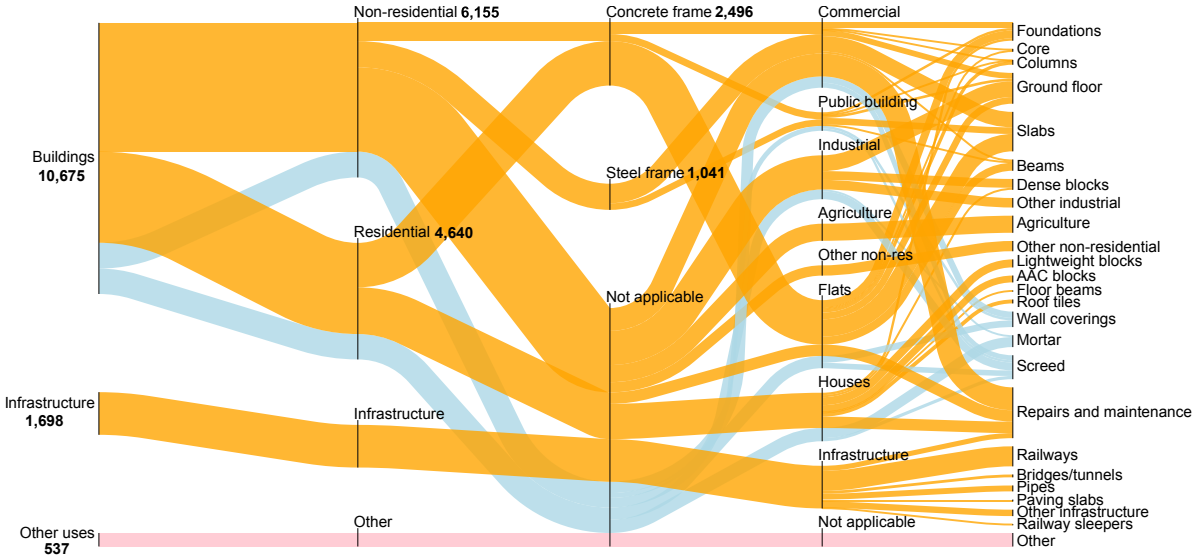
Coordination — steel reuse as an example



Material Utilisation in Construction

1. MC Moynihan, JM Allwood — Proceedings of the Royal Society A, 2014
2. CF Dunant *et al.* — Resources Conservation and Recycling, 2018
3. W Shanks *et al.*— Resources Conservation and Recycling, 2019

Where cement (and steel) goes

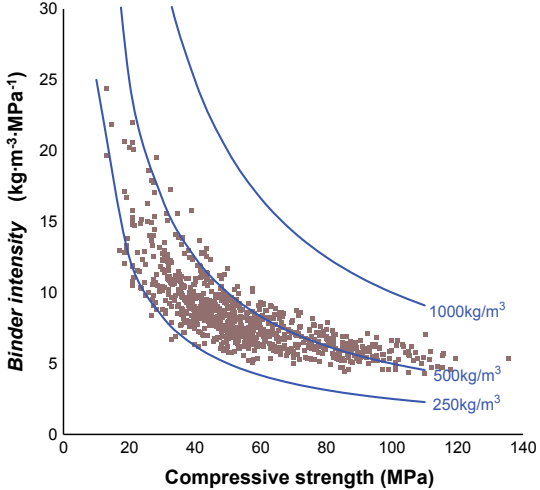


Better concrete?

- Concrete strength depends on
  1. Cement composition
  2. Water/cement Ratio
  3. Aggregate PSD
- $\frac{w}{c}$ can be lowered using admixtures
- Using an 'optimal' PSD

$$f_c = 24.6 f_{\text{cem}} \left(\frac{c}{w} - 0.5 \right)$$

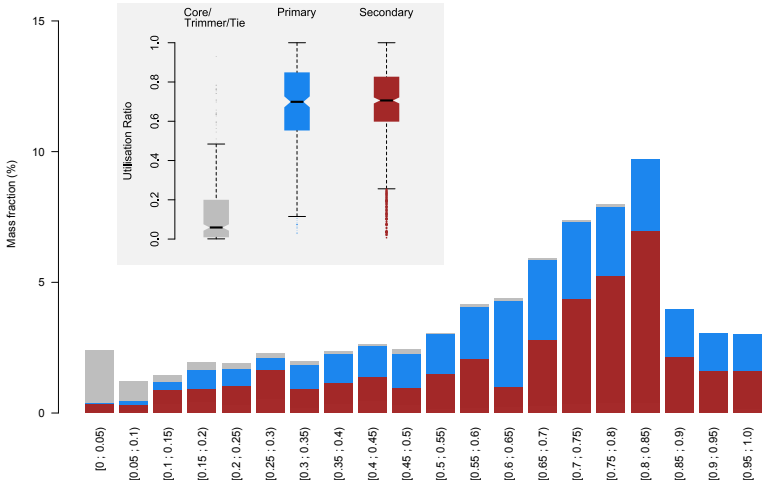
- 'Optimal' PSDs from approx. 4 aggregate classes. Commonly, 2 used



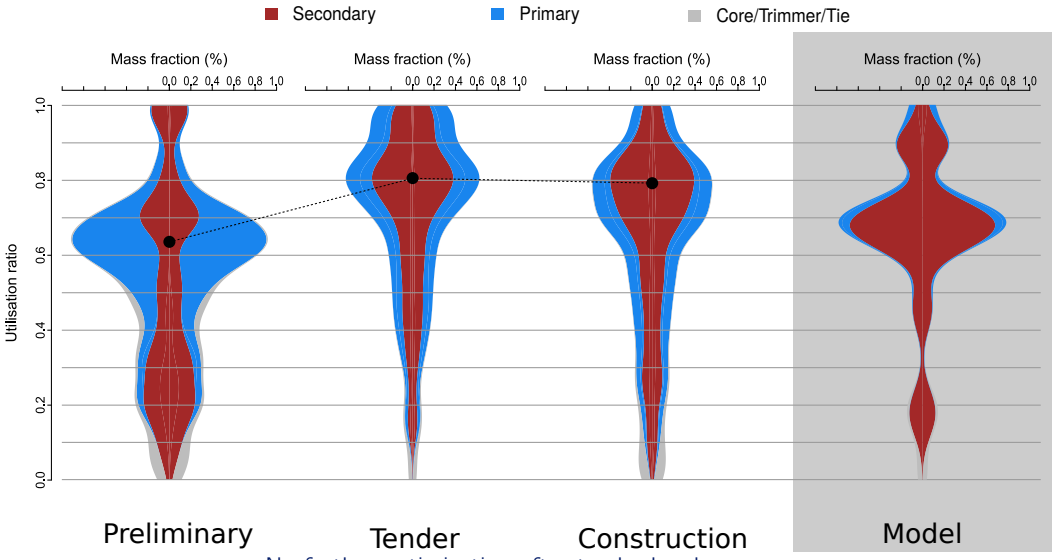
1. BL Damineli *et al.Cement & Concrete Composites*, 2010
2. J Bolomey, *Travaux*, 1935

Steel Utilisation

- Drop-off for UR > 0.8
- Long tail suggests important role of spans
- Cores/Trimmers/Ties?

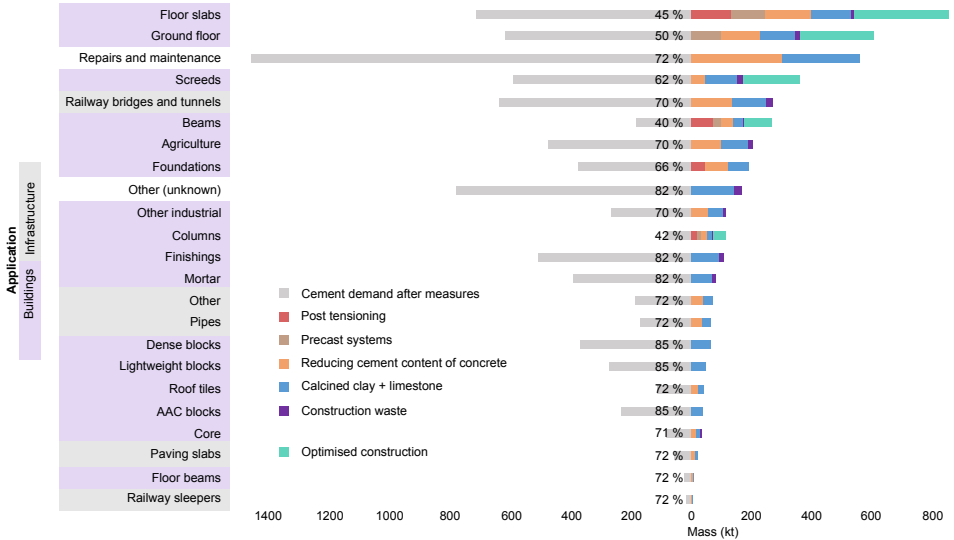


The optimisation process



No further optimisation after tender has been won

Options for material saving



Optimising construction only a partial solution

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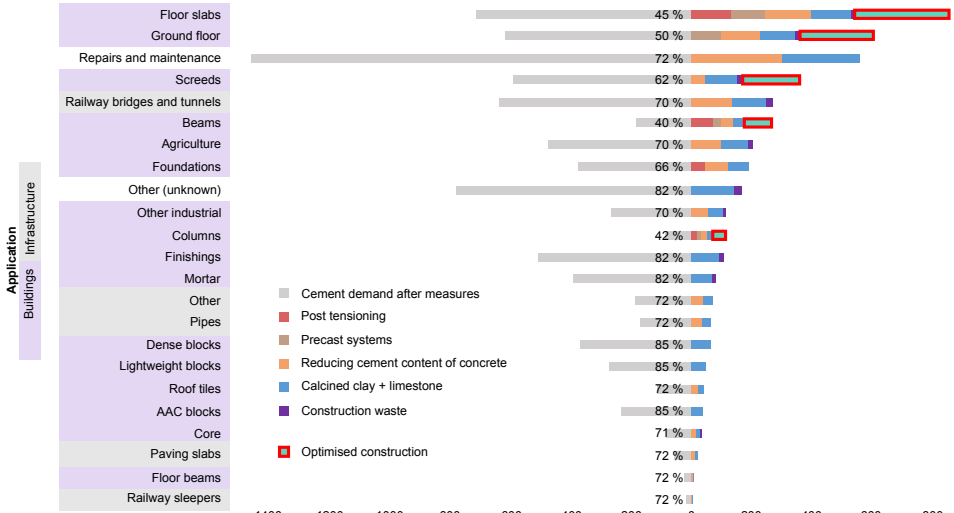
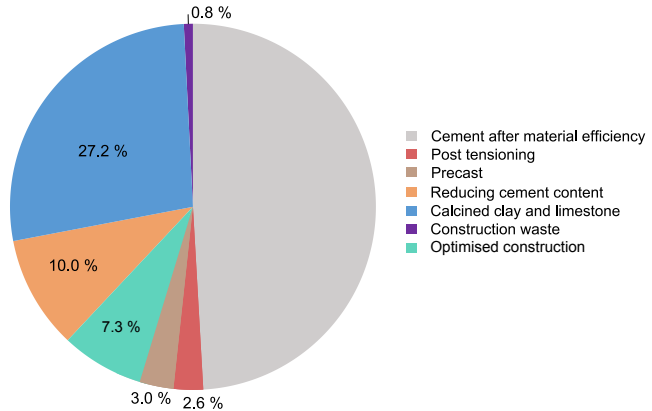


Optimising construction only a partial solution

Design is the first thing to improve

- Cement is a modern material, still not used optimally
- Substitution on a large-scale would need a transformation of the supply chain
- Better design can bring gains immediately



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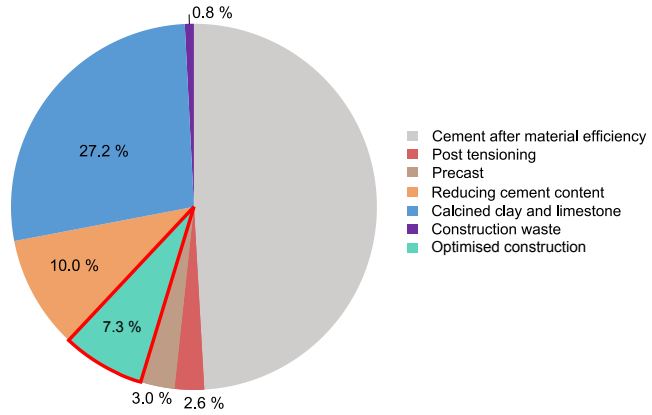
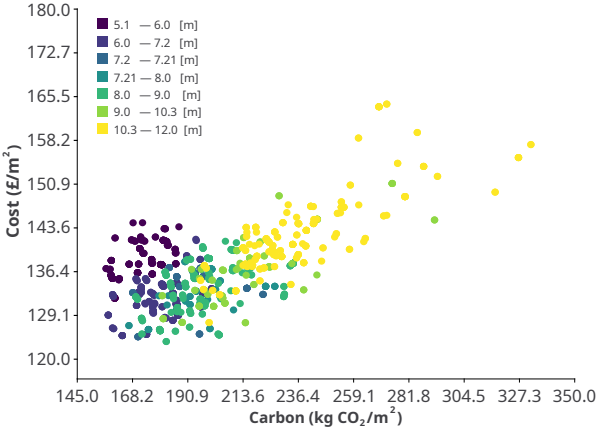
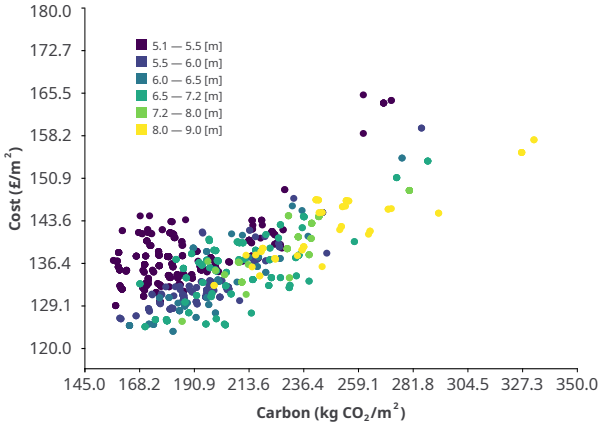


Role of the Layout

Choosing a grid



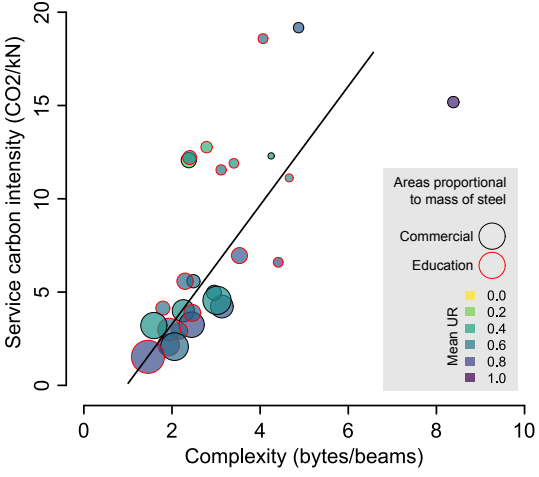
Max column spacing

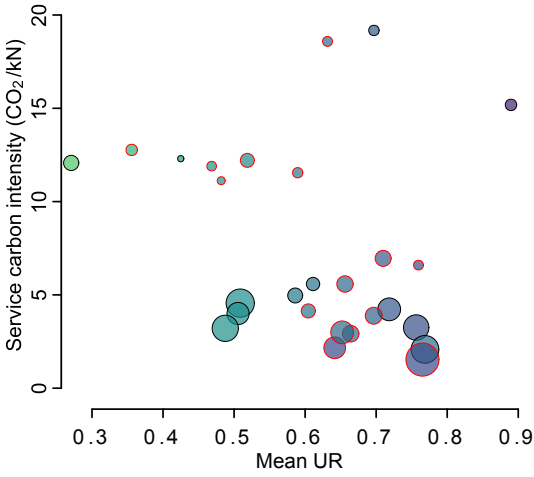


Min column spacing

Grid choice can double carbon for only 30% more cost

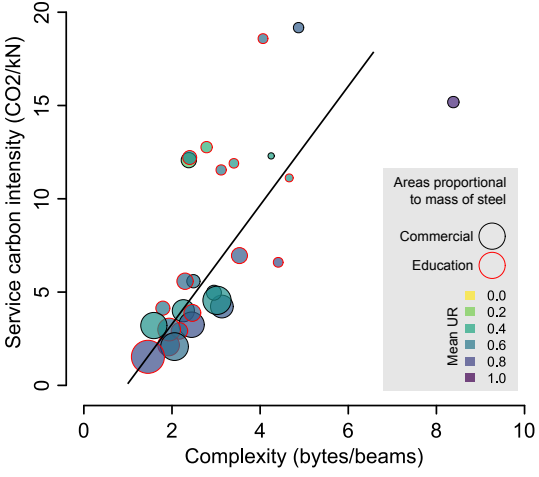
Optimisation and complex layouts

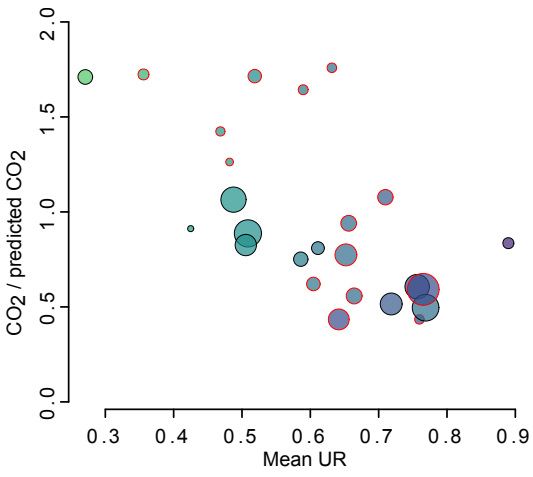




Extra CO_2: optimisation $\frac{1}{3}$, design $\frac{2}{3}$

Optimisation and complex layouts

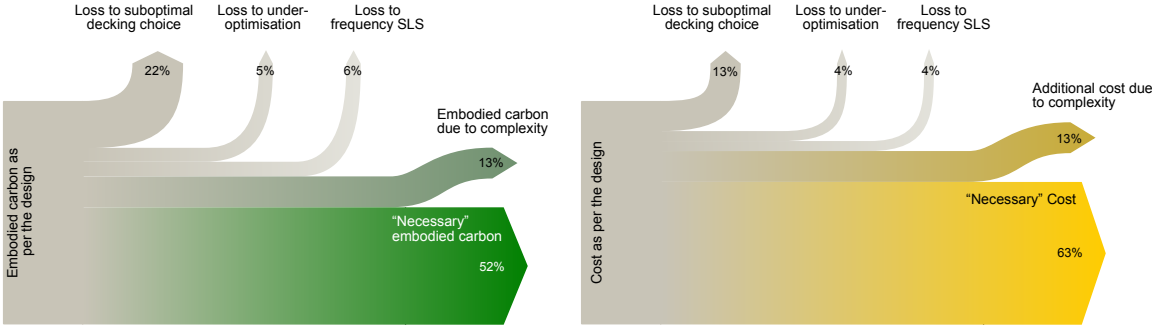




Extra CO_2: optimisation $\frac{1}{3}$, design $\frac{2}{3}$

Choosing the decking

- Deckings are not optimal (it's the best you can do, picking 1 of 2000 options)
- The carbon impact is similar to the choice of the grid
- The choice is made early and typically not revised.



Changes in designs can save both money and embodied CO_2

Better buildings design?

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- 5-10% of extra embodied carbon due to under-optimisation

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- The same things are likely true for initial massing choices
- Poor planning/craftsmanship causes the same thing in cement mix design

Thank you

Special thanks to:

PRICE & MYERS

And to all the Use Less Group and Resource Efficiency Collective