REBUILD - Regenerative Buildings and Construction systems for a circular economy

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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:
1. Assessment of the in-use stock
2. Technical aspects of brick reuse
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
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

- Starting at the level of individual buildings and coming up with regional models as well as material contents
Sources of raw data in the UK

- Ordnance Survey (OS) and Historic landscape characterisation (HLC) are the crucial data sources
Methodology of stock assessment

- Temporal ranges (Pre 1945/ 45-60 / 61-85 / 85-Present)
- Residential and non-residential types
- GIS and 3D modelling
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>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre1945</td>
</tr>
<tr>
<td>High rise flats</td>
<td></td>
</tr>
<tr>
<td>Low rise flats</td>
<td>797</td>
</tr>
<tr>
<td>Terraced</td>
<td>207,618</td>
</tr>
<tr>
<td>Detached</td>
<td>9,515</td>
</tr>
<tr>
<td>Semi-detached</td>
<td>15,537</td>
</tr>
<tr>
<td>Housing Estates</td>
<td>39,003</td>
</tr>
<tr>
<td>Non-residential</td>
<td>43,872</td>
</tr>
<tr>
<td>All Bradford</td>
<td>316,344</td>
</tr>
</tbody>
</table>

Note: The potential value is calculated based on the assumption of an average value for each category.
REBUILD - Typology mapping and validation
REBUILD - Typology mapping and validation

- validating the results of the REBUILD stock analysis against the council records and the satellite imagery
- 83% confidence in the numbers of buildings
- 99% confidence on building types.
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

2.93mm/s for the initial six slips

15mm

10mm

10mm
### Compressive strength of perforated and solid bricks

*(Punching method)*

<table>
<thead>
<tr>
<th>Type No.</th>
<th>( \sigma_c ) (MPa)</th>
<th>SD</th>
<th>( \sigma_c ) (MPa)</th>
<th>SD</th>
<th>( \sigma_c ) (MPa)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>New</td>
<td>63</td>
<td>3.9</td>
<td>44</td>
<td>2.6</td>
<td>30</td>
<td>2.6</td>
</tr>
<tr>
<td>Reclaimed by punching</td>
<td>60</td>
<td>5.1</td>
<td>44</td>
<td>3.0</td>
<td>30</td>
<td>3.5</td>
</tr>
<tr>
<td>With Mortar (M12)</td>
<td>65</td>
<td>7.8</td>
<td>48</td>
<td>3.7</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

[BS EN 772-1-2011+A1-2015]
Full-scale masonry wall

- Perforated/Hollow brick
- Breeze blocks (7N)
- Cement: 32,5R
- Wall ties
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

• Brick reclaiming
  – Deconstruction of full-scale wall

• Steel reclaiming
  – Laser cutting of composite structure

• Assessment of future market for reclaimed/remanufactured products

Stock and flow modelling:

• System dynamics of stock and flows
• LCA of materials (reclaimed vs virgin)
• Economics
• Full city assessment