REBUILD - Regenerative Buildings and Construction systems for a circular economy

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REBUILD

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• Exeter, Manchester and Bradford
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Introduction

• A vision for a circular economy model of the construction industry
• Decoupling resource consumption from the construction industry by encouraging material reuse
• Focus on bricks, steel and concrete
• Challenges of reusing these materials

❖ This presentation: Stage 1 of the project
1. Assessment of the in-use stock
2. Technical aspects of brick reuse
Overall vision:
Future Circular construction economy
Overall project structure
Urban Mining – the potential availability of product for reclaim and re-use

Building stock assessment

• A framework for quantifying the reclaim/re-use potential of structural building products in urban areas for circular building and construction systems

• Estimating quantities of bricks, steel and concrete
The challenge

• Buildings and structural properties are not designed for deconstruction or disassembly
• Industrial and planning practices are cost/time driven
• New construction systems – new materials
• Research literature claims structural components cannot be reclaimed and remanufactured either technically or economically
Objectives of the in-use stocks model

• Compiling a spatiotemporal dataset and GIS layers of all buildings
• Dimensions, spatial outlines and typologies
• Construction years
• Spatially-explicit material contents
• Estimating potential reclaim values
• Environmental footprints
Similar attempts in building stocks models

• Japan


• China
Methodology and raw data

Bottom-Up assessment and dataset integration

Spatial Analysis

- Structures’ polygon
- Building heights
- Land cover history
- Building types
- Material intensity
- Average dimensions
- Modular analysis

OS

HLC

Literature - LCA

Building model tools

3D model

Spatio-temporal layer

Construction material stock over time

Material intensity for building typologies

Intermediate results

Datasets/ tools

Preparation

Integration

Final results
Methodology of stock assessment

Archetypes

- Material Intensity (MI) signifies the amounts of construction materials per area of structures
- For each material, stocks (MS) can be calculated by:

Key equation: \[ MS_{m,a,b}(t) = \sum_t \left( A_{a,b}(t) \times MI_{a,b,m}(t) \right) \]
REBUILD 3D models: characterisation

• A foundation for stocks, flows and visualisation

https://youtu.be/L3ITZmGPjLU
### Preliminary results

#### Brick analysis - Bradford

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of Bricks (in thousands)</th>
<th>Potential Value £1,000,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>High rise flats</td>
<td>-</td>
<td>1,106</td>
</tr>
<tr>
<td>Low rise flats</td>
<td>797</td>
<td>-</td>
</tr>
<tr>
<td>Terraced</td>
<td>207,618</td>
<td>1,149</td>
</tr>
<tr>
<td>Detached</td>
<td>9,515</td>
<td>112</td>
</tr>
<tr>
<td>Semi-detached</td>
<td>15,537</td>
<td>1,982</td>
</tr>
<tr>
<td>Housing Estates</td>
<td>39,003</td>
<td>25,641</td>
</tr>
<tr>
<td>Non-residential</td>
<td>43,872</td>
<td>15,375</td>
</tr>
<tr>
<td><strong>All Bradford</strong></td>
<td>316,344</td>
<td>45,368</td>
</tr>
</tbody>
</table>
Technical Aspects of material reclaiming
New separation techniques for Bricks, Steel and Concrete

- The feasibility of reclaiming bricks with two methods, i.e. saw-cutting and punching.

- Performance testing of reclaimed bricks

- A full-scale (4 m x 2 m) masonry wall construction and deconstruction using above approaches
Masonry block separation (*saw-cutting method*)

(a) Specimen type 1 - masonry block

(b) Specimen type 2 - masonry block
Masonry block separation (*punching method*)

(a) Specimen type 1 - masonry block

(b) Specimen type 2 - masonry block
Reclaimed bricks

• Reclaimed rate:
  ▪ 97.8% (saw cutting)
  ▪ 93.3%-100% (punching),

• Reclaiming speed:
  ▪ Saw cutting method
    (20s along one bed joint)
  ▪ Punching method
    (6s along one bed joint)
Brick slips by *saw-cutting*
IPG/Kuka 16kW fibre laser robotic remote cutting system

- Capable of cutting metallic materials of up to 25mm thickness.
- Laser cutting of pipes and concretes (nuclear decommissioning)
Next Steps

Task 1: Technical aspects:

- Brick reclaiming
  - Deconstruction of full-scale wall
- Steel reclaiming
  - Laser cutting of composite structure
- Assessment of future market for reclaimed/remanufactured products

Task 2: Stock and flow modelling:

- System dynamics of stock and flows
- LCA of materials (reclaimed vs virgin)
- Economics
- Full city assessment
Thanks for listening!

Questions?
Task 3: Scaling up and automation
A future Circular Construction System

- Building design and construction techniques
- Building Product Information Management
- New selective deconstruction techniques
- Fabrication centres for repair and remanufacture
- Upcycle facilities
- Logistics, Resource banks
- On line matchmaking market places
- Key players- designers, legal, finance, procurement, manufacturers, operators, demolishers etc.