REBUILD
Circular economy of construction materials

EPSRC
Pioneering research and skills

REBUILD - Regenerative Buildings and Construction systems for a circular economy

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BUILDING AS MATERIAL BANKS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 642384.

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

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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

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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

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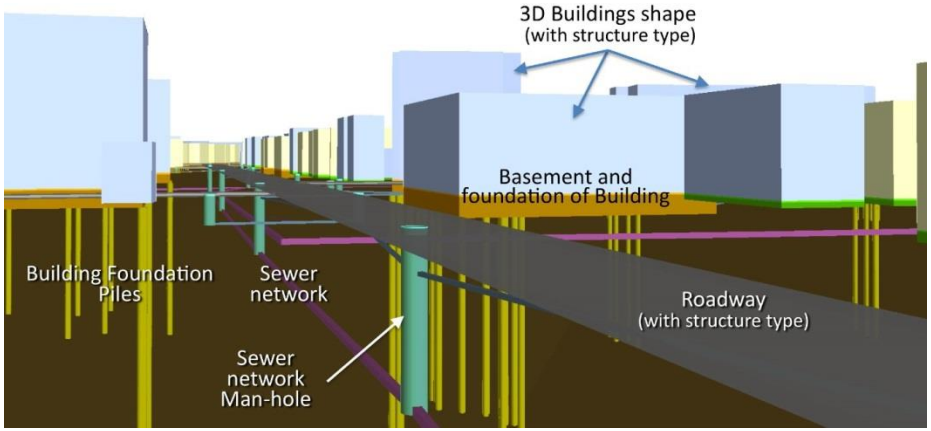
Similar attempts in building stocks models

- Japan



- Tanikawa, H. & Hashimoto, S. (2009) Urban stock over time: spatial material stock analysis using 4d-GIS. Building Research & Information. 37 (5–6), 483–502.

- China

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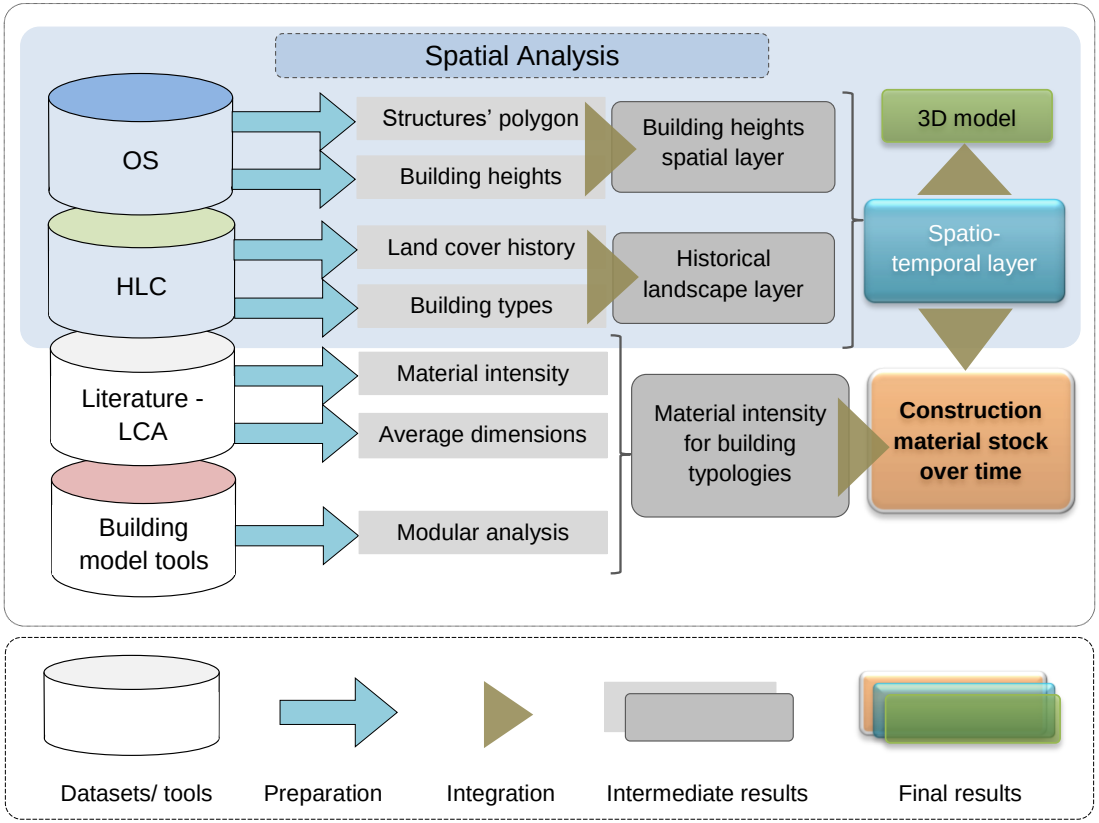
Methodology and raw data

Bottom-Up assessment and dataset integration



- Starting at the level of individual buildings and coming up with regional models as well as material contents

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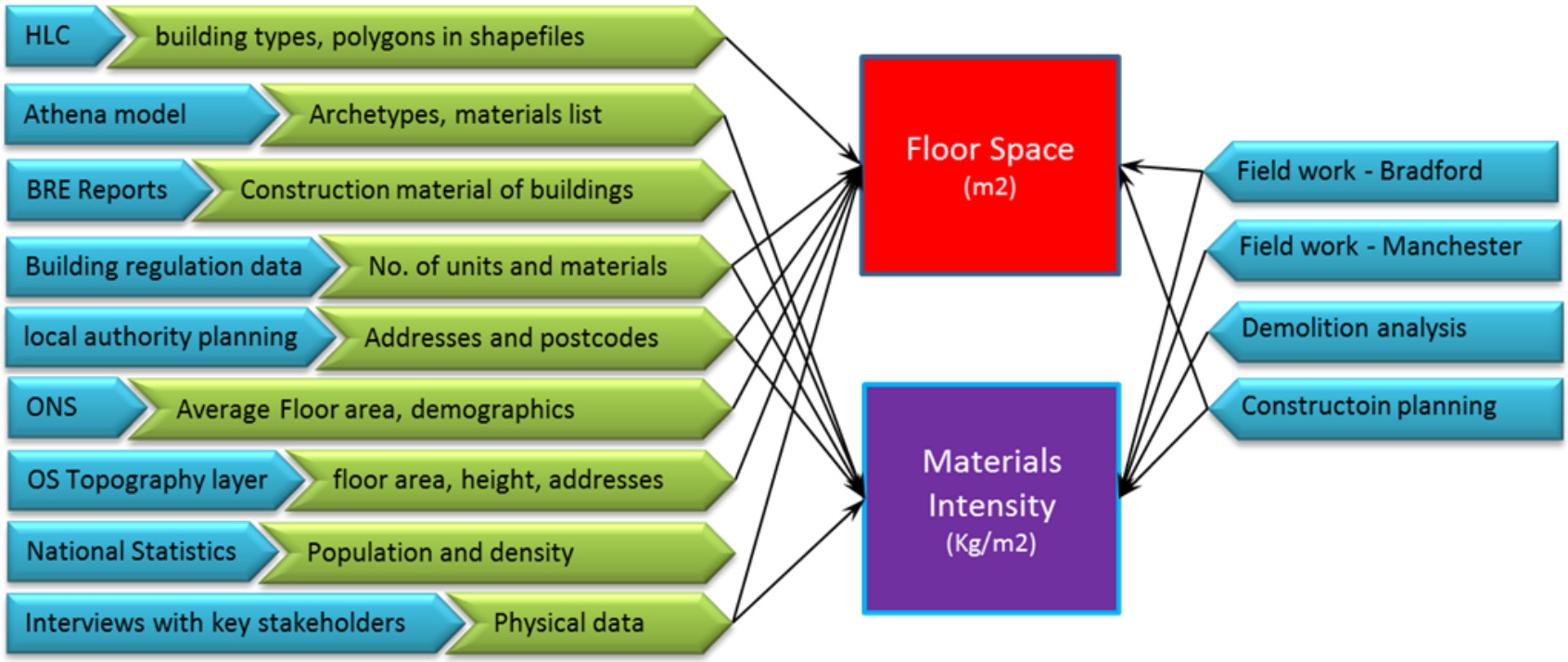
Sources of raw data in the UK



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

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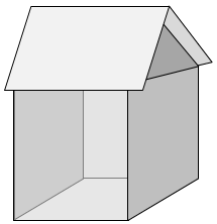
Methodology of stock assessment

- Temporal ranges (Pre 1945/ 45-60 / 61-85 / 85-Present)
- Residential and non-residential types
- GIS and 3D modelling



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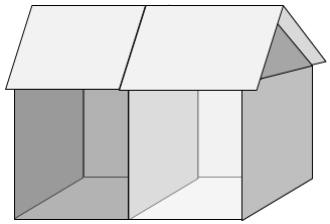
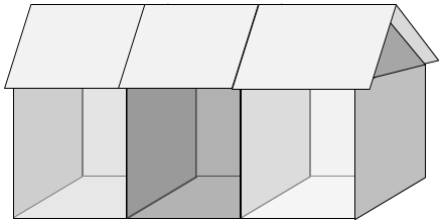
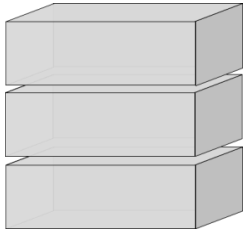


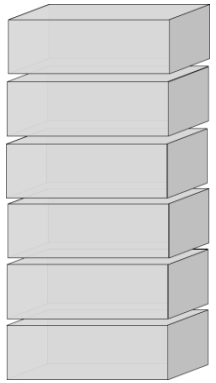
Semi-Detached



Terraced



Low-Rise



High-Rise

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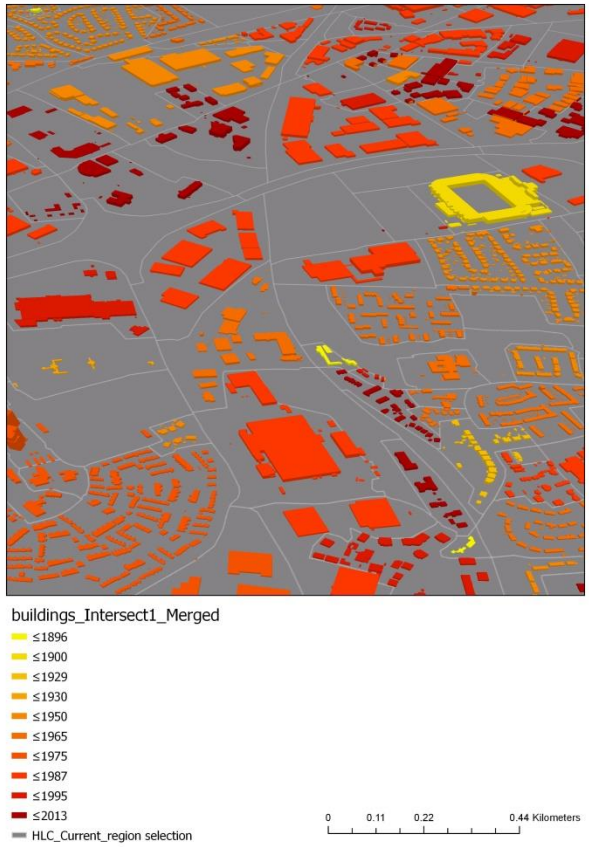
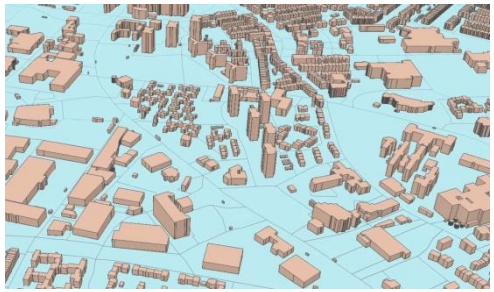
REBUILD 3D models: characterisation

- A foundation for stocks, flows and visualisation





https://youtu.be/L3ITZmGPjLU

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Preliminary results

- Brick analysis - Bradford

Type	Number of Bricks (in thousands)					
	Pre1945	1945-1960	1961-1985	1986-Present	Total	Potential Value £1,000,000
High rise flats	-	1,106	3,399	533	5,039	3.7
Low rise flats	797	-	10,938	5,268	17,005	12.8
Terraced	207,618	1,149	3,352	5,136	217,257	163
Detached	9,515	112	644	76	10,349	7.7
Semi-detached	15,537	1,982	1,994	939	20,454	15.3
Housing Estates	39,003	25,641	44,198	28,899	137,742	103.3
Non-residential	43,872	15,375	63,216	57,409	179,874	134.9
All Bradford	316,344	45,368	127,745	98,265	587,723	440.7

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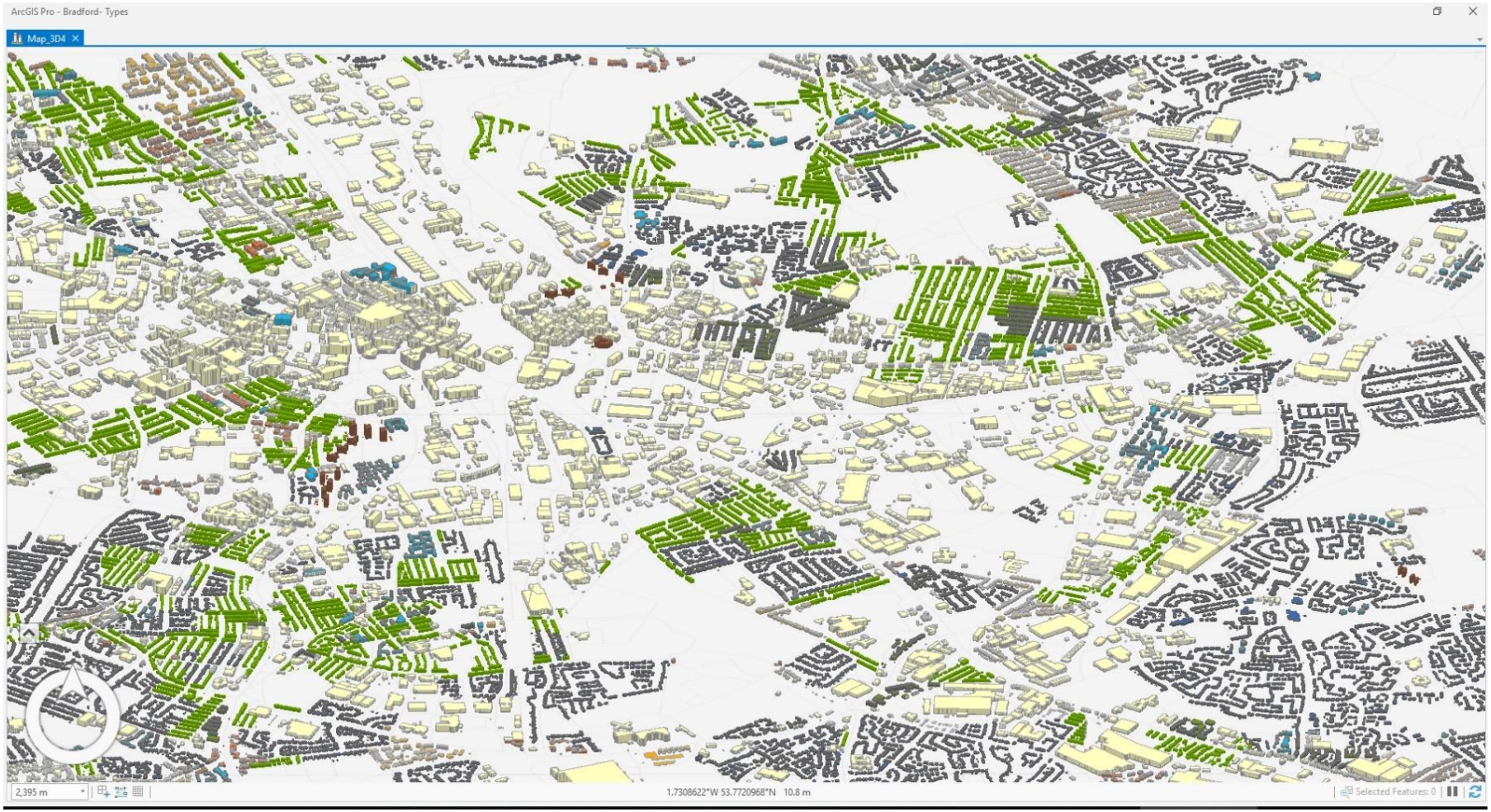
REBUILD - Typology mapping and validation



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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.

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Technical Aspects of material reclaiming

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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

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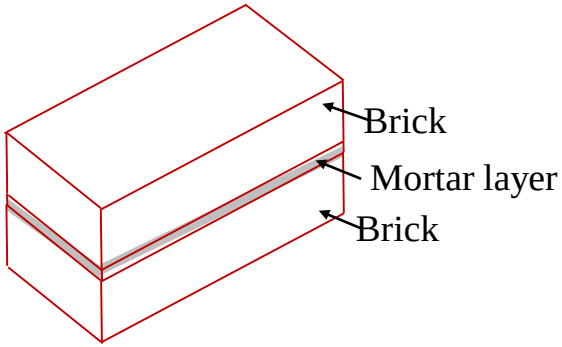
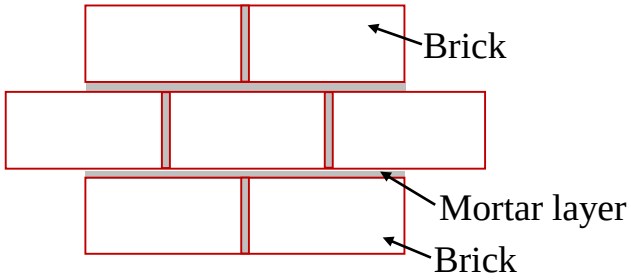
Masonry block separation (*saw-cutting method*)



(a) Specimen type 1- masonry block



(b) Specimen type 2- masonry block

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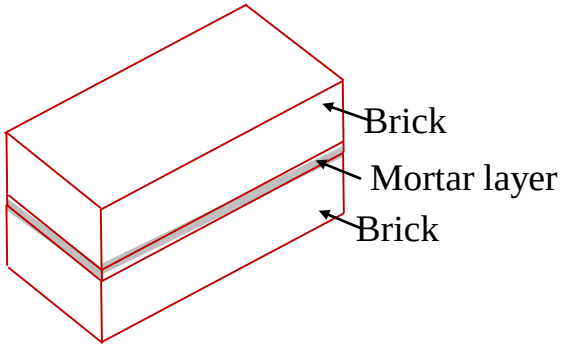
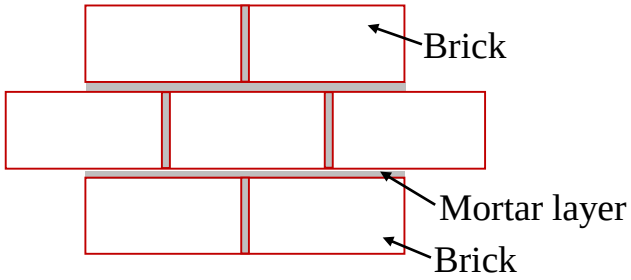
Masonry block separation (*punching method*)



(a) Specimen type 1- masonry block



(b) Specimen type 2- masonry block

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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)

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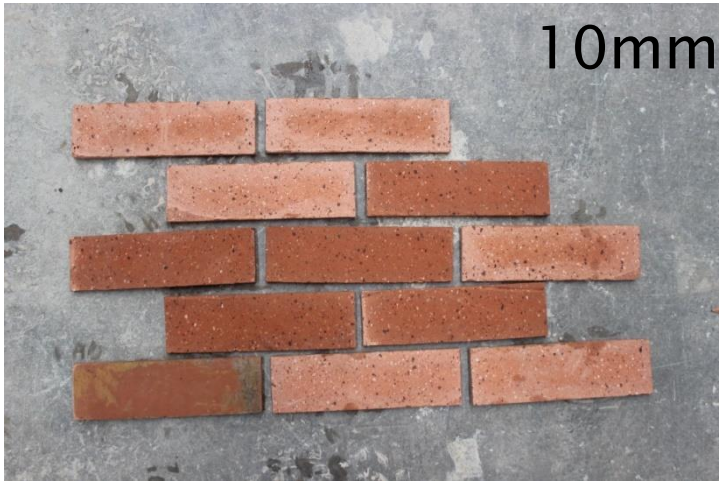
Brick slips by *saw-cutting*

2.93mm/s for the initial six slips



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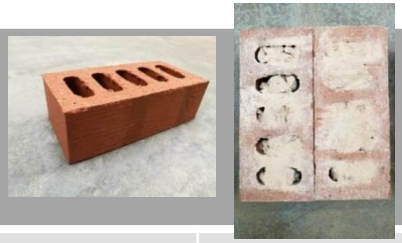
Compressive strength of perforated and solid bricks (*Punching method*)

Type No.						
	σ_c (MPa)	SD	σ_c (MPa)	SD	σ_c (MPa)	SD
New	63	3.9	44	2.6	30	2.6
Reclaimed by punching	60	5.1	44	3.0	30	3.5
With Mortar (M12)	65	7.8	48	3.7	-	-

[BS EN 772-1-2011+A1-2015]

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Full-scale masonry wall

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

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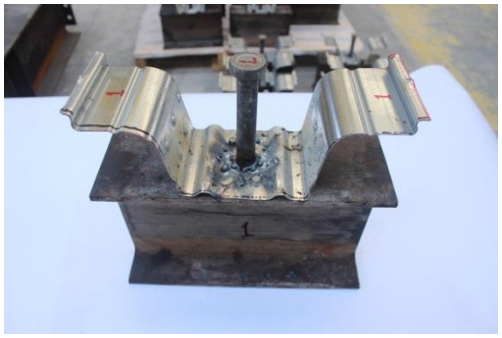
IPG/Kuka 16kW fibre laser robotic remote cutting system

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



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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

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