

Design optimisation and impact assessment at early stage design

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Outline

Introduction

Model construction

Validation and scenarios

Conclusion

Introduction

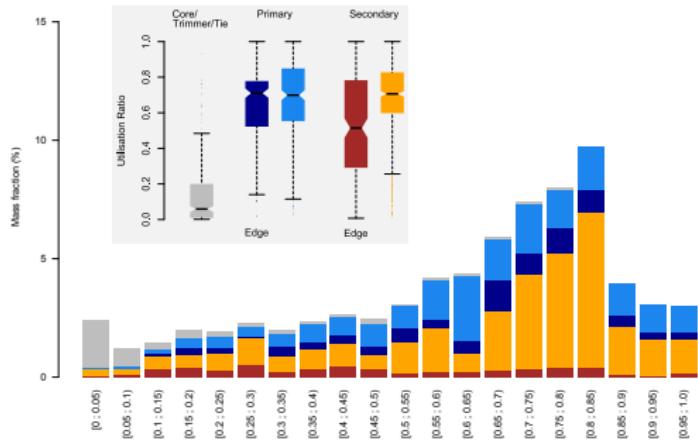
The project

- Article by Moynihan and Allwood suggests beams overdesign
- Questions raised:
 - Analysis correct?
 - Representative?
 - If true, what are the causes?
- Innovate UK project to provide answers and develop better design strategies

1. MC Moynihan, JM Allwood — Proc. R. Soc. A, 2014
2. CF Dunant et al — Res Conc Rec, 2018

Background

- UR studies show that in general, the choice of beams is not optimal
- This is likely due to defensive design



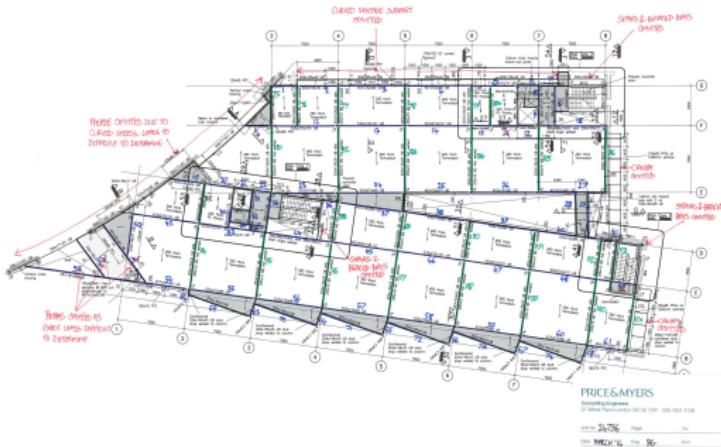
Key Question

- What explains the UR distribution?
- Is optimisation an important factor in building mass?

What makes a building heavy?

CASE STUDY 3

- Overall design
- Choice of decking
- Detailing

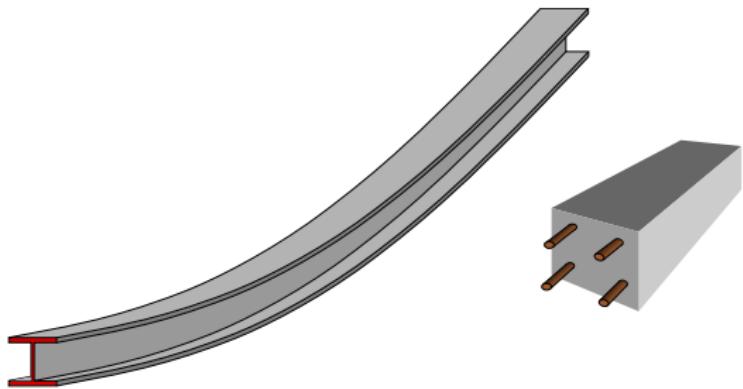


How important are each one?

- How can we measure design?
- How can we measure optimisation?
- How wide is the solution space for detailing?

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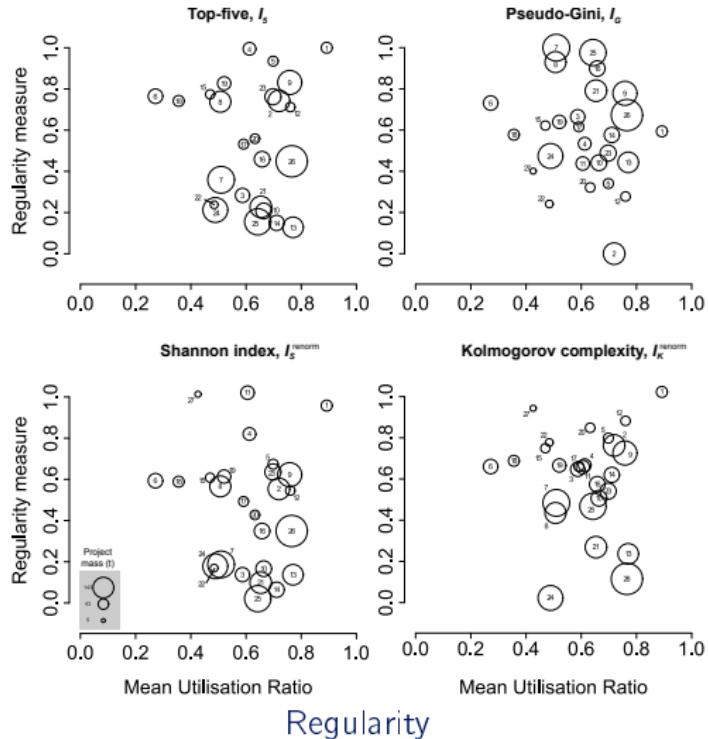
Measuring design

■ Design

- Regularity
- Complexity

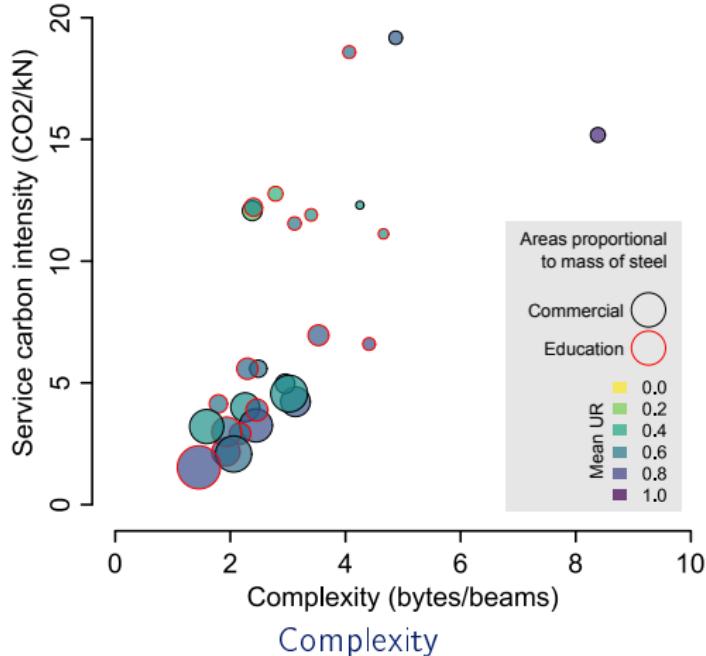
■ Service/externalities

- Service: load
- Externality: CO_2



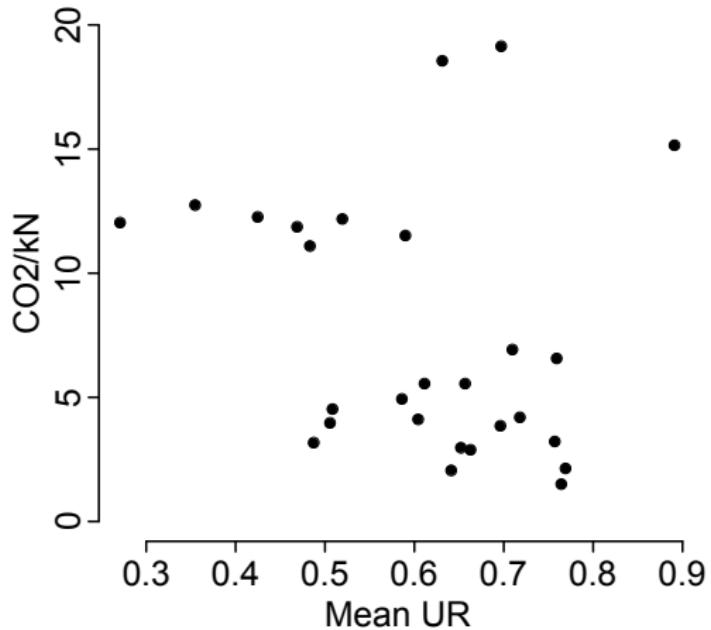
Measuring design

- Design
 - Regularity
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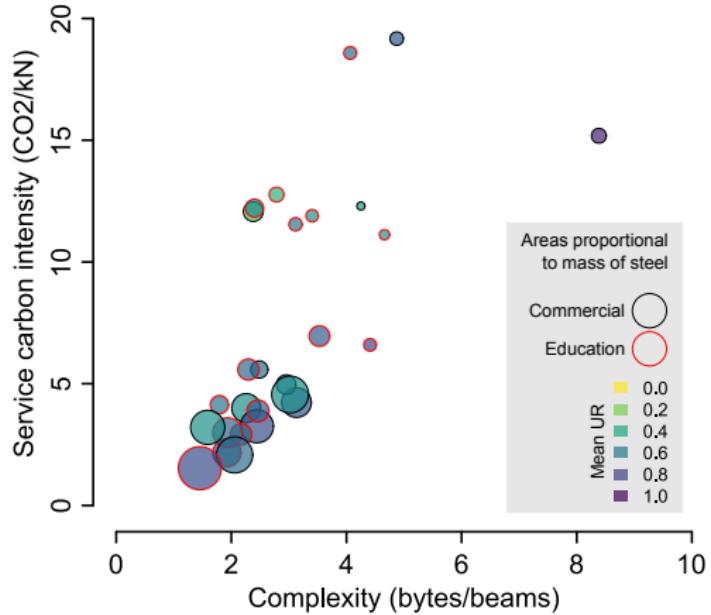
Optimisation is not so important

- Optimised buildings
≈25 % lighter



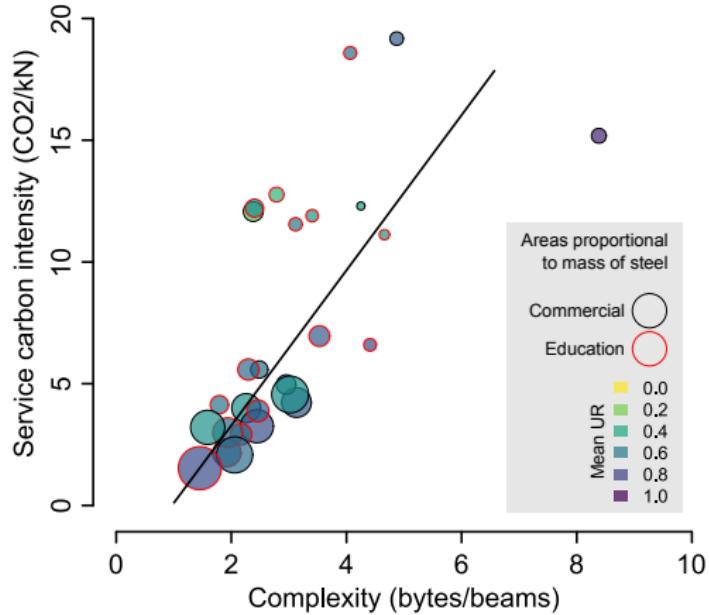
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- Complex buildings
≈100 % more CO₂



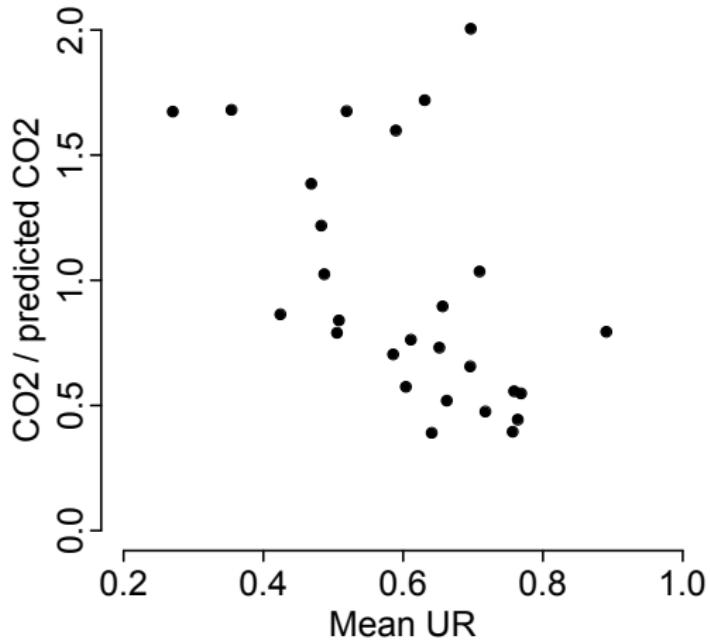
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- Complex buildings
≈100 % more CO₂
- **Extra carbon:
optimisation 1/3,
design 2/3**



Why is design complexity linked to mass?

- Intrinsically heavier?
- Harder to optimise?
- Harder to *design*?

Need for a model

It is difficult to answer such questions without a model of design

Summary of questions

- What explains the distribution of UR?
- Are complex buildings intrinsically heavier?
- How difficult is optimisation?

Two purposes for model

A model which can *answer these questions* can also be used to *guide design*

Model construction

What the model is not

- An automatic design tool
- A topology optimising tool

Why not?

There are plenty of tools that do that, and (that I know) are not used in the industry, because they do not mesh with the process of design.

What the model is

- A benchmark generator
- A 'suggestion engine'
- A patterning tool

The model should answer the questions:

- How light could I make my structure in principle?
- With which technology?

- Produce a *distribution* of bays which matches overall design requirements
- Place ‘Corners’, ‘Sides’, and ‘Bulk’
- Design individual bays
- Load from adjacent bays guessed from assuming an ‘average’ adjacent bay

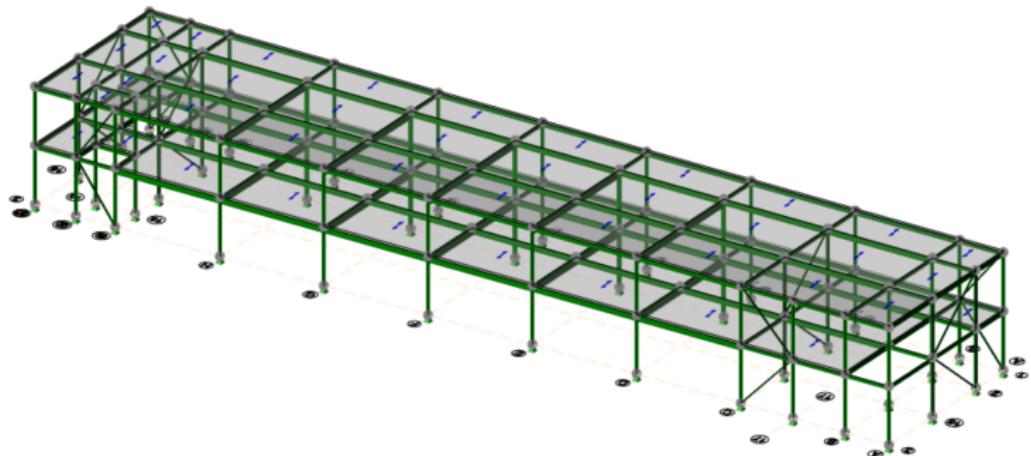
- Generate a potential solution, test all decking types
- Cheapest/lower CO₂ retained
- This means:
 - Precast design based on span and load tables
 - Composite design based on span and load tables
 - All beam sections
 - All profile types
 - If plate girders are used all possible geometries within 20 % of the appropriate UB are tested

- The model will return cheapest and less carbon intensive options which match EC3 constraints

Validation and scenarios

Validating Results

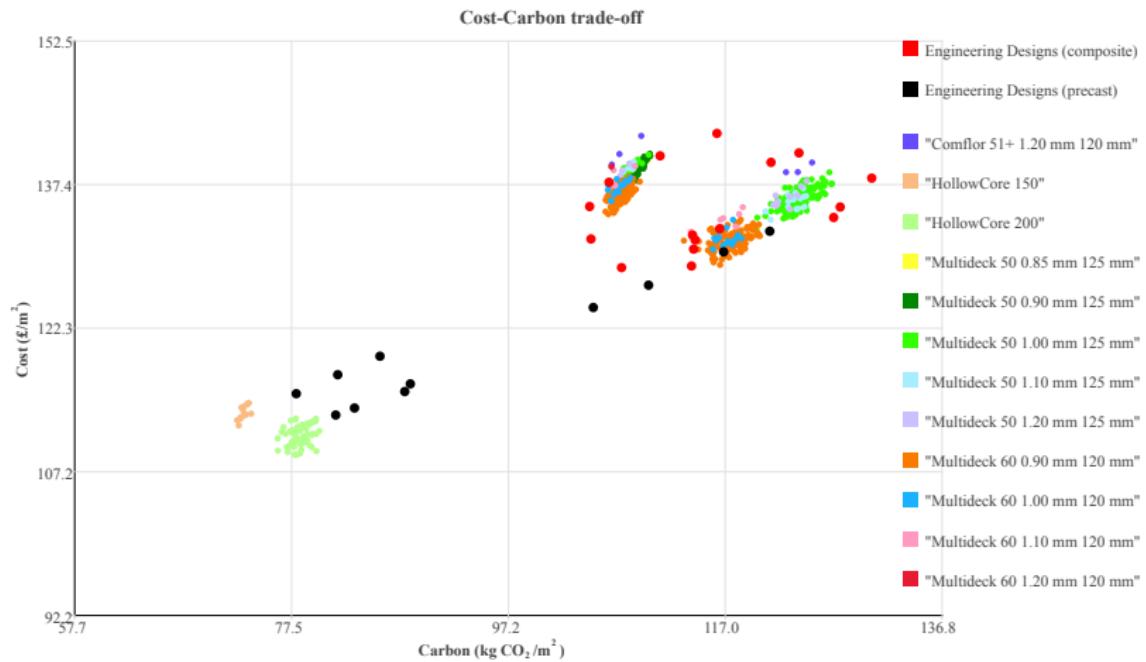
Design scheme



Compare engineer's designs with generated patterns

Validating Results

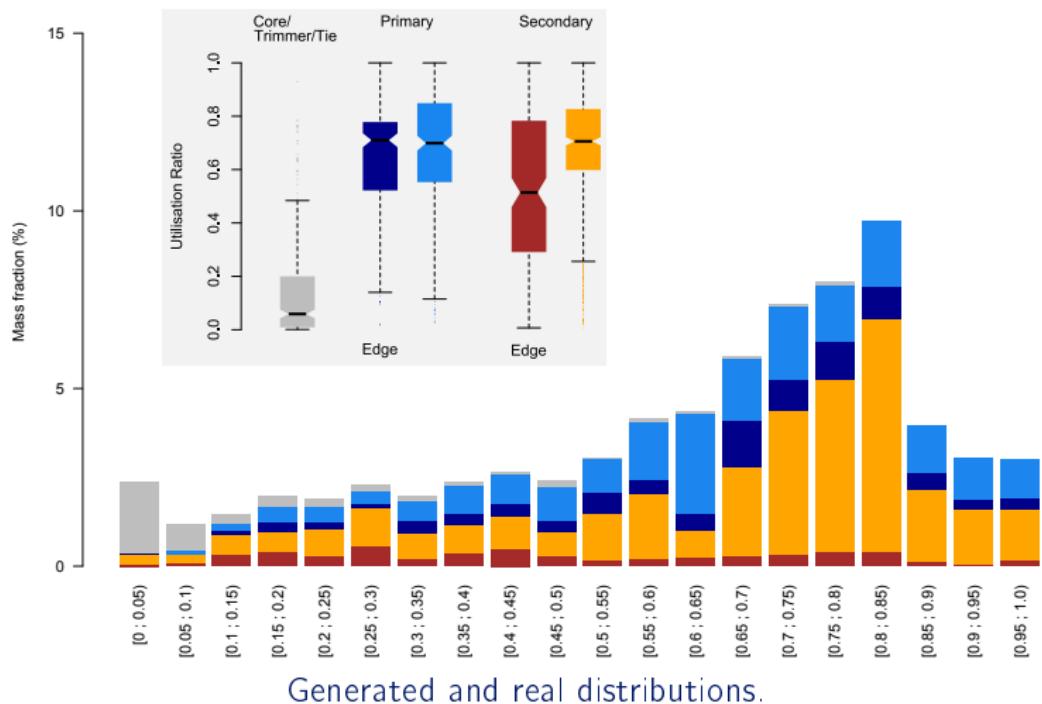
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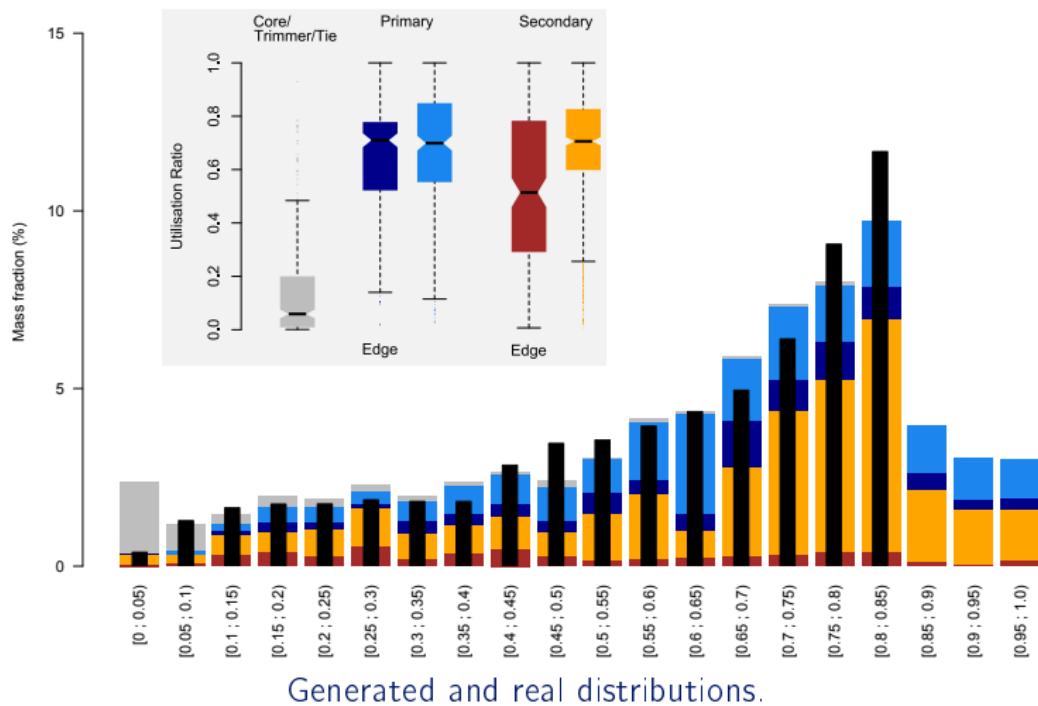
Validating Results

Utilisation Ratios distribution



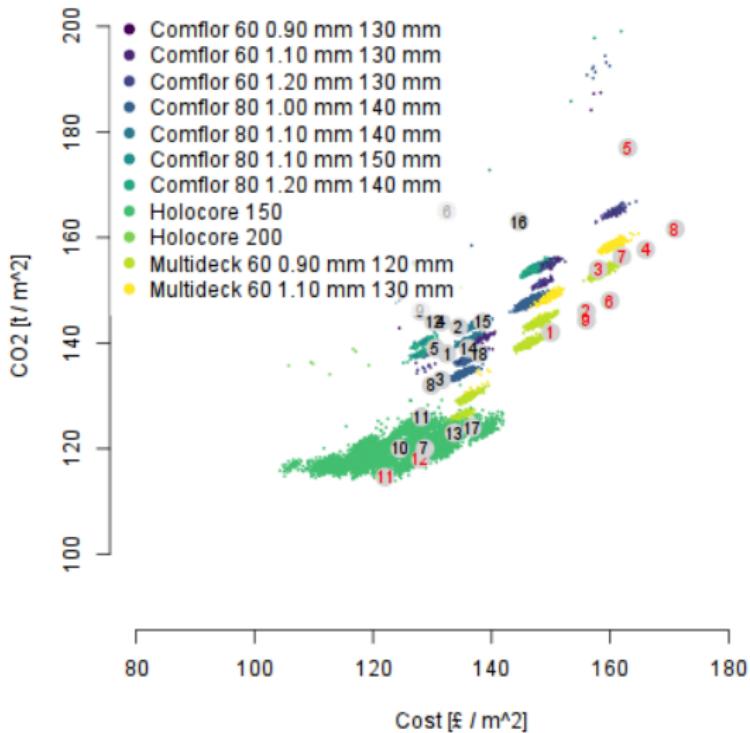
Validating Results

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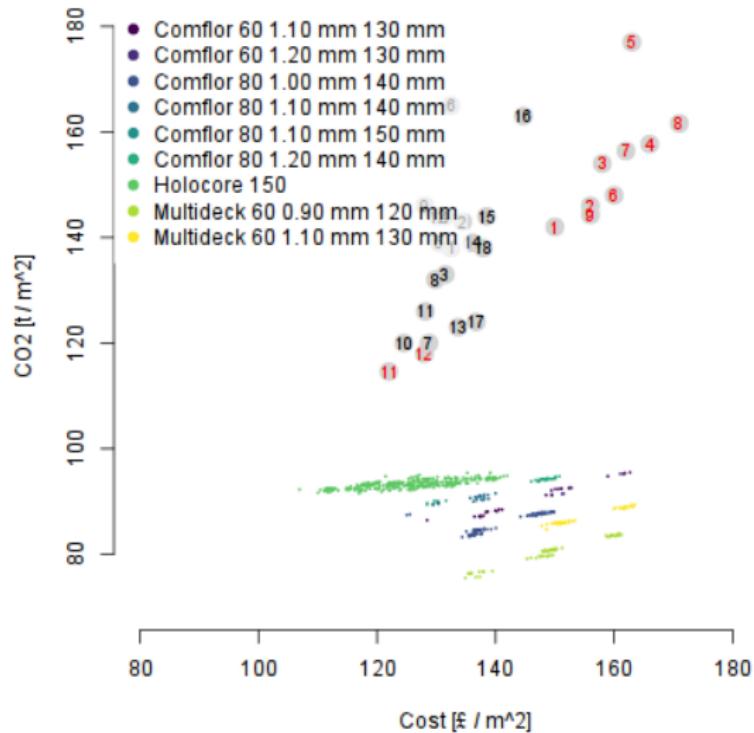
Exploring Scenarios

■ Baseline



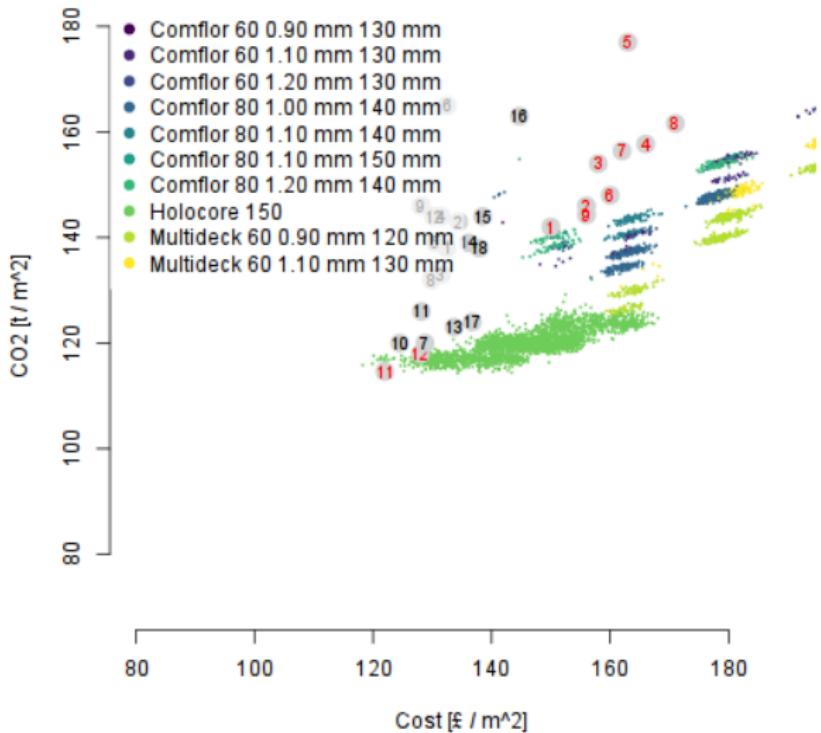
Exploring Scenarios

- Baseline
- Recycled steel



Exploring Scenarios

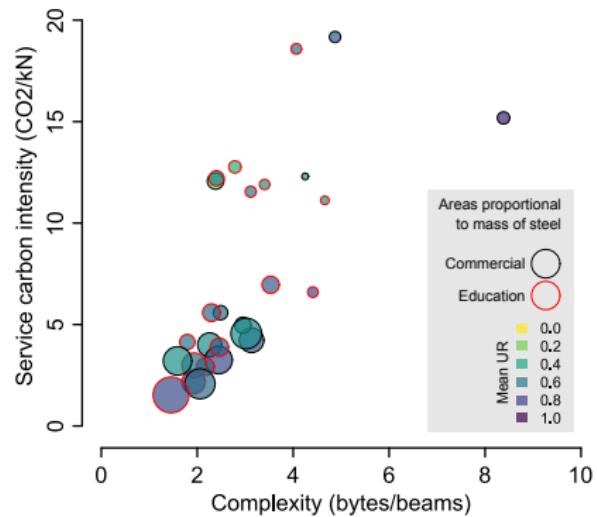
- Baseline
- Recycled steel
- Labour costs



Conclusions

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- Not automated design
- Should help scheme
- Should enable discussions
- Automated *benchmark*



Thank you

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